Featured Stories

Giving an invited talk at California Nanosystems Institute during a symposium. Image Credit: Shouleh Nikzad

In Her Own Words: The Science Division's New Leader

By Celeste Hoang

When Shouleh Nikzad was named the first woman to lead the Science Division at JPL (32x) in March, it was the kind of history-making news at the Lab that Nikzad hopes will soon be the last of its kind.

"What I feel is that this should be unremarkable," Nikzad said with a gentle laugh when asked how she feels about being the first woman in this role. "I also feel honored and grateful for the opportunity, and will work hard alongside the great team there. Hopefully, one day there won't be that many firsts left for women to achieve. It will be ordinary for a woman to get this position."

Nikzad herself, of course, is far from ordinary. Born and raised in Iran, she grew up in a home where education was prized and prioritized. Although intellectual discussions and pursuits were a way of life in her family, Nikzad was the first one in the family to pursue an education in science and math.

“With the encouragement of my parents, I grew up believing I could do anything I set my mind to and that there were no differences between boys and girls,” she says.

That belief took her far. After finishing high school in her native country, she studied electrical engineering and electrophysics at USC, before earning her master’s in electrical engineering at Caltech—all while working 30 hours per week to keep her green card sponsorship. Later, she earned her PhD in applied physics at Caltech before joining JPL, where she has been a principal engineer, a senior research scientist, and a JPL Fellow during her nearly 30 years on Lab.

Nikzad’s professional interests and accolades have been wide-ranging and numerous: She has studied and developed ultraviolet technologies, detectors, instruments, and science; low-energy particle detectors; and focal plane arrays and their applications, especially in astrophysics and planetary science, to name a few. She has over 200 publications and more than 20 patents under her name, and has won more than a dozen prestigious awards and honors, including being named a 2021 SPIE Luminary, a 2020 IEEE Fellow, 2017 National Academy of Inventors Fellow. In 2020, she received the NASA Outstanding Leadership Medal.

Below, Nikzad shares how she’s grown through life’s personal and professional challenges, how she sees 32x evolving under her leadership, and the one piece of advice she would offer to all JPLers trying to get their ideas off the ground.

On her early obsession with space exploration:

I remember seeing “2001: A Space Odyssey,” and I could not leave the theater. Of course, the Moon landing left an incredible impression on me. In the summer after my first year in high school, I read a book on the whole Apollo program. I was just so fascinated that I told my classmates and friends and family, ‘I’m going to get my PhD in physics and work for NASA.’ Being at JPL now, this was exactly what I had wished for.

On her early years in America and supporting herself as a student while working full-time:

After USC, I had an opportunity to work for a small company that would sponsor my green card. This also allowed me to attend Caltech while working. The company would support my tuition as long as I worked 30 hours per week.

It was tough and I don’t necessarily recommend it. But I had the support of family, which enabled me to manage it. I didn't want to delay schooling, and the opportunity to get my permanent residency was too good to pass up. This was such a great opportunity that I had to think of it long-term. It’s tough for a period of time, but then it’s worth it for the rest of your life.

On her love for both physics and electrical engineering:

Physics to me was so fundamental in the sense that you could gain an understanding about things from basic principles. I learned a lot from engineering as well. I wouldn’t say electrical engineering and physics are that far apart: one is more fundamental and one is more applied. You’re building something as an engineer and as a physicist you are trying to understand the reason behind things. From there, you solve problems together. I have used both trainings, and I have felt that studying both could help me jump from one field to another.

Inspecting the handiwork of her grad student intern inside JPL's Microdevices Laboratory. Image Credit: Shouleh Nikzad

How do you push yourself through tough times at work?

For me, the tool of choice is humor. I look at the really big picture in order to deal with it. Those who have worked with me for many years know that the higher the stress, the funnier they seem to get. That's a way for me to handle it.

Every time you face a big challenge, it's true that it's stressful. But it's also an opportunity to shine and grow, so that's what I emphasize for myself and for the team—sometimes over coffee, lunch, or dinner: Yes, it's challenging, there are also eyes on us and there will be much scrutiny, but look at what an opportunity this is for us to show what we're made of and what we can achieve and make a difference.

Tell us about your journey to becoming a manager. Has this always been a goal of yours or did it come as a bit of a surprise?

The short answer is that this opportunity came as a bit of a surprise. What I've always wanted to do from the moment I came to JPL was to do good work and achieve scientific and technical objectives in my field and the Lab. At different times, that took different forms for me. It was kind of a gradual growth. At the beginning, I was very focused on my individual achievements, and I wanted to be able to do interesting research with long-term applications for JPL and NASA. It was important—and it remains important to me—to be able to publish and invent. At some point in my career, I had sufficient research funding that I was working with a number of people and a group naturally formed around what I was doing. I've had the privilege of working with incredible colleagues and university collaborators including students.

To be here now, it's an amazing journey in the sense that I feel this position will give me an opportunity to have a bigger impact.

On bringing her unique traits and background to the role:

I've been at the group level in line management for a long time. I've learned to put together teams that didn't seem a natural grouping at first. I come from 38x and I have worked a lot with 32x and with external collaborators. Most of my successes in research, technology development, and infusion, have come from

extensive brainstorming and working closely with end users: building relationships, learning to speak each other's language, and appreciate the nuances of each field. My hope is to enable similar collaborations in an organic way across divisions and across organizations: start from 'What do we want to measure that we cannot measure today? Can technologies be invented/reimagined, or instruments built or repurposed, to make those measurements possible?' I want to make those connections across divisions to make the future we dream of a reality.

It's very much about people. The best resource we have are people, their knowledge, creativity, and passion. We need to be intentional about making it possible for everyone to do their best work. It may seem cliche, but the work-life balance has to be considered.

How do you see 32x evolving under your leadership?

There is so much talent and resources that Division 32 has to offer and help us pave the path for winning future missions in various directorates, from astrophysics to planetary and Earth science. To do that, I plan to reach across divisions and directorates to make sure we put in place resources, people, and what we might need in terms of infrastructure so that we can be ready for future missions, create opportunities, and have an environment that fosters productivity and creativity.

What I want to do now is help the scientists in Division 32 navigate some of the things I had to learn myself in terms of getting ideas communicated and funded, matured, and hopefully turned into instruments and missions for the future at JPL and NASA.

Speaking to the public in a show and tell at Explore JPL. Image Credit: Shouleh Nikzad

What does it mean to you to be in such an influential role at JPL?

I've always wanted to do good and interesting work. That was my number one goal. The scope, of course, changed over time. I believe this role allows me to have more impact as I hopefully will be able to help people with their aspirations and ideas now.

It helps me to think that there are challenges ahead where I have a chance to do some good at a bigger scale. It also makes me mindful of the fact that decisions could have a bigger effect on more people.

What has been the most challenging part of your career to date?

For people who have ideas and want them to come to fruition, the number one obstacle is to get people interested and get your ideas funded. That's a learning process. I remember the moment that I realized what I need to do: I needed to really engage with the end users. At the time, because I was developing technology, the end user was an astrophysicist, a planetary scientist, and on occasion Earth scientist. I had to get them to engage with me and exchange ideas. It took effort and perseverance, which paid off. This has to happen while you also continue to learn and grow in your own field.

If you don't get funded for the first proposal, you have to keep pushing if you know the idea is good and it has impactful applications. It's never easy to see your ideas be rejected—even after all these years of experience. You have to honestly assess and ask yourself if this is really not a good idea. Maybe you just have to present it in a different way. You learn to think about it logically and that a rejection is not an indictment of your ideas, and you get through it.

In addition to the obvious—knowledge and skills in your field—funding and communication are really important in science and engineering. I teach a project-based class at Caltech and I tell students that in addition to having a great idea and making it work, you have to be able to communicate it. What's your elevator pitch? What if we were on a flight or seated together at a dinner, how would you explain your idea?

What has been the most rewarding part of your career to date?

Working with amazing people. That's been just so wonderful. And getting a chance to make an impact: you get an idea, make it work, and get it to measure and understand something in the universe. What's so rewarding and exciting is that I've had the chance to work on science and applied science at the level of tiny atomic scales and nanoscales that have a big impact on the galactic scale. Both are fascinating and amazing. And to have fun doing it? It's been incredible.

With Stephen Hawking in his office in Cambridge University. Image Credit: Shouleh Nikzad

You once met Stephen Hawking. How did that happen and what was that experience like for you?

It was exciting and awe-inspiring to meet him. I had a chance as the president of the Society for Brain Mapping and Therapeutics to present the award of "Beacon of courage and dedication" to him. The society was focused on bringing together multidisciplinary scientists, physicists, engineers,

neuroscientists, and neurosurgeons to solve the mystery of the human brain and its ailments. Hawking famously and routinely had turned down awards and honors, but with the help of his friend and a prominent physicist at Caltech, and my sincere explanation of the purpose, he accepted.

You're also on the Inclusion Advisory Committee (IAC). Why is being part of this initiative and having this role important to you?

Experiences in my youth instilled a strong sense of equity in me. My own experiences, and my observation of others' experiences, made it a priority for me to get involved. I was excited about the establishment of the IAC, and was honored to have been selected to be part of it. A lot has happened since then, and I'm looking forward to much more to come.

What do you like to do outside of work?

I like to read. I enjoy classics like Jane Austen as well as contemporary authors and Persian authors. I got to visit Austen's home several years ago. I first read "Pride and Prejudice" the summer before junior high. It's really interesting the way she weaves feminism into her seemingly simple stories.

I am a cinephile—classics as well as other genres. I also write on occasion. I have a few [essays] that I'm working on when I get a chance, a couple of things about humor, culture, and the application of physics. I have a family, I have cats, I garden a bit, and I love to take walks and exercise. I had neglected that for some time—but have made it a priority again especially during the pandemic. It's a good balance for the fact that I also like to cook and to eat.

On dreams coming true:

One of my high school friends brings her students to JPL once in a while. She told me that on the bus, she has said to them, 'You're going to meet someone who at age 14 said they're going to work for NASA. And she does.'

I tell my students and mentees that there's no substitute for being good at what you do and being willing to learn and work hard and put in the effort. Having mentors, having sponsors, having a good peer group, being in the right place at the right time—all of those things have to come together. Bottom line is that I really ended up doing what I love to do and I am grateful.

Answers have been edited for length and clarity.

JPL Helps Lead the Way With First-ever Space Industry Diversity Pledge

Twenty-three space industry executives, including JPL's Interim Director Larry James, gathered at the 37th Space Symposium in Colorado Springs on April 5 to pledge their commitment to advancing diversity across the collective workforce in coming years.

The executives signed the "Space Workforce 2030" pledge, the first-ever space industry commitment of its kind to "significantly increase the number of women and employees from underrepresented groups." Each company will agree to annual reporting of data on diversity in our collective technical workforce; a regular cadence of exchanges of best practices; and work with universities to increase the number of diverse and underrepresented students ready to join the space industry.

Cozette Hart, JPL's Director for Human Resources, is proud of JPL's partnership in this effort.

"As an organization, JPL has shared DEI data and we post in our Annual Report as well as on JPL's inclusion website," said Hart. "The unification and seeing this commitment broaden is positive for all within the industry."

Neela Rajendra, the Lab's manager of Diversity, Equity and Inclusion, acknowledged the importance of being part of a cohort of other aerospace organizations where companies can identify trends and learn from each other.

"This is industry-specific and even more powerful," she said. "There's a recognition that if we can advance diversity, equity, and inclusion for the industry as a whole, we'll all benefit from it."

Collaboration also helps JPL refine its diversity focus areas as the Lab continues to develop its strategic plan, Rajendra added.

"Sometimes, sample sizes are too small within one organization to really understand what are drivers of workforce trends," she said. "But by continuing to look at the data from an industry-wide lens, it will help

us identify and test specific interventions that can have real impact, rather than completely doing this work on our own."

By signing the pledge, the companies vow to accomplish the following by 2030:

- Significantly increase the number of women and employees from underrepresented groups in our collective technical workforce
- Significantly increase the number of women and employees from underrepresented groups who hold senior leadership positions in our collective technical workforce
- Work with universities to increase the percentages of women and students from underrepresented groups receiving aerospace engineering degrees to levels commensurate with overall engineering programs
- Sponsor K-12 programs that collectively reach over 5,000,000 underrepresented students annually
- Meet twice a year at the working level to exchange best practices on strengthening diversity recruitment, STEM education outreach and representation at leadership levels
- Seek like-minded leaders and organizations to join this effort

"This effort links to the DEI recruitment efforts already in place at JPL," shared Hart. "In partnership with these companies and our universities, colleges, and organizations such as Society of Women Engineers (SWE), National Society of Black Engineers (NSBE), etc., we will be implementing even more opportunities for current and potential employees in the future."

"Essentially, we're committing to continuing the focus on our talent pipeline and really supporting future employees," said Rajendra. "It's about ensuring that all students have the opportunity to join the technical fields in aerospace regardless of background, socioeconomic status, or self-identity."

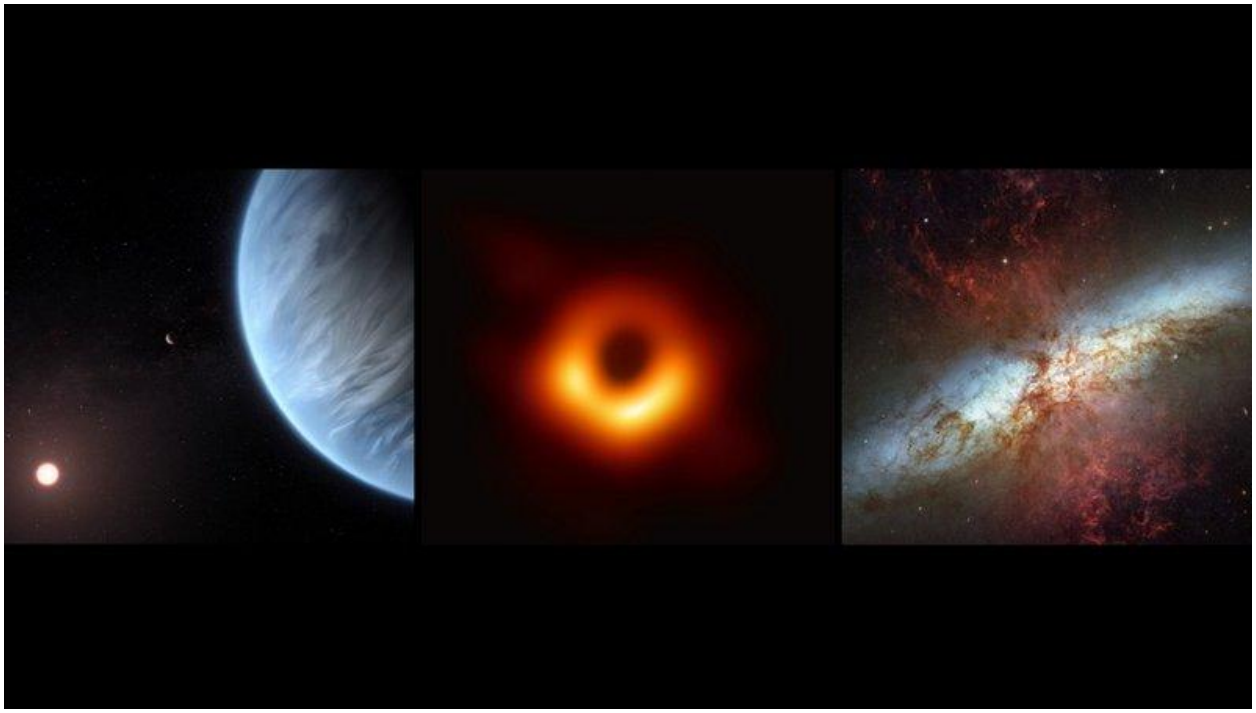


Image Credit: NASA

The Astrophysics Decadal Survey Spells Opportunity for JPL

By Taylor Hill

At the end of 2021, the National Academies of Sciences, Engineering, and Medicine put out its decennial wishlist of goals for the astronomy community to strive for, and the broad and ambitious report bodes well for JPL.

Titled “Pathways to Discovery in Astronomy and Astrophysics for the 2020s,” the recommendations in the new report are not binding, but bring scientific consensus to budget keepers in Congress and decision makers at NASA, the National Science Foundation, and the Department of Energy, all of which use the report to determine what missions they should invest in.

“This is a scientifically broad and exciting program; it’s not a surprise,” said 7x Chief Scientist Charles Lawrence. “These themes have been around for a while. We have anticipated these major science areas at JPL, and we’ve been working toward these. This is good news for the Astronomy and Physics Directorate and good news for JPL.”

So, what’s included in the 600-plus-page report? A lot. Top level highlights include a proposed $11 billion flagship space telescope with a mirror twice the diameter of Hubble’s; a new “Probe-class” program of mid-sized space telescopes; and a call to increase efforts to recruit a more diverse and inclusive workforce in the astronomy community.

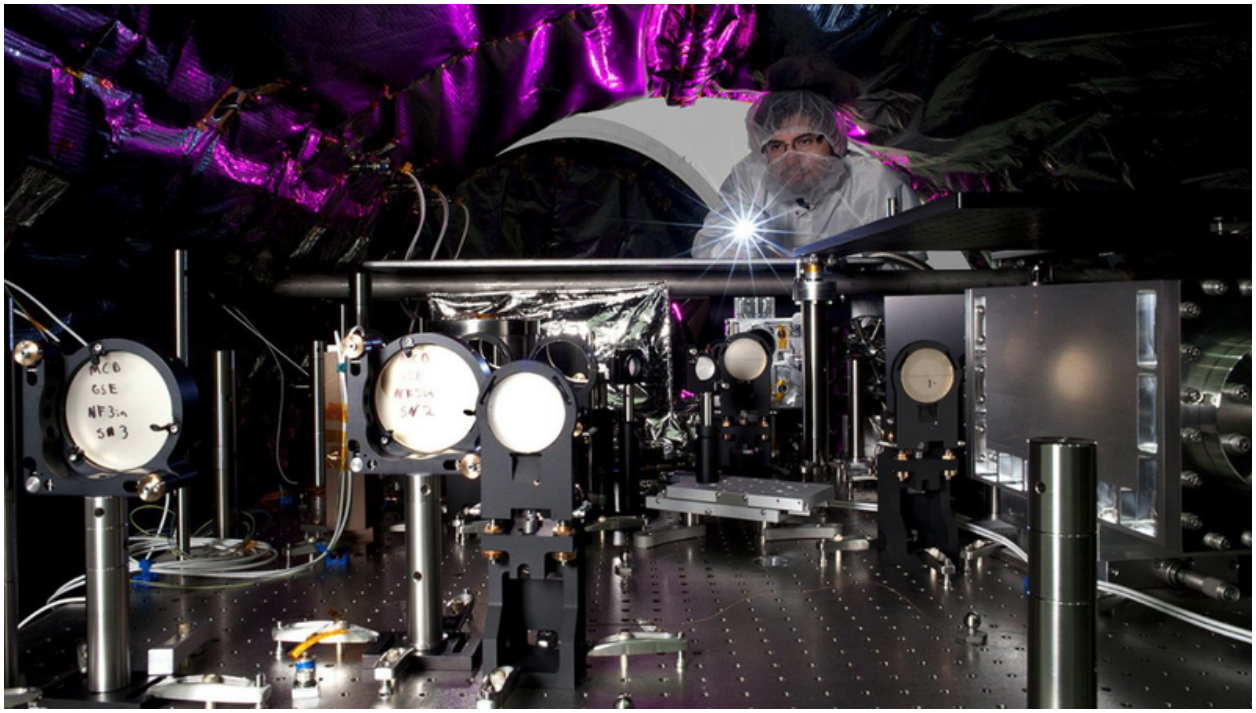
And while it’s easy to focus on the proposed missions, projects, and sleek technological advancements, the National Academies broke the survey down into identifying the most promising avenues of scientific research, framed around three broad science themes—Worlds and Suns in Context, New Messengers and New Physics, and Cosmic Ecosystems. Each theme has a priority area specifying the science areas of emphasis.

Prioritizing the Science

Starting with Worlds and Suns, the priority area noted in the decadal survey is dubbed “pathways to habitable worlds,” which emphasizes science and technology development for finding and characterizing Earth-like exoplanets that could harbor life. For JPL, that means creating observational techniques, and developing hardware and technology that allows for imaging and spectroscopy of those potentially habitable worlds.

In the New Messengers and New Physics theme, the survey prioritizes “New windows on the dynamic universe,” revealing phenomena that Lawrence refers to as “universal fireworks,” including understanding rapid, powerful events (such as neutron star collisions, black hole collisions, and stellar explosions) over time using gravitational waves, neutrinos, and the full electromagnetic spectrum.

Many missions and projects already planned or underway were given a ringing endorsement in the survey. They include Euclid—the ESA/NASA space telescope looking at mapping the dark energy and matter in the universe—set to launch in 2023; the Vera C. Rubin Observatory—an 8.4-meter ground-based telescope in Chile set to start deep-imaging the sky in 2024, The Nancy Roman Space Telescope—with the JPL-developed coronagraph instrument (CGI)—is set to launch in 2027; and Caltech’s Laser Interferometer Gravitational-Wave Observatory (LIGO).



Optical Engineer Camilo Mejia Prada shines a light on the interior of a testbed at JPL for the coronagraph instrument that will fly aboard the Nancy Roman Space Telescope. Image Credit: NASA/JPL-Caltech

With existing and planned missions to come in the next decade, the survey recommends establishing a “Time Domain Program,” that takes information about gravitational waves, elementary particles and electromagnetic radiation and combines it all to gain deeper insights into the underlying astrophysics of the universe.

The goal of the third theme, called Cosmic Ecosystems, is to study the origins and evolution of galaxies, massive black holes, stars, and planets, and better understand the connections between these processes. Lawrence noted the theme as inherently multi-scale, covering an enormous physical range. The priority area the survey prioritized “Unveiling the drivers of galaxy growth,” is aimed at unlocking the secrets of

how galaxies form and gain complexity, and how their surroundings, the black holes in their nuclei, and other inputs drive their evolution.

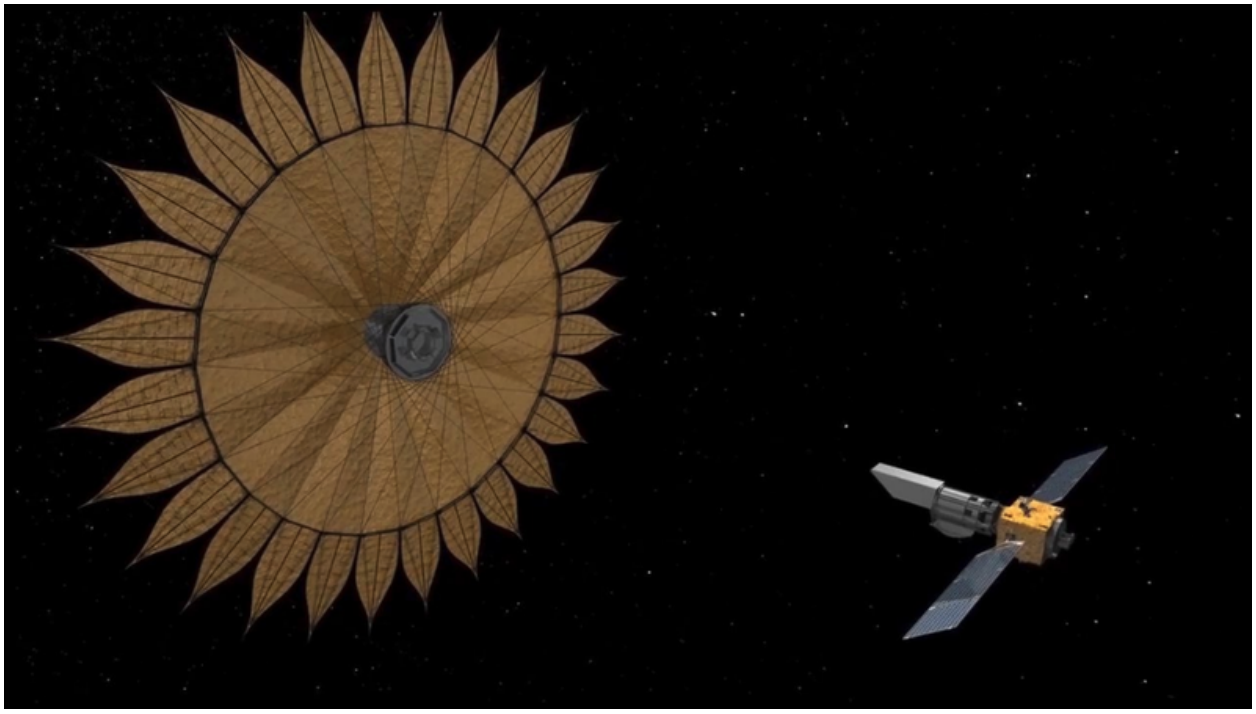
Recommending the Right Tools to Answer the Big Questions

With the science themes outlined, the report gave recommendations outlining the tools, projects, and programs needed to reach the new goals:

The first recommendation of the 2020 decadal survey was not a mission. Instead, the survey recommended starting and investing $1.2 billion in a program called “The Great Observatories Mission and Technology Maturation Program.” Lawrence sees it as a paradigm change from previous decadal reviews, and from how NASA has tended to operate.

“The idea is to invest in maturation before implementation,” Lawrence said. “It may not seem like such a strange concept, but it hasn’t come up in the decadal review before. And speaking for myself, it’s a welcome recommendation.” Within the program’s budget would be funding for the maturation of the first recommended flagship mission: a six-meter space telescope for observations at ultraviolet, visible, and infrared wavelengths capable of detecting biosignatures in the atmospheres of roughly 25 Earth-sized exoplanets, in addition to other useful science, launching by the mid-2040s.

The concept described in the report is a compromise between two NASA-funded mission concepts studied for the decadal. One, called LUVOIR, offered a telescope between 8 and 15 meters in diameter for ultraviolet, optical and infrared observations. The other, a JPL-led proposal called the Habitable Exoplanet Observatory (HabEx), devised a telescope between 3.2 and 4 meters across that could be combined with a separate spacecraft, called Starshade, and would be capable of direct-imaging exoplanets.



This artist's concept shows the geometry of a space telescope aligned with a starshade, a technology used to block starlight in order to reveal the presence of planets orbiting that star. Image Credit: NASA/JPL-Caltech

7x Formulation Program Manager Jeff Booth noted JPL’s experience in mission formulation fits well within the program.

“The next flagship mission is not starting tomorrow, but the formulation of the mission and the technology is going to be a major emphasis over the next decade,” Booth said. “JPL is well-suited in the area of formulation, and I think we can play a leading role there.”

New Probe Mission Line Promising for JPL

In addition to the flagship mission recommendation, the decadal report recommended the start of a new “mid-sized” space telescope program (with a total NASA cost per mission of $1.5 billion), with the goal of launching one mission per decade. In the first Probe call for proposals, only missions in X-rays and far-infrared wavelengths will be solicited. JPL is expected to put forth a proposal for a space telescope looking at far-infrared wavelengths.

“The technology for this type of mission rests with its detectors, and for two decades, JPL research and technology development have built on infrared detectors for far infrared capabilities,” Booth said.

State of the Astrophysics Profession

Finally, the decadal survey looked inward at the state of the astrophysics profession, examining issues with diversity and inclusion, workplace climate, and the contributions of astronomers to education and outreach. The report mentions improving representation for women in the astrophysics community, but a continued lack of racial/ethnic diversity in the profession.

At JPL, Booth mentioned the efforts to reach a more diverse potential workforce with the start of the Astrophysics Mission Design School. The school would be modeled after Planetary Science Summer School that JPL has run for 20 years.

“By creating this school, we can directly influence the pipeline of the future leaders of astronomy and science missions for NASA,” Booth said.

Additionally, all of JPL’s astrophysics proposal submissions going forward will include explicit plans for addressing Diversity, Equity, Inclusion and Accessibility issues, as part of the management plan of those missions.

“In the end, with all of these great mission concepts and technology, none of it will go forward if we don’t have a community and workforce at JPL that’s fully engaged,” Booth said.

JPLers who contributed to the Decadal Survey on Astronomy and Astrophysics 2020 included Daniel Stern (panel member on galaxies), Tiffany Kataria (panel member on exoplanets, astrobiology, and the solar system), Alina Kiessling (panel member on enabling foundation for research), Charles Lawrence (panel member on electromagnetic observations from space), David Bearden (panel member on optical and infrared observations from the ground), and Rosaly Lopes (Space Studies Board member).

The first TV image of Mars has been relocated to Building 179, and is now accessible to Lab visitors. Image Credit: Dan Goods

The First Spacecraft Image of Mars Lands at the Highbay

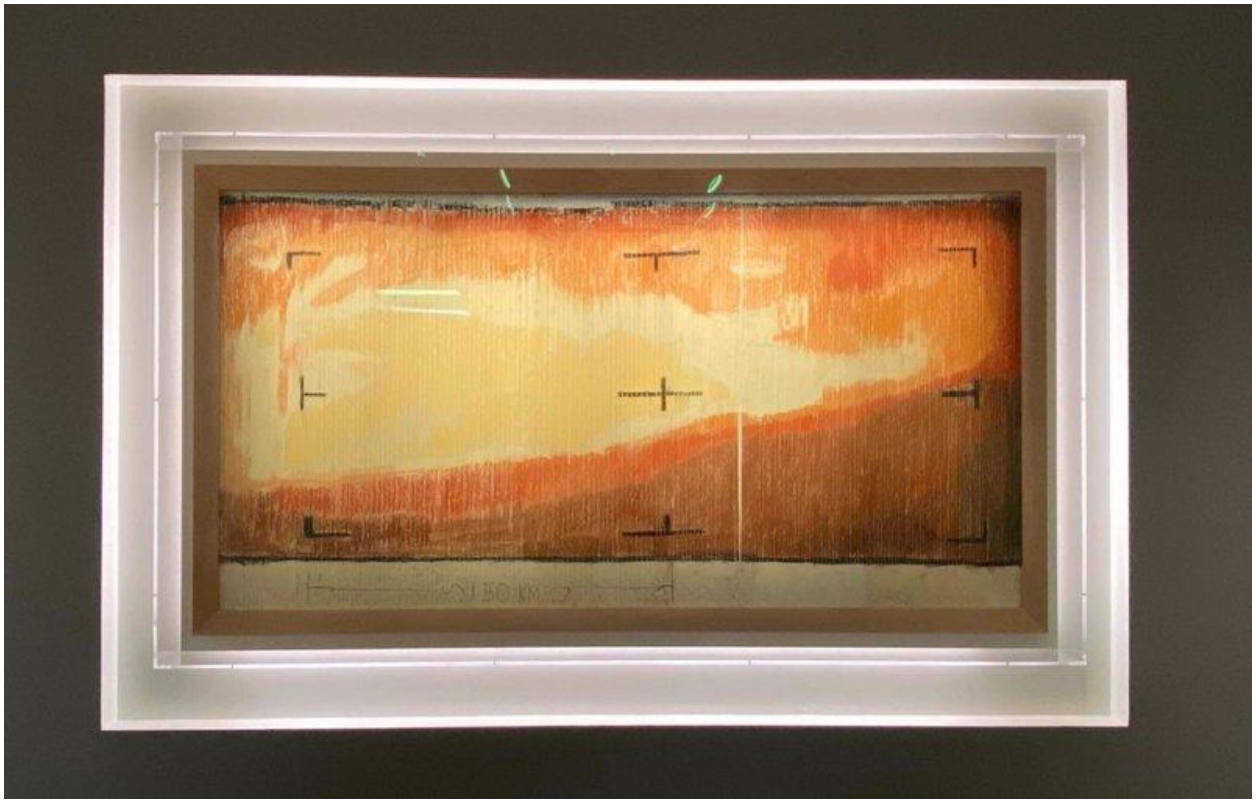
By Taylor Hill

Ten years ago, Mechanical Engineer Evan Hilgemann—then an intern working at the Lab—came across a piece of JPL history he hadn't seen or heard of during his orientation.

"They were premiering the 'Changing Face of Mars' documentary in Pickering Auditorium, and they had pulled out the Mariner 4 Mars image for it, since it's in the film, and that's when I learned its amazing story," Hilgemann said.

That story goes something like this: In 1965, JPL's Mariner 4 spacecraft was completing its flyby of Mars, snapping images along the way. Back then, computer processing took some time, and imaging processing took even longer. So a few impatient JPLers too anxious to wait found a workaround; they printed the color data on ticker tape strips, tacked them up on a wall, and used pastels to paint the surface of Mars by number.

The brown, orange, and red-colored panorama became the first TV image of Mars. After the flyby, the image was cut out of the wall, framed, and given to then-Director William Pickering. Decades passed, and the image eventually ended up in the hallway of Building 186—out of sight to many JPLers and in an area inaccessible to public tours.



The framed "First TV image of Mars," made out of printed strips of paper converted from Mariner 4 data. Image Credit: NASA/JPL-Caltech

After seeing it exhibited for the movie premiere, Hilgemann thought it a shame that such a special piece of JPL's history should return unceremoniously to its tucked-away location. Alas, as mechanical engineers tend to do at JPL, he was pulled back into work and robot-building. Still, the image remained in the back of his mind until 2018, when JPL organized a "Pitch Day" on Lab, giving JPLers an opportunity to put forward ideas that typically don't have a place to be heard.

On the judge's panel that day was Director for Communications and Education Michael Greene, listening intently to Hilgemann's pitch.

"When Evan started talking about this historic Mars TV image I thought, 'Hey, that's in the hall right outside my office!'" Greene recalled. "He made a pretty compelling case about why this image should be treated as an artifact and displayed in a location where more visitors could see it."

From Pitch to Permanent Exhibit

That Pitch Day kicked off the creation of a permanent home for the image: It's now staged prominently alongside a collection of images and artifacts in a hallway corridor outside the viewing gallery of Building 179's Highbay 1.

Following Hilgemann's lead, the Studio—part of JPL's DesignLab team—worked to incorporate the Mariner 4 image into a gallery installation. The accompanying plaques and images adorning the walls provide background and help tell the image's complete story.

"When we started on this project, it was really about making sure we preserved the image properly," said Dan Goods, Studio manager.

And that was no small feat. First, the original frame had to be removed and replaced with a museum-quality protective acrylic face. But since the strips that make up the image are still stuck to a section of a 1960s-era office wall, the piece had to be tested for asbestos.

“Luckily it passed, or we wouldn’t have been able to even open it up,” Goods said.

Next, a paper conservator from Los Angeles Art Conservation inspected the image. They checked for rusted staples that could cause damage to the piece, and suggested framing options to best preserve and display the image.

From there, Goods and his team worked to tell the story of the image, surrounding the central piece with pictures of the engineers who colored the paper strips; side-by-side comparisons of the black and white image processed by Mariner 4 and the engineers’ color-by-number piece; and even the original pastels used by the engineers 57 years ago.

“About 10 or 15 years ago, I talked with Dick Grumm, the engineer who actually did the coloring, and he told me the story about how he had printed out the strips, and wanted to color them on some sort of grayscale,” Goods said. “He went to a local art store in Pasadena looking for chalk, but that was too ‘low brow,’ and the store didn’t carry chalk, so he had to get these pastels.”

Grumm then created a brown/red color key, designating different colors for different number sets—giving a color range to match up with the data and create a picture.

“It’s unbelievable how close the color scheme is to the actual colors of Mars’ surface,” Goods said.

The color key was thought lost until Goods and the team removed the image from the wall in Building 186, and found it taped to the back of the frame.

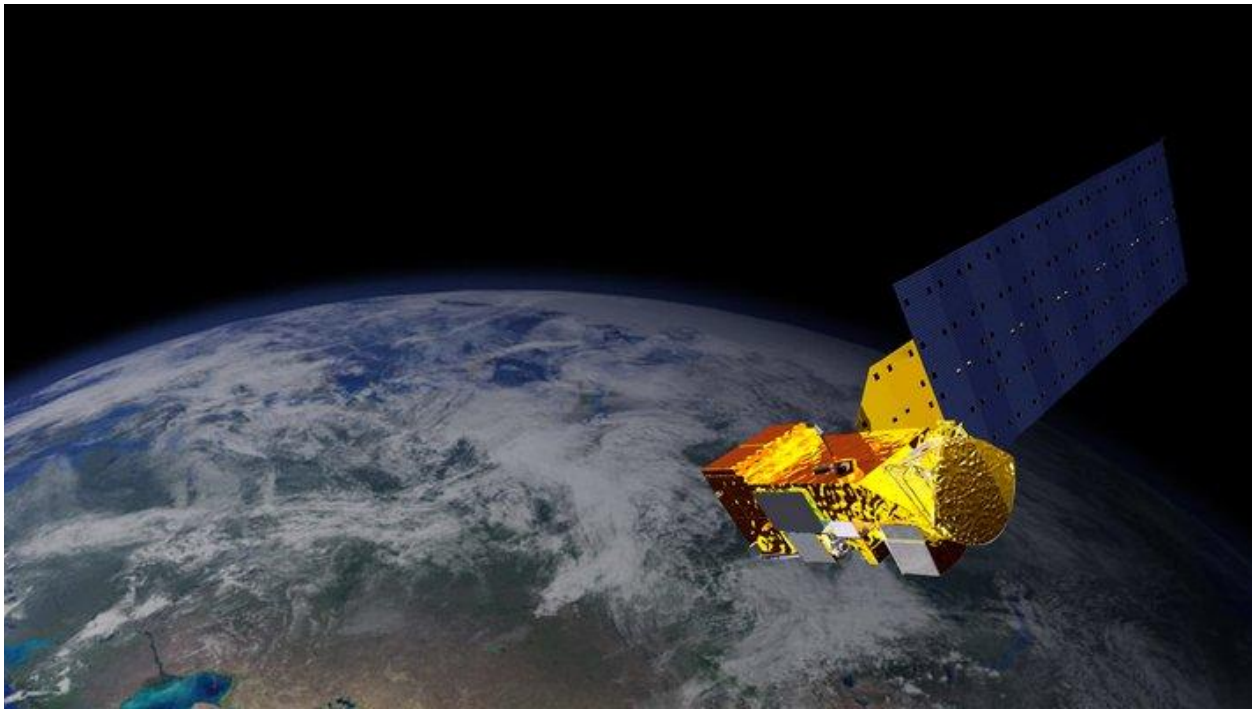
As for the pastels, Goods said Grumm had them in his attic for years, with a note on the back of the box that read, “Save this.”

Ready for the Limelight

JPL’s Public Services Office plans on leading tour groups around the display when possible, fulfilling Hilgemann’s original vision for the image.

“Seeing what they’ve been able to do with it, it’s really an amazing job that’s exceeded any expectations I had,” Hilgemann said. “I hope the gallery conveys the culture of adaptability and ingenuity we strive for here at JPL. The engineers that made the picture could have just sat around and waited for the computer to crunch numbers, but instead came up with and acted on a clever solution to solve the problem quickly. I think we’ll continue to do well at JPL as long as we can maintain that sort of attitude.”

And showcase it for everyone to see.



AIRS at 20 Years: A Bounty of Data

By Erik Conway

May marks the 20th anniversary of the launch of JPL's Atmospheric Infrared Sounder (AIRS) aboard NASA's Aqua satellite, on May 4, 2002. AIRS was the brainchild of the late Moustafa Chahine, once manager of JPL's science division, who had the idea of improving weather forecasting through hyperspectral sounding back in the 1970s. Hyperspectral sounding uses thousands of infrared channels to better discern temperature and water vapor variations in the atmosphere. AIRS was selected for NASA's Earth Observing System constellation in 1988.

As the first in a series of hyperspectral sounders for weather forecasting, AIRS was a trailblazer for understanding and assimilating hyperspectral data into weather forecast models. The new generation of European meteorological satellites now hosts a hyperspectral sounder, the Infrared Atmospheric Sounding Interferometer. A similar U.S. instrument called the Cross-track Infrared Sounder flies aboard the NASA satellite Suomi NPP and the next generation National Oceanic and Atmospheric Administration (NOAA) weather satellites.

Weather's the Main Story

Weather forecasting is where AIRS had its greatest early impact. In 2006, a group led by the NOAA's John Le Marshall showed that using AIRS data in weather forecasting models provided a significant improvement in forecast "skill." Skill is the name of the calculation meteorologists use to quantify the closeness of a forecast to the observed weather. Ghassem Asrar, who was NASA's Associate Administrator for Earth Science in the 2000s, says, "AIRS truly advanced the field of short-term weather prediction, but has also contributed to what is called now seasonal to sub-seasonal climate. We have learned more about internal variability of the Earth system and have used that knowledge to expand predictability across scales."

During its first decade of operation, AIRS also scored some major scientific achievements. One was quantification of the water vapor feedback effect. A team led by Andrew Dessler of Texas A&M University tested the theory using AIRS' humidity data product. AIRS could quantify the amount of water vapor at

different levels of the atmosphere globally, permitting them to derive the average strength of the water vapor feedback across the globe. Dessler found that the water vapor feedback "is extraordinarily strong, capable of doubling the warming due to carbon dioxide alone."

Trace Gases, and an Ammonia Bonus

Another achievement was development of data products that quantify various atmospheric trace gases, starting with carbon dioxide. AIRS' ability to measure air temperature depends on its ability to detect carbon dioxide's temperature at many different altitudes, so AIRS science team members had widely expected to be able to derive carbon dioxide's concentration in the atmosphere from AIRS' data, too. Chahine was ultimately able to produce the first global map of carbon dioxide in the mid-troposphere. While the relentless increase in carbon dioxide in Earth's atmosphere was known from NOAA's Mauna Loa observatory in Hawai'i, AIRS' global view filled in some details.

One unanticipated result from efforts to make use of AIRS data for understanding trace gases in Earth's atmosphere was demonstration of rapidly increasing ammonia concentrations in most of the world's agricultural regions. Ammonia is released primarily by fertilizer and large-scale livestock operations. It's very reactive with other gases and is involved in both the production of smog and particulate pollution. Ammonia is destroyed in these reactions, so any given molecule of ammonia stays in the atmosphere only a few days. Partly because ammonia is difficult to measure and partly because few countries regulate it, measurements of ammonia levels have been sparse, so global trends weren't readily discernible.

A team led by Juying Warner of the University of Maryland, Baltimore County, set out to extract the signature of ammonia from AIRS data, hoping to identify global or regional trends over the instrument's then 14-year lifespan. In 2016, they demonstrated steadily increasing levels of ammonia in Earth's atmosphere, concentrated over four of the world's major agricultural regions.

But the details were interesting. Even though fertilizer use in the United States had remained relatively constant over the period, ammonia had increased significantly. Warner's team tied this to successful regulation and reduction of sulfur emissions from power plants, which had caused acid rain. The same sulfur products that were responsible for acid rain also removed ammonia, so their rapid reduction in the 2000s had the unintended consequence of increased ammonia concentrations. Essentially the same thing had happened in Europe and China. But in South Asia, where ammonia concentration was the highest, there was little trend despite rapidly expanding fertilizer use. The team argued this was likely due to rapid expansion of coal burning, without corresponding regulation of the resulting sulfur emissions.

Eric Fetzer of JPL, currently the AIRS project scientist, commented that while AIRS wasn't designed to observe ammonia, "the unexpected large ammonia increase is one example of rapid atmospheric changes from human activities that AIRS is observing."

Applying AIRS Science: Drought Monitoring

In AIRS' second decade, Tom Pagano of JPL, the project manager, focused on expanding the range of uses for the team's data. One initiative has been to bring AIRS data into NOAA's aviation weather system, the Advanced Weather Interactive Processing System, so forecasters can use it more effectively.

One application the team pursued was drought monitoring. Typically, the U.S. warning of impending drought conditions has been done by monitoring precipitation. Meteorological drought--shortfalls of rain and snow--generally precede agricultural drought, defined by insufficient soil moisture. So the onset of agricultural drought can be predicted from the onset of meteorological drought.

But AIRS team member Stephanie Granger of JPL, who is also the group supervisor for applied science systems engineering, had read some work on monitoring early onset of drought from an index called vapor pressure deficit (VPD), which is calculated from temperature and relative humidity. "These teams

were using ground-based sensors in the U.S. It occurred to me that we have these global observations of temperature and relative humidity. So, I put in a proposal to the AIRS project to produce the vapor pressure deficit anomaly as a drought product along with temperature and relative humidity anomalies. It turned out to be a pretty good idea."

She and a small team used the VPD product to retrospectively monitor the onset of the 2012 drought in the U.S. High Plains region, which had been sudden and severe. The vapor pressure deficit provided more than a month's lead time over the precipitation onset of the drought. They also examined the average statistics of all droughts between 2002 and 2014, and on average, the predictiveness of the vapor pressure deficit held up.

JPL's Alireza Farahmand had also demonstrated the potential strength of AIRS relative humidity data to monitor drought onset before precipitation for up to 3 months in a 2015 paper. In his latest work, he looks at the development of four major historical droughts using satellite data. He showed that anomalously high VPD was largely responsible for the initiation of two of four case studies (2012 Midwest and 2011 Texas), and contributed to the development of one drought event (2006-2008 Southeastern). So AIRS' global vapor pressure deficit product proves to be one useful tool for drought early monitoring among several.

AIRS Data, Volcanoes, and Airplanes

Another useful tool derives from AIRS's dust and sulfur dioxide products, the Volcanic Plume Detection Rapid Response system developed at JPL. Clouds of volcanic ash are hazards to jet aircraft, as the ash can damage jet engines. The 2010 eruption of the Icelandic volcano Eyjafjallajökull dramatized the problem to the flying public by causing European authorities to essentially shut down air service for several weeks, but that volcanic ash could be hazardous to aviation had been known since at least the 1980s.

Ash, and dust, appear in AIRS data as contaminants, in a sense. Their presence in a scene could be misconstrued by an unwary weather forecaster as clouds, so the AIRS data production system provided error flags for scenes that might be contaminated with dust or ash. But it was hard to distinguish between dust and ash. However, use of sulfur dioxide, a gas produced by volcanos and power plants, could help determine whether a particular scene contained dust or volcanic ash. A scene with dust or ash but no sulfur dioxide would likely be dust, while a scene with dust or ash with sulfur dioxide would likely be volcanic ash.

Sulfur dioxide had first been measured from space by NASA's Total Ozone Mapping Spectrometer in 1982. That instrument used ultraviolet measurements, but sulfur dioxide also has an infrared signature. A group at the University of Maryland first identified sulfur dioxide's signature in AIRS data shortly after launch in 2002. Because sulfur dioxide's infrared signature is weak and near that of water vapor, AIRS couldn't detect it at lower altitudes, where most of the water vapor is. The sulfur dioxide signal is overwhelmed by the water. But that's a benefit insofar as volcanic plume detection is concerned. Volcanoes can inject sulfur dioxide high enough for AIRS to detect it, while power plants at the surface generally cannot.

After the Eyjafjallajökull event, the European Space Agency funded development of a volcanic plume warning service, the Support to Aviation Control Service, which utilizes AIRS and other remote sensor data to provide automated warnings via email.

The JPL volcano team decided to make a public website that performed a similar function, the Volcanic Plume Detection Rapid Response page. The developer, Vince Realmuto, recalls that "our effort was mainly to put together, in a very high-information form on the websites, the tools to use the data. The idea was to produce a consumer-grade product that you didn't need to be an expert to use."

Tracking Hints of Flu Outbreaks

JPL's Joao Teixeira, the AIRS science team leader, suggested another possible application to Heidar Thrastarson: use of AIRS specific humidity data to forecast flu outbreaks. There was already some literature noting that local flu outbreaks occurred during periods of lower humidity, though there was no agreement in that literature about which of the various suggested mechanisms would explain the link. There was also plenty of evidence of regional and even local variation in outbreaks.

In one recent effort, Thrastarson and some collaborators at JPL and the University of Southern California examined the variation in flu outbreaks and its dependence on average humidity among the 48 contiguous U.S. states. They found that each state has its own "threshold," a point at which a flu outbreak became much more likely. There were some regional similarities, with states that have generally drier climates having thresholds at lower specific humidities than wetter states. But each had a different average threshold, and the year-to-year variations from those thresholds suggest that socioeconomic and/or other factors were at play beyond those played by climate, though these were not part of the study.

Thrastarson also forged a collaboration with the Los Angeles County Department of Public Health to build and validate a prediction model using AIRS data that's still in progress. It was somewhat interrupted by the Covid-19 pandemic. "And then the pandemic came and there were a lot of personal behavior changes so flu temporarily vanished, especially last season. But while seasonal flu is expected to return, it's also an opportunity to build on the system to possibly say something about Covid and other diseases," Thrastarson commented.

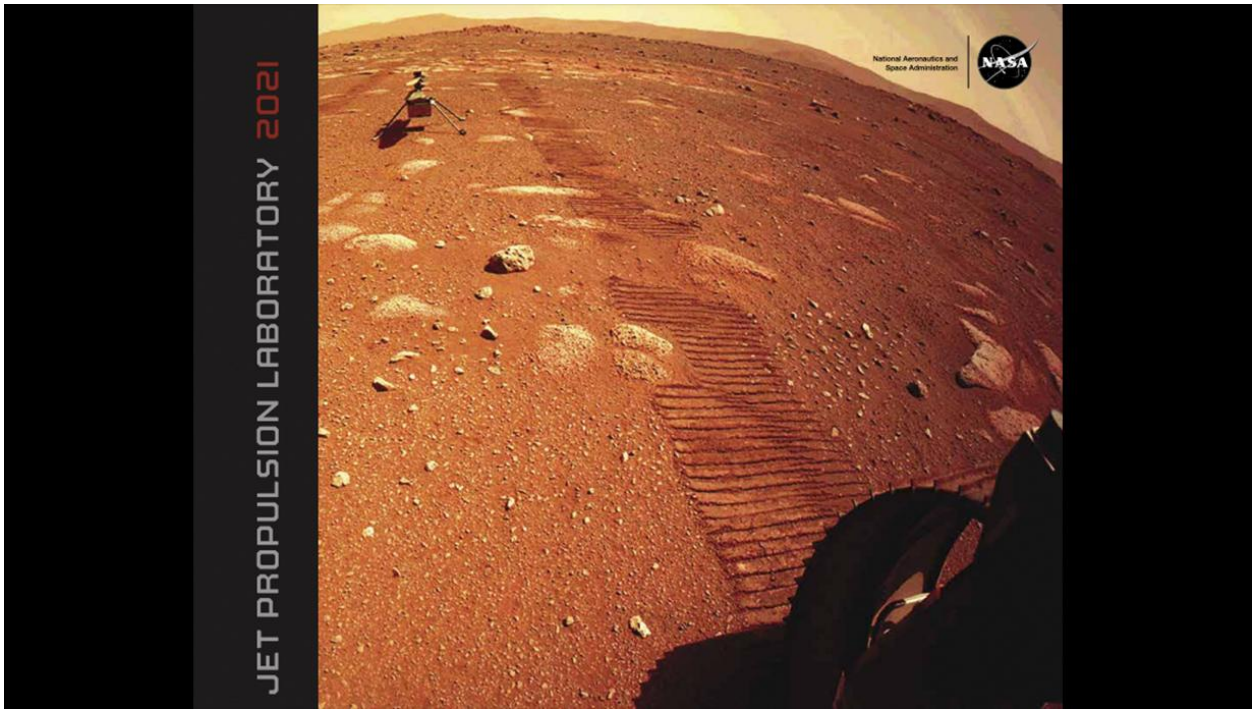
Building confidence in their prediction models is another future project of Thrastarson's group. "AIRS has very consistent data for the past 20 years, so we can do long-term studies. We also have long-term flu surveillance data, so we can use these to do past forecasts for validation," he says.

What's Next for AIRS?

Future use of the AIRS data is a current topic. The Aqua satellite is expected to have sufficient power to operate into 2026, after which its climate-quality data record will end. But Vivienne Payne, AIRS' atmospheric composition lead at JPL, believes there are "unrealized possibilities in integrating different wavelengths in the near and thermal infrared" that can be explored using the two decades of data already accumulated.

As part of NASA's Earth Observing System, AIRS was also intended to develop a climate-quality record across the many wavelengths it senses. It has also proven to have unprecedented stability. This enables discernment of long-term trends from a single instrument's data, avoiding the challenge of intercalibrating multiple instruments to remove biases and ensure consistency of the resulting data. Teixeira thinks that preserving and extending AIRS' hyperspectral data record will be key to understanding ongoing but subtle changes to Earth's atmosphere. "AIRS data has much more information in it than we are using," he says.

With proper curation, that climate record will be available for future researchers to help expand our knowledge of humanity's impact on Earth's climate.



2021 JPL Annual Report Published

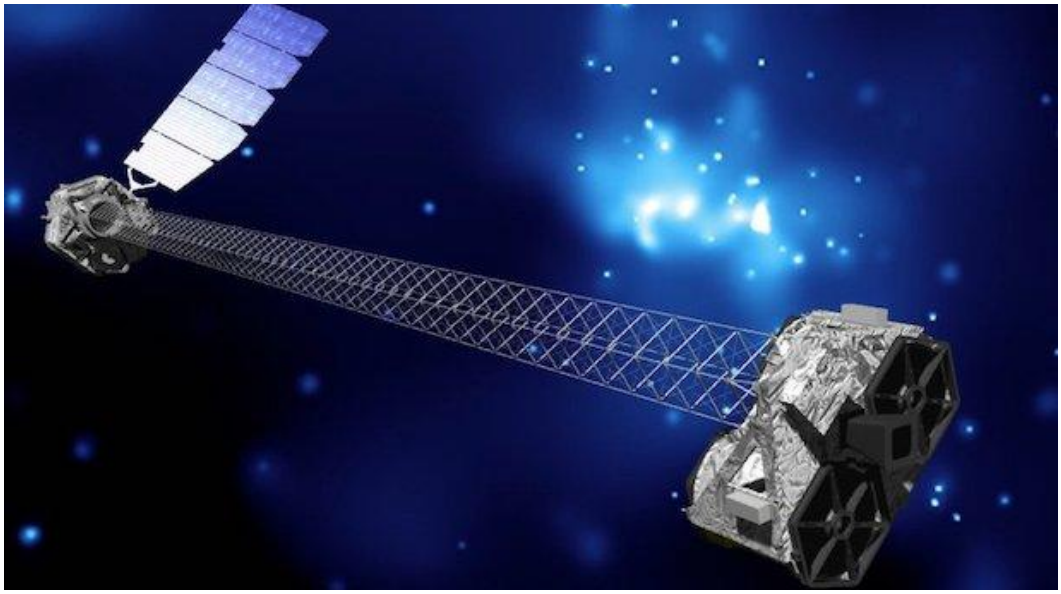
The 2021 JPL Annual Report is available here.

In the middle of some of the most acute phases of the Covid pandemic, JPL landed the most advanced Martian rover in history, achieved the first powered, controlled flight on another planet, and launched a key instrument on the James Webb Space Telescope that will reveal the earliest stars and galaxies – all while advancing many other missions to explore space and Earth.

In his introduction to the annual report, Interim Director Larry James noted about the year's accomplishments on Mars alone: "When future generations look back on 2021, they will see an entire planet in the pall of pandemic, and a neighboring world marked with a speck of the uncontainable human spirit."

"We have an awesome team that always pulls together to focus on the mission and get the job done, with or without a global pandemic. I could not be prouder of our community, and I know our incoming director Dr. Laurie Leshin will find the Lab a place of warmth, inspiration and daring," James added.

Events



Von Karman Lecture Series: NuSTAR - Studying the Universe in X-ray

May 26 at 7 p.m.
YouTube link

The Nuclear Spectroscopic Telescope Array, or NuSTAR, mission studies the universe in high energy X-rays giving us a better understanding of the dynamics of black holes, exploding stars, and the most extreme active galaxies. How has NuSTAR changed the way we look at the universe?

- **Speaker:** Dr. Brian Grefenstette, NuSTAR Principal Mission Scientist, Caltech
- **Host:** Marc Razze, Public Services Office, NASA/JPL
- **Co-host:** Kaitlyn Soares, Public Outreach Specialist, NASA/JPL

Caltech Event: Seminar Day

May 14 from 9:30 a.m. to 3:30 p.m.
Registration link

For 85 years, Caltech's annual Seminar Day has given alumni from around the world the opportunity to hear about exciting, cutting-edge research and new discoveries from alumni and faculty experts across various fields of science, technology, and engineering. Join Caltech for this virtual event.

Email: info@alumni.caltech.edu.

JPL Family News

Retirees

The following JPL employees recently announced their retirements:

40+ Years:
Nicholas R. Alvarado, Section 357E, 48 years

John L. West, Section 312A, 47 years

30+ Years:
Ricardo Espinoza, Section 1430, 38 years

Caroline S. Racho, Section 313F, 36 years

Gary S. Bolotin, Section 3491, 36 years

Ulf E. Israelsson, Section 7000, 34 years

20+ Years:
Payam Zamani, Section 398B, 29 years

Christopher S. Tippit, 357C, 23 years

Javier Sanchez, 393G, 20 years

10+ Years:
Arlene Cass, Section 1165, 18 years

Letters

Thank you to my JPL colleagues for your support and kindness following the passing of my father and to the JPL Hospitality Group for the lovely plant. **– Carolyn Barela**

I would like to thank my JPL colleagues for their kind words and support following the passing of my mother. I also want to thank JPL Hospitality Group for the beautiful plant. **– Camille Hayes**

Passings

Passings must be submitted through Human Resources, which coordinates with the family of the deceased.

Donna Wu, whose work at JPL included working in Section 312A: Mission Concept Systems Development, died on April 19, 2022, at the age of 56.

She worked at JPL for 34 years as a computer systems engineer. Wu assisted with Earth science decadal studies, piloting enterprise technologies for proposal teams, and helped to deploy the JPL computing service.

Wu is survived by her parents, Larry and Nancy Wu; siblings Daniel (Paulina) Wu and Della (Edwin) Domingo; nieces and nephews Darryl J. Wu, Larissa Domingo, Adalynn Wu and Natalie Khiev; and her Boston Terrier Bogey. She is preceded in death by her brother Darryl K. Wu and dog Izzy.

A service is scheduled for May 19, 2022 at 11 a.m. to noon at Rose Hills Memorial Park – Memorial Chapel, 3888 Workman Mill Rd., Whitter, California 90601. Details: Donna Wu Obituary (rosehills.com)

Larry B. Dean died on April 9, 2022, at the age of 72. Dean worked at JPL for 47 years, and was property administrator in org 2721 before retirement.

He is survived by his daughter, Danette Dean; son, Larry B. Dean Jr.; and ex-wife/mother of children, Margo Dean.

A service is scheduled for May 21, 2022 at 10 a.m. at Arnolds Family Funeral Services, 2561 N. Fair Oaks Ave., Altadena, California 91001.

Aron Wolf died on Feb. 13, 2022, at the age of 66. He worked at JPL for 39 years, most recently in the Guidance and Control section.

Wolf was a talented engineer who pushed the boundaries of deep space exploration, renowned for his expertise in trajectory design and entry, descent, and landing (EDL) technologies. Among his triumphs were: designing the complex orbital tour trajectories flown by the Galileo spacecraft at Jupiter and the Cassini spacecraft at Saturn; leading the Stardust-NExT mission navigation team to a close re-encounter of comet Tempel 1, for which he was awarded the NASA Exceptional Achievement Medal; supervising the EDL/Aerodynamics application group, and managing the development of Mars pinpoint landing systems. As a member of the JPL Advanced Projects Design Team, Wolf will always be remembered as a generous engineer who freely shared his knowledge and experience to develop future deep space missions. In recent years, Wolf was the Deputy Guidance, Navigation, and Control Technical Fellow of the NASA Engineering and Safety Center, contributing to improving mission success and safety across the Agency.

Wolf is survived by his wife, Michelle K. Wolf; daughter Rachel Wolf; son Daniel Wolf; sister Judith Wolf (Barry Wolf).

His funeral was held on Feb. 15, 2022 at Temple Beth Am with internment at Mt. Sinai in Simi Valley

Dr. Walter S. Tsuha died on April 7, 2022, at the age of 63. He joined JPL in 1984 and was an authority in the field of spacecraft and payload structural launch loads and dynamics. He most recently worked in Section 352 – Spacecraft Mechanical Engineering, Spacecraft Structures & Dynamics Group. Walter received his PhD in Aerospace Engineering from UCLA; Dynamics minor: Controls & Applied Mathematics; M.S. Aerospace Engineering, Caltech; and B.S. Mechanical Engineering, University of Hawaii.

Walter significantly improved JPL's capabilities for launching its missions through his exceptional sustained contributions. In his 38 years at JPL, Walter was integral to a long list of flight projects including Galileo, Cassini, Mars Pathfinder, Deep Space 1, MER, SMAP, MSL, M2020, Europa Clipper, Psyche, and most recently SRL. Additionally, Walter was JPL's primary interface with KSC/LSP, ULA, SpaceX, and other NASA centers including MSFC for the Space Launch System, and he collaborated with the European Space Agency, Applied Physics Lab, and the National Centre for Space Studies on launch loads, launch models, SoftRide systems, and launch environments.

Walter was recognized nationally as one of the leading experts in structural dynamics in the aerospace field, and was invited to be a member of the NASA Engineering & Safety Center (NESC) Loads & Dynamics Technical Discipline Team. Walter recognized the importance of preparing others to lead, so in addition to his project and NESC commitments he was an engaged and patient mentor. With his open-door policy, Walter provided valuable insight and guidance to numerous JPL project managers, and to engineers at all career levels across multiple disciplines. Walter was a highly regarded expert who made numerous contributions to his discipline, and he accomplished all those things while exhibiting humility, kindness, and optimism. His cordial demeanor and cheerful attitude led many teams through challenging times. Walter will certainly be missed, but his legacy will live on in the numerous tool and process improvements he led, the projects he worked, and people he impacted during his illustrious career.

His family is very heart -broken with the passing of Walter, deeply loved and cherished husband. He is survived by his wife, Barbie, father-son (Ryan), son (Mom-Ai), son-in-law, brother and sister-in-law, step-brothers, uncle, ohana-Hawaii family, friends and his JPL/Caltech family. He will be missed by everyone and forever remembered.

Private family service and burial was held on May 6, 2022 at 2 p.m. at Eternal Valley Memorial Park and Mortuary at 23287 North Sierra Highway, Newhall, California.

Jack Dawson, JPL retiree, filmmaker and cameraman, passed away peacefully on March 12 at the age of 79 on Maui, Hawaii. Despite an eight-year battle with idiopathic pulmonary fibrosis, Jack never lost his curiosity, his infectious enthusiasm, and the joie de vivre he was known for.

Before joining the JPL Photolab in late 1979, Jack served as a U.S. Navy cameraman filming at the Kwajalein Missile Range and sites throughout the Pacific. After his military service, he worked for several Hollywood production companies, earning him the nickname “Mr. Hollywood” among his JPL work mates. In the Photolab, Jack was the group’s chief cameraman, director, and film editor. He was involved in historic projects including the Voyagers, the NASA-FAA Controlled Impact Demonstration (CID), the Wide Field Planetary Camera, the Deep Space Network, the W.M. Keck Observatory, the U.S. Army and virtually every project at JPL during his career. As the chief photographer/cameraman for the CID, Jack planned all the camera angles for the 127 remotely triggered high speed film cameras documenting the crash of a remotely piloted full-scale 720 jet testing Anti-Misting Kerosene fuel for the FAA.

Of the many JPL projects Jack supported, the Keck Observatory on the summit of Mauna Kea on the Big Island of Hawaii perhaps most captivated his interest. He traveled to the Keck on many occasions over the seven-year construction to document its progress from groundbreaking to completion of the dual Keck Interferometers. In 1998, Jack transferred from the Photolab to Media Relations, where he continued in educational and documentary tasks and arranging nationwide “live shot” interviews for NASA TV until his retirement in 2006.

Jack is survived by his wife, Sharon “Sam” O’Brien-Dawson, and by his friends in the Photolab, Media Relations, and NASA Headquarters.

Awards

JPL Wins Two Webby Awards, One People's Voice Award for 2022

NASA has earned three Webby awards and five People's Voice awards in the 26th annual Webby Awards Competition, recognizing excellence in online communications.

Webby award winners are selected by a panel of judges. JPL-managed sites that won this year include:

- NASA's Global Climate Change – The latest news, features, and data about our changing planet. This is the site's third Webby Award, and it has also won four People's Voice awards. (Webby winner for Best Website, Sustainability & Environment)
- NASA's Solar System Exploration – Launched in October 1998, the Solar System Exploration website is a real-time, living encyclopedia of the robotic exploration of our solar system. This is the site's second Webby Award, and it has also received four People's Voice awards. (Webby winner for Websites and Mobile Sites - Science)

Alongside the juried Webby Awards, which are selected by members of the Academy, the winners of the People's Voice Awards are determined by a public vote. JPL-managed sites selected for People's Voice Awards include:

- NASA's Global Climate Change – Also chosen for a Webby award, this JPL-managed site tracks real-time data about how Earth's climate is changing. (People's Voice Award winner for Websites and Mobile Sites - Sustainability & Environment)
- NASA's Jet Propulsion Laboratory Virtual Tour – Takes visitors across the 168-acre laboratory, including mission control, spacecraft assembly clean rooms, and the Mars Yard. Each location is embedded with dozens of points of interest – including videos, fun facts, and images. (People's Voice Award winner for Virtual & Remote - General: Science & Education)

For the full list of NASA's Webby award winners, click here.