

AR20

Jet Propulsion Laboratory



2020 JPL Annual Report Contents

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Director's message

IN THE PANDEMIC YEAR OF 2020, some of our greatest accomplishments had nothing to do with the extraordinary missions we led or science we championed.

We came together as a community to figure out a new way to work, we implemented incredible safety measures to protect the health and safety of our on-Lab employees, we worked hard to take care of our families at home and to help our children with their schoolwork, and we reached out regularly to one another for support. But as much as we struggled to stay connected, the social and economic impacts have been significant.

Dozens in our community were directly affected by the virus, and we also lost two members of the JPL family. While we may never know the full impact to our community, I am grateful for all of the efforts over this past year to keep our employees safe, both physically and mentally.

From the start of the pandemic, JPLers jumped into action to find ways to help fight the virus. In little more than a month we designed and built a simple ventilator that could be mass-produced. Designed for Covid-19 patients, the device uses readily available components and does not compete for parts with traditional ventilators. More than 100 manufacturers worldwide

applied for a free license and built scores of the life-saving units.

JPLers also designed and tested three types of 3D-printed respirators, posting all instructions and specs on open source forums. And when paper masks started to run low on Lab, employees with contacts in the quilting community commissioned a vast volunteer effort to make hundreds of cloth replacements.

Even during the worst of the pandemic, we had teams reporting to Lab around the clock to keep us safe: the experts from Safety and Mission Success who developed our Covid-prevention protocols; Facilities crews who sanitized common areas and gave us clean indoor air; Protective Services officers who screened their JPL co-workers at our entrances to Lab.

I also want to express my gratitude and admiration for the hundreds of JPLers who came on Lab voluntarily for mission-critical work. They are the reason we averted a two-year launch delay of Mars 2020. They are the reason we continued our progress on Europa Clipper, on Psyche, on SWOT and NISAR, on national programs critical to our country's security. They are the reason we rescued the RIME instrument from a series of setbacks and delivered it on time to the European Space Agency.

We launched Sentinel-6 Michael Freilich on schedule and in fitting honor to a pioneer of Earth science. JPL's fleet of missions will continue to monitor our influence on Earth, and Earth's influence on us.

Designed to image Earth-like exoplanets, the coronagraph instrument is getting ready for integration with the Nancy Grace Roman Space Telescope. Aboard the International Space Station, a JPL team upgraded the quantum-scale measurement capabilities of Cold Atom Lab with an atom interferometer.

Our Interplanetary Network Directorate, which manages the world's flagship network for communicating with spacecraft, completed the critical design review for a new Deep Space Optical Communications system that will deliver 10 to 100 times better performance than current technologies, with no increase in mass, volume or power. We brought back online the asteroid-tracking Goldstone Solar System Radar after an 18-month restoration. We refurbished a historic antenna in Canberra, Australia, and sent new greetings through interstellar space to our old friend Voyager 2.

This was also a year in which JPL recommitted to its core value of Inclusion. As society struggled with issues of social equity and racism, I am proud of how we came together in various forums over the year to discuss diversity, equity, and inclusion at JPL. And I continue to be excited about several commitments we have made as an institution.

2020 was a year like no other in so many ways. But just as the JPL community has met daunting challenges in the past, this year has been no exception. We continue to dare mighty things, even in the face of long odds. I am grateful for the dedication, the sacrifice, the innovation, and the teamwork and caring that has allowed us to continue our journey of exploration and discovery, but to do it in a way that keeps us connected and safe.



MICHAEL WATKINS

A handwritten signature in black ink that reads "Michael M. Watkins". The signature is fluid and cursive, written in a professional style.

A Year Like No Other

A YEAR LIKE NO OTHER FOR MOST OF 2020...
...and asked how can

Director's message

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We came together to find a new way to work, to implement safety measures to protect the health of our on-Lab employees, we worked to care of our families at home and to support our children with their schooling. I have seen no regularly to one another, but we have continued to do mighty things, as we struggled to stay connected, the social and economic impacts have been significant.

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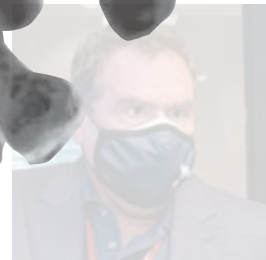
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It was a year in which JPL recommitted to diversity, equity, and inclusion. As society struggled with uncertainty, safety and racism, I am proud to continue to be excited about several initiatives we have made as an institution. This year like no other in so many ways. I have seen no regularly to one another, but we have continued to do mighty things, as we struggled to stay connected, the social and economic impacts have been significant. I am grateful for the sacrifice, the innovation, and the resilience that has allowed us to continue our mission of exploration and discovery in a way that keeps us connected and safe.

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Designed to image Earth-like planets, the coronagraph instrument is being ready for installation with the NASA's James Webb Space Telescope. Aboard the International Space Station, a JPL team upgraded the quantum-scale measurement capabilities of Cold Atom Lab with an atom interferometer.



MICHAEL WATKINS



A VIRULENT PARTICLE NEARLY EMPTIED JPL for most of 2020, disrupting projects and dismaying people like no event in the Lab's 84 years. JPLers, who pride themselves on daring mighty things, regrouped and asked: "How can we help?"



A front-facing portrait of VITAL (Ventilator Intervention Technology Accessible Locally), a ventilator designed and built by JPL.

A vital idea

AS CORONAVIRUS HIT, JPL engineers teamed up to invent a simple ventilator that could be mass produced to fill a massive need — and they did it in 37 days.

On April 30, the Food and Drug Administration approved VITAL (short for Ventilator Intervention Technology Accessible Locally) for an Emergency Use Authorization. Designed specifically for Covid-19 patients, the prototype is composed of far fewer parts than traditional ventilators and is intended to last three to four months.

More than 100 manufacturers from around the world quickly applied for a free license to build VITAL.

The ventilator came into being thanks to a team of engineers fueled by a desire to help.

On March 11, Mechanical Systems Engineer David Van Buren found himself waiting in line for a cup of coffee at JPL's facility in Pasadena. It felt like a normal bustling Wednesday, though unbeknownst to Van Buren and every other JPLer, that day would be the last normal one in months. The

mushrooming pandemic forced the Lab to urge voluntary telework the next day, and to declare mandatory telework for almost all employees the following Monday.

Van Buren wasn't focused on his typical workload. Instead, the mechanical systems engineer was crunching coronavirus numbers. In February, he'd given a lecture on pandemics in relation to Covid-19 for his physics course at Cal State Los Angeles, and he saw clear signs of a developing pandemic.

"It didn't take much extrapolating to see the potential of what could happen here," Van Buren said. "And at the same time, I was thinking about our work; we have these missions and efforts to explore other planets, but I started questioning if what we were doing at JPL was what we should be doing," Van Buren said.

That same morning, Chief Engineer Rob Manning's thoughts were preoccupied by the virus, and he needed coffee, too.

"I had just seen some projections, and I was worried," Manning said.

In a chance encounter that could not have happened any later, the two chatted about their coronavirus concerns.

"I went back to my desk after talking with Rob, and the question was still nagging me," Van Buren said. "We have incredible engineering talent and capabilities here. How can we help reduce the ventilator shortage that could be coming?"

This, well before many people even knew the meaning of "ventilator," let alone the fatal implications of a shortage.

Van Buren sent an email, outlining a plan to develop and proof a low-cost respirator design that could be made quickly and in volume. Manning was hooked.

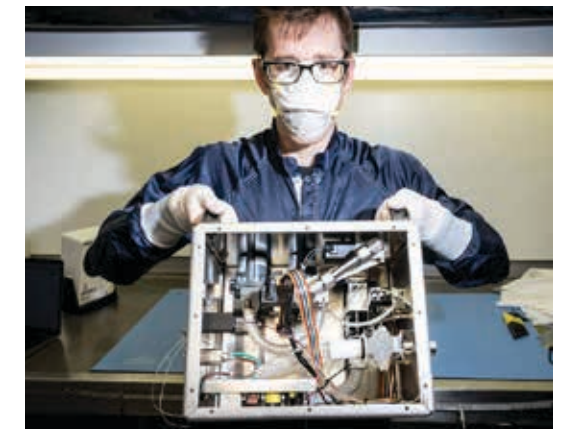
"We needed to do something, and this was it," Manning said.

Thirty-seven days later, a team of more than 50 — some working on-site with safety precau-

tions, but most from home — had designed, built and tested VITAL, a breathing aid that would help critically ill Covid-19 patients and bolster scarce stocks of traditional hospital ventilators.

The timeline is a feat nearly unheard of in medical device development, completed by a research and development center that makes robots for space, not breathing aids for humans. In JPL terms, the team would say they crammed an entire planetary flight mission — from formulation to launch to landing — in a little more than a month. Most team members worked 14-hour days, seven days a week. Van Buren said the obstacles discouraged no one.

"The difference is the purpose," Van Buren said. "Landing something on Mars is incredibly exciting, but saving lives is a different beast."



Making masks to cover shortages

DOUG HOFMANN HAD A BAD FEELING in early March.

As doctors and nurses around the world scrambled for protective gear while their hospitals filled with infected and infectious patients, he knew he couldn't sit by idly. A technologist at JPL and founder of the Lab's Metallurgy Facility, Hofmann found himself in a position of unique knowledge: at a time when people still got respirators and ventilators confused, he often wore respirators on the job; he was trained in the safe handling of the specialized masks; and he worked with machines that could make more.

When JPL moved to mandatory telework, Hofmann reached out to Robotics Mechanical Engineer Don Ruffatto with an idea: What if the Lab could 3D-print respirators for healthcare workers by reverse-engineering the fit and function of his own respirator mask? And what if the instructions could be made available for anyone to use who had access to a 3D printer?

"That second week of March, we were watching people die in Italy, and we knew it

was coming here," Hofmann recalls. "We were thinking, 'If this happens here, there's no way JPL is sitting this one out. We're going to do everything possible.'"

As with JPL's ventilator project, eager JPLers came running. Together, they designed and tested three different 3D-printed respirator models — invitingly named Performance, Conforming, and Comfort — in less than a month, including test results, instruction videos, manuals, and specs available through Open Source.

"It was the right group of people with the right skillset at the exact right time," says Hofmann.

The supply of personal protective equipment also became an issue on Lab, and for one group in particular: the Mars 2020 clean room team could not afford to deplete their store of certified paper masks by using them outside the clean room. They needed a whole other supply of masks.

"We looked at the inventory, and we saw that the number of paper masks we had wouldn't last us through the Mars 2020 project if we didn't do something," recalls Mike Christensen, section manager for Safety and Mission Success. "How do you do clean room work if you don't have clean room-certified masks? How do we preserve those masks while protecting others?"

Christensen — a certified industrial hygienist who specializes in personal protective equipment — began researching reusable cloth masks following CDC guidelines, which call for two layers of cotton. One source that came to mind? One hundred percent quilting cotton fabric — something he was familiar with thanks to his wife, Susan, a longtime avid quilter.

"I said to her, 'What do you think about making masks?'," Christensen said. "She immediately went and made one."

That first mask set off a chain of events. The Christensens knew they would need about 1,000 cloth masks, but they couldn't do it alone.

"I like serving and I just wanted to help," says Susan, who herself has sewn nearly 200 masks. "I started sewing with scraps at my house, and it was obvious that was going to be depleted very fast."

But she knew exactly who to reach out to for help: Her friend, LeAnn Goettel — wife of Director for Business Operations Marc Goettel — was a fellow quilter with a large network of quilting friends.

"The call went out that JPL needs our help because the Mars 2020 rover might be held up," says LeAnn, who extended the request to about 50 women across three quilting networks — including the women who toured the Lab last year.

"They were blown away by what JPL does. They all knew what the rover was about and said, 'Whatever we can do to help JPL, we'll do it.'"

Cloth masks made by volunteers underwent out-of-this-world sterilization overseen by JPL Planetary Protection experts.



One of the open-source, 3D-printable respirators designed by JPL volunteers.

Below: Other 3D-printed JPL respirator designs.



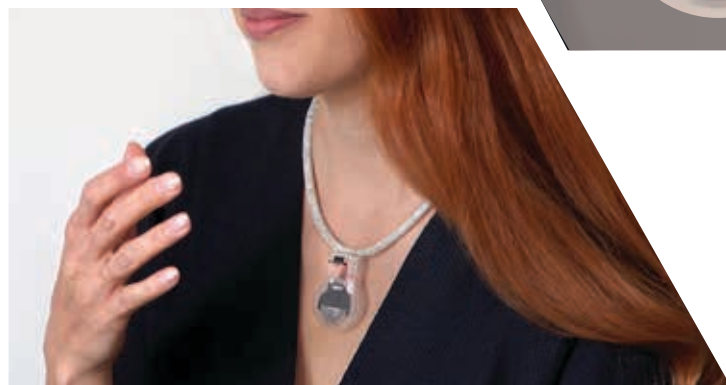
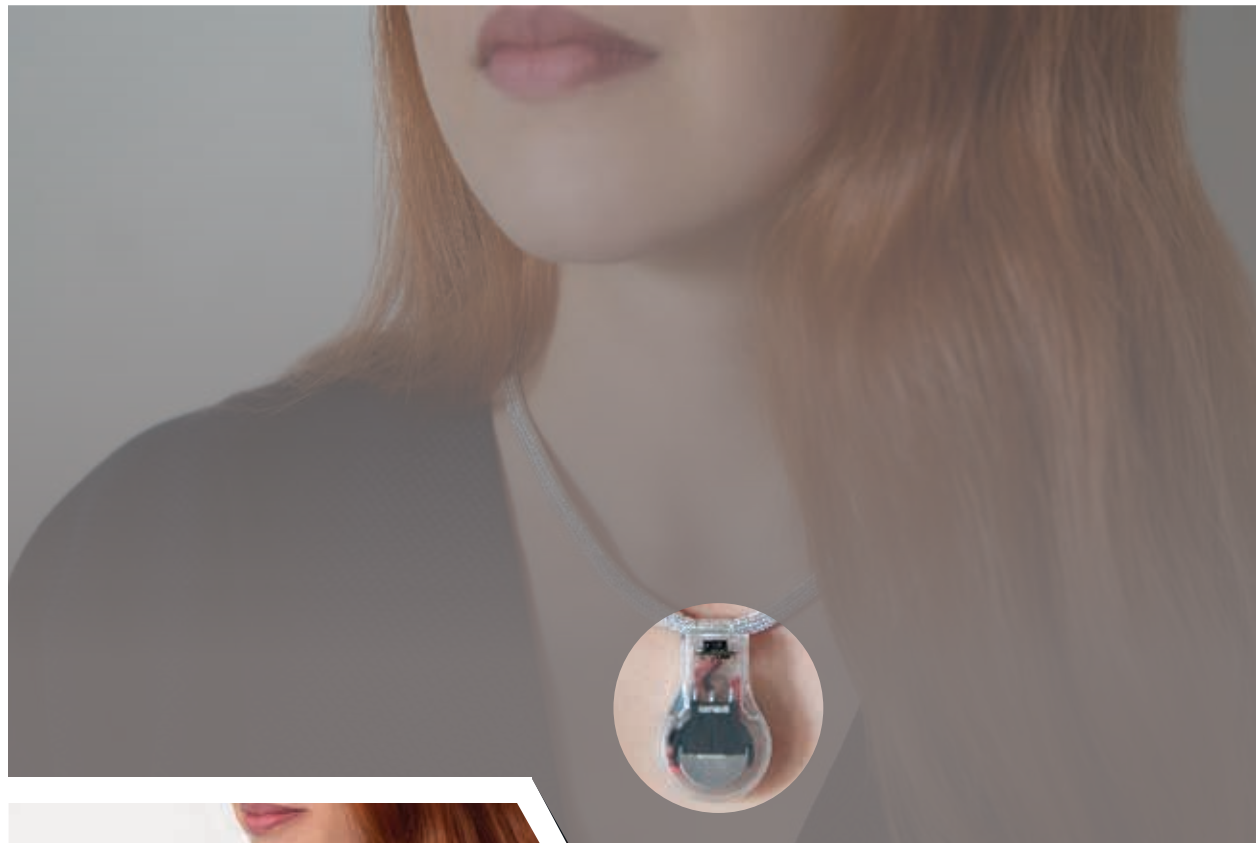
Hands-free operation

IT STARTED as a lighthearted comment in a Monday meeting.

A few JPLers were seated in a conference room one day in late February, discussing the headlines no one could avoid: the coronavirus was spreading quickly around the world. The public health guidelines at the time included sanitizing — the group had already thrown out all the food in their office and put hand sanitizer on the coffee counter — and not touching your face.

“Everyone became so self-aware of how often they touch their face, and we started laughing about it,” recalled Product Designer Faith Oftadeh. “Then someone said, ‘Wouldn’t it be funny if we had a device that warned us when our hands were coming toward our face?’”

That funny idea turned out to be a seriously good one. PULSE is now a pendant designed to be worn around the neck — aptly named because it begins pulsing when the wearer’s hands are nearing their face — and it can be 3D-printed and assembled for less than \$20 and in under two hours, thanks to open-source designs the team published in May.



PULSE is a 3D-printed wearable device that pulses, or vibrates, when a person’s hand is nearing their face.

Homegrown research

TWO VIDEO MEETINGS, two online purchases, and a kitchen counter led to what could be “one small step” for future astronauts to grow food on the Moon.

While others perfected sourdough starter or whipped up chocolate chip cookies during the pandemic, NASA scientist Max Coleman was toiling in his kitchen over containers of baby radishes — all in the name of science.

One day in April during a video team meeting from home, an idea sprouted in Coleman’s head for a homemade radish lab. He and his team were discussing how they could, hypothetically, try growing some radishes with no nutrients and some with a small amount of nutrients.

“Let’s not theorize about this; why don’t we just do it!” was Coleman’s battle cry. And before the virtual meeting had ended, he had bought a batch of radish seeds online to be delivered to his home. A subsequent video meeting prompted another impulse buy. “Video chats clearly stimulate me,” Coleman joked. This time, it was desert sand, which is often sold to be used as a top layer to make indoor potted plants look pretty.

Armed with the radish seeds and desert sand, Coleman was ready for serious business.

“We’re trying to show astronauts can use horticulture to grow their own food on the Moon,” he explained. “We want to do one tiny step in that

direction, to show that lunar soil contains stuff which can be extracted from it as nutrients for plants. This includes getting the right chemical elements to allow plants to make chlorophyll and grow cell walls.”

The team’s research is aimed at biological in-situ resource utilization — tackling such challenges as where to get food, as opposed to how to get water and oxygen. Coleman explained that, for future astronauts, “the more you can use what’s already there, the more efficient you can be because you don’t have to carry that much with you.”

Their goal is to develop a small payload on a commercial spacecraft going to the Moon, which, if selected, would be delivered to the lunar surface through the NASA Commercial Lunar Payload Services (CLPS) initiative. By going to the Moon, the radish experiment would complement plant predecessors tested under microgravity conditions on the International Space Station. For example, the currently flying Vegetable Production System, or Veggie, features plants growing in specially prepared soil, with the goal of eventually providing food for space station astronauts.

“We can’t properly test here on Earth with perfect lunar soil, but we’re doing as much here as we can. Then we want to show that it actually does work on the Moon,” Coleman says.

Principal Investigator Pamela E. Clark leads the JPL radish research team, which includes John Elliott, who started the project, and Gerald Voecks, who works with Coleman on measurements.



JPL Senior Research Scientist Max Coleman in his kitchen.


IN THE MIDST OF PANDEMIC, A PAUSE FOR REFLECTION

PROTESTS ERUPTED in June 2020 over the homicide of George Floyd, an unarmed Black man, as headlines still echoed from the fatal shooting of Ahmaud Arbery, an unarmed Black man. Floyd's last words echoed those of Eric Garner, an unarmed Black man who died in police arrest.

If not for the vagaries of timing and the news cycle, more victims could have gained the same renown. A campaign to #sayhername honors Breonna Taylor and other Black women killed in police encounters.

Above: "William," the headline typeface used above and additionally on the cover of this book, was provided by Vocal Type Co. Its design references type treatments used in the data visualizations created by W.E.B. Du Bois for the Paris World Fair of 1900, which portrayed Black life in America.

In response to the broader movement for social justice, and in support of JPL's core value of Inclusion, Director Michael Watkins announced the following 10 actions:

- JPL will release internal demographic data that are similar to what other NASA centers and FFRDCs publish in their annual reports. The Lab will continue to collect additional data that will help us measure our progress in all areas of diversity.
 - Unconscious Bias Training will be mandatory for all line managers, project managers, system managers, and product delivery managers.
 - Employees will be required to take at least one course each year from a suite of options focused on diversity, equity, and inclusion topics.
 - JPL will more widely implement Bystander Training and will strongly encourage all employees to engage with this course.
 - JPL will hold an annual half-day of reflection for personal training, learning, and engagement.
 - Lab leadership and outside speakers will hold regular town halls and other events in order to increase awareness and understanding of diversity, equity, and inclusion concerns and actions.
 - JPL will facilitate "listening sessions" for employees to share, learn, and engage.
 - The internal Inclusion website will gather resources about diversity, equity, and inclusion, available to all JPL employees.
 - JPL will explore the best way to create and fund a Diversity, Equity, and Inclusion Office and supporting roles.
- 
- JPL will continue to communicate to the Lab that retaliation, racial discrimination, microaggressions, or any form of reprisals will not be tolerated for those who participate in ERGs and related activities supporting social justice, diversity, equity, and inclusion at the Lab, and/or in the scientific and technical communities with which we are engaged.

In a down year, a bold look goes up

A GIANT VERSION of NASA's classic red, white, and blue logo now proudly adorns a building that has played a central role in space-exploration history.

A new 30-foot NASA logo installed in October on the side of the Spacecraft Assembly Facility welcomes JPLers and visitors alike. The red, white, and blue insignia — designed in 1959 and nicknamed “the meatball” — can be spotted from the freeway nearby.

“We have two strands of DNA — one NASA and one Caltech. We wanted to proudly show our NASA heritage with this logo,” said JPL Director Michael Watkins. “With the appearance of the new sign, I think that more than a few people will be surprised to realize there’s a NASA center tucked away right here in the foothills of the San Gabriel Mountains.”

Weighing 6.5 tons, the logo is a vinyl covering stretched over an aluminum frame, then fastened to a steel structural ring. It was assembled in a parking lot at JPL before being hoisted via a 50-ton crane and fastened onto the side of the High Bay of the Spacecraft Assembly Facility, the robot factory where NASA's twin Voyager spacecraft, Galileo, and all of the agency's Mars rovers were built. Structural steel beams were welded in place to support the new sign.

The job of creating, sizing, and placing the sign fell to The Studio, part of DesignLab, JPL's graphic design and visual strategy team. The historic location they chose for the sign was only fitting, although the decision was grounded in pragmatism.

“We were trying to find a building that worked both in location and was the right size, height, and shape,” said Dan Goods, manager of The Studio. “While we were originally just looking for a proper surface, the fact that it’s our High Bay was a happy accident that gives it more significance.”

JPL's location at the base of the foothills dates back to 1936, when a group of rocket enthusiasts, working under Caltech graduate student Frank Malina, conducted rocket-firing tests at the site.

JPL grew throughout the 1940s and '50s and ultimately built and helped launch America's first satellite, Explorer 1, in 1958. The feat also led to the creation of NASA, which then integrated JPL as a federally funded research and development center. Caltech now manages JPL for the agency.



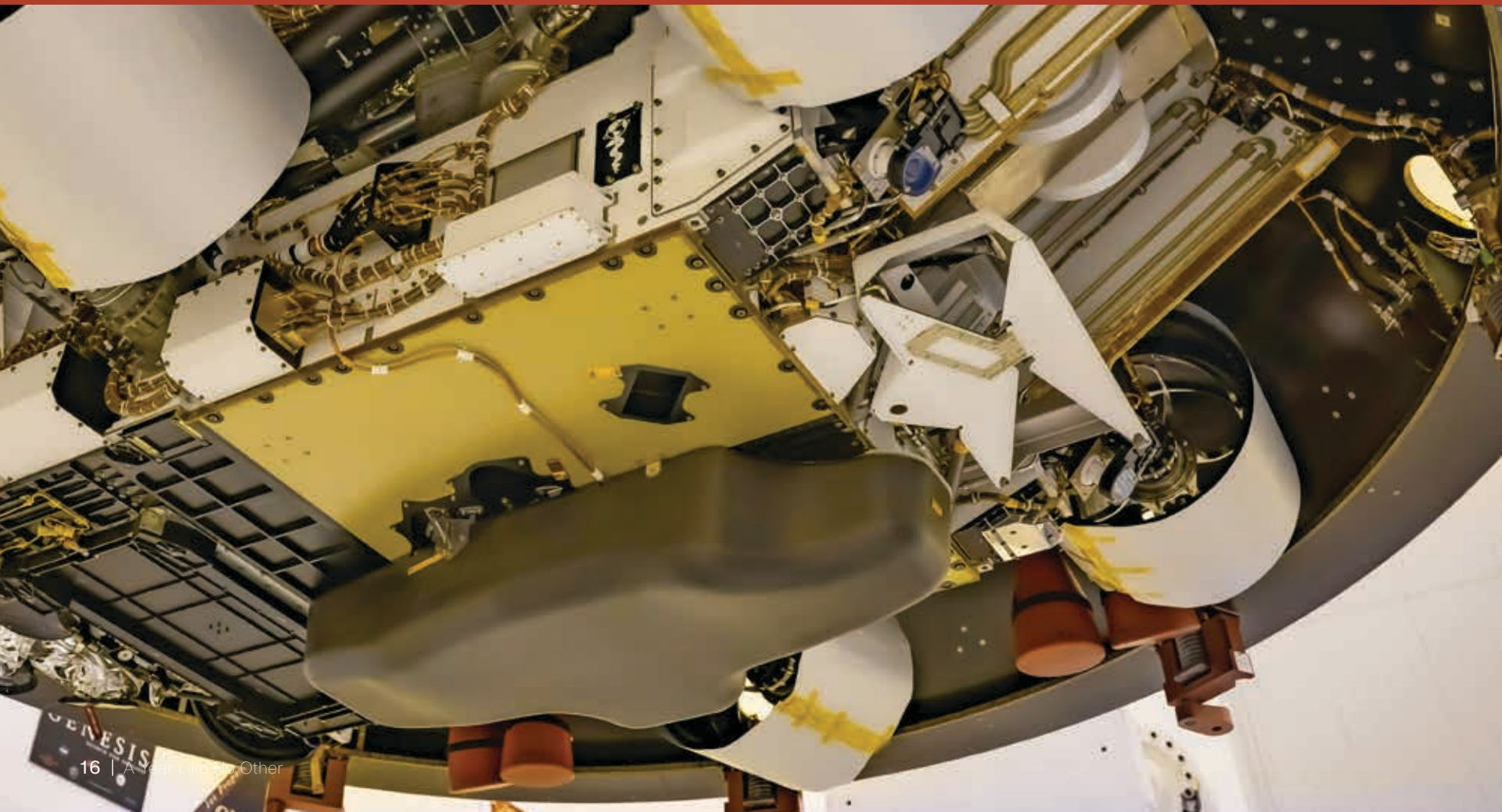
A Martian symbol of human kindness



AMID THE ADDED STRAIN of staying on schedule while incorporating additional pre-cautions — and keeping friends, families and colleagues safe — the Mars 2020 mission team was acutely aware of the dedication and hard work of people in the medical community around the world during the pandemic. With them in mind, the mission installed a plate on the left side of the Perseverance rover chassis, between the middle and rear wheels. The graphic on the 3-by-5-inch (8-by-13-centimeter) aluminum plate depicts Earth, supported by the medical community — represented by the ancient symbol of the serpent-entwined rod. A line depicting a spacecraft's trajectory rises from Central Florida toward Mars, represented as a small dot in the background.

“We wanted to demonstrate our appreciation for those who have put their personal well-being on the line for the good of others,” said Matt Wallace, Perseverance deputy project manager at JPL. “It is our hope that when future generations travel to Mars and happen upon our rover, they will be reminded that back on Earth in the year 2020 there were such people.”

“A Year Like No Other” includes excerpts of articles written for the JPL community by C. Taylor Hill, Celeste Hoang, Carl Marziali and Jane Platt.



Planetary

AS ONE MICROBE BROUGHT EARTH TO A STANDSTILL, a new mission to Mars lifted off to continue our search for the fossilized microbes that would imply a universe churning with life.

A Martian symbol of human kindness

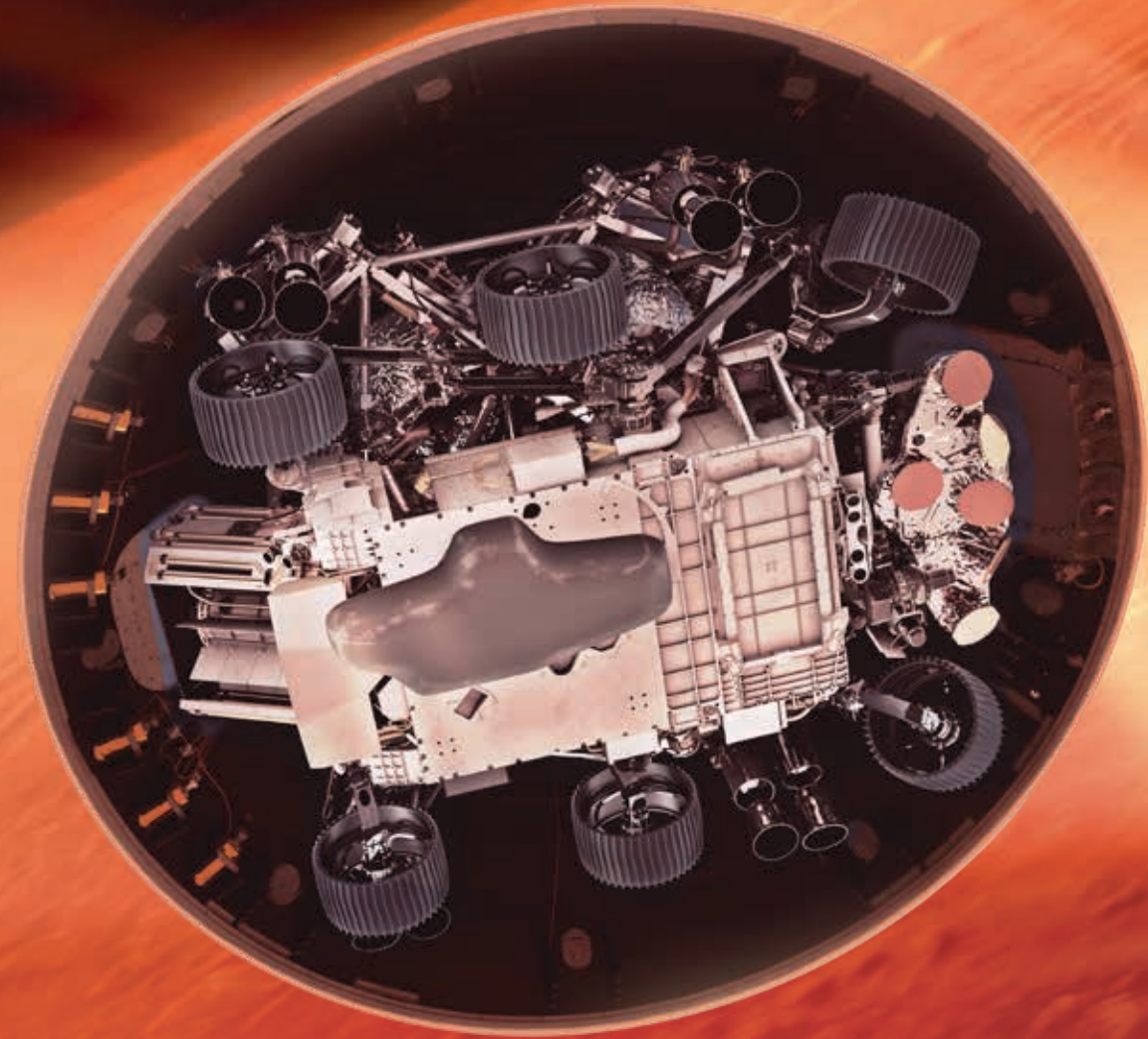


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“No Other” includes articles written for humanity by Thi Thanh Hoang, and Jane Platt.

Perseverance



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Artist's concept of Mars 2020 launching from Cape Canaveral Air Force Station via an Atlas V rocket.



The Perseverance rover undergoing mobility tests in JPL's Spacecraft Assembly Facility.

AS OF THE TIME OF PRINTING of this annual report, the Perseverance rover has landed safely and is preparing to search for signs of ancient life, and to collect samples for retrieval and return to Earth by a future mission. The Ingenuity Mars Helicopter soon will detach from its dock on the rover's belly and attempt the first flight on another planet.

"Perseverance sets a new bar for our ambitions at Mars," said Lori Glaze, planetary science director at NASA Headquarters in Washington. "We will get closer than ever before to answering some of science's longest-standing questions about the Red Planet, including whether life ever arose there."

JPL's mission team persevered because Mars gave it no choice. Launch windows for large payloads to Earth's closest neighbor open for only three weeks every 26 months. Mars 2020 was the only NASA mission facing an orbital deadline as the pandemic unfolded.

The project team shifted 90% of its members to full-time telework, and created a community page to share best practices and provide moral support. They allowed time in daily schedules for virtual "hallway conversations" and one-on-one time with project management. Some critical assembly and testing tasks needed to continue on site, so JPL established a set of safety protocols to protect team members, while drastically restricting access to Lab.

Perseverance is the first rover to bring a sample-gathering system to Mars. NASA and the European Space Agency are planning a Mars Sample Return mission to bring those packages to Earth for analysis.

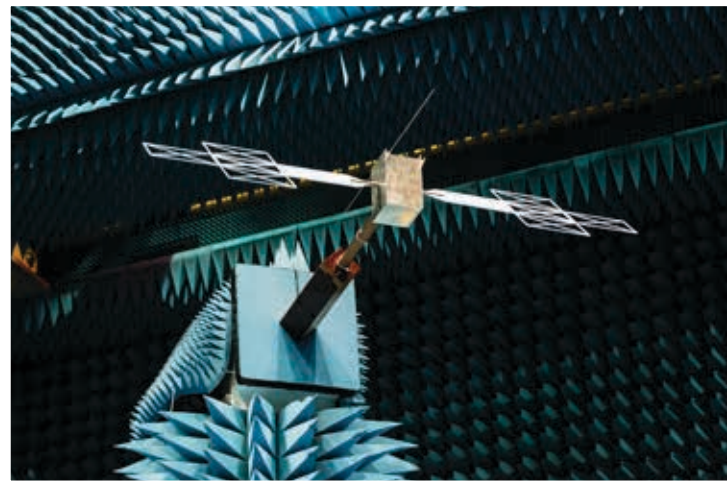
The rover also carries the MOXIE instrument (Mars Oxygen In-Situ Resource Utilization Experiment), designed to show that Martian carbon dioxide could be converted to oxygen by eventual human explorers.

JPL delivers RIME without missing a beat

MID-MARCH was when everything important was supposed to happen for RIME, an ice-penetrating radar instrument. The JPL engineering team was about to run an intense battery of tests, including vibration, shock, and thermal vacuum testing, which simulates the extreme conditions of deep space.

Unfortunately, mid-March of 2020 became an important time for a different reason. The pandemic exploded, and nearly all JPL employees switched to remote work on March 16.

It took a month before the RIME team could reassemble safely on Lab with extensive precautions. Despite the delay, the team met their deadline for delivering the transmitter, receiver and other key components to the Italian Space Agency. The Italian team will complete assembly and testing of RIME. Then the instrument will launch in 2022 on a European Space Agency mission to explore Jupiter and its icy moons Callisto, Europa and Ganymede.



A scale model of JUICE's RIME antenna – Radar for Icy Moons Exploration – during electromagnetic compatibility tests. Credit: ESA-M. Cowan

Psyche clears a critical hurdle

PSYCHE, a NASA mission to explore the eponymous metal-rock asteroid, sees a clear path to launch after passing its critical design review.

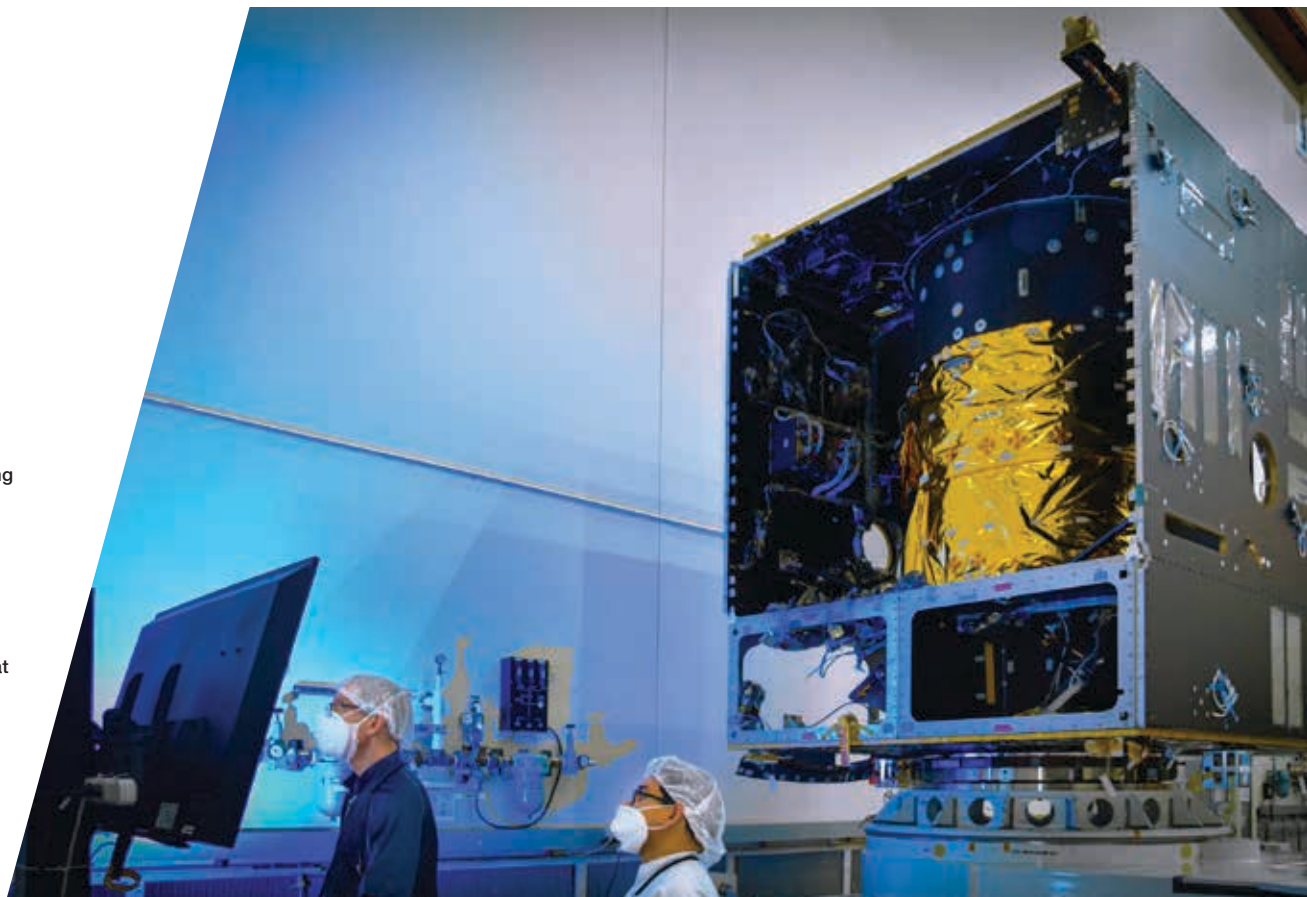
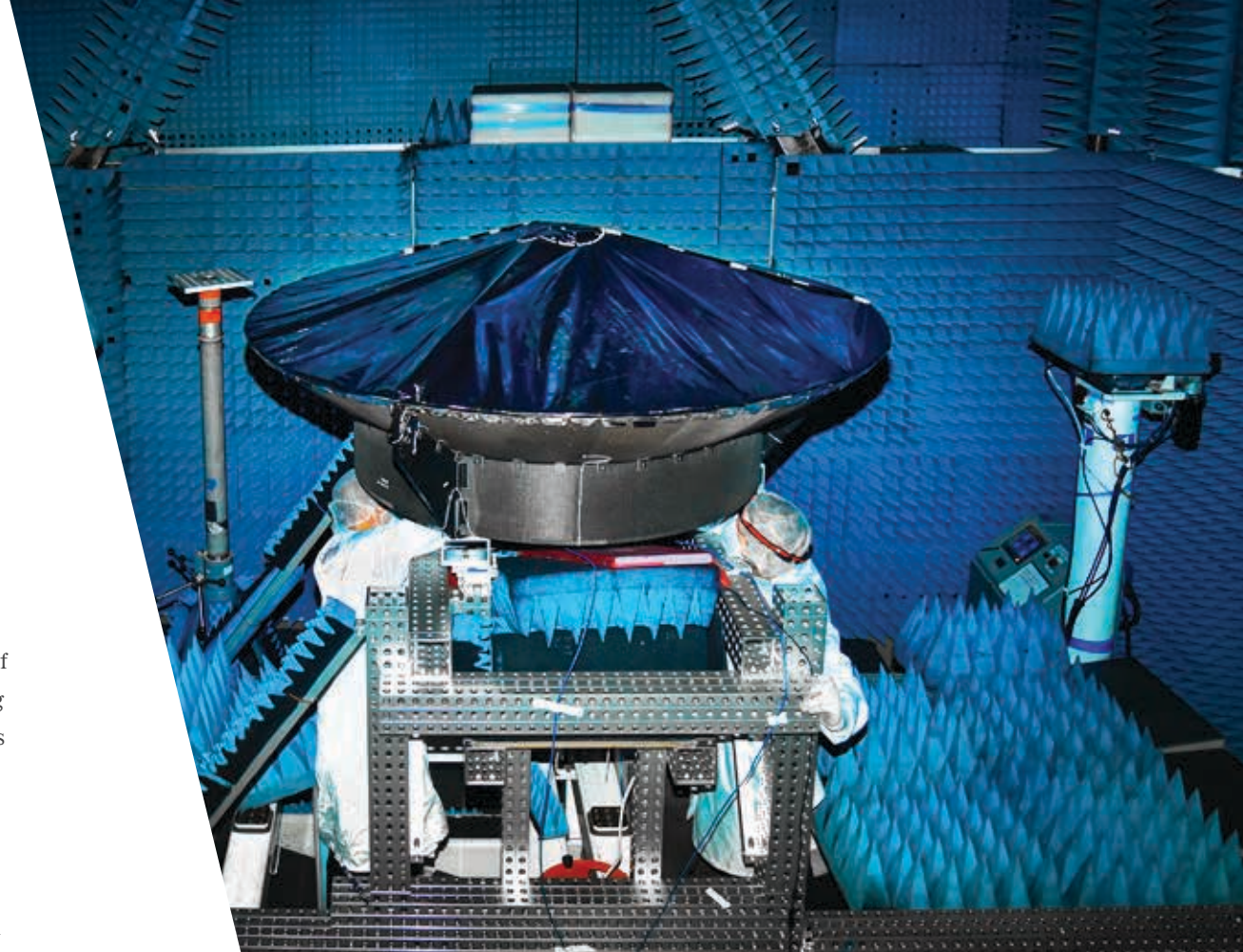
During the July 2020 review, NASA examined the designs for all of the project systems, including the three science instruments and all of the spacecraft engineering subsystems, including telecommunications, propulsion, power, avionics and flight computer.

Now the mission — led by Arizona State University and managed and operated by JPL — is manufacturing and testing the spacecraft hardware that will fly to its target in the main asteroid belt between Mars and Jupiter. Launch is scheduled for August 2022.

Scientists believe that Psyche is largely metallic iron and nickel — similar to Earth's core — and could be the heart of an early planet that lost its outer layers. That presents a unique opportunity to examine an exposed planetary core, potentially providing valuable insight into the formation of all planets, including Earth.

Above: Psyche's high gain antenna has completed fabrication and is undergoing standard testing in Maxar's Near Field Range. Credit: Maxar

Below: Psyche undergoing manufacturing and testing at Maxar Technologies in Palo Alto, California.



JPL-DEVELOPED INSTRUMENTS ON TWO OF NASA'S upcoming space telescopes passed critical milestones this past year; the Cold Atom Lab upgraded its measurement capabilities; and a newly selected CubeSat constellation project aims to show how the Sun generates and releases giant space storms.

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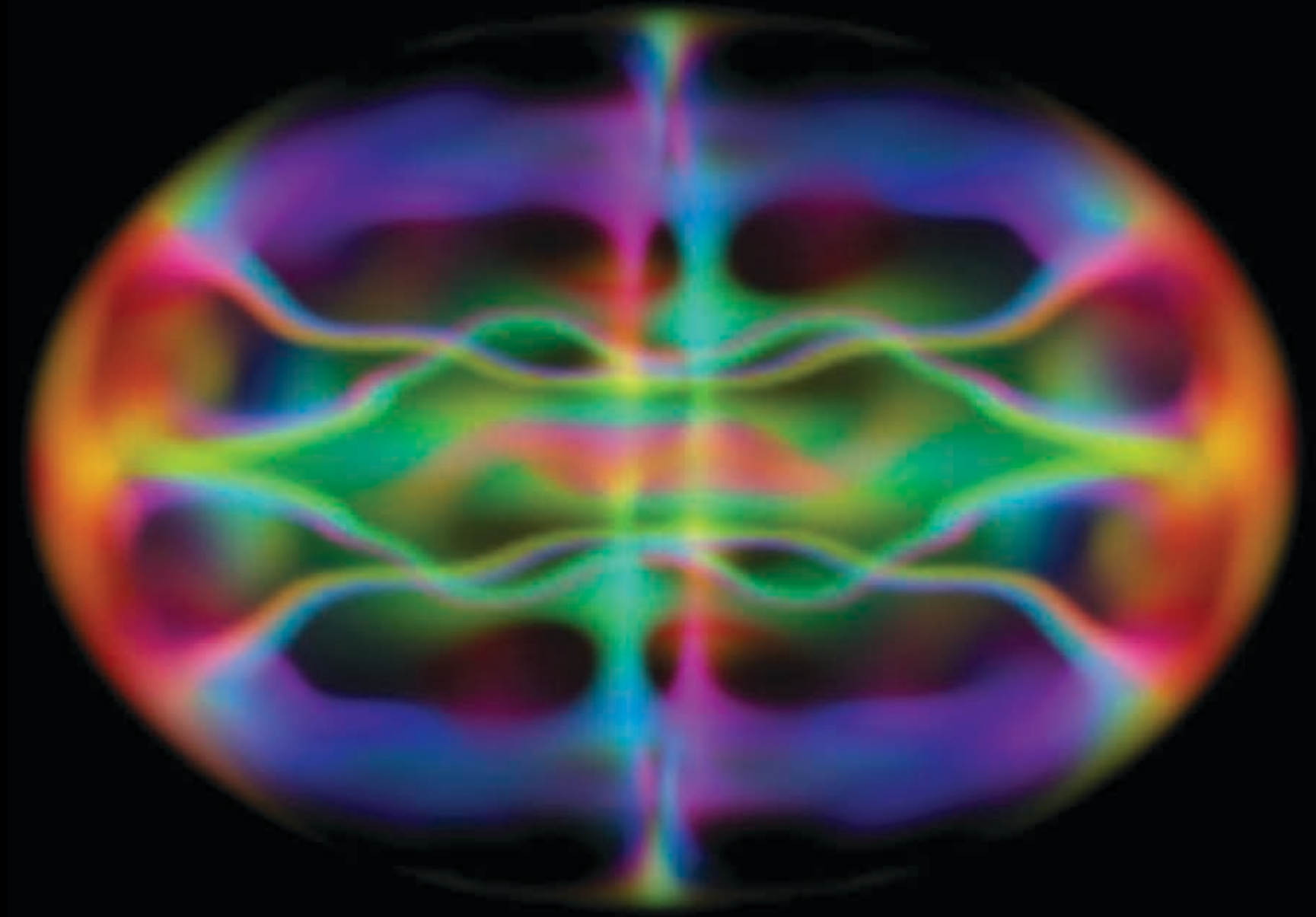
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University



JPL-DEVELOPED INSTRUMENTS ON TWO OF NASA'S upcoming space telescopes passed critical milestones this past year; the Cold Atom Lab upgraded its measurement capabilities; and a newly selected CubeSat constellation project aims to show how the Sun generates and releases giant space storms.

A new window on the stars...

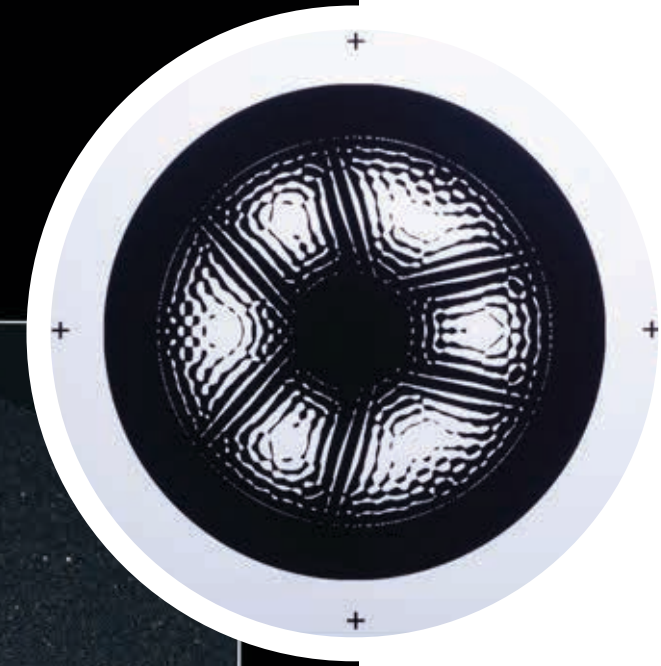
THE MID-INFRARED INSTRUMENT (MIRI), nestled aboard the fully built, assembled, and integrated James Webb Space Telescope (JWST), met major milestones in 2020 on its path to the launchpad this year. The observatory and its four scientific instruments passed a comprehensive systems test in July, a communications test in August, and final environmental stress tests in October.

MIRI has both a camera and a spectrograph that measure light in the mid-infrared region of the electromagnetic spectrum. Once launched aboard JWST in fall 2021, MIRI's unique capabilities and sensitive detectors will allow it to make unprecedented observations of a variety of astronomical objects, including distant galaxies, newly forming stars within the Milky Way, planets around nearby stars, and comets and trans-Neptunian objects in our own solar system.



Images of the James Webb Space Telescope and the Mid-Infrared Instrument.

Newly developed masks will allow the Roman Space Telescope's Coronagraph Instrument to reveal exoplanets.



...and on the planets

WHEN THE NANCY GRACE Roman Space Telescope, formerly the Wide Field InfraRed Survey Telescope (WFIRST), opens its eyes in the mid-2020s, it will rely on the most sophisticated sunglasses ever designed to peer at distant planets.

The Coronagraph Instrument (CGI) is an advanced-technology demonstrator preparing for future missions which will be designed to directly image Earth-like exoplanets. It will use a system of masks, prisms, detectors, and even self-flexing mirrors to block out the glare from nearby stars — and reveal the planets in orbit around them.

In 2020, the CGI team successfully completed a coronagraph mask manufacturing readiness review at JPL's Microdevices Lab and achieved technical readiness level (TRL) 6 for the deformable mirror, in preparation for the CGI's Critical Design Review in 2021.

Cold Atom Lab catches the wave

THE COLD ATOM LABORATORY, a facility for fundamental physics experiments that has been in orbit aboard the International Space Station since 2018, added a new tool called an atom interferometer, which is based on the wave-like properties of atoms. CAL demonstrated atom interference for the first time in space in May, and showed that such atom interferometers can form the basis of a new generation of exquisitely precise quantum sensors — well suited for space applications. Upcoming experiments will include demonstration of inertial sensing required for applications in spacecraft navigation, tests of Einstein's theory of gravity, and searches for dark energy candidates.

A new day dawns for SunRISE

IN MARCH, NASA selected the Sun Radio Interferometer Space Experiment (SunRISE) to study how the Sun generates and releases giant space storms. To get a better understanding of how these massive coronal ejections shower planetary space with energetic solar particles, the mission plans to launch six solar-powered CubeSats operating as one single radio telescope roughly 10 miles across, orbiting high above the Earth. The CubeSat constellation will create 3D maps to pinpoint where giant particle bursts originate on the Sun and how they evolve as they expand into space. The project passed its Project Mission System Review (PMSR) in November 2020.

Asteroid watcher on a trajectory towards implementation

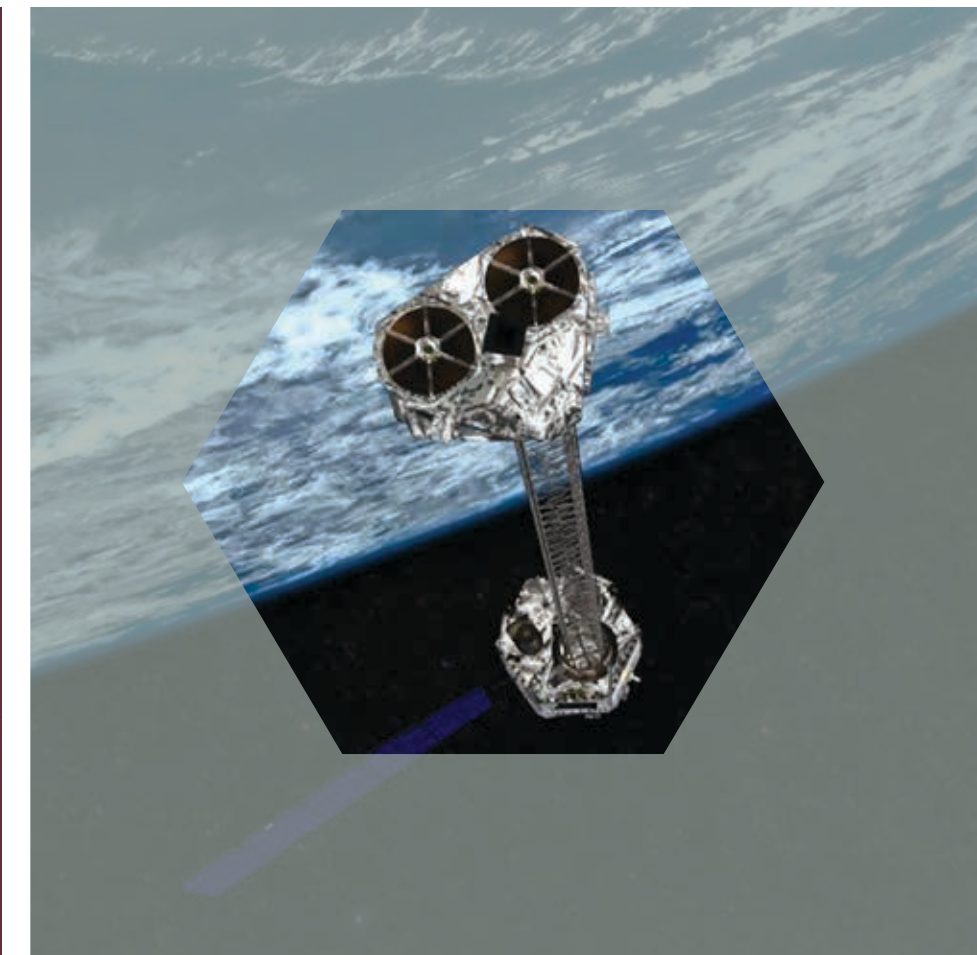
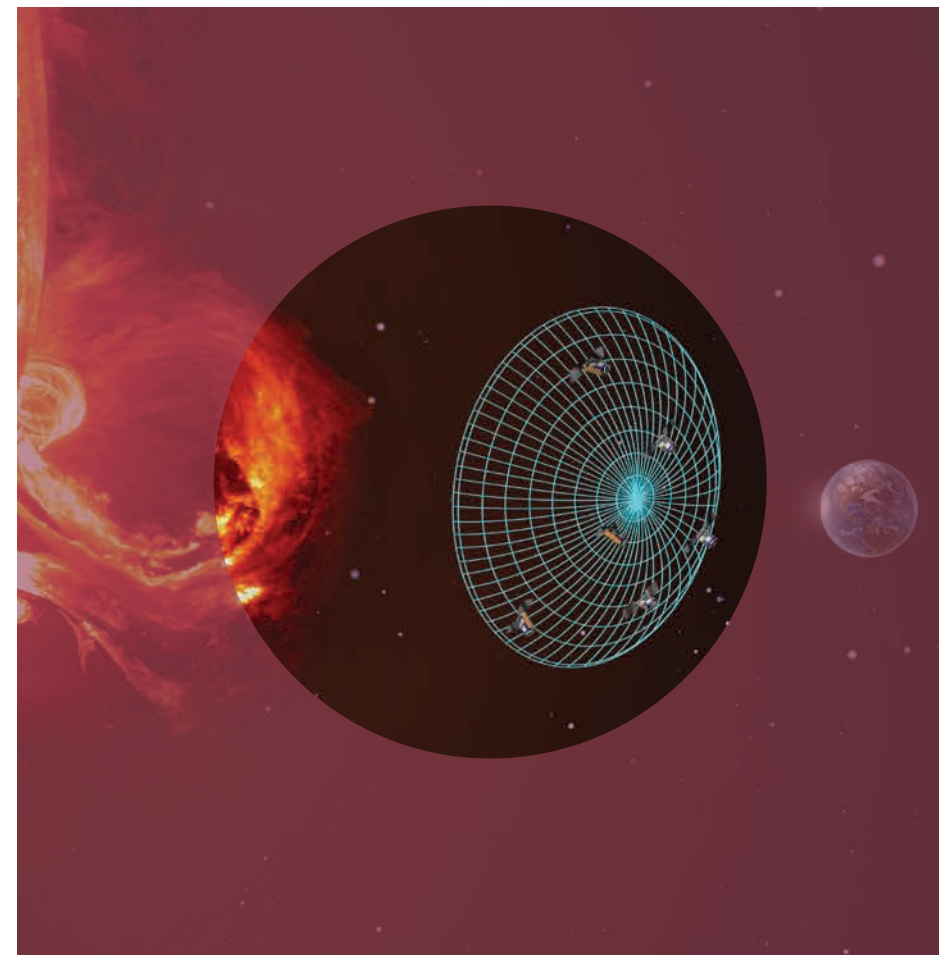
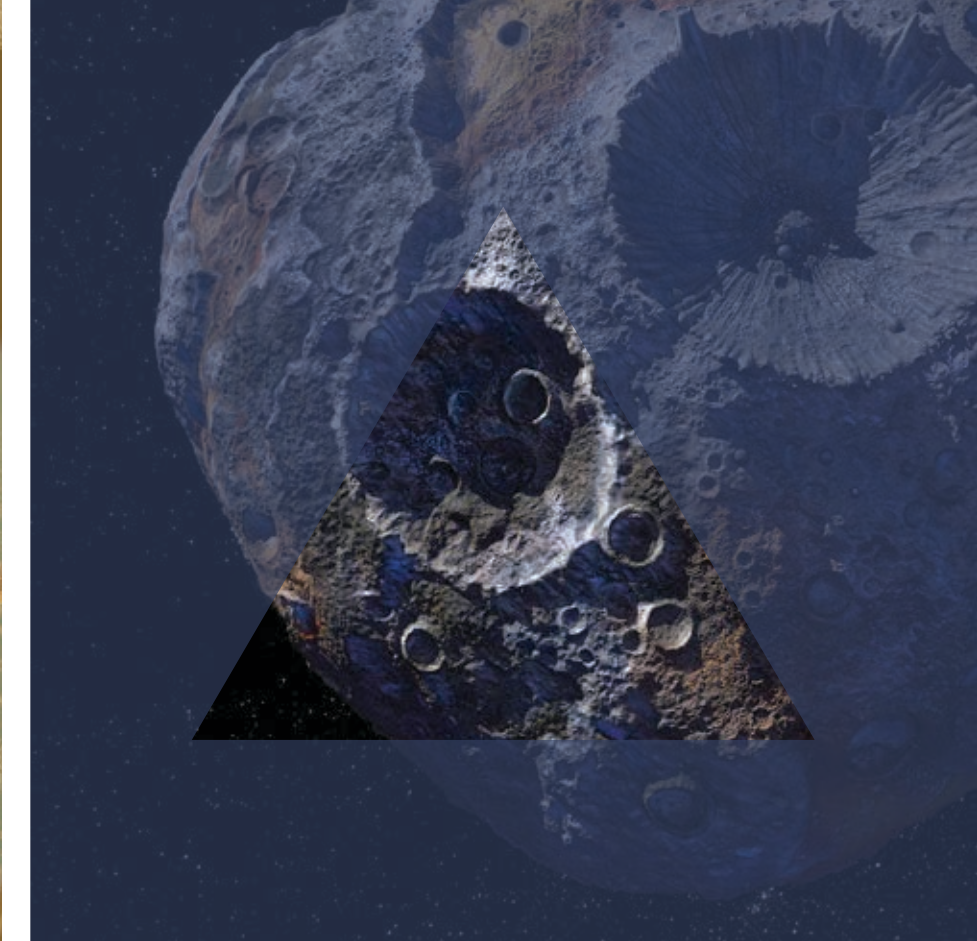
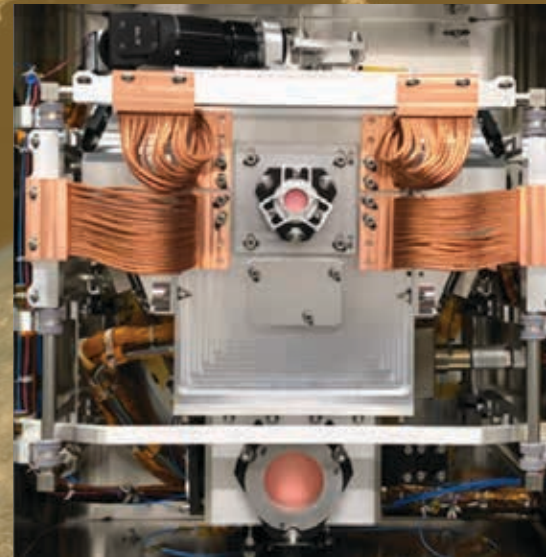
THE NEAR-EARTH OBJECT (NEO) SURVEYOR project has come a long way since it was proposed as the Near-Earth Object Camera (NEOCam) Discovery mission back in 2006. The current concept calls on NEO Surveyor to discover and characterize the orbit of most potentially hazardous asteroids larger than 460 feet (140 m) in diameter. The project passed its System Requirements Review/Mission Definition Review in 2020.

Newborn neutron star

THE NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR) detects light in the high energy X-ray region of the electromagnetic spectrum. Now in its eighth year in space, it recently helped researchers confirm observations of a neutron star estimated to be only about 240 years old — a newborn by cosmic standards.

Neutron stars have cores made of neutrons left over after massive stars go supernova and explode. They are some of the densest objects in the universe (second only to black holes). The young star, named Swift J1818.0-1607, belongs to a special class of objects called magnetars, which are the most magnetic objects in the universe. And it appears to be the youngest magnetar ever discovered.

NASA's Neil Gehrels Swift Observatory spotted the young object on March 12, when it released a massive burst of X-rays. Swift alerted the global astronomy community to the event, and XMM-Newton (which has NASA participation) and NuSTAR performed quick follow-up studies.





CHARLES ELACHI MISSION CONTROL CENTER

Mission Control, where JPL sends signals to and receives signals from a fleet of interplanetary and interstellar spacecraft.



Earth Science

AS THE TUMULTUOUS YEAR DREW TOWARD A CLOSE, the NASA/JPL-European Sentinel-6 Michael Freilich ocean-observing satellite launched from Vandenberg Air Force Base on a sunny November morning in central California, providing a welcome and uplifting sight. The mission — the latest in an international campaign spanning three decades of ocean studies — reminded the world of what humanity can achieve.

Earth Science



Mission Control, where JPL sends signals to and receives signals from a fleet of interplanetary and interstellar spacecraft.



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The spacecraft is designed to monitor sea level closely and gather precise data on atmospheric temperature and humidity, helping improve weather forecasts and climate models. It took less than a month after launch for the first measurements to arrive.

Sentinel-6 Michael Freilich hails from a long line of sea-watching spacecraft, including the NASA/JPL-France TOPEX/Poseidon, and Jason-1, 2, and 3 missions. For 30 years, these satellites have been the gold standard for spaceborne sea level studies. Sentinel-6 Michael Freilich and its twin, Sentinel 6-B — launching in 2025 — will extend that lengthy data set.

The mission name pays a singular honor to Michael Freilich, a pioneer of Earth science for over 40 years at NASA and JPL (see sidebar, page 36).

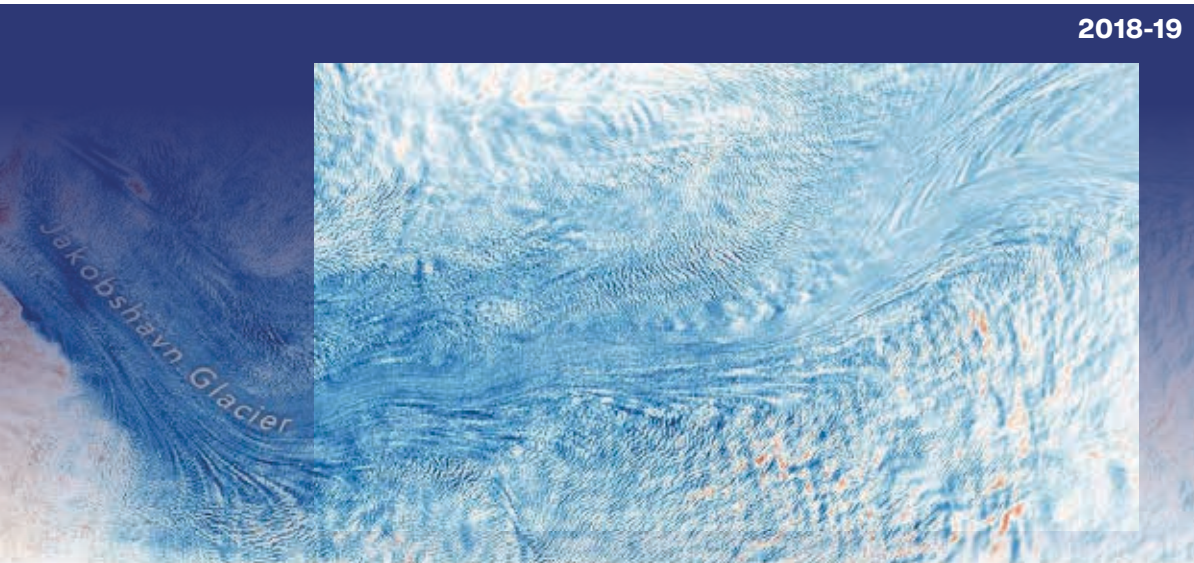
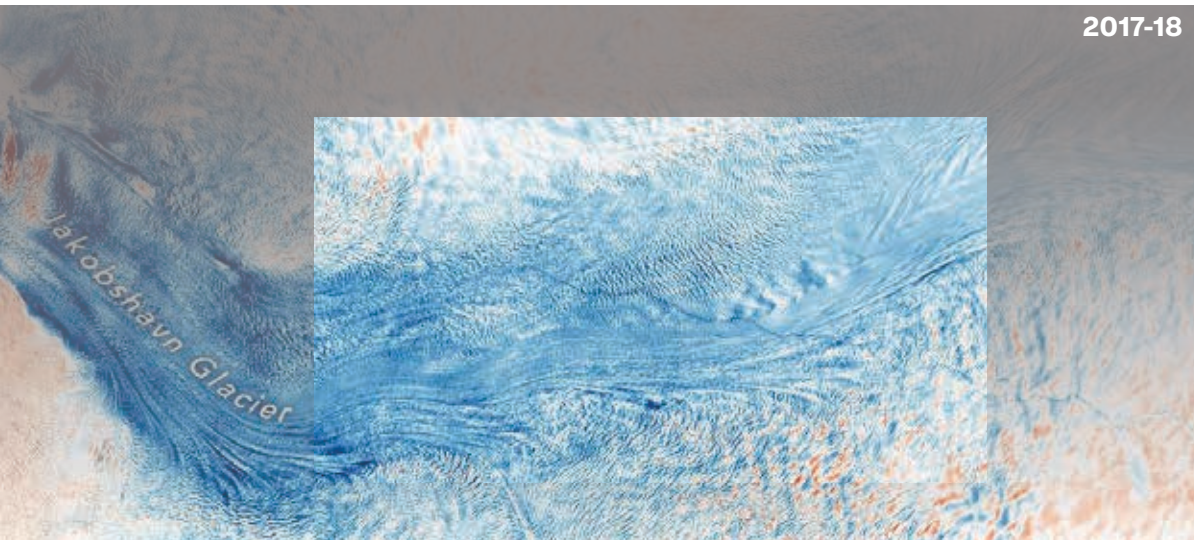
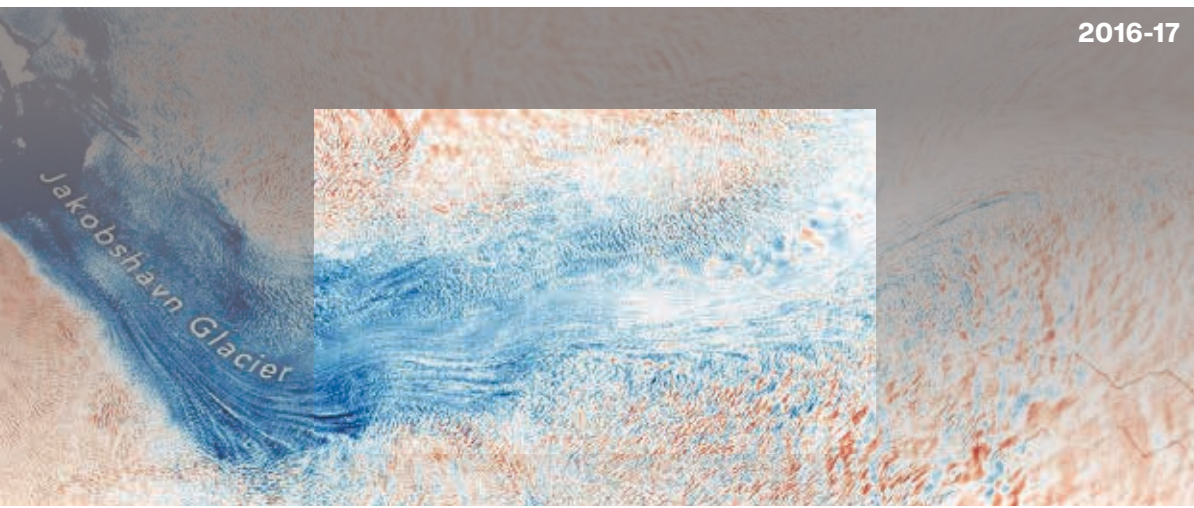
Above: Airborne tests of NASA's Gulfstream-III aircraft with the UAVSAR pod on its underbelly.

Below: A NASA Gulfstream 3 carrying UAVSAR flew above California fires to penetrate thick smoke and see how fires altered the landscape.

Trails of destruction

AS IF A PANDEMIC WERE NOT ENOUGH, the year 2020 included widespread disruptions and damage from massive wildfires in the western states. JPL researchers assembled proxy maps revealing areas of greatest damage via the Uninhabited Air Vehicle Synthetic Aperture Radar (UAVSAR) instrument. The maps helped emergency responders identify damaged structures, as well as burn areas that may be vulnerable to future landslides and debris flows.

The fires released carbon monoxide high into the atmosphere, where the NASA/JPL AIRS instrument observed it in plumes, which were ultimately carried eastward by the jetstream, and reached across the Atlantic to Europe. A byproduct of wildfires along with other gases, ash and smoke, carbon monoxide is significant because it affects air pollution. Carbon monoxide also affects levels of such greenhouse gases as methane and carbon dioxide, which in turn affect climate change.



Tons of thawing

THE OCEANS MELTING GREENLAND (OMG) airborne mission team had weeks of pandemic-related delays before being allowed to continue their studies of glacier melting and sea level rise. Their late-summer research revealed that, following a cooling period when glaciers grew or melted more slowly at Jakobshavn – Greenland’s fastest-moving, fastest-thinning glacier – warmer waters were returning and accelerating the melting.

Additional research, based on measurements from the GRACE and GRACE Follow-On satellites, combined with computer models that simulate snowfall and ice-sheet melting on Greenland, showed that the melt set a new record for ice loss. Greenland shed more mass from its ice sheet in 2019 than in any year since at least 1948.

Images from GLISTIN-A radar data, as part of NASA’s OMG mission, show mass increase of the Jakobshavn Glacier over time. Dark blue areas represent most growth, and red areas indicate thinning.

Worse weather, better forecasting

THE 2020 ATLANTIC HURRICANE season was the most active and the seventh costliest on record. A study of factors associated with the sudden intensification of hurricanes led to a novel use of machine-learning to augment and improve traditional hurricane forecasts. Using data from NASA/JPL’s CloudSat mission and from the JPL Microwave Limb Sounder on Aura, with the IBM Watson Studio, the experimental model augmented with machine learning nearly doubles the accuracy of forecasts for the rapid intensification of hurricanes.

Drought forecasting and management also benefited from the first seasonal forecasts of groundwater and soil moisture for the contiguous U.S. that included observations from GRACE-FO.

Above: The Aura spacecraft, NASA’s atmospheric chemistry mission, monitors Earth’s protective atmosphere.

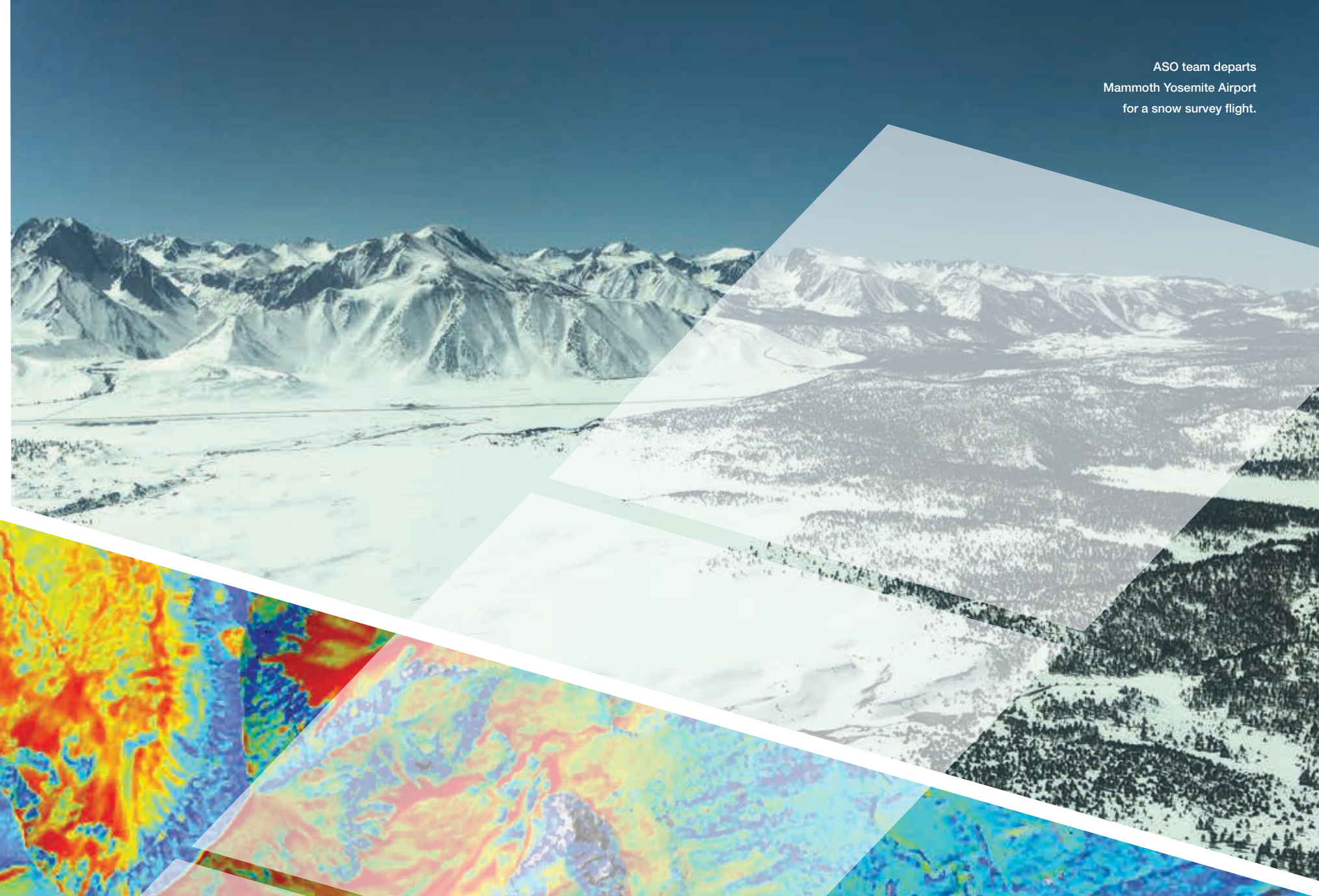
Below: CloudSat overpassed the center of Hurricane Laura in the Gulf of Mexico on Aug. 25.



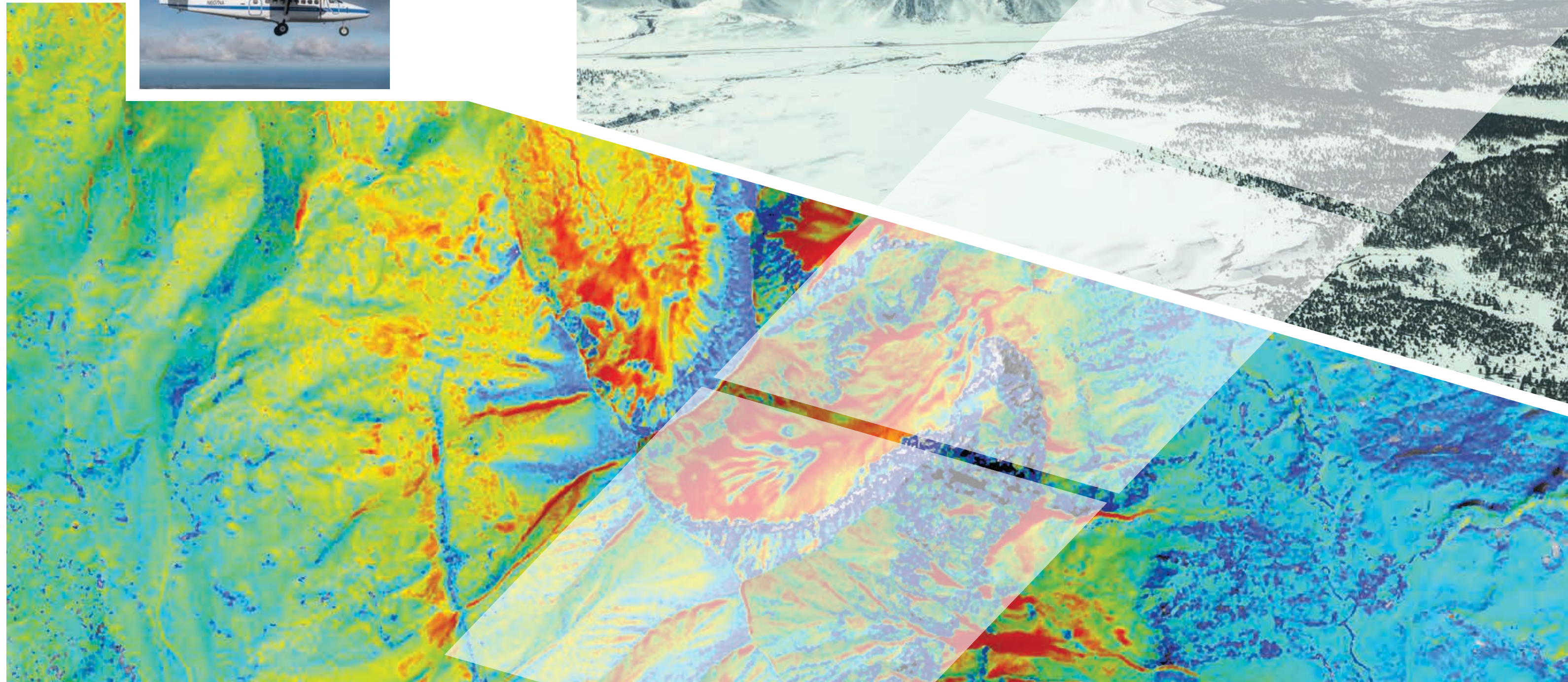
The snow pack, unpacked

JPL HELPED WATER MANAGERS and the community at large through the Airborne Snow Observatory, a pioneering way for the State of California to accurately measure snowpack levels in mountain ranges. Using airborne instruments — a scanning lidar and imaging spectrometer — derived from their spaceborne cousins, JPL uniformly evaluated snow levels over entire mountain basins.

Coupled with spectrometer data and snow density models, JPL demonstrated accurate estimates of the rate of snow melt and total volume of water stored as snow. This technology reduced reliance on people venturing to remote mountain sites in the dead of winter to make limited measurements, which had been used to project the total amount of water stored as snow. JPL recently licensed the data processing software for this technology to a private company, which will enable routine measurements for the state.



ASO team departs Mammoth Yosemite Airport for a snow survey flight.



Above: Twin Otter is the type of aircraft used for Airborne Snow Observatory.

Below: First mapping of snow water equivalent across mountain basins from Airborne Snow Observatory

Credit: Jeffrey Deems, Airborne Snow Observatories, Inc.



Legacy of an Earth science pioneer



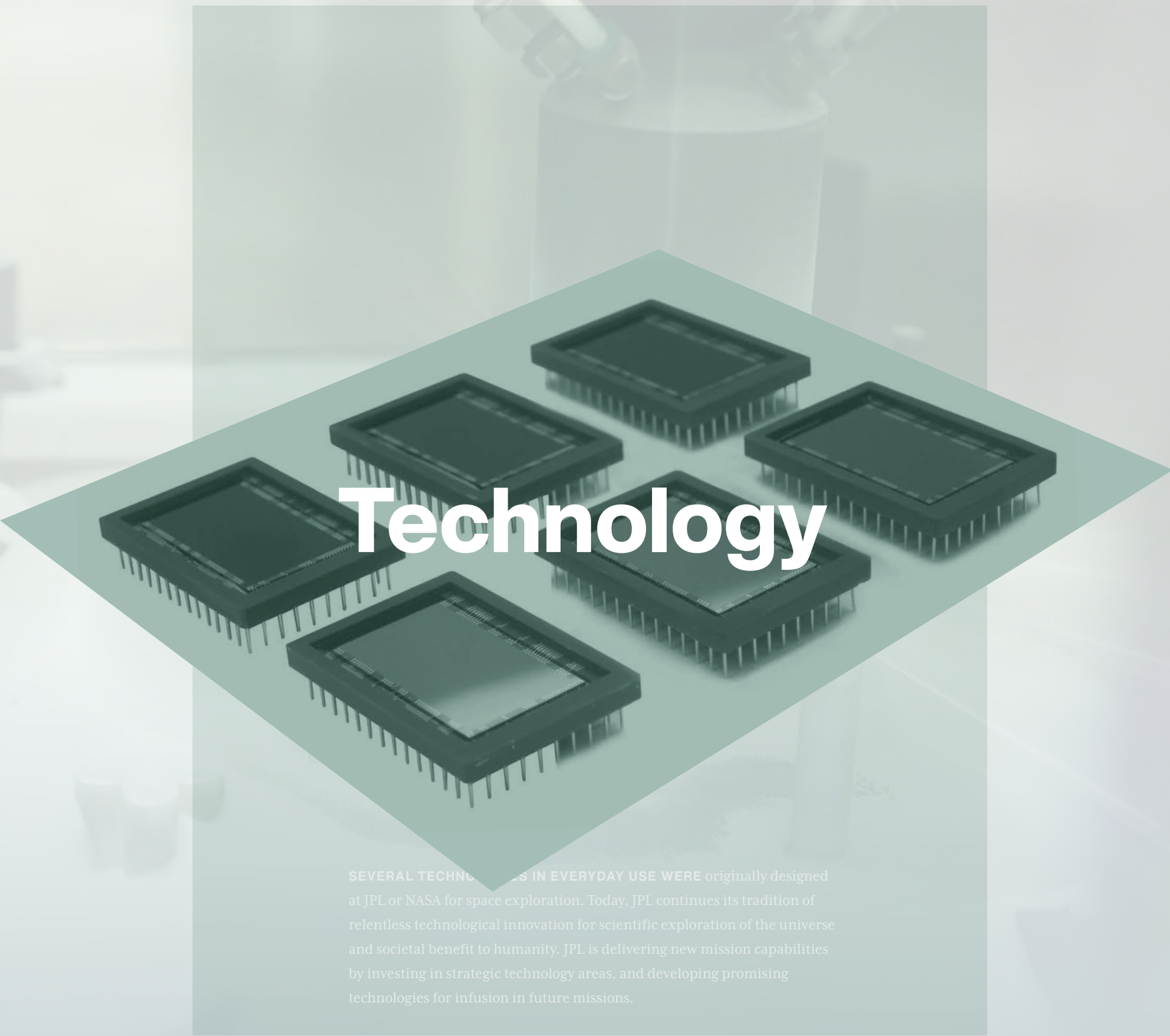
WHEN THE LATEST IN A SERIES OF NASA Earth-observing satellites blasted off from Vandenberg Air Force Base in central California, it carried the name and the legacy of a world-renowned Earth science pioneer. The Sentinel-6 Michael Freilich mission honors the man whose 40-year career included heading NASA's Earth Science Division from 2006 until his retirement in 2019, and breaking new ground in Earth research at JPL from 1983 to 1991.

After Michael Freilich's retirement, but before his death from complications of pancreatic cancer, NASA and Sentinel-6 partner agencies added his name to the mission as a fitting tribute to his role in gathering critical information about the oceans.

Jim Graf, Director for JPL's Earth Science and Technology Directorate, said Freilich "revitalized the program through his creative vision, his powerful intellect and tireless commitment to excellence."

Freilich's work at JPL included roles as project scientist for the NASA Scatterometer (NSCAT) and principal investigator for the SeaWinds Scatterometer. He was one of the pioneers of building the model function to convert radar measurements into accurate, all-weather winds at the ocean surface. This work led to routine use of scatterometer measurements to improve weather forecasts.

Freilich said from 10th grade on, he knew he wanted to be a near-shore oceanographer, and that he was driven by "understanding how nature works."



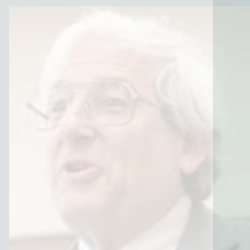
Technology

SEVERAL TECHNOLOGIES IN EVERYDAY USE WERE originally designed at JPL or NASA for space exploration. Today, JPL continues its tradition of relentless technological innovation for scientific exploration of the universe and societal benefit to humanity. JPL is delivering new mission capabilities by investing in strategic technology areas, and developing promising technologies for infusion in future missions.



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Legacy of an Earth science pioneer

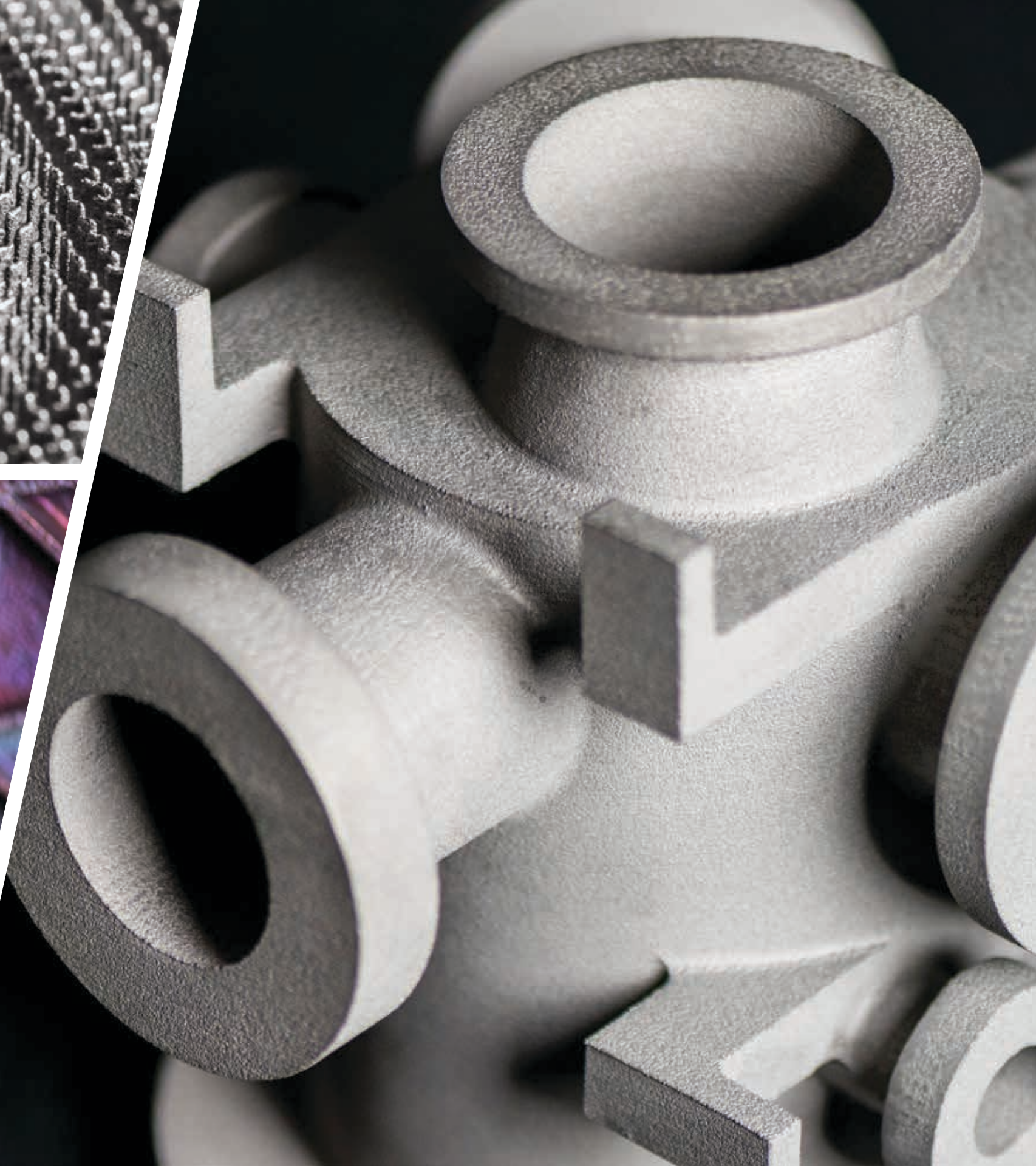
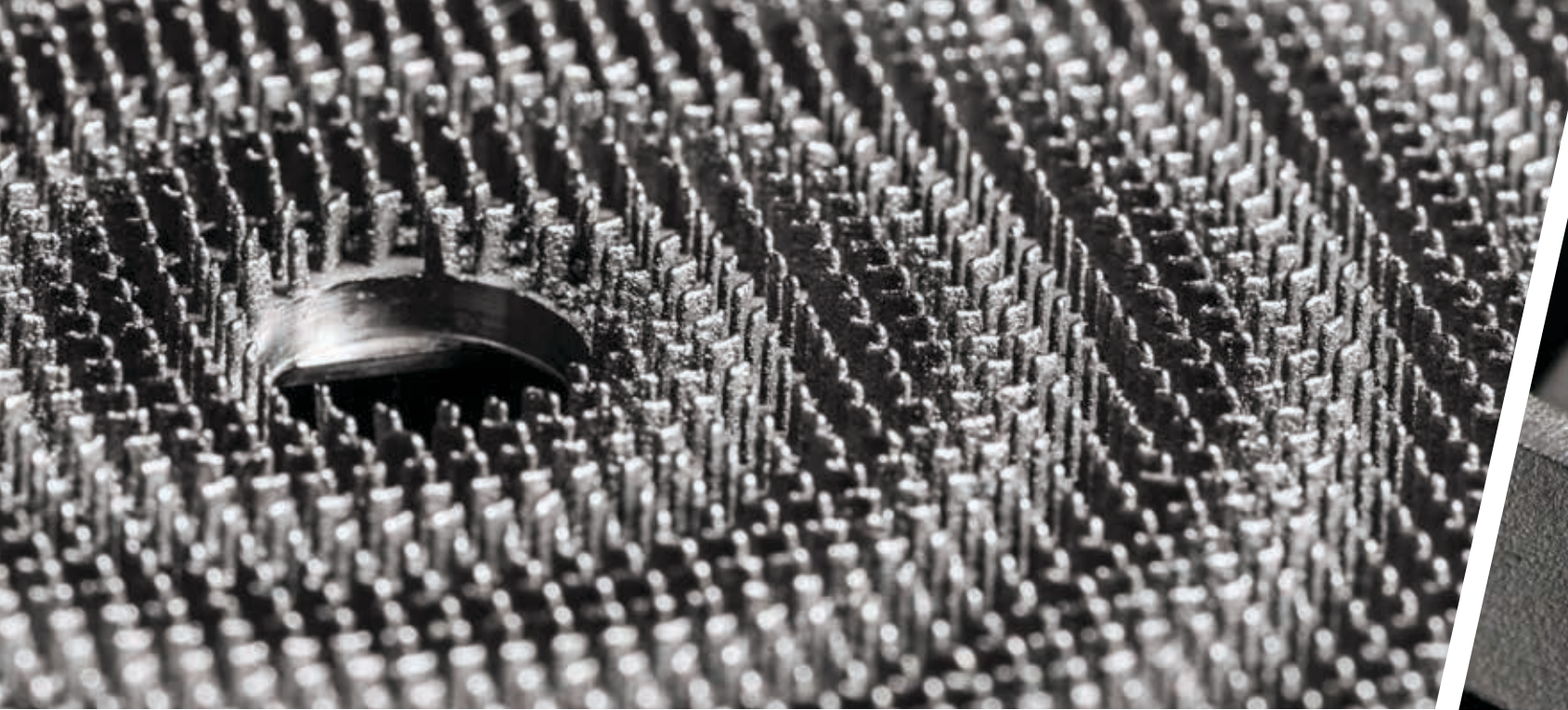


Michael Freilich's career at JPL included roles as project manager for the NASA Scatterometer (NSCAT) Science Division from 1995 to 2000, principal investigator for the SeaWiFS instrument in 2019, and breakthrough investigator for the SeaWiFS research at JPL from 1983 to 1995. He was one of the pioneers of building the model function to convert radar measurements into accurate, all-weather winds at the ocean surface. This work led to routine use of scatterometer measurements to improve weather forecasts.

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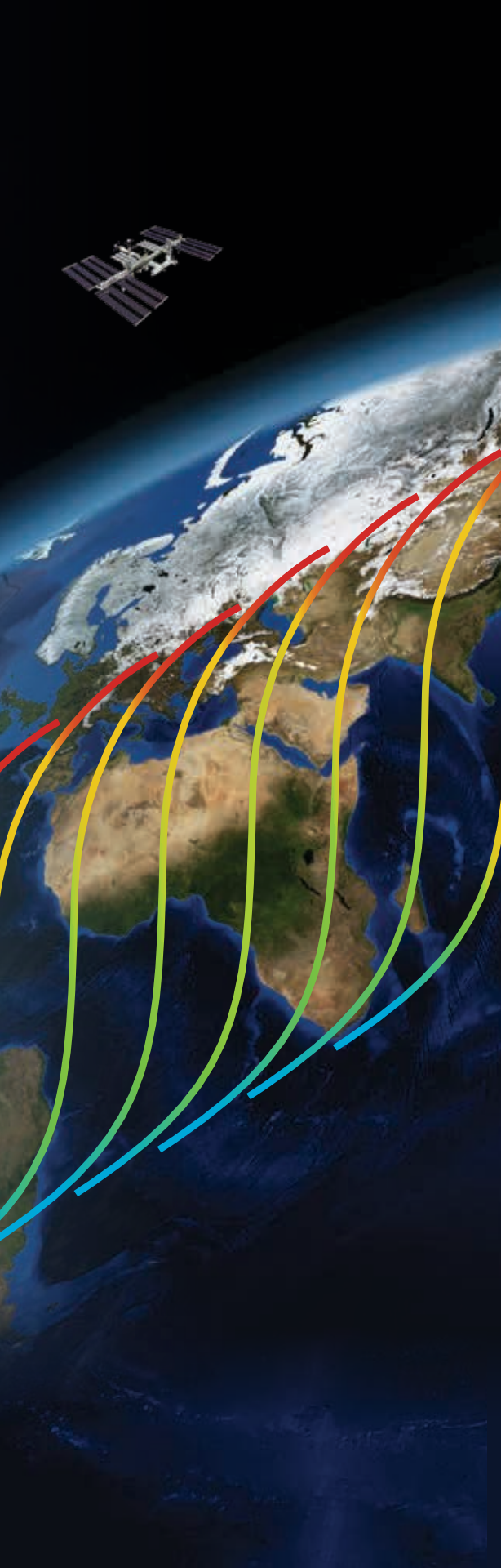


Material matters

JPL HAS ESTABLISHED ITSELF AS A LEADER in advanced manufacturing technology development. This technology area is critical to future science missions, as it affects the physical properties of hardware. For example, a major barrier to miniaturizing electric propulsion technology consisted of developing magnetic shielding that would remain effective at smaller scales.

JPL overcame this obstacle thanks to Directed Energy Deposition, an advanced manufacturing process which optimizes the magnetic and structural performance of soft magnetic alloys. Using this process, technologists can control grain size at various points in a structure, thereby creating materials with custom magnetic properties, and an electric propulsion thruster that can propel SmallSats to the outer Solar System.

Examples of 3D-printed metal components manufactured at JPL.



When the Earth exhales

THE ORBITING CARBON OBSERVATORY-3 (OCO-3), which launched on May 4, 2019 and began its three-year prime mission that September aboard the International Space Station, allows continuous observation of carbon dioxide levels on Earth. The past year was the first in history during which scientists could observe changes in carbon dioxide levels throughout the day and across many regions of the globe.

OCO-3 uses three high-resolution spectrometers to measure light absorption in atmospheric oxygen, as well as carbon dioxide's light absorption at two different wavelengths. Along with two high-resolution pointing cameras and its agile two-axis Pointing Mirror Assembly, OCO-3 produces dozens of 80 km x 80 km "snapshot area maps" each day. This data will be key not only to understanding the carbon cycle itself, but also to improving atmospheric models and weather prediction.

A capsule carrying JPL's OCO-3 observatory nears its rendezvous with the International Space Station.

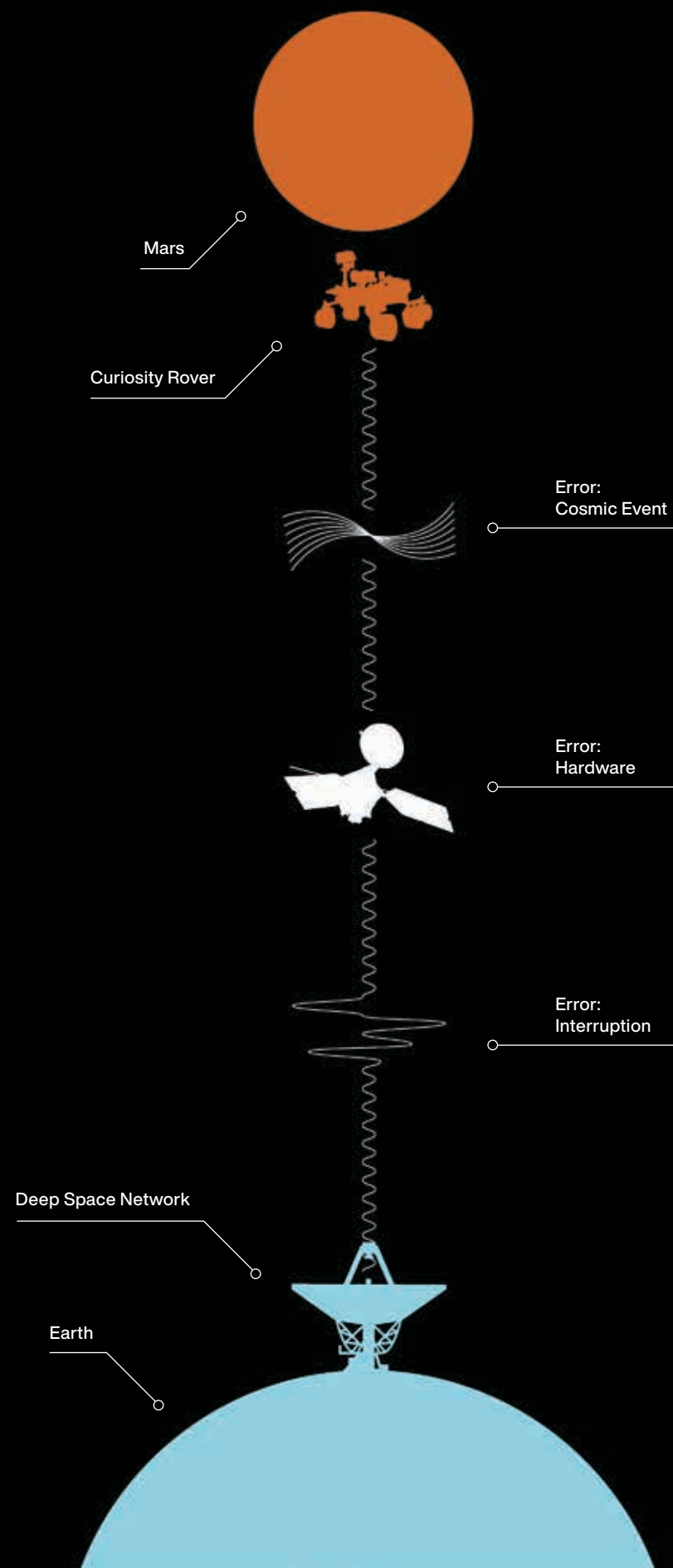
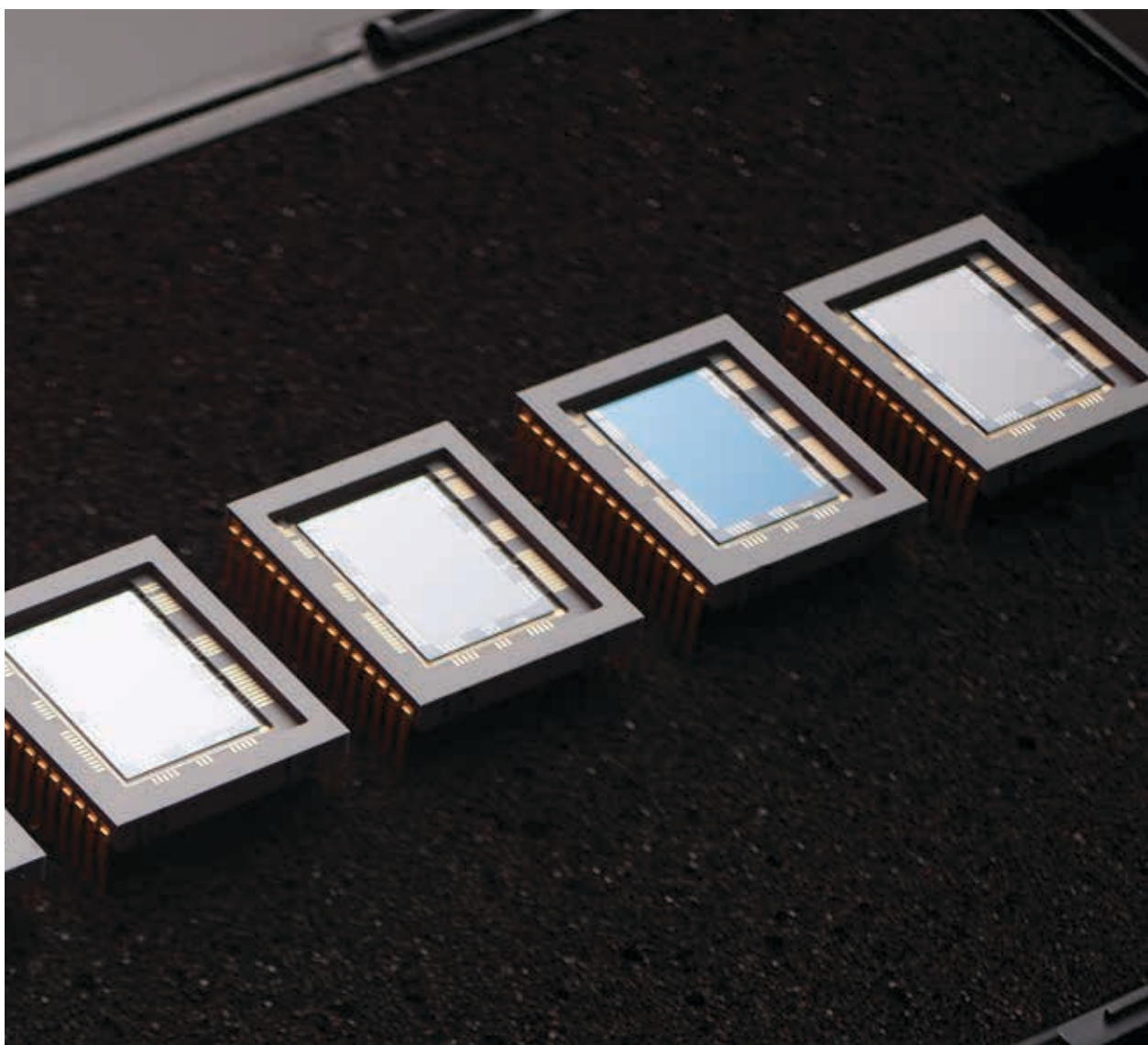


The more UV, the more you see

FUTURE SCIENCE MISSIONS require increasingly sensitive instruments to achieve ambitious goals, like mapping the largest structures of the Universe in 3D. Ultraviolet radiation is particularly useful for understanding the evolution of galaxies, but can only be observed in space due to the atmosphere's absorption of ultraviolet light.

JPL has flown the first spaceborne Electron Multiplying Charge-Coupled Device (EMCCD). This technology was originally developed for biomedical applications, but has been adapted to astronomy and astrophysics applications. The EMCCDs are optimized for extremely low-level light detection thanks to three advances: single photon counting, 2D delta doping, and atomic layer deposition. The capability demonstrated in flight could allow future telescopes to be four times smaller, with 10 times improved performance.

JPL delivered a novel high-performance UV detector to FIREBall-2, a balloon-borne spectrograph studying the primordial remains of the Big Bang.



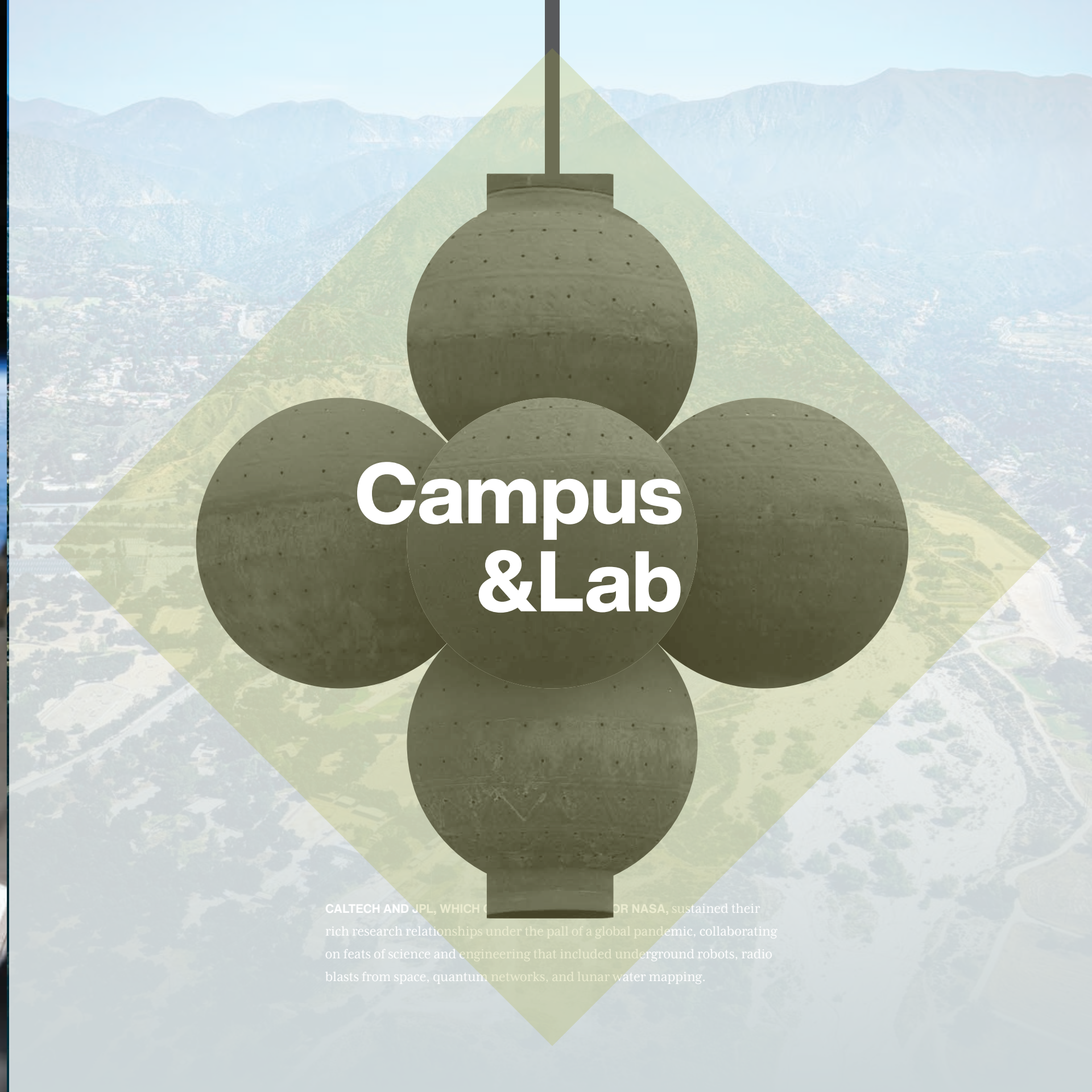
Managing expectations

INFUSING THE TECHNOLOGIES JPL develops into missions provides both tactical and strategic benefits to the Lab's and NASA's long term goals. The Automated Data Accountability for Missions system is an example of an early stage investment turning into a mission capability. The emerging machine learning technology of adversarial autoencoders, allowing data fidelity issues to be diagnosed accurately and automatically, was foundational to this advance.

This former JPL Center Innovation Fund (CIF) project was integrated into the Mars Science Laboratory Ground Data System in October 2019, where its daily use is already increasing scientists' ability to use incomplete Curiosity data by 40%. Expect more examples of artificial intelligence applications that improve JPL's mission science return and overall effectiveness in years to come.



View of OCO-3 docked on the Japanese Experiment Module of the International Space Station.

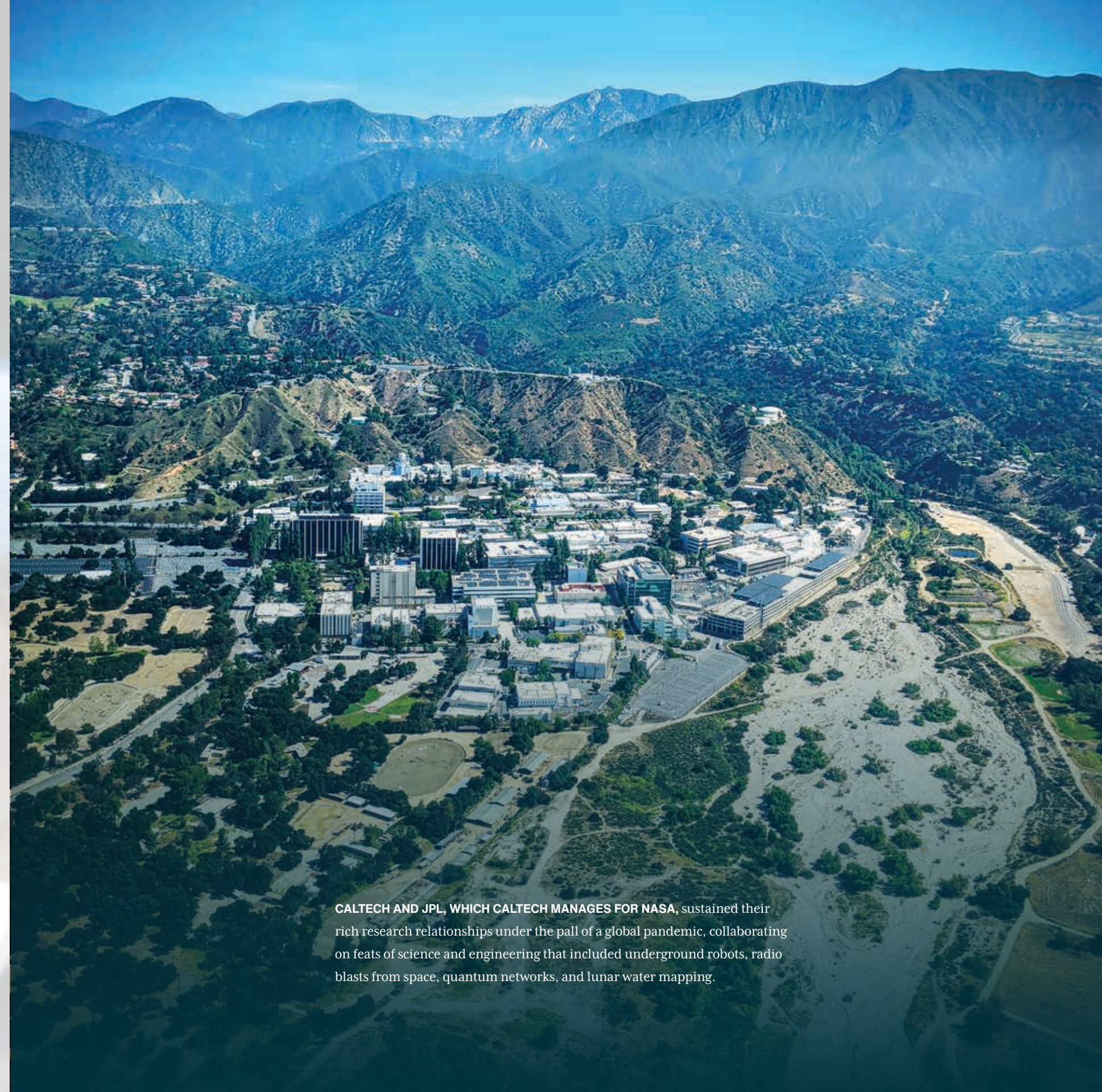


Campus & Lab

CALTECH AND JPL, WHICH COLLABORATE WITH NASA, sustained their rich research relationships under the pall of a global pandemic, collaborating on feats of science and engineering that included underground robots, radio blasts from space, quantum networks, and lunar water mapping.

View of OCO-3 docked on the Japanese Experiment Module of the International Space Station.

Caltech & JPL



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Developed for the DARPA Subterranean Challenge, this four-legged explorer prototype combines JPL's autonomy "smarts" with Boston Dynamics' doglike walker.



Left: This illustration of a magnetar shows its superstrong magnetic field, which can produce a fast radio burst. Credit: NASA's Goddard Space Flight Center

Right: STARE2 "sees" with three radio detectors located in California and Utah.

Robots learn self-reliance

WHETHER EXPLORING CAVES on other planets or buried disaster sites on Earth, robots need to operate without human guidance.

Demonstrating that wayfinding is not just a human skill, Team CoSTAR, led by researchers from Caltech and JPL, won the second stage of the Subterranean Challenge in Feb. 2020. The international robotic competition is sponsored by the Defense Advanced Research Projects Agency, or DARPA.

The winning team, co-led by JPL's Ali Agha and Caltech/JPL's Joel Burdick, comprised 60 engineers from campus and Lab, MIT, the Korea

Advanced Institute of Science and Technology (KAIST) and Sweden's Lulea University of Technology.

"The goal is to develop software for our robots that lets them decide how to proceed as they face surprises," said Agha.

The four-stage contest, which requires robots to navigate simulated complex settings such as mines and caves, will culminate in August 2021.

A fast radio blast, and faster detectors

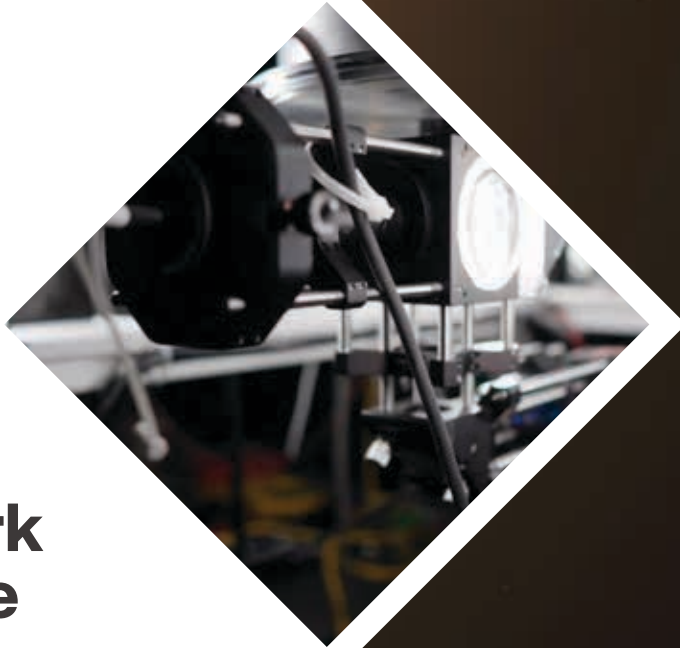
THE SURVEY FOR TRANSIENT Astronomical Radio Emission 2 (STARE2) project has helped pinpoint at least one cause of mysterious "fast radio bursts," linking them to a type of neutron star called a magnetar — a crushed, city-size, but magnetically seething remnant of a star once many times bigger than our Sun.

On April 28, 2020, a Canadian radio telescope and STARE2's detectors independently observed an intense radio blast that was later linked to a magnetar in our Milky Way, 30,000 light years from Earth.

The discovery confirms that the intense magnetic fields of magnetars can produce the mysterious and powerful radio blasts previously observed in other galaxies, but never traced definitively to a source.

"It's surreal. I never thought STARE2 would work this well," said Chris Bochenek, lead author of a new Nature study on the project's results, and a Caltech doctoral student. He co-leads STARE2 with Shri Kulkarni at Caltech, and Konstantin Belov at JPL.

This focusing laser system is used to test quantum sensors.
Credit: Caltech Quantum Network



Building a global network on a tiny scale

A JOINT TEAM OF RESEARCHERS led by Caltech and including collaborators from JPL and the Fermi National Accelerator Laboratory (Fermilab) has established two test beds using state-of-the-art quantum devices to accurately teleport quantum information for a sustained period across a distance of 44 kilometers.

Published in PRX Quantum, this research represents an important step in establishing a quantum internet of the future, which would revolutionize the fields of secure communication, data storage, precision sensing, and computing.

In a quantum internet, information stored in qubits (the equivalent of computer bits) would be teleported over long distances while maintaining high fidelity of information — in this case over 90%.

“We are very proud to have achieved this milestone on sustainable, high-performing, and scalable quantum teleportation systems,” said Maria Spiropulu, the Shang-Yi Ch'en professor of physics at Caltech and director of the Intelligent Quantum Networks and Technologies (IN-Q-NET) program, which was jointly founded by Caltech and AT&T.



A smallsat with a big water budget

LUNAR TRAILBLAZER, approved in December 2020 to proceed to its final-design and fabrication phase, will produce the best maps of water on the Moon. Trailblazer is one of NASA's first small satellite missions for planetary science.

The mission will measure the tiny amounts of water on the Moon's sunlit side and also peer into shadowed craters to map ice deposits. Trailblazer will use a shortwave imaging spectrometer built by JPL and a multispectral thermal imager built by the University of Oxford, both carried by a Lockheed Martin small spacecraft.

Bethany Ehlmann, Caltech professor of planetary science and JPL research scientist, is the mission's principal investigator, and Calina Seybold is the JPL project manager.

“The water cycle of airless bodies is one of the solar system's most surprising occurrences and is important for the support of future human lunar exploration,” said Ehlmann.

Lunar Trailblazer will produce the best maps of water on the Moon.
Credit: Lockheed Martin Space

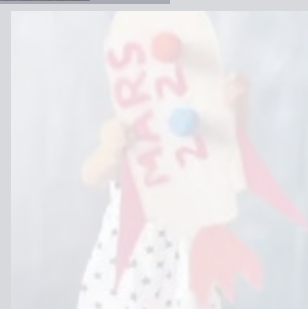


Nestled against Pasadena's foothills, JPL is a regular host to the local deer population.



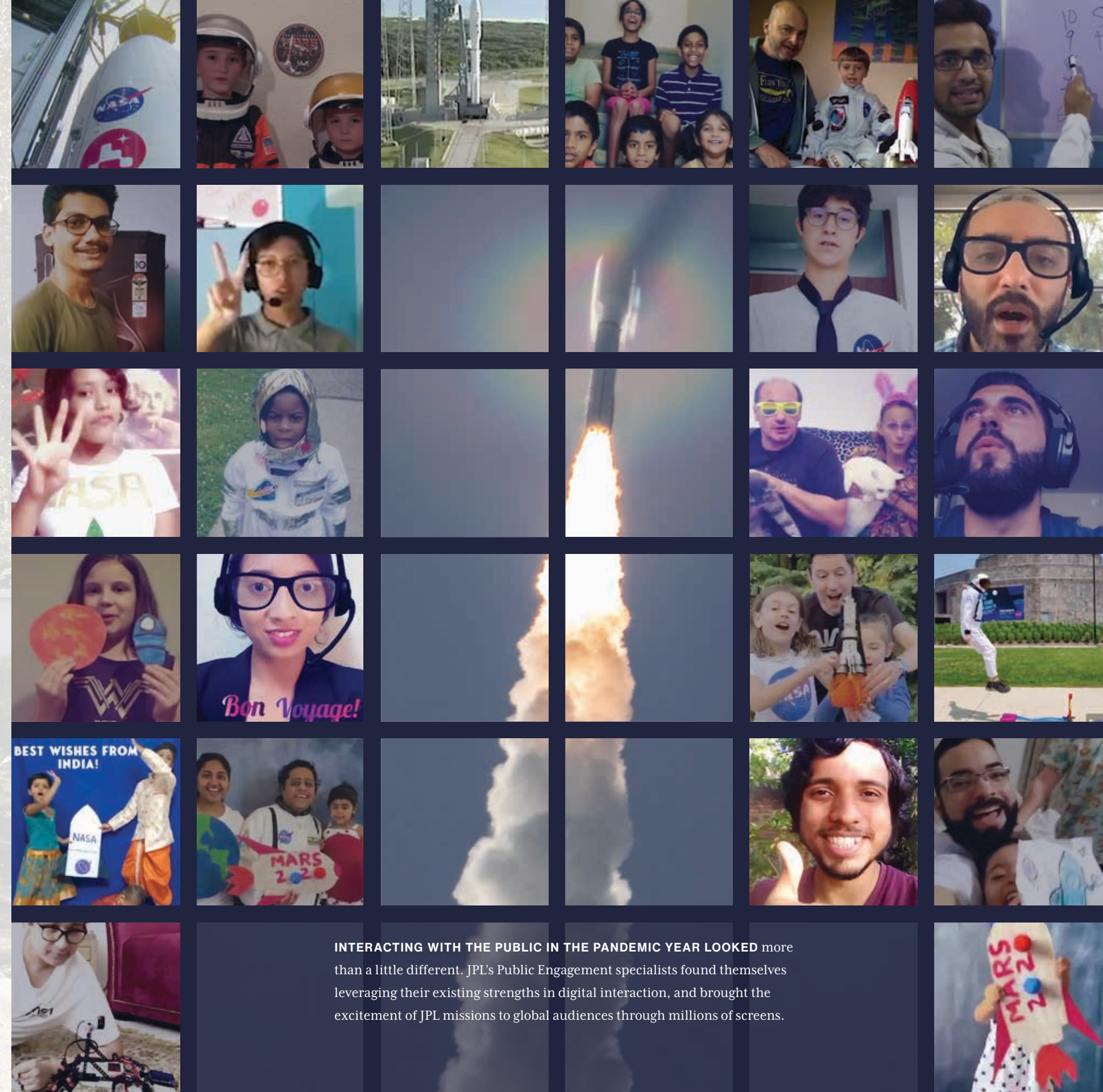
Public Engagement

INTERACTING WITH THE PUBLIC IN THE PANDEMIC YEAR LOOKED more than a little different. JPL's Public Engagement specialists found themselves leveraging their existing strengths in digital interaction, and brought the excitement of JPL missions to global audiences through millions of screens.





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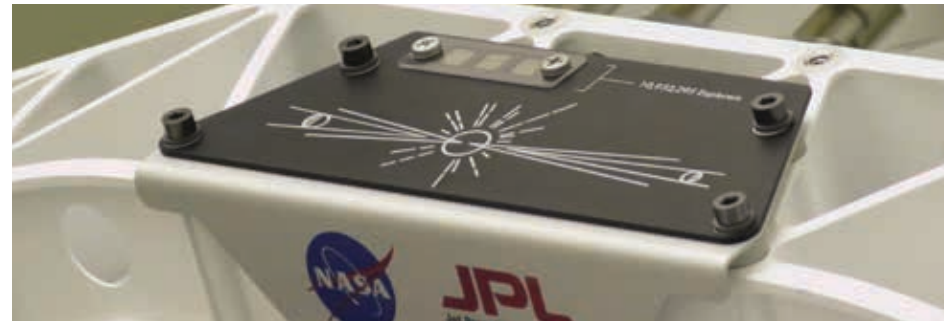
When locked down, persevere online

AS THE SPRING'S LOCKDOWNS stretched into early summer, the Mars Public Engagement team pivoted to an all-online launch experience built around a #CountdownToMars campaign.

Members of the public participated in the launch virtually, receiving mission updates and opportunities usually reserved for on-site guests; an interactive digital guest packet; a behind-the-scenes look at the mission; augmented reality filters for social media and NASA's 60 million followers on Instagram; a call-to-action video with video clips submitted by the public; a launch web toolkit; a chance to take a souvenir photo with the Mars Photo Booth; and the opportunity to Send Your Name to Mars on a future mission.

When the Mars Perseverance rover launched to Mars on July 30, more than half of all NASA website traffic for the day went to Mars.nasa.gov. The rover left Earth carrying three dime-size chips with nearly 11 million names from all over the world.

Millions of new flyers have already submitted their names for the next mission to the Red Planet — Mars Sample Return.



Top: A NASA enthusiast cheers on the Mars Perseverance rover as it lifts off into space.

Middle: A placard commemorating NASA's "Send Your Name to Mars" campaign was installed on the Perseverance Mars rover.

Bottom: NASA Public Affairs Specialist Kristi Irastorza hosts a "Mars 2020 Social Media Q&A: En Español" program.



Rink Glacier in western Greenland, with a meltwater lake visible center.

LEGO teamed up with NASA Earth to celebrate the 50th anniversary of Earth Day.

Earth Day turns 50

THE WORLD OBSERVED the 50th anniversary of Earth Day on April 22. NASA highlighted the agency's many contributions to sustaining and improving our home planet's environment with a week of online events, stories and resources.

Due to the Covid-19 pandemic, in-person NASA activities were canceled. However, NASA brought people together virtually for Earth Day with new online content, programming and activities, including an extensive array of at-home projects in the #EarthDayAtHome collection.

NASA's observation of the Earth Day golden anniversary began on March 3 with a "50-Day Countdown" of daily social media posts highlighting many of the agency's Earth images and environmental projects.

#EarthDayAtHome (an unused hashtag before the campaign) was trending as high as #4 on Twitter on April 22 and garnered a reach of 2.2 billion across social platforms, 20% higher than the average of #PictureEarth in 2019 on non-NASA related accounts.

NASA also partnered with LEGO on their "Build a Planet" challenge to promote Earth Day at Home with NASA, which became LEGO's most successful build challenge to date.



Right: NASA previews the Sentinel-6 Michael Freilich launch during press briefing.

Below: An aspiring future NASA astronaut looks to the stars.



Sentinel-6 Michael Freilich launches

THE WORLD'S LATEST sea-level observation satellite launched on Nov. 21, and now is in orbit and ready to make critical ocean measurements over the next five-and-a-half years.

Sentinel-6 Michael Freilich satellite is named in honor of the former director of NASA's Earth Science Division, who was instrumental in advancing space-based ocean measurements (see tribute on p. 36).

The satellite will be followed in 2025 by its twin, Sentinel-6B. Together, the pair is tasked with extending NASA's nearly 30-year-long record of global sea surface height measurements. Instruments aboard the satellites will also provide atmospheric data that will improve weather forecasts, climate models, and hurricane tracking.

The Sentinel-6 Michael Freilich launch garnered 926,000 total engagements and an estimated reach of 1 billion across all of NASA's social platforms. During the launch broadcast, the #Sentinel6 hashtag trended in the #3 spot across the U.S. on Twitter.

More than 21,000 fans attended the launch day virtual NASA Social, which included real-time interactions with members of the international team and a live broadcast.



NASA goes @home

THE AGENCY RESPONDED to the pandemic with a "NASA at Home" campaign, and JPL Public Engagement teams quickly mobilized to compile content from across all the themes.

Exoplanet Communications developed a suite of products that highlighted exoplanet science and discovery. NASA Space Place content was repurposed for the NASA at Home website, NASA

STEM at Home, and the JPL educational team. New coloring pages, videos, at home activities and repurposed content brought badly needed resources and ideas to home learners.

And JPL's vaunted von Karman Lecture Series switched to an online format, drawing an average of thousands of virtual attendees every month from April through December.



NASA at Home provides space and science activities for kids in all grade levels.

Top center: JPL's von Karman Lecture Series in its online format.



Major contractor partners

APPLIED PHYSICS LABORATORY, THE JOHNS HOPKINS UNIVERSITY

Europa Clipper, Mars 2020, Mars Reconnaissance Orbiter, Psyche

COLUMBUS TECHNOLOGIES AND SERVICES INCORPORATED

Labor Support Services

BALL AEROSPACE & TECHNOLOGIES CORPORATION

CloudSat, NEOSurveyor, NEOWISE, SPHEREx

MANTECH ADVANCED SYSTEMS

Institutional Computing

PERATON, INC.

Deep Space Network Operations, Mars 2020

RAYTHEON

Engineering, Implementation, Science, Operations and Communications (EISOC)

SSL

Psyche

SOUTHWEST RESEARCH INSTITUTE

EMIT, Europa Clipper, Mars Science Laboratory

LOCKHEED MARTIN CORPORATION

Europa Clipper, InSight, Juno, Mars 2020, Mars Odyssey, Mars Reconnaissance Orbiter, Spitzer Space Telescope

MORI ASSOCIATES, INC.

Information Technology Infrastructure Support

Major external awards

DONALD ARGUS

Geological Society of America George P. Wollard Award

ARVIN BARONI

Federal Computer Week Rising Star Award

NACER CHAHAT

Institute of Electrical and Electronics Engineers Region 6 Outstanding Engineer of the Year Award

COLD ATOM LABORATORY

American Institute of Aeronautics and Astronautics Space Science Award

COMMUNICATIONS & EDUCATION DIRECTORATE

Webby Awards:

Advertising, Media & PR Social Community Building and Engagement—Send Your Name to Mars

People's Voice Award—Send Your Name to Mars

People's Voice Award—Green—NASA Global Climate Change website

People's Voice Award—Education & Reference App, Mobile, and Voice—Solar System Interactive Experience

DAWN FLIGHT TEAM

International Space Ops Award for Outstanding Achievement

DARIUSH DIVSALAR

Institute of Electrical and Electronics Engineers Best Paper Award

ANDREA DONNELLAN

American Association for the Advancement of Science Fellow

CHARLES ELACHI

National Air and Space Museum Michael Collins Trophy, Lifetime Achievement

COSTAR

Team CoSTAR Best Paper Award at IROS 2020

ECOSTRESS

RNASA Stellar Award

DAN GOEBEL

2019 American Institute of Aeronautics and Astronautics Electric Propulsion Best Paper Award

SONA HOSSEINI

SPIE Early Career Achievement Award

A. SCOTT HOWE

American Institute of Aeronautics and Astronautics Gordon Woodcock Award for Professional Excellence in Space Architecture

INSIGHT

American Institute of Aeronautics and Astronautics Space Systems Award

INSIGHT — MARS CUBE ONE JOINT PROJECT FLIGHT TEAMS

Space Foundation John L. “Jack” Swigert, Jr. Award for Space Exploration

JPL

Talent Board North American Candidate Experience (CandE) Award

International Data Group CIO 100 Award

ANDREW KLESH

American Institute of Aeronautics and Astronautics Engineer of the Year Award

LESLIE LIVESAY

American Astronautical Society Carl Sagan Memorial Award

MARS CUBE ONE MISSION

Aviation Week & Space Technology Laureate Award

MARS HELICOPTER

Time Inc—The Best Inventions of 2020

ANDREY MATSKO

American Physical Society Fellow

SPIE Fellow

DANIEL J. MCCLEESE

COSPAR William Nordberg Medal

SHOULEH NIKZAD

Institute of Electrical and Electronics Engineers Fellow

GLENN SCOTT ORTON

American Geophysical Union Fellow

MARZIA PARISI

Italian Scientists & Scholars in North America Foundation Franco Strazzabosco Award for Engineering

CETH PARKER

American Society for Gravitational and Space Research Best Technical Merit Award

NIKUNJ PATEL and ARTURO RANKIN

Institute of Electrical and Electronics Engineers Best Paper Award

EVA PERAL

American Institute of Aeronautics and Astronautics Spacecraft Structures Best Professional Paper Award

PERSEVERANCE ROVER

Popular Science 2019 “Best of What’s New” Grand Award Winner

CHRISTINA RICHEY

American Astronomical Society Fellow

MIGUEL SAN MARTIN

American Institute of Aeronautics and Astronautics and National Academy of Engineering Yvonne C. Brill Lectureship in Aerospace Engineering

HELENE SEROUSSI

American Geophysical Union Cryosphere Early Career

RASHMI SHAH

Space Ops GRSS Early Career Award

TEAM COSTAR

Winner, Urban Circuit of the DARPA Subterranean Challenge

JOHN TRAUGER

American Astronomical Society Fellow

ASHITEY TREBI-OLLENNU

Royal Aeronautical Society Silver Medal for contributions to InSight

SVEN VAN BERKEL

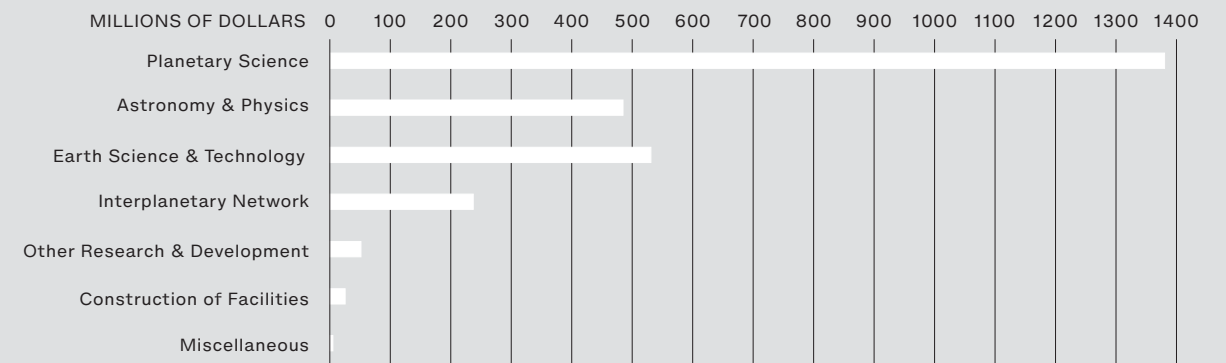
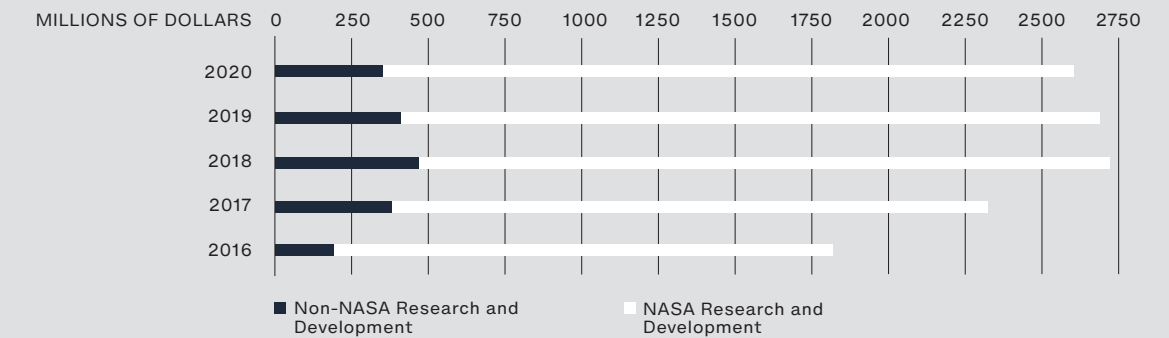
Vederprijs 2020

MICHAEL WATKINS

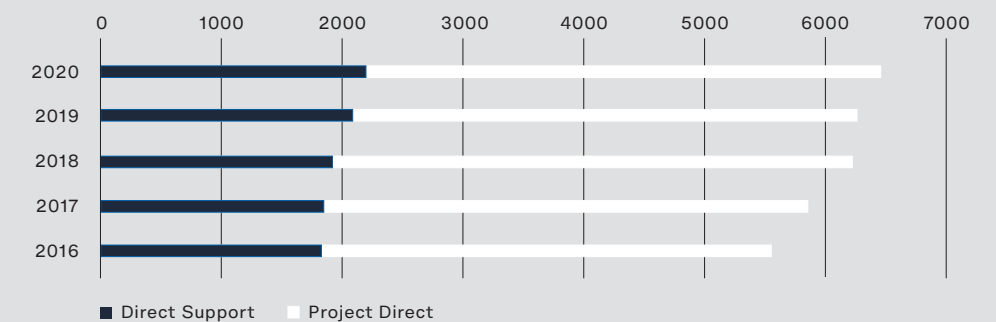
American Institute of Aeronautics and Astronautics Fellow

Budget and workforce

2020 BUDGET



JPL PERSONNEL - FULL-TIME EQUIVALENTS



Leadership

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Entrepreneur

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Raytheon Missile Systems

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Entrepreneurs Roundtable Accelerator

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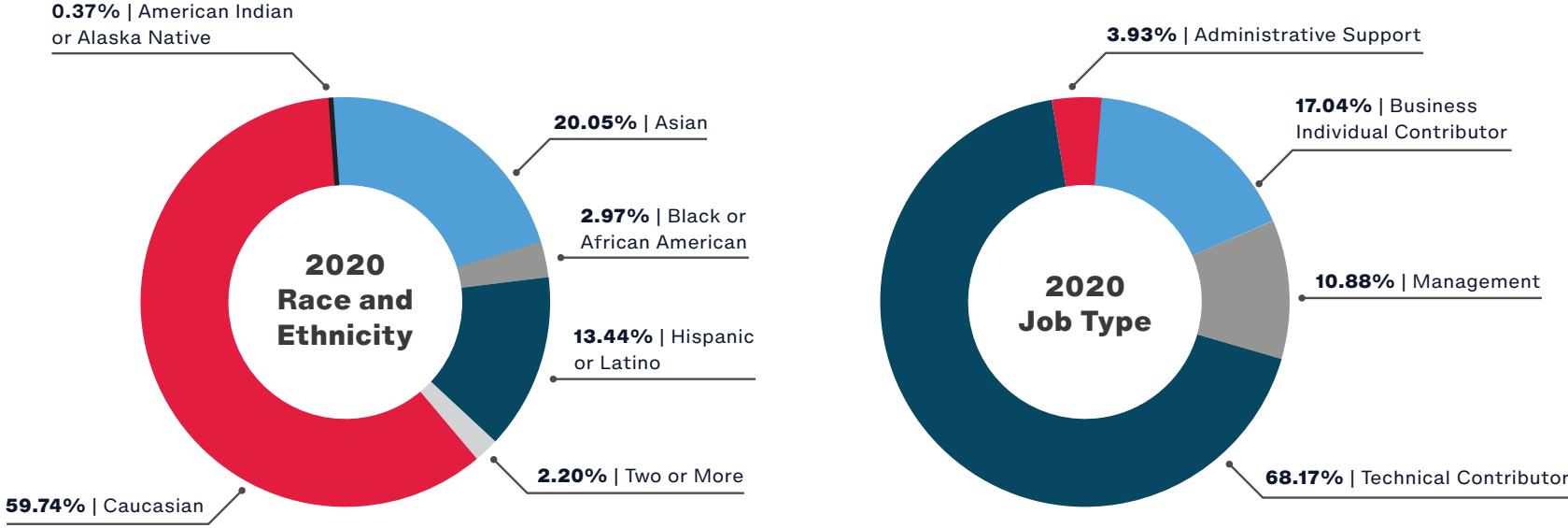
DAVID SPERGEL | Princeton | Theoretical Astrophysics

ED STOLPER | California Institute of Technology | Geology & Planetary Science

ED WEILER | NASA Associate Administrator (retired) | NASA Administration

TOM YOUNG | Lockheed Martin (retired) | Aerospace Management

Workforce demographics



	FY20 Total Lab*	FY20 Technical Disciplines**
% of Females in the Population	30.58%	21.81%
% of Females Hired	39.63%	31.11%
% of Minorities in the Population	40.24%	36.30%
% of Minorities Hired	42.72%	36.89%

*Population: The population in this data consists of JPL Employees in the Core Workforce (which excludes Students, Part Time, and Temporary workers) on Active or Paid Leave Status.

**Technical: This population consists of JPL Employees in the Core Workforce whose assignment is in the following Job Families: Engineering, Institutional Leadership, LPPL, Research, and Software and Computing Systems.



The Deep Space Network's giant "Mars Antenna" at Goldstone, Calif. got its name from its first task: tracking the Mariner 4 spacecraft.



Executive council

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Deputy Director

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Flight Projects and Mission Success

DAVID GALLAGHER

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Strategic Integration

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