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JPL

May 2021

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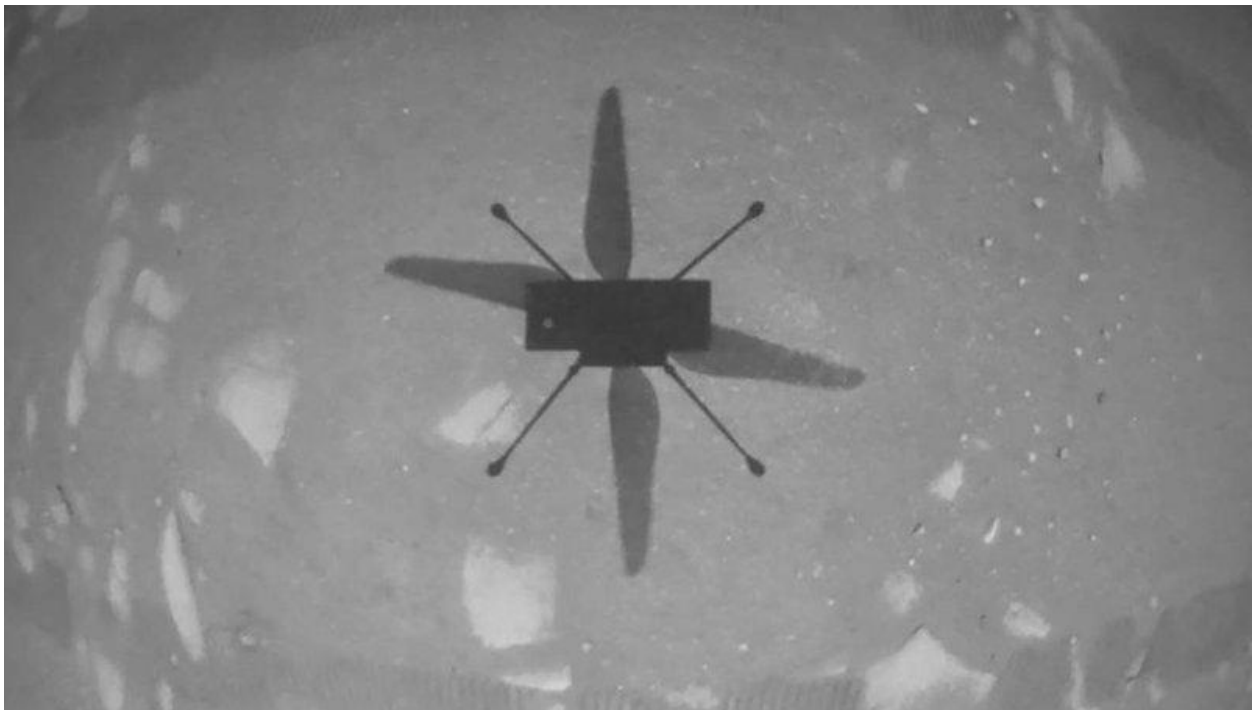
Featured Stories



NASA's Ingenuity Mars Helicopter took this shot while hovering over the Martian surface on April 19, 2021, during the first flight on another planet. It used its navigation camera, which autonomously tracks the ground during flight. Image Credit: NASA/JPL-Caltech

Ingenuity Successfully Completes First Flight

By Taylor Hill

At 3:30 a.m. on April 19, the Mars Helicopter team—some stationed in a control room deep within Building 230 and others watching from home—awaited a data downlink that would unveil whether Ingenuity successfully completed the first powered, controlled flight on another planet.

By 3:46 a.m., the team had their answer. Data relayed from the helicopter, to the Perseverance rover, to the Mars Reconnaissance Orbiter, to the Deep Space Network, to JPL, confirmed thatIngenuity had performed spin-up, takeoff, climb, hover, descent, landing, touchdown, and spin-down.

"Altimeter data confirms that Ingenuity has performed its first flight, the first flight of a powered aircraft on another planet," announced Havard Grip, Ingenuity's Guidance Navigation and Control Lead.

Watch the first video of Ingenuity in flight, including takeoff and landing:
https://www.youtube.com/watch?v=wMnOo2zcjXA

Ingenuity, a technology demonstration stowaway that hitched a ride to the Red Planet aboard the Perseverance rover, had spun up its oversized rotor blades to about 2,500 rotations per minute, successfully gaining enough lift in the planet's tenuous atmosphere to complete the pre-programmed flight. The solar-powered helicopter became airborne at 12:34 a.m. (12:33 Local Mean Solar Time/Mars time) – a time the Ingenuity team determined would have optimal energy and flight conditions. Altimeter data indicate Ingenuity climbed to its prescribed maximum altitude of 10 feet and maintained a stable hover for 30 seconds. It then descended, touching back down on the surface of Mars after logging a total of 39.1 seconds of flight. Additional details on the test are expected in upcoming downlinks.

Never before has something like an airplane or a helicopter taken off on another world. Now, just as Kitty Hawk, North Carolina, is known as the location where humans first took flight, Mars' Jezero Crater will be recognized as the place where controlled, powered flight went interplanetary.

The first image beamed back from the helicopter's onboard navigation camera shows the image from Ingenuity looking straight down at its shadow.

Parked not too far away at Van Zyl Overlook was Perseverance, acting as both a communications relay for the helicopter, and as paparazzi, snapping a series of images showing the rotorcraft spinning up, hovering, and descending back to the surface.

The team erupted into cheers seeing the photos, and prompted Ingenuity Project Manager Mimi Aung to rip up her contingency speech—prepared in case of a non-nominal flight.

"Lucky for you, I have a much shorter speech for success," Aung said. "We've been talking for so long about our Wright Brothers moment on Mars, and here it is. We don't know from history what Orville and Wilbur did after their first successful flight, but I imagine the two brothers hugged each other. Well, you know I'm hugging you all virtually."

The pictures from Perseverance's Mastcam-Z and Navcam imagers gave a view of the helicopter's flight from Van Zyl Overlook. Image Credit: NASA/JPL-Caltech

After years of milestones and guarded optimism, Aung implored the team to fully celebrate the moment. “And then after that, let’s get back to work and more flights,” she said.

“The Mars Helicopter project has gone from ‘blue sky’ feasibility study to workable engineering concept to achieving the first flight on another world in a little over six years,” said JPL Director Michael Watkins. “That this project has achieved such a historic first is testimony to the innovation and doggedness of our team here at JPL, as well as at NASA’s Langley and Ames Research Centers, and our industry partners. It’s a shining example of the kind of technology push that thrives at JPL and fits well with NASA’s exploration goals.”

The flight came a bit later than the originally planned April 11 date, after a high-speed spin test of the rotors on April 9 revealed a “watchdog” timer issue that prevented the helicopter from transitioning to flight mode. The team immediately went into solutions mode, coming up with a command sequence workaround to engage the flight sequence.

Tim Canham, Mars Helicopter Operations lead and architect behind a component of Ingenuity’s flight software, said the large amounts of data coming in from the craft gave the team the information needed to work through the issue.

“The F Prime (JPL-developed software) implementation on the Helicopter Base Station and the helicopter gives us enormous insight into data coming from the vehicle,” Canham said. “We have logs that store telemetry at 500Hz as well as transmitting hundreds of channels real-time during the flight. When we encountered the hardware bug that was preventing us from going to flight, we were able to use existing software backdoors originally used for hardware testing to directly prod the hardware into a state that would allow us to fly.”

Ingenuity was deployed to the surface of Jezero Crater on April 3, meaning the helicopter is just under half way through its allotted testing time of 30 Martian days before Perseverance heads off to commence its search for ancient Martian life. Over the next few days , the helicopter team will receive and analyze all data and imagery from the test and formulate a plan for the second experimental test flight, scheduled for no earlier than April 22. A total of five flights—of increasingly longer durations and complex patterns—are planned.

Watch a replay of the "First Flight of the Ingenuity Mars Helicopter: Live from Mission Control" here: https://www.youtube.com/watch?v=p1KolyCqICI&t=107s

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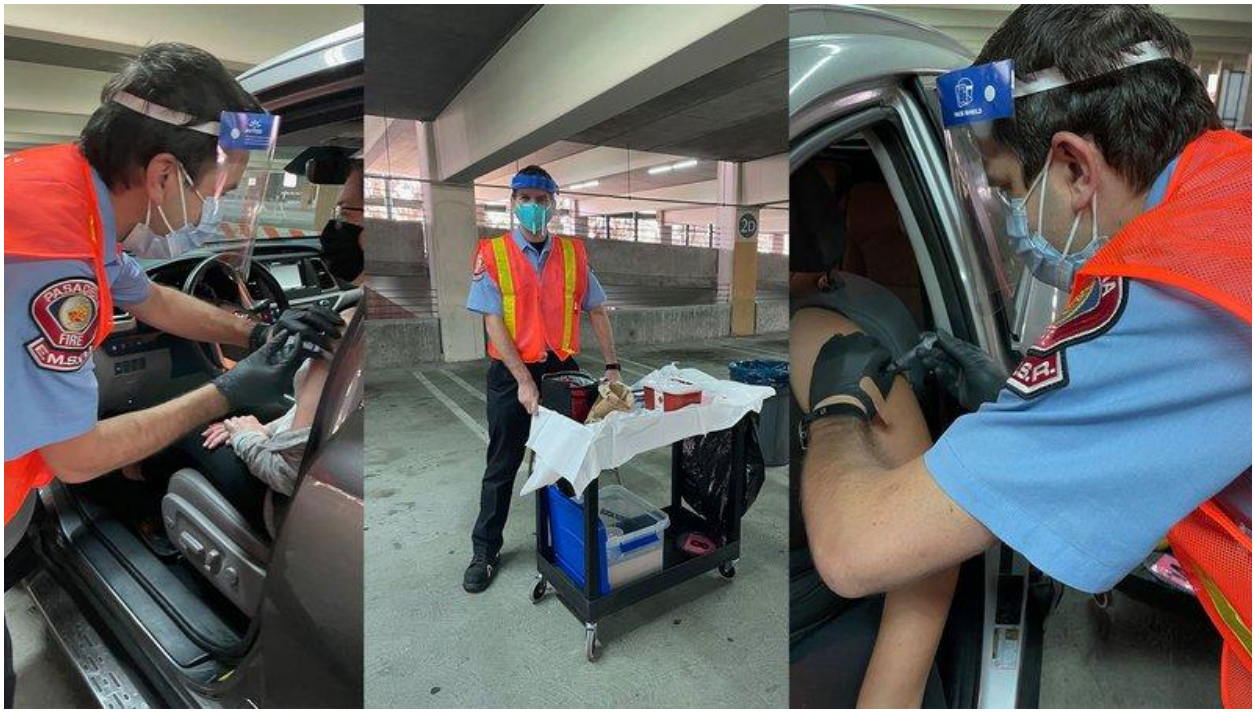


JPLer Andrew Klesh volunteering to administer vaccine shots at a community clinic. Image Credit: Pasadena Public Health Department/Pasadena Fire Department

Volunteering to Vaccinate

By Celeste Hoang

Andrew Klesh is helping where he can.

As the country ramps up one of the largest mass vaccination campaigns in American history, Klesh—a project systems engineer at JPL and an Emergency Medical Technician (EMT) member of the Pasadena Fire Department's volunteer Emergency Medical Services (EMS) reserves—is one of a handful of JPLers offering up their skills at the front lines of inoculation efforts.

"I would like to give back to the community," Klesh says. "There are only a limited number of medical professionals out there, and doctors and nurses are so overwhelmed. If we can help, they can go home and see their families."

Klesh first learned about Pasadena's EMS reserves through his JPL colleagues and has been a volunteer since 2018, providing on-ambulance support for regular Pasadena Fire Department calls, and first responder medical services at Rose Bowl events. During the pandemic, the city evaluated how the EMS reserves could assist and by January, the answer was clear: help vaccinate the public.

This spring, Klesh and reserve EMTs completed a required training course on how to administer vaccines and work on site under supervision of registered nurses. On March 26, they were called up to start inoculating their first patients, and the group has contributed more than 200 hours to date.

"Some people have been nervous and many people have been excited," Klesh says of his experiences so far at community clinics in Pasadena where he is assigned. "It's a very human moment. It's something we've been waiting for so long, and it means so much to so many people."

For Klesh, the practical and technical knowledge of administering a shot is important, but his composure is also key during each appointment.

“You want to exude confidence because they are trusting you with something quite personal,” he says. “You want to make sure they’re comfortable and know that they’re one step closer to us being done with all of this.”

To accommodate his volunteer vaccination duties, Klesh has worked out a schedule with his JPL managers that allows him to volunteer a couple of days a week, while making up his work on nights and weekends.

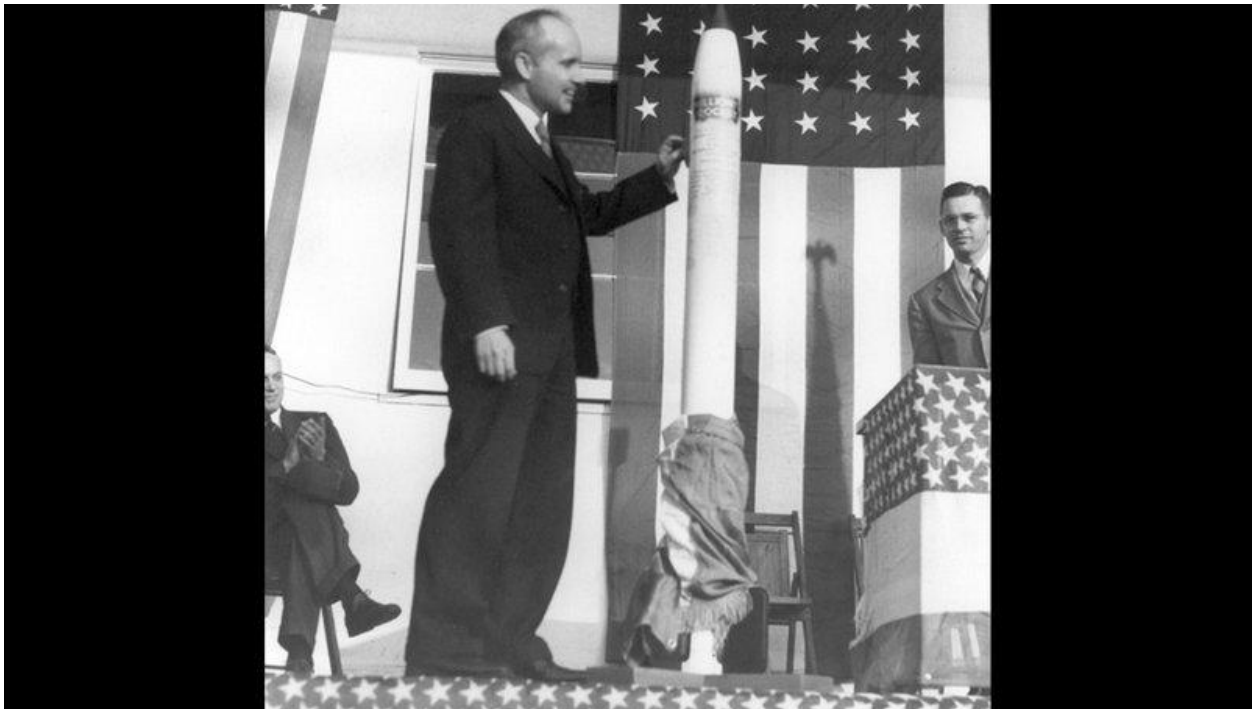
While his assistance may be more in demand than ever during a pandemic, Klesh has always been drawn to community service, specifically in the medical field. He previously volunteered with the Red Cross and is currently a captain on JPL’s Urban Search and Rescue (USAR) team, which is part of the Lab’s Disaster Assistance Response Team (DART). He spent much of 2020 remotely working for JPL from Catalina Island while on-call at the Wrigley Hyperbaric chamber, a 24/7 volunteer-staffed emergency facility.

Klesh’s medical background also comes in handy for his work at JPL, where his role in researching and testing robotic systems has taken him on nearly 30 expeditions around the world, from Alaska and Hawaii, to Antarctica and Greenland.

“The better I can be trained on the medical side, the better our team [of JPL engineers] can perform,” he says. “And when I'm not traveling, I can bridge my experience with the fire department to be prepared for JPL expeditions.”

In May, he’ll head off on his next expedition, this time to test autonomous submersibles along the East Coast, from Cape Canaveral, Florida to Norfolk, Virginia.

Until then, Klesh will continue inoculating the public. And JPLers can rest assured—members of the Lab’s USAR and DART teams will be volunteering at the JPL/Caltech vaccination clinics, serving on the observation side to ensure no JPLer has an adverse reaction to their shot.



Physicist Earnest Watson posing with Caltech's 1 millionth rocket. Image Credit: Caltech Archives

The First JPLers, Part 7: Caltech's Other Rocket Project

By Erik Conway

In previous history columns, I've been gradually telling the story of the GALCIT Rocket Research Project, which turned into JPL in 1943. But during World War II, Caltech had a second rocket project, organized not by GALCIT but by its Physics Department. Its initial facility was in Eaton Canyon, not the Arroyo Seco, and as it grew, it adopted Goldstone and then China Lake, near Inyokern, as additional test facilities. Unlike JPL, those on the Physics Department project built weapons—more than a million by war's end. They proved the utility of rocket-based weapons to skeptics in the U.S. military, enabling JPL's postwar growth.

Charles Lauritsen was the faculty member most responsible for the Physics Department's effort. Lauritsen came to the U.S. from Denmark, completed a Ph.D. in physics at Caltech in 1929 and joined the faculty in 1930. Lauritsen specialized in X-rays, then a very important research front in physics.

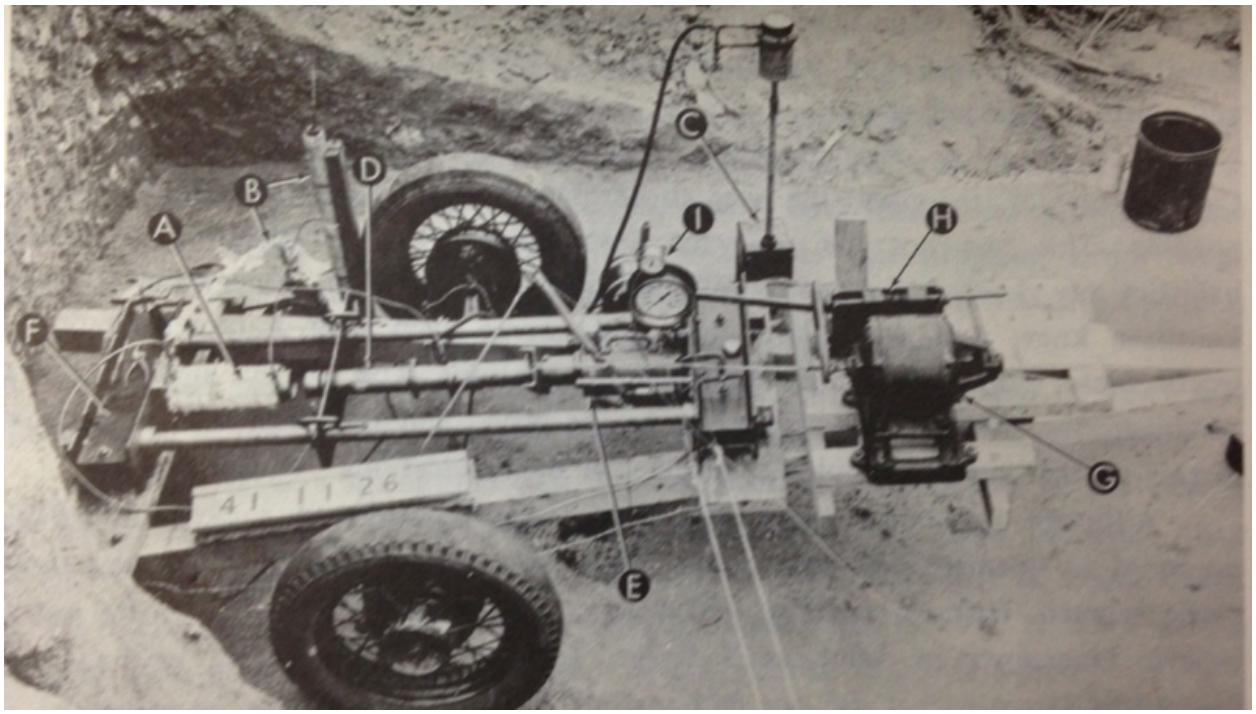
In the fall of 1940, a delegation of British researchers visited the U.S. to recruit help in exploiting and manufacturing some secret military technologies that British researchers had conceived. The most famous of these was the cavity magnetron for radar, but for this story, the key invention was rockets. Two types were important motivators for the physics rocket project: anti-aircraft missiles and anti-submarine rockets. Both used what's known as a "double base powder," a compound of nitroglycerin and nitrocellulose, that the British called "cordite." Only one U.S. company manufactured something similar, the Hercules Powder Company, which produced a somewhat higher energy propellant called "ballistite."

U.S. research during World War II was coordinated by an organization known as the National Defense Research Committee (NDRC), and it had recruited another Caltech physicist, Richard Tolman, to be the committee's vice-chairman. Tolman also served as chair of NDRC's armor and ordnance research committee. Tolman had promptly recruited Lauritsen to Washington. Lauritsen went to Washington in August 1940, in time for the Tizard commission visit. He also discovered that the month before his arrival, the NDRC had established a rocket research section. That work was getting started at the Naval Powder Factory at Indian Head, Maryland.

Lauritsen quickly decided that Hercules' process for making ballistite wasn't very effective. The British used a dry extrusion method, and Hercules did not. Instead, it used a solvent-based process that required considerable drying time, and as the Indian Head work progressed, it became clear to Lauritsen that making propellant grains large enough for rockets by this process was going to be extremely difficult. The extrusions warped as they dried, developed internal bubbles, and thus tended to explode.

Lauritsen went to England in the spring of 1941, learned how the British dry extrusion process for cordite worked, and in April he wrote to Tolman to advocate setting up another rocket project at Caltech to refine a dry extrusion process for ballistite and exploit the result. Tolman did not initially agree. Lauritsen did not let the issue rest, and by the end of August, Lauritsen had gotten a second rocket program at Caltech funded.

The new rocket project was formally established Sept. 1, 1941, the month following the GALCIT crew's Ercoupe flight at March Field. Lauritsen chose not to be the administrative lead; instead, physicist Earnest Watson took on that task, and Lauritsen took the title Director of Research. Watson and Lauritsen set a team led by Lauritsen's son Thomas, also a physicist, to designing a portable dry extrusion press. Nov. 15 was their first trial out in Eaton Canyon, using ballistite sheets provided by Hercules. This press, dubbed the Little Giant, was operating reliably by the end of the year, and Tommy Lauritsen's group began to design faster and larger presses.

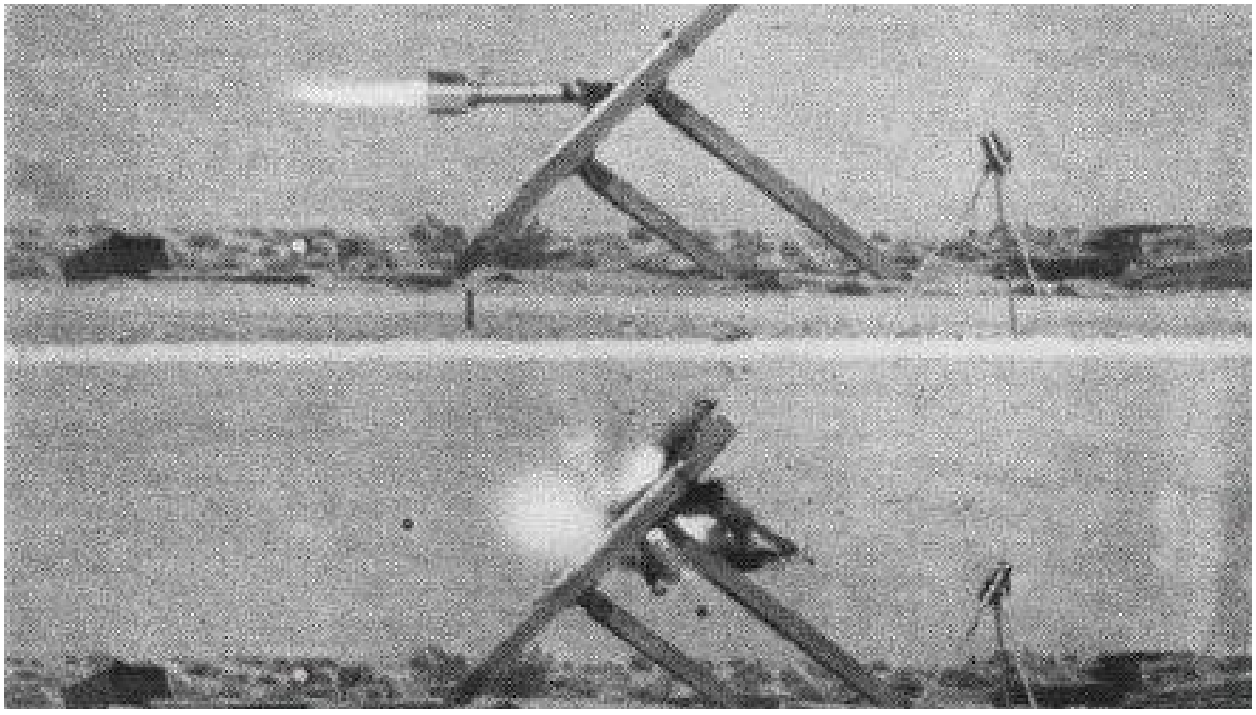


The portable dry extrusion press dubbed "Little Giant." Image Credit: Caltech Archives

The work of this second rocket project evolved rapidly, and it grew explosively. After having solved the ballistite production problem in the first few months of its existence, it turned to exploitation. Initially, the team focused on developing what they called a "target rocket," a slow-moving (about 300-350 mph) rocket designed to be shot at for anti-aircraft training. The target rocket demonstrations were up at the Army's Mojave Antiaircraft Artillery Range, later named Fort Irwin and now host to NASA's Goldstone Deep Space Network station. They also embarked on an effort to copy the British "Hedgehog" antisubmarine rocket, which worked by using rockets to fire depth bombs away from shipboard launchers. Their Hedgehog copies were first tested in Eaton Canyon during the winter of 1942, and March 30, 1942, was their first sea-going test.

Their anti-submarine rocket became known as "Mousetrap," and was immediately put into service by the U.S. Navy. It also attracted attention from the Navy's amphibious forces. The Mousetrap was launched

from vertical tubes and had a range of about 1,200 yards. The Navy's amphibious commander saw in it the potential for a bombardment rocket that could be mounted on assault craft, and that became the group's next rocket weapon. First used in the WWII Allies' North Africa landings in November 1942, this variant was called "Old Faithful." Then they embarked on air-to-surface rockets, the largest of which was called Tiny Tim, designed to destroy fortifications.



Testing of "Tiny Tim" air-to-surface rockets at Inyokern against a 3-inch armor plate. Image Credit: Caltech Archives

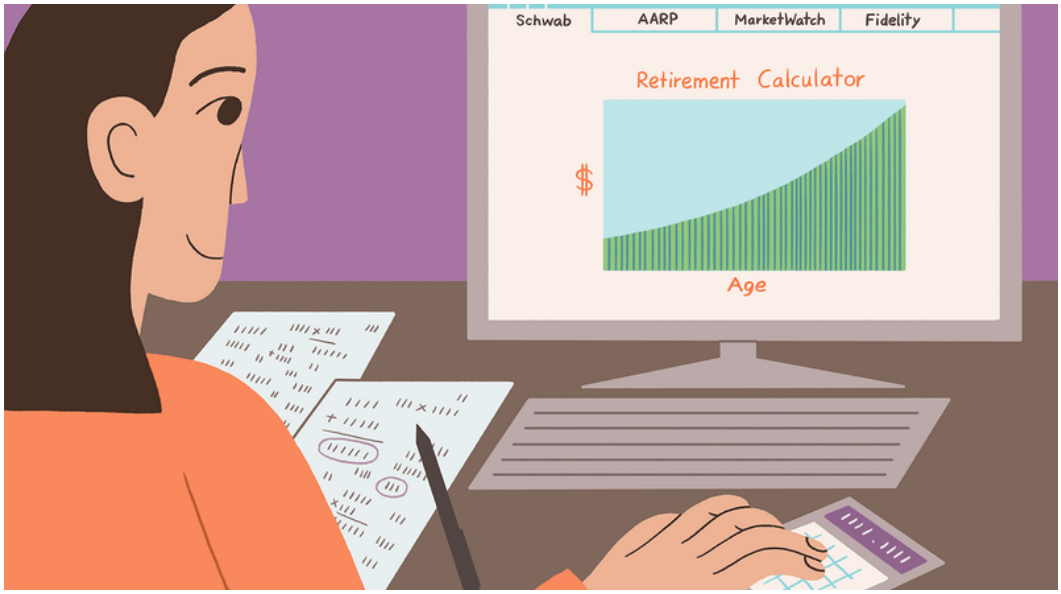
Throughout the war, Kellogg Radiation Lab on campus was the operation's headquarters. But the physics team rapidly outgrew their Eaton Canyon facility, even when they'd expanded their lease to 180 acres, slightly larger than JPL is today. They established other production facilities around Pasadena, ultimately occupying 20 area buildings. As the scale of their testing grew, they started looking for more sizeable and more remote facilities. They began to set up in the Goldstone area, where they had done the target rocket work, but it was not large enough for testing of the airborne rockets that they were developing. During the summer of 1943, they found a new site in an unused, but paved, airfield near Inyokern. It was named for a nearby dry lake bed, China Lake.

The Physics Department's program made Caltech a major weapons manufacturer during World War II. It employed more than 3,000 people in the Pasadena area at its peak, 10 times JPL's employment in 1945. The Navy transferred its designs to other manufacturers, and by the end of the war the Navy was spending $100 million per month on rockets.

A month before the Pacific War ended, General Tire and Rubber took over the manufacturing facilities. The Eaton Canyon facility closed down in October. About 200 of Caltech's wartime hires took civil service positions to run the China Lake facility for the Navy, though the Lauritsens and Watson remained at Caltech. Now known as Naval Air Weapons Station China Lake, it developed the first U.S. heat-seeking air-to-air missile, and it remains the Navy's principal airborne weapons research organization.

Next month, we'll look at JPL's own conversion from JATO research to guided missiles.

Events



TIAA Webinar—Lifetime Income: Paycheck For Life

Tuesday, May 11
Noon to 1 p.m.

Learn how creating a diversified income plan—one that uses a combination of income sources and includes fixed annuity income that's guaranteed for life—can help reduce the longevity risks you may face in retirement and ensure you have income that never runs out.

Register here or visit www.TIAA.org/webinars and log in with your TIAA user ID and passcode to register.

Questions: Contact joseph.p.silvagnoli@jpl.nasa.gov.

United Way of Greater LA: Volunteers Needed for Virtual Resume Workshop

Thursday, May 13
4:30 to 6 p.m.

Help local young adults with resumes. United Way of Greater LA is excited to partner with InnerCity Struggle whose impact work includes training youth to educate, empower and mobilize Eastside LA voters. While the youth are dedicating hours in service of their vision for a better tomorrow, it's our responsibility to ensure they're on track for their future, today. Volunteers will be paired with the young leaders of InnerCity Struggle to help craft an effective resume. Lend your professional expertise!

Learn more and register through the following link: https://www.eventbrite.com/e/volunteer-resume-workshop-for-local-young-adults-tickets-142567347775.

Von Karman Lecture Series: Space Cameras - A Sharper Image

Thursday, May 20
7 to 8 p.m.

Watch on YouTube or Ustream

Are you ready for your close-up? Our newest space exploring cameras are bringing the universe into even sharper focus. We'll discuss how we get these extraordinary images of the solar system and beyond back to the phone in your pocket.

Speakers:
Dr. Justin Maki, Imaging Scientist/Mastcam-Z Deputy PI, NASA/JPL
Hallie Abarca, Mars 2020 Image and Data Processing Operations Lead, NASA/JPL

Host: Marc Razze, Public Services Office, NASA/JPL
Co-Host: Brian White, Public Services Office, NASA/JPL

Awards

International Cooperation Award for Watkins and Gross for GRACE

The AIAA 2021 International Cooperation Award goes to JPL Director Michael Watkins and Autonomous Systems Manager Michael Gross, and their counterparts in Germany–Frank Flechtner of GFZ/German Research Centre for Geosciences and Albert Zaglauer of Astrium GmbH.

The award from the AIAA (American Institute of Aeronautics and Astronautics) cites "outstanding leadership of the international consortium in the planning and implementation of the successful Earth gravity missions." Specifically, that means the GRACE and GRACE Follow-on (GRACE-FO) missions, each with two identical spacecraft flying about 137 miles (220 kilometers) apart. By precisely measuring the varying distance between the two spacecraft, scientists could map Earth's gravity field and detect effects of ocean currents, glaciers, ice sheets, and other phenomena.

The international collaboration was a necessity at first, according to Watkins, an originator of GRACE. He left the University of Texas to come to JPL and help make the mission a reality, then served as the project scientist leading science development for GRACE and GRACE-FO before becoming JPL director in 2016.

"Money was tight, so we needed a partner," Watkins said. This GRACE alliance turned out to provide so much more than a financial benefit.

"We've known each other now for 25 years, and the team is so much greater than the sum of its parts." Watkins points out that "we've had an incredible amount of research from a viewpoint of science around the world...about 5,000 science papers covering Greenland ice sheet melting, water storage around the world" and other topics of global impact.

"The camaraderie is so palpable," says Gross, who served as GRACE-FO deputy project manager. "We created a family of people who shared a similar passion for the missions that directly affect our home

planet." He notes that the GRACE teams represent "a borderless organization“ where everyone worked together, set their egos aside, and learned from each other. Gross says teamwork was especially crucial for the GRACE missions, where extreme precision was needed.

And Watkins points out another major benefit to international teamwork: It attracted some key talent to JPL who worked on the missions–Carmen Boening, now deputy manager of Section 329, and Felix Landerer, GRACE-FO project scientist.

The award will be presented virtually at a ceremony on Aug. 12, with a potential in-person celebration when pandemic conditions have subsided sufficiently.

Gross calls the award "humbling” and says, "It means a lot to me that people I've worked with at JPL and abroad are winning this award, together."

The AIAA explains that its International Cooperation Award is presented to "recognize an individual/s who have made significant contributions to the initiation, organization, implementation and /or management of activities with significant United States involvement that includes extensive international cooperative activities in space, aeronautics, or both."

More information is available at:
https://www.aiaa.org/get-involved/honors-awards/awards/award/award-international-cooperation-award

Watkins says JPL has recently increased its support for the organization and has been a corporate member for two years. He believes the AIAA and similar organizations represent an important way to stay connected to colleagues in the field.

AAS Carl Sagan Memorial Award Goes to Leslie Livesay

The Lab's Associate Director for Flight Projects and Mission Success, Leslie Livesay, has received a prestigious award from the American Astronautical Society—the Carl Sagan Memorial Award.

The award is presented each year to "an individual who has demonstrated leadership in research or policies advancing exploration of the Cosmos." Livesay is specifically being recognized “For exceptional

leadership of space missions that produced technological and scientific breakthroughs of major and lasting importance."

Livesay began her role as JPL's associate director this month. Previously she served as the Lab's Director for Astronomy and Physics, and before that, as Director for Engineering and Science, and Kepler Project Manager.

"It is such an honor to be selected for this award, and I have had the great fortune during my career at JPL to work with the most amazing people," Livesay said.

Conditions allowing, Livesay plans to attend the Von Braun Symposium in October in Huntsville, Alabama, to accept the award, and Lab Director Michael Watkins, who nominated her, also plans to attend.

More information about the Sagan Award is at https://astronautical.org/awards/sagan/

This is the second straight year a JPLer has earned the Carl Sagan Memorial Award. Last year's honor went to longtime Spitzer Project Scientist Michael Werner. Other previous JPL recipients include three former directors: Charles Elachi, Ed Stone, and Bruce Murray.

Yoseph Bar-Cohen receives SPIE Founding Chair

The SPIE (the International Society for Optics and Photonics) has honored Dr. Yoseph Bar-Cohen with its Founding Chair Award for "visionary contributions to the Smart Structures community" involving Electroactive Polymer Actuators and Devices.

Electroactive Polymers are also called "artificial muscles," because they bend, stretch and contract like biological muscles when an electrical charge is applied to them.

SPIE recognizes two conference chairs who established foundational topics in the field and helped to champion key technologies. Bar-Cohen received the honor on March 23, during the virtual Smart Structures and NDE Symposium Digital Forum.

In 1999, Bar-Cohen initiated the annual Electroactive Polymers (EAP) conference and its EAP-in-Action Session, which became the most widely known and attended international forums of their type. He chaired the conference till 2019 and continues to organize and chair its EAP-in-Action Session.

Bar-Cohen joined JPL in 1991 and is supervisor of the Electroactive Technologies Group. He is also a senior research scientist and heads the Nondestructive Evaluation and Advance Actuators Lab. His specialty as a physicist involves electroactive materials/mechanisms (including sample handling technologies), biomimetics, and ultrasonic Non-Destructive Evaluation. He is listed as Subject Matter Expert in NDE and Piezoelectric Actuators and Sensors on JPL's Procurement Quality Assurance List.

Under Bar-Cohen's leadership, many innovative concepts and mechanisms were initiated, developed, and tested for planetary exploration, commercial, medical, and other applications. He made two notable discoveries of ultrasonic wave phenomena in composite materials: polar backscattering and the leaky Lamb waves. He is a former chair of JPL's Senior Research Scientists Council, and a Fellow of SPIE and the American Society for Nondestructive Testing.

He received his Ph.D. in Physics (1979) and M.Sc. in Materials Science (1973) from the Hebrew University, Jerusalem, Israel.

Postdoc Ceth Parker Earns Honorable Mention for 'Microbiome Art'

An art competition held during the annual American Society for Gravitational and Space Research conference gives scientists an opportunity to showcase their creative side and research. A submission by postdoctoral fellow Ceth Parker received honorable mention for his piece entitled "To Boldly Go Where No Microbiome Has Gone Before!"

The award was presented virtually in November after the Society's annual conference.

Parker's portrait of American astronaut Anna Fisher is 'painted' on potato dextrose agar with a strain of the biofilm-forming yeast Rhodotorula mucilaginosa, the most common yeast found aboard the International Space Station (ISS). Its vibrant pigmentation is caused by high levels of carotenoids that may help both biofilm formation and resistance to the radiation levels found in orbit.

ASGSR art submission "To Boldly Go Where No Microbiome Has Gone Before!"

He is doing his research in JPL's Biotechnology and Planetary Protection Group working with Dr. Kasthuri Venkateswaran. He tests microbial resistance to gamma radiation in hopes of better mitigating microbial dangers to future spacecraft. His work also included testing and optimizing antibiofilm surface coatings to help protect astronauts and water systems aboard the ISS and future crewed spacecraft. This research has led him to numerous discoveries about biofilm formation in microgravity environments, and to the development of novel biofilm growth devices designed to analyze biofilm formation in microgravity environments, both simulated on Earth and on the ISS.

Retirees

The following JPL employees recently announced their retirements:

40+ Years:

John J. Simmonds, Section 4210, 46 years
Robert L. Staehle, Section 3800, 44 years
Katherine A. Dumas, Section 1020, 42 years
Hanh T. Milam, Section 3216, 41 years
Fuk Li, Section 4000, 41 years
Don T. Potter, Section 172K, 40 years

30+ Years:

Timothy A. Mccann, Section 3821, 30 years

20+ Years:

Narendra J. Patel, Section 173D, 20 years

Passings

Some of the material in obituaries is provided by family members.

Christopher Carl, 82, of Irvine, CA died on Feb. 26, 2021 at Saddleback Memorial Hospital from complications of a stroke.

Chris was born on Aug. 7, 1938 in New Rochelle, New York. He was the son of George H. Carl Sr. and Jane Curll Carl. The family lived in Larchmont, New York, where he attended Mamaroneck High School. There he won the Bausch and Lomb Honorary Science Award. He then went on to attend the Massachusetts Institute of Technology graduating in 1960 with a BSEE degree. He later went on to earn his MSEE from the University of Southern California in 1966.

In 1961, Chris moved to Southern California to work at his first job at Autonetics, Division of North America Aviation. He remained there until 1963. After Autonetics, he worked at the Jet Propulsion Laboratory for 35 years. Chris developed communications gear that flew in Mars orbit (Viking), to the Sun (Helios), and on Voyager. The rest of Chris' career was in management. He went from group supervisor, to section manager, to deputy division manager and finally, to manager of the Information Systems Development and Operations Division. He retired in 1998 from JPL, receiving NASA's Outstanding Leadership Medal.

On June 22, 1974, Chris married Gertrude, who he met while on detail to NASA Headquarters in Washington. They have one daughter, Jennifer.

In retirement, Chris had many interests including American History (focusing on the colonial, Civil War and WWII periods), building precision models of WWII planes and ships, travel (five round trips across the United Stated by car) and playing tennis. He had a great interest in classical music and its history. Chris also interviewed local high school seniors for MIT as part of the application process. He loved good food and wine and trying out new restaurants with friends.

With all of Chris' achievements, his greatest love was his family. He is survived by his wife of 46 years, Gertrude; daughter Jennifer and her husband Dr. Michael Louie; and his three grandchildren Lauren, Nathan, and Isabel. They were his pride and joy.

In lieu of flowers, donations can be made to the Wounded Warriors Project.

Duane J. Batenhorst died on April 8, 2021 at the age of 86. He worked at JPL for 31 years and was a division manager for contracts and purchasing. Batenhorst is survived by his wife of 59 years, Mary; daughters Beth (Mike) and Tammy (Scott); grandchildren Megan, Michelle, and Cameron; and great granddaughter, Harper.