National Aeronautics and
Space Administration

INNOVATION
DISCOVERY
EXPLORATION

2019 ANNUAL REPORT

NASA'S LANGLEY
RESEARCH CENTER

LANGLEY LEADERSHIP

Langley Research Center's leadership team, pictured left to right: Cathy Mangum, Associate Director; Clayton Turner, Director; Dave Young, Deputy Director; Jill Marlowe, Associate Director for Technical. Credit: NASA/David C. Bowman

Fifty years after Neil Armstrong made those famous first steps, NASA is once again setting a course for the Moon — this time to create a sustainable presence there before going on to Mars.

Just like half a century ago, the women and men of NASA's Langley Research Center stand ready to make these expeditions possible with new technologies, innovative concepts and recognized expertise.

With the Artemis mission, NASA is preparing to land the first woman and next man on the Moon. Langley will be a key contributor to reaching that goal by leveraging world-renowned capabilities created by our people, facilities and tools. We'll move the mission forward with our expertise in systems architectures, aerosciences, structures and materials, and EDL — entry, descent and landing.

Our experts are already contributing to getting there, landing there and building humankind's first sustained outpost on another world.

Langley is also utilizing some of those same capabilities to shape what will be revolutionary changes in air travel and atmospheric flight vehicles. We are leveraging our unique atmospheric characterization capability to give the world a deeper understanding of the Earth.

When I consider the significance of this work, I'm thankful to be part of an agency dedicated to reaching for new heights to reveal the unknown for the benefit of humankind.

I was honored and humbled to be selected as director of Langley, a place with a legacy of innovation and technical excellence. Also, I was fortunate to have worked with previous director Dave Bowles.

Following in his footsteps won't be easy, but with our amazing Langley team I see great days ahead.

In this report you'll learn how Langley made a difference for our nation in 2019. I believe you'll be inspired by the dedication, skill and passion these achievements illustrate.

Clayton P. Turner
Director, NASA's Langley Research Center

FOND FAREWELL

Dave Bowles, Langley's previous center director, retired in September 2019, ending a 39-year career at NASA. As director, he oversaw an era of growth. Two major new facilities took shape under his leadership, the Katherine G. Johnson Computational Research Facility, which opened in 2017, and the Measurement Systems Laboratory, which will open in 2020. He also launched a future-focused transformation initiative and led a spirited observance of the center's 100th year in 2017. "I was so fortunate to be center director during the centennial," Bowles said. "We looked back at all the great things we've done and looked forward to all the great things to come. The first 100 years were great, but the next 100 will be even better."

FORWARD TO THE MOON, ON TO MARS

A Space Launch System rocket model is prepped for testing by engineer Courtney Winski at Langley's Unitary Plan Wind Tunnel. Pink pressure-sensitive paint glows when reacting with oxygen in the presence of high-pressure airflows. The uncrewed Artemis 1 launch will be the first integrated flight test of the Space Launch System and the Orion spacecraft.

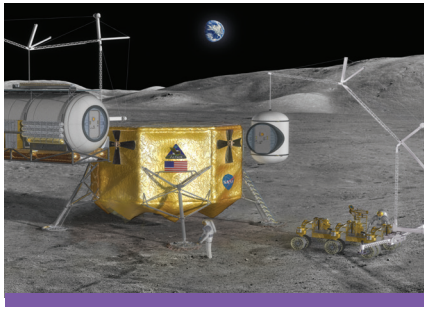
As NASA celebrated the 50th anniversary of the first Moon landing, Langley researchers honed space technologies and shaped concepts essential to the Artemis program's goal of landing the first woman and next man on the Moon – a step toward a sustained lunar presence.

Langley's **Navigation Doppler Lidar**, or NDL, technology will help spacecraft arrive safely at precise locations — including on the Moon. NDL was chosen as one of 12 Commercial Landing Payload Services and was included in two of three selected commercial lander proposals planning Moon missions for 2021. An NDL test unit is to fly on Blue Origin's New Shepard spacecraft in a suborbital launch.

NASA is speeding up exploration work and saving tax dollars by forging new kinds of partnerships. Through **Tipping Point Solicitations**, for example, the agency seeks to collaborate with industry to develop new space exploration technologies.

The powerful **Space Launch System** rocket being developed will kick off trailblazing NASA missions. Langley's aerosciences team made sure different configurations of the rocket will function well during all phases of flight. They tested configurations in the center's Unitary Plan Wind Tunnel, 14- by 22-Foot Subsonic Tunnel and National Transonic Facility wind tunnel.

Langley also shapes technologies for robotic construction in space, allowing longer, more distant missions. The



The Lightweight Surface Manipulation System blends the structural efficiency, large reach and mass lifting capabilities of a crane with the dexterity, precision and versatility of a robotic manipulator. The system is designed to give NASA the ability to robotically build, handle payloads and repair facilities on the surface of the Moon or Mars.

Lightweight Surface Manipulation System will be used by companies selected to land payloads on the Moon. Through a set of On-orbit Servicing, Assembly and Manufacturing projects, researchers will learn how to use robotics and autonomy to build infrastructure on the Moon and in space.

From Apollo through to Artemis, Langley's expertise continues to fuel journeys of discovery — both human and robotic.

TEST BRINGS MOON MISSION A STEP CLOSER

At NASA's Kennedy Space Center in Florida, the Launch Abort System is assembled in preparation for the July 2, 2019, Orion Ascent Abort-2 flight test. The team that manages the Orion Launch Abort System program is based at Langley and the mock Orion capsule used in the test was built at the center.

A 180-second, rocket-powered ballet in the sky climaxed with a mock space capsule appearing from a puff of smoke, then plunging as planned into the Atlantic Ocean off the Florida coast.

NASA's successful Ascent Abort-2 test flight was a complex technical feat — as well as an important step toward protecting the astronauts who will soon embark on missions to the Moon and, one day, Mars.

Around 7 a.m. on July 2, a crewless rocket blasted off from Space Launch Complex 46 at Cape Canaveral Air Force Station, near NASA's Kennedy Space Center.

At an altitude of about six miles, while traveling faster than 1,000 mph, an abort sequence kicked in. Within milliseconds, the vehicle's abort motor fired to yank a mock version of NASA's Orion crew capsule away from the rocket. Then, a set of control motors ignited, flipping the capsule end-over-end to properly orient it. Once that took place, a jettison motor fired, allowing the capsule to make a choreographed dive into the waves below. It all happened according to plan and showed that the Launch Abort System is ready for prime time.

Langley's José Ortiz, lead systems engineer for the Orion Launch Abort System, was glad to see the Ascent Abort-2 test run smoothly. "We try to think through all possible interactions between components, but it is not until you have an integrated test like this that you see it all together working as it should."

The Orion Launch Abort System program is managed at Langley Research Center. A team here is devoted to making sure the abort system is ready if needed. Also, the mock Orion capsule used in the July test was built by technicians here.

José Ortiz, the Langley-based lead systems engineer for the Orion Launch Abort System, felt a mix of pride and satisfaction watching the system work as intended. "I'm confident the crew escape system will do its job if needed," Ortiz said. "I'm really proud to be part of such a talented team."

A Langley-based group called Scientifically Calibrated In-Flight Imagery (SCIFLI), also played a role in the AA-2 test. It captured photos and video of the moment when the mock Orion capsule blasted free from the rocket. Flying at a safe distance aboard a NASA WB-57 aircraft, SCIFLI recorded the system's flawless performance.

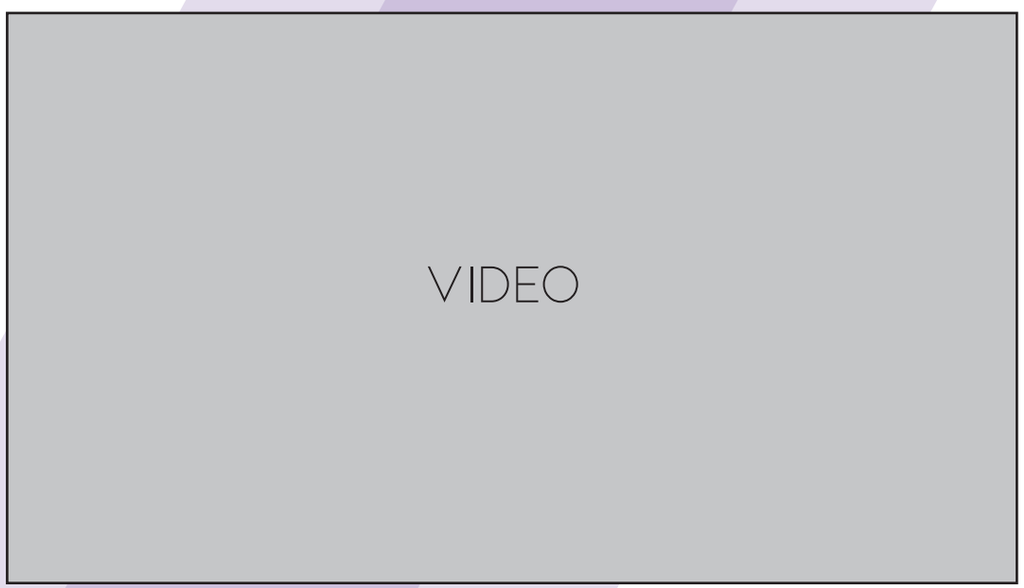
The Orion capsule is a vital part of NASA's plans for a new deep space exploration.

Three minutes in the skies over Cape Canaveral helped raise a curtain on an exciting new era.

A Launch Abort System with a test version of an Orion capsule attached launches atop a Northrop Grumman booster on July 2, 2019.

LIFE AT THE LAB: CLICK CHEMISTRY

Langley researchers see click chemistry as a way for explorers to build tools and other necessities out of reusable materials. Such techniques will be essential for long-duration missions to the Moon and Mars.



VISION FOR REVOLUTIONARY FLIGHT

A crash test at Langley yielded a wealth of data intended to help make flying safer in the years ahead. Researchers hoisted a 33,000-pound Fokker F-28 airplane more than 150 feet in the air at the center's Landing and Impact Research Facility. The aircraft, laden with sensors and crash test dummies, was then released and allowed to slam into the soil below. It was the largest airframe ever dropped at the facility.

Whether working to make coast-to-coast supersonic commercial airline flights possible or helping to make aircraft safer, quieter and more fuel-efficient, Langley's aeronautics experts guide ideas from the drawing board to reality.

Working with the Federal Aviation Administration, Langley researchers conducted a test that will help experts **assess aircraft crash safety**. With an eye toward reducing fatalities, researchers dropped a full-sized F-28 Fokker transport aircraft at Langley's Landing and Impact Research Facility to generate data for computer models that measure crashworthiness. The data will help set standards for innovative aircraft of tomorrow.

Technician Cecil Garber fastens the eXternal Vision System camera to the nose of a Beechcraft King Air UC-12B research aircraft for testing. The system is designed to give NASA's new X-59 supersonic aircraft a high-tech alternative to a forward-facing cockpit window.

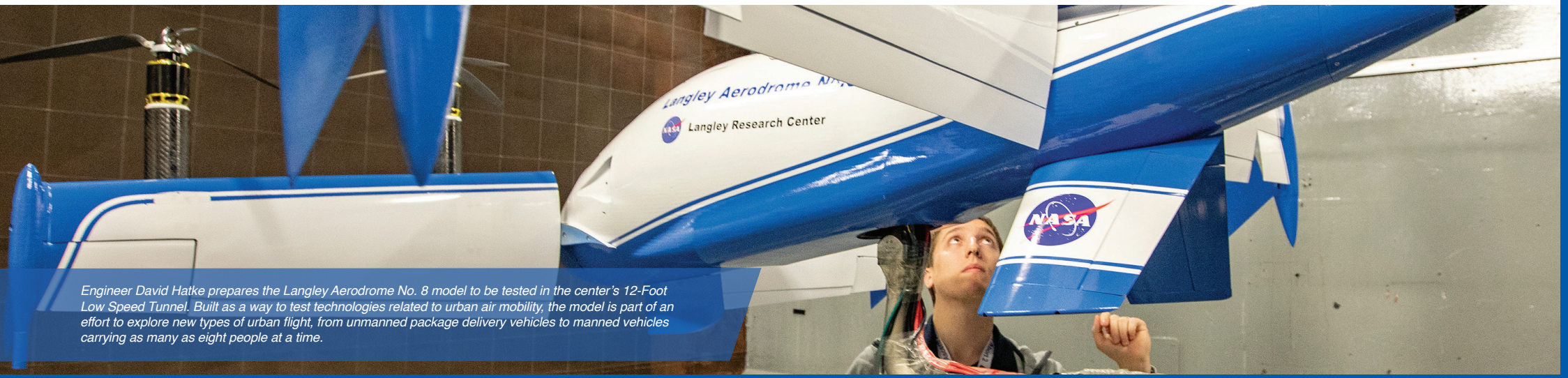
Imagine jetting across the United States in less than three hours. This year, NASA continued to open possibilities for future quiet supersonic flight through its **Low-Boom Flight Demonstration Mission**. For this mission, Langley shares management responsibility for developing the X-59 Quiet SuperSonic Technology aircraft and spearheads plans to evaluate response to the sound of the X-59 across several U.S. communities, a step toward lifting current bans on supersonic overland flight. As the X-59 takes shape in California, Langley researchers successfully tested the X-59's eXternal Vision System. It replaces a forward-facing cockpit window with a combination of sensors, cameras and computer displays, giving the pilot an augmented-reality view ahead. It will be ready for the X-59's first flight in 2021.

Through the five-year, $170 million **Advanced Composites Project** — which concluded in 2019 — NASA and 12 industry and government partners created a plan to speed up development and approval of new lightweight materials for aircraft. Industry partners covered half the total cost of their participation as an investment in future improvements and profits. The team improved analysis methods, inspection techniques and manufacturing processes to help America maintain its competitive advantage in aircraft manufacturing.

A research engineer inspects a composite structure being manufactured with robotic automated fiber placement or AFP.

Langley also tested new efficient aircraft concepts and studied all-electric technologies to make flying both cleaner and quieter. With Boeing, Langley researchers designed, built and tested a transonic **truss-braced wing** model that could lead to more fuel-efficient aircraft. They also contributed design methods and analysis for the **X-57 Maxwell**, NASA's first all-electric experimental airplane.

EXPLORING AIR MOBILITY - ONE FLIGHT AT A TIME



Engineer David Hatke prepares the Langley Aerodrome No. 8 model to be tested in the center's 12-Foot Low Speed Tunnel. Built as a way to test technologies related to urban air mobility, the model is part of an effort to explore new types of urban flight, from unmanned package delivery vehicles to manned vehicles carrying as many as eight people at a time.

With affordable electric drones swarming the marketplace and businesses channeling money into concepts such as air taxis and autonomous personal aircraft, it seems a new aviation age is dawning.

However, government and industry will need to overcome a number of challenges before drones can routinely deliver packages to your doorstep or you can summon a pilotless aircraft to whisk you downtown for dinner.

Researchers at Langley work hard each day to address those challenges and bring transformative change closer to your doorstep.

Drone safety tools developed at Langley — Safeguard, Safe2Ditch, ICAROUS and DAIDALUS — address the practicalities of pilotless flight: How to keep unmanned aerial vehicles, or UAVs, from flying where they shouldn't; how to keep them from crashing into each other; and how to help them land safely in an emergency.

On Langley's CERTAIN test range, NASA researchers and their partners try out technologies under real-world conditions.

"Working with Langley, you can take your ideas all the way from concept to flight," said William Johnson, Langley's urban air mobility planning lead. "We're helping to drive the story for urban air mobility."

To understand how new air vehicles will operate in towns and cities, a team of researchers created Langley Aerodrome No. 8, an electric airplane that takes off like a helicopter. The unmanned vehicle, created with 3D-printed parts, was tested in Langley's 12-Foot Low Speed Wind Tunnel.

At Langley, researchers strive to make autonomous flight reliable and trusted. Through a project called ATTRACTOR, they devised a system for using autonomous drones for search and rescue.

Partnering with MIT, the team showed how a squadron of autonomous quadcopters could fly under the tree canopy to find a person lost in the woods.

The ATTRACTOR team won a humanitarian award from the Association for Unmanned Vehicle Systems International.

Along with autonomy, Langley explores a host of other issues vital to new air vehicles: air traffic management, no-fly zones, communication and guidance systems, safe flying procedures, and noise suppression.

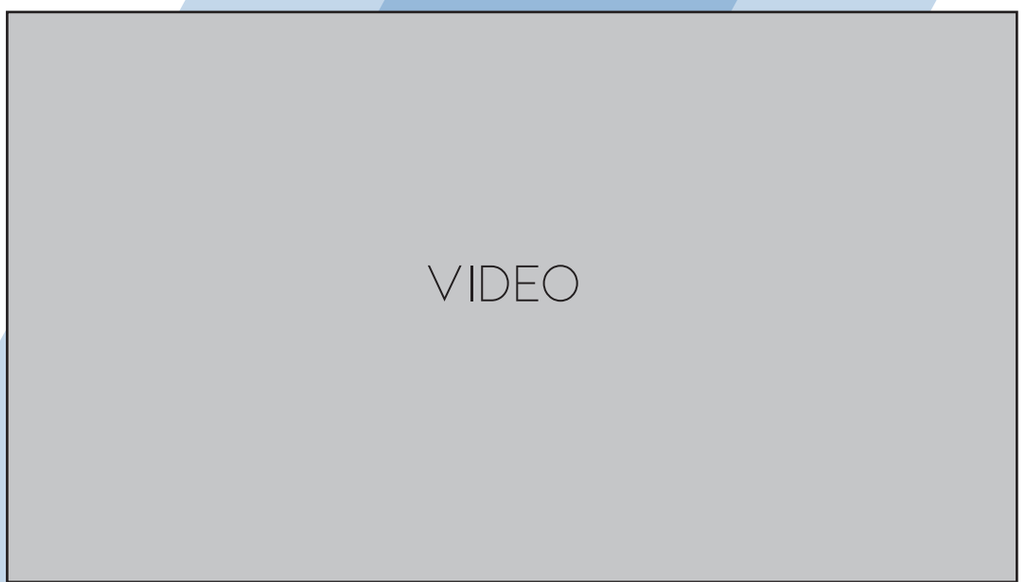
How vehicles, humans, technology and infrastructure all work together is another focus.

On the CERTAIN test range, researchers conducted a campaign of more than 230 flights testing how Langley technologies could blend with a drone air traffic management system. They flew two UAVs on near-collision courses to see how these systems interact and how they would respond in emergencies. "We're seeing how all of this fits together," said engineer Louis Glaab. "It's one of the most complex projects I've ever worked on. We're looking at how these vehicle- and ground-based systems contribute to autonomous traffic management."

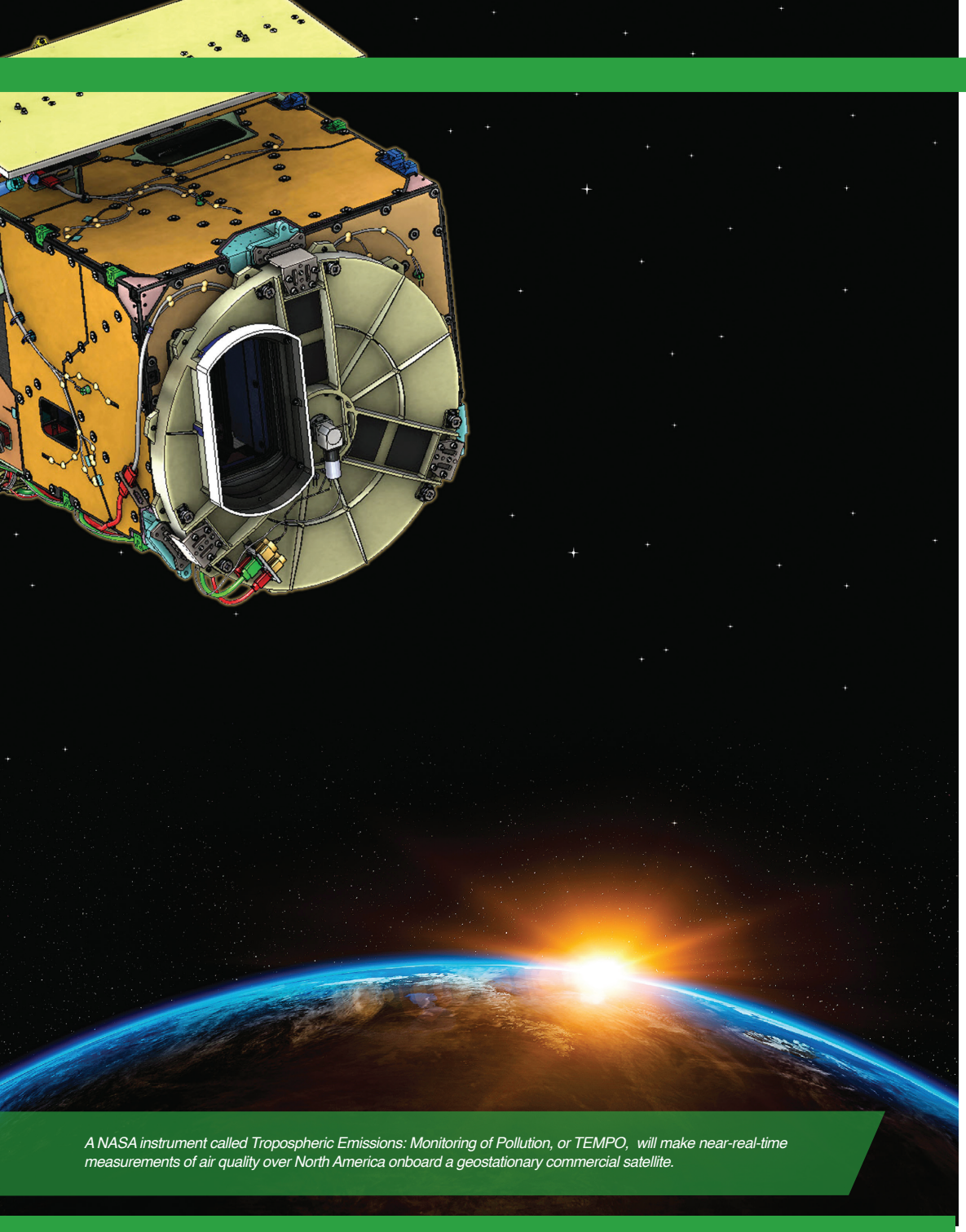
Langley researchers collaborated with MIT on a system for using autonomous drones for search and rescue work.

LIFE AT THE LAB: ALL-ELECTRIC IN THE AIR

The X-57 Maxwell is NASA's first all-electric experimental aircraft. Researchers at Langley say electronic flight propulsion could help shape the future of transportation and contribute to urban air mobility.



UNDERSTANDING EARTH'S ATMOSPHERE



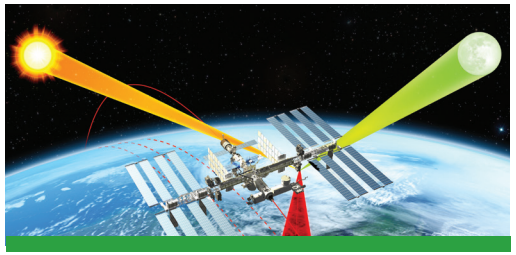
A NASA instrument called Tropospheric Emissions: Monitoring of Pollution, or TEMPO, will make near-real-time measurements of air quality over North America onboard a geostationary commercial satellite.

Langley researchers lead the way toward a better understanding of Earth's atmosphere, climate, weather and air quality. The data they collect and analyze will help inform us about our home planet.

An orbiting instrument called the Tropospheric Emissions: Monitoring of Pollution, or **TEMPO**, will observe air pollution over North America with unprecedented detail. In 2019, the TEMPO team pushed closer to launch. Ball Aerospace completed the instrument and Maxar Technologies won a contract to host it on a commercial platform. TEMPO will make hourly measurements of atmospheric pollutants and form part of a global air-quality constellation of similar satellites over Europe and Asia.

TEMPO WILL OBSERVE AIR POLLUTION OVER NORTH AMERICA FROM A GEOSTATIONARY ORBIT
22,236 MILES HIGH

Smoke from wildfires causes public health risks. A mission called Fire Influence on Regional to Global Environments Experiment - Air Quality, or **FIREX-AQ**, studied what happens to this smoke as it rises and moves downwind. A partnership between NASA and the National Oceanic and Atmospheric Administration, FIREX-AQ conducted flights allowing researchers to gather data on smoke from wildfires and prescribed burns.



The Climate Absolute Radiance and Refractivity Observatory, or CLARREO, mission will help scientists create more accurate and reliable climate records and identify trends.

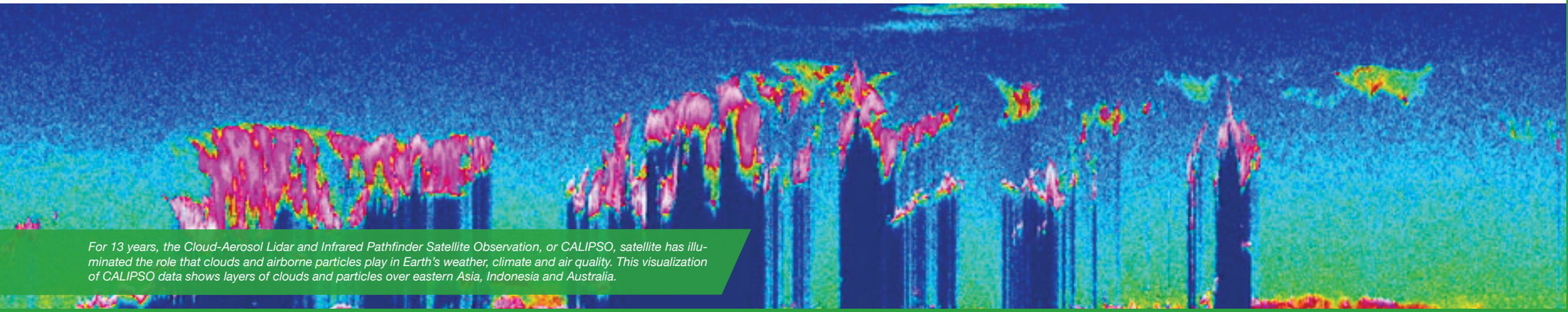
In a series of spring flights, Doppler Aerosol Wind Lidar, or **DAWN**, created 3D maps of winds — showing speed and direction — over the Pacific Ocean. During the same mission, and the final flight campaign for Atmospheric Carbon and Transport-America, or **ACT-America**, the High-Altitude Lidar Observatory instrument, or **HALO**, made concurrent water vapor and methane measurements. The data collected will help improve weather and climate forecast.

Researchers Anna Noe and Eric Altman inspect the Doppler Aerosol Wind Lidar, or DAWN, an airborne instrument that uses pulsed lasers to detect movement of atmospheric particles such as dust or sea salt. In the process, DAWN measures wind speed and direction.

Elsewhere, Langley partnered with Wallops Flight Facility — sharing pilots and expertise — for a project called **ACTIVATE** to measure clouds, aerosols and weather interactions over the western Atlantic Ocean. Using aircraft based at Langley, they will collect data on marine boundary layer clouds which affect climate.

Also, the Climate Absolute Radiance and Refractivity Observatory Pathfinder, or **CLARREO** Pathfinder, instrument passed a key milestone, receiving approval to proceed into detailed design. Once on orbit, CLARREO Pathfinder will reduce uncertainty in climate predictions by calibrating the instrument using reliable readings from the Sun and Moon and transferring that calibration to other orbiting instruments.

LEADERS IN LIDAR INNOVATION



For 13 years, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, or CALIPSO, satellite has illuminated the role that clouds and airborne particles play in Earth's weather, climate and air quality. This visualization of CALIPSO data shows layers of clouds and particles over eastern Asia, Indonesia and Australia.

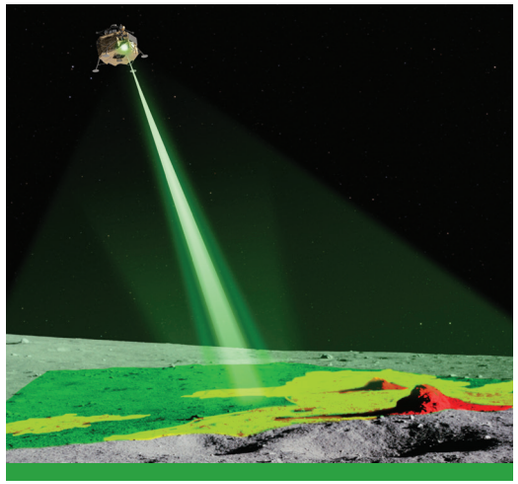
The technology called lidar — short for light detection and ranging — has emerged as a powerful and versatile tool for NASA.

It has potential to give new vision to spacecraft landing on other worlds. Already, this laser-powered sensor has given scientists unprecedented views of our Earth — its land, oceans and air.

Researchers at Langley are pioneers in using lidar for atmospheric science.

"Atmospheric lidar measurements have greatly expanded our knowledge of the vertical structure of clouds, the sources of aerosols and the composition of the atmosphere," said Chip Trepte, project scientist at Langley. "In each of these areas, lidar measurements have been transformative and have elevated understanding of weather, air quality and climate to new levels."

Lidar research at Langley dates to the 1970s, but 1994 was a turning point. That's when Lidar In-space Technology Experiment, or LITE, flew aboard space shuttle Discovery during its STS-64 mission. It was the world's first spaceborne atmospheric lidar.



Navigation Doppler Lidar is a technology designed to help spacecraft land safely and precisely at destinations such as those on the Moon and Mars. Using lasers, it produces highly accurate velocity and range measurements.

The LITE instrument successfully gathered and analyzed reflected laser light — or backscatter — from clouds, aerosols and the Earth's surface, then converted it into data. LITE demonstrated the viability of lidar measurements from space.

The experiment revealed intricate, multi-layered cloud structures and gave researchers a new way to study Earth's atmosphere.

That success 25 years ago paved the way for NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, or CALIPSO, a joint satellite mission with the French space agency, CNES. Launched in 2006, CALIPSO has given science its most detailed picture of clouds and dust in the atmosphere, readings that are vital to understanding Earth's climate.

SINCE REACHING ORBIT IN 2006, CALIPSO LIDAR INSTRUMENT HAS TAKEN **7.92 BILLION** EYESAFE LASER SHOTS

"Now, the technology is advanced to the point where we can not only measure clouds and aerosols, we also use lidars to measure water vapor, ozone, winds in the atmosphere, methane, carbon dioxide and a multitude of constituents of the atmosphere — all pieces we need to understand the whole Earth system," said David Young, head of Langley's Science Directorate.

This data benefits everyone. "We can measure things like volcanic eruptions that send particles into the upper atmosphere, impacting air traffic; or wildfires in the west that send smoke to the East Coast a week later," Young said.

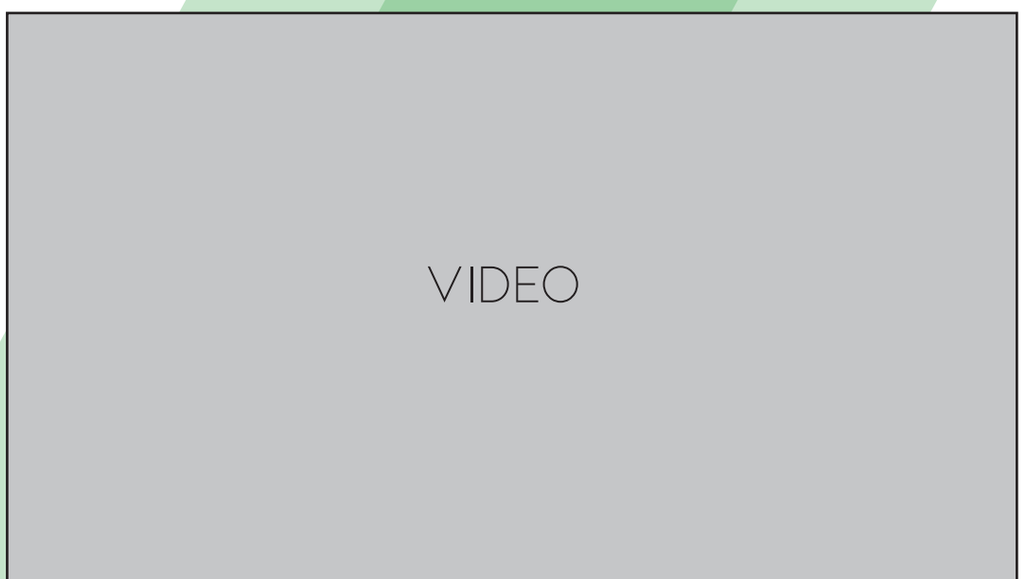
Langley also develops lidar systems for use in space exploration.

Navigation Doppler Lidar, or NDL, is being considered to assure safe and precise landings on planetary bodies. NDL, which accurately measures vehicle speed and position, could help NASA land the first woman and next man on the Moon.

Lidar will have a growing impact in many areas, predicted Farzin Amzajerdian, a Langley researcher who is developing NDL. "It's game changing," he said. "It's going to change the way we travel, the way we explore space, the science we learn."

LEARNING HOW WILDFIRES AFFECT AIR QUALITY

NASA, NOAA and university partners took to the skies in 2019 to chase smoke from fires burning across the United States. The Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) campaign aimed to improve our understanding of how smoke from fires affects air quality.



This image is a computer simulation of a conceptual human-scale Mars lander with supersonic retro propulsion, a technology that would help slow a spacecraft to a soft landing. It was generated on the world's most powerful supercomputer, Summit, a GPU-based system at Oak Ridge National Laboratory using NVIDIA visualization technology.

HARNESSING THE POWER OF CHANGE

In 2019, Langley researchers rolled up their sleeves and faced the challenge of implementing change.

The previous year, the center launched an ambitious Transformation initiative to quicken the pace of research by tapping new digital technologies and shifting Langley's work culture toward a fast-moving, more collaborative model. **Langley's Transformation Network**, a group of employees from all levels and organizations, tackled a list of tasks that leaders predict will produce breakthroughs. The team launched over 40 projects ranging from agile information technology networks to uses of virtual reality and machine-learning-based inspection systems for security.

The head of Langley's Center Operations Directorate, Loretta Keleman, and former Langley Center Director Dave Bowles walk the grounds during a tour of the 175,000-square-foot Measurement Systems Laboratory, which is seen in the background. When completed, the laboratory will contain 40 modular labs and workspace for 245 researchers.

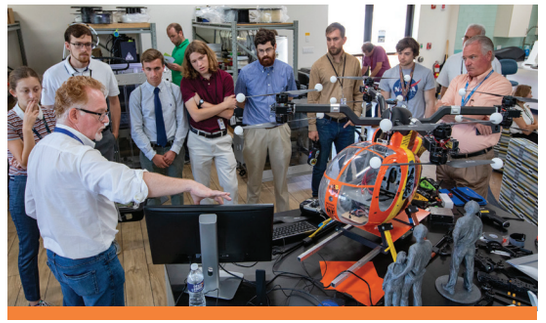
A **High Performance Computing Incubator** is training Langley's workforce to use powerful new computing hardware and software tools. Courses ranged from machine-learning techniques to tips on writing efficient code for high-performance computers.

Also in the world of high performance computing, Langley teamed with NASA's Ames Research Center, NVIDIA Corporation and Old Dominion University to run computer simulations of a space capsule entering the Mars atmosphere. Using the world's most powerful super computer at Oak Ridge National Laboratory, simulation times were trimmed from months to a single work week.

An ongoing project called **SmartLab** seeks to improve laboratory efficiency by capturing, visualizing, analyzing and sharing information. Data processing that took up to five hours using different sets of software is now done in 15 minutes using a single tool. This project includes collaborations with Christopher Newport University.

Elsewhere, a new facility opened doors to wider use of rapid prototyping. In July, the **Larkworks MakerSpace** debuted. It's a lab where researchers meet, collaborate, try new ideas and create solutions by using small-scale manufacturing methods and tools.

Construction continued on the **Measurement Systems Laboratory**, a 175,000-square-foot facility where transformational sensor technologies will be developed. The five-story structure neared completion as crews added exterior finishes and installed mechanical and electrical systems for what will be 40 clean rooms and labs. A ribbon-cutting is planned for 2020.



Engineer Garry Qualls leads a tour of the Larkworks MakerSpace at Langley, which opened in 2019. The lab gives workers at the center a way to experiment with rapid prototyping tools such as 3D printers, robotics kits, laser cutters, computer numerical control mills and a virtual reality station.

BIG VALUE IN SMALL PACKAGES

This illustration shows how Athena, a technology demonstration project at Langley, would look on orbit. By installing existing remote sensing hardware on a NovaWurks small satellite platform, the team intends to reveal a new method for making innovative science measurements.

"If everything seems under control, you're not going fast enough."

Those words, taped to a corridor wall, serve as a reminder to Langley's Michelle Garn, manager of a quick-turnaround, small-satellite project called Athena.

The project's goal is to demonstrate how new spacecraft technology can provide a smaller, cheaper platform to enable future missions measuring solar energy reflected and absorbed by the Earth. Athena is on track to go from conception to payload in less than a year. A more traditional, full-scale mission might take five years.

With Athena, Garn witnessed the real value of a galloping pace.

"What we are learning by doing this is just immense," she said. "You have to be flexible enough to go this way. It's a different mindset."

Leaders say this faster, cheaper, more agile mode of working holds great promise. Small satellites — defined by NASA as spacecraft weighing 180 kilograms (397 pounds) or less — can help the agency advance science and human exploration by providing new options for cutting costs of space missions and expanding access to space.

Athena, which will be ready for launch in 2020, contributed to a pivotal year for Langley's use of smallsats.

Shields-1, a radiation protection demonstration, became Langley's first successful free-flying smallsat project. Riding on a 2018 launch by Rocket Lab, it blasted to orbit along with a set of other demonstrations and experiments. Shields-1 tested new shielding material developed at Langley. Positive results have created a flurry of interest.

That success came on the heels of Langley's first small spacecraft payload reaching orbit. The instrument Rapid Response Radiation Survey was hosted on a smallsat developed by the Defense Advanced Research Projects Agency, built by NovaWurks and launched on a SpaceX Falcon 9 rocket.

Work also progressed on a project called SAGE IV, designed as a miniature, less expensive, smallsat version of the Stratospheric Aerosol and Gas Experiment III, or SAGE III, instrument now monitoring Earth's ozone layer from the International Space Station.

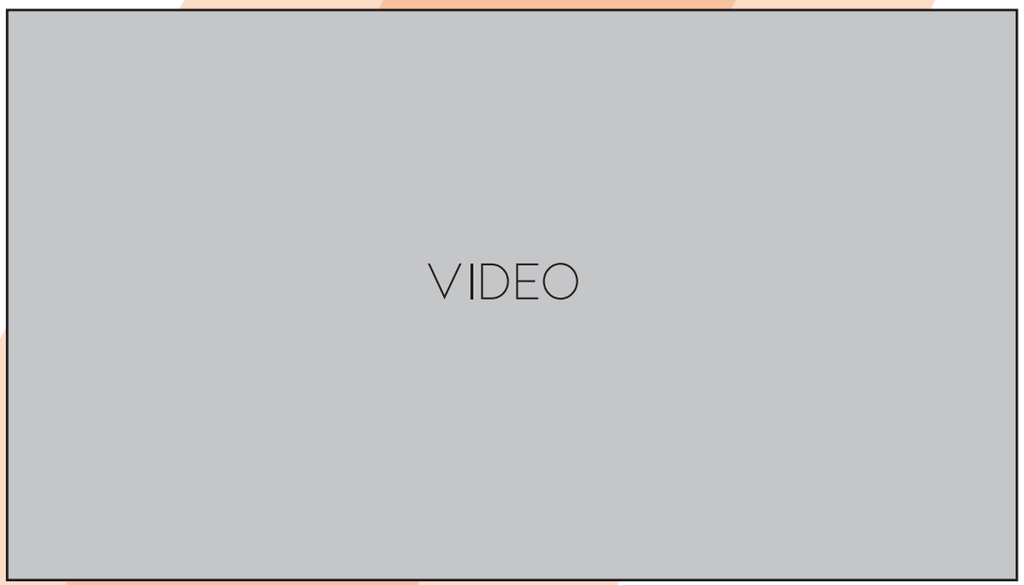
Langley is actively bringing innovators, architects, scientists and engineers together to get small payloads to space quickly and efficiently. At least six new technologies to be demonstrated on smallsats are in progress at the center. They're at the vanguard of a change in how the center approaches technology development and science. Carrie Rhoades, who has done smallsat work at Langley since 2015, sees Athena's quick pace as a sign that researchers are pushing the envelope.

"Being able to deliver a payload in less than a year is pretty impressive," she said.

In her office at Langley, Michelle Garn shows off an actual-size, 3D-printed mockup of Athena's core elements. The project is on track to deliver a completed, space-ready instrument in 2020.

LIFE AT THE LAB: SOFT ROBOTS

In Langley's Larkworks MakerSpace, researchers study soft robotic actuators for possible use in space. The ultimate goal is for soft robots to move, morph and link together, giving astronauts valuable help as they explore the Moon and beyond.



ECONOMIC IMPACT OF NASA LANGLEY

YOUR TAX DOLLARS AT WORK IN FISCAL YEAR 2019

LANGLEY RESEARCHERS ANNOUNCED

170 INVENTIONS

FOR INTERNAL REVIEW IN FISCAL 2019

THE U.S. PATENT AND TRADEMARK OFFICE ISSUED

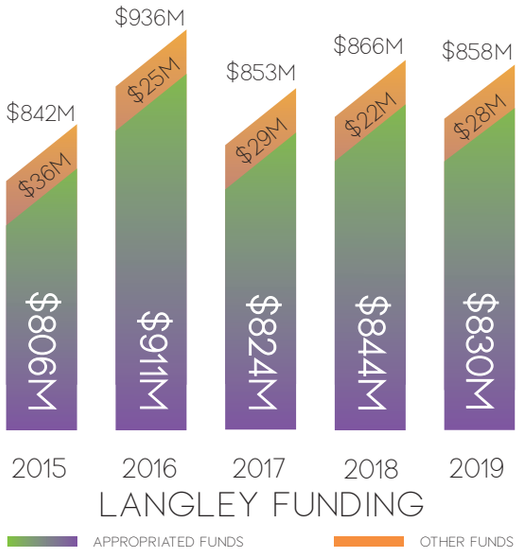
42 NEW PATENTS

FOR LANGLEY INVENTIONS IN FISCAL 2019

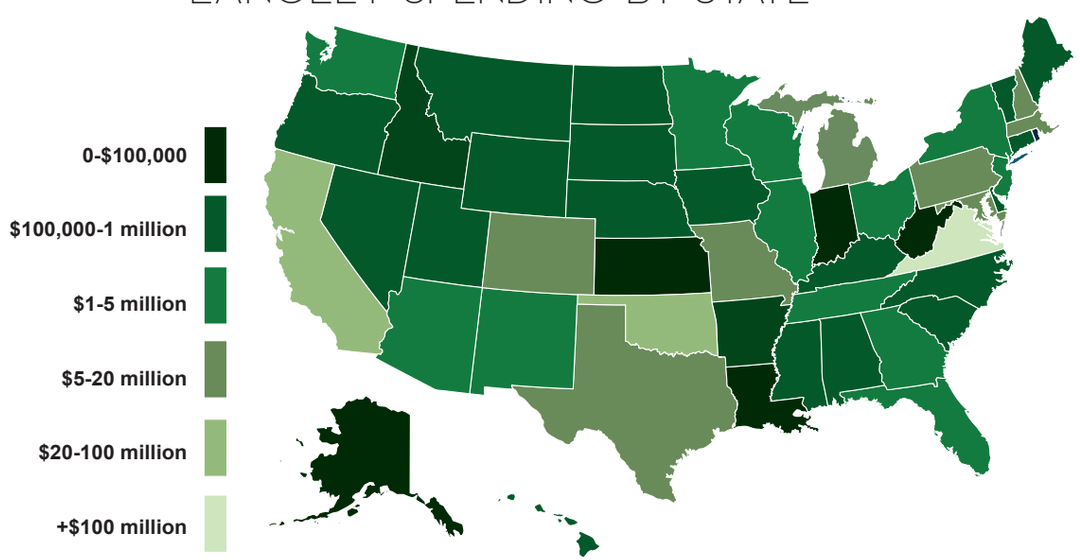
IN TOTAL, ALL OF LANGLEY'S PATENTED INVENTIONS PRODUCED

$544,201

IN ROYALTIES IN FISCAL 2019



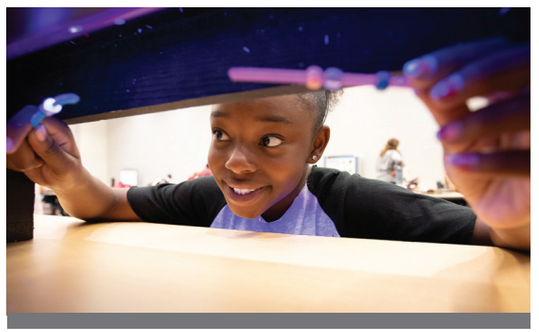
LANGLEY SPENDING BY STATE



NASA'S NEXT GENERATION

Katherine Johnson and John Houbolt, inspirational figures from Langley's history, showed that a combination of persistence, teamwork and technical excellence can lead to a giant leap for humankind.

Today, Langley's Office of STEM Engagement stokes that same sense of opportunity in a new generation of future researchers and explorers.



Langley's Science Directorate hosted 30 students from Northern Shores Elementary School in Suffolk, Virginia. The visit by third-, fourth- and fifth-grade students recognized their work in STEM-related, extended-day programs at the school. In this photo, student Madyson Knox experiments with UV-sensitive beads.

Engagement professionals created classroom lessons related to NASA's new X-59 supersonic aircraft currently under construction in California. Elsewhere, Langley partnered with Radford University to host a one-week modeling and simulation, or **MODSIM**, workshop for 25 secondary mathematics teachers, immersing them in Langley's work through tours, speakers and activities.

Ahead of the July 2019 Ascent Abort-2 test in Florida, Langley's team participated in the Society of Allied Weight Engineers International Conference, presenting related topics and providing **webinars on NASA's Artemis program** for educators across the country. In 2019, over 27,000 students, educators, interns, industry professionals and citizens were inspired by these activities.

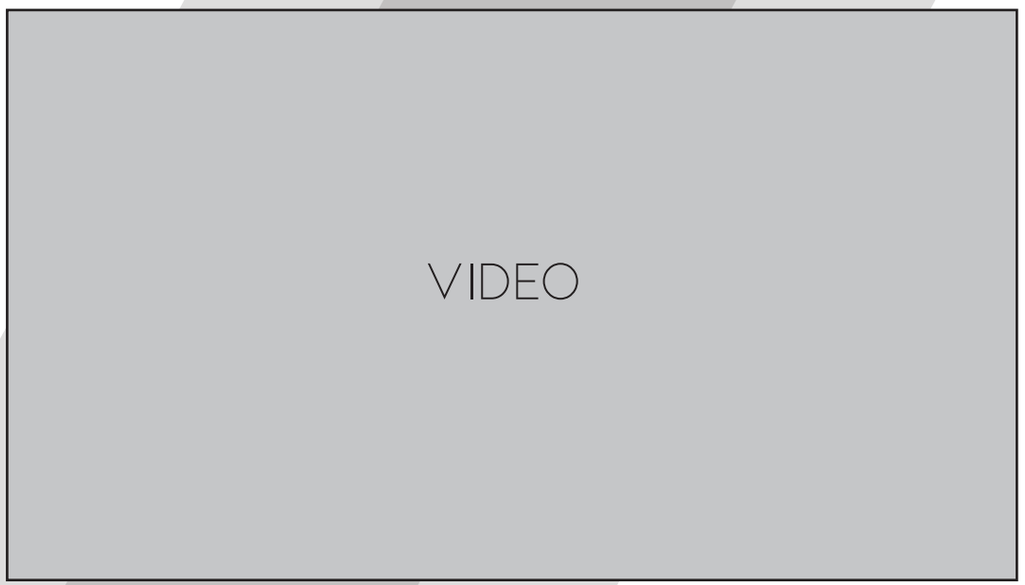
Langley seeks to spread NASA's message of STEM to students at every stage. In August, elementary school children attended an **International Space Station downlink event** at the Slover Library in Norfolk, Virginia. Also, the Virginia Space Grant Consortium organized **week-long summer academies** at Langley for high school students. Through the **HUNCH Culinary Challenge**, students from Phoebus High School in Hampton, Virginia, won a competition to develop a recipe for a dish that will eventually be sent to the International Space Station for astronauts to savor.

Phoebus High School of Hampton, Virginia, won the 2019 NASA HUNCH Culinary Challenge with an entrée of organic harvest hash with butternut squash. NASA's Johnson Space Center Food Lab in Houston will process the entrée and send it to the International Space Station for astronaut meals.

Nearly 400 interns worked side by side with researchers in 2019. Also, students learned robotics through the **National Community College Aerospace Scholars** program. Others traveled from across the nation for the **Moon to Mars Ice & Prospecting Challenge**. Held inside Langley's hangar, the summer competition required college teams to design, build and test methods of harvesting water from existing resources off the Earth. A team from West Virginia University took first place with MIDAS, Mountaineer Ice Drilling Automated System.

A NASA INTERN'S STORY

Karen Moore shares how her internship at NASA's Langley Research Center supported the Minority University Research and Education Project for American Indian and Alaskan Native STEM Engagement.





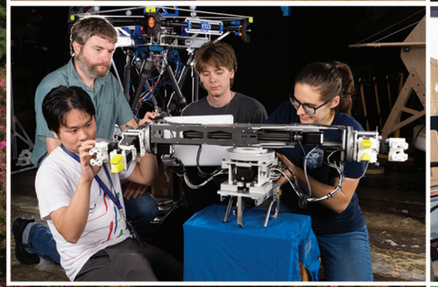




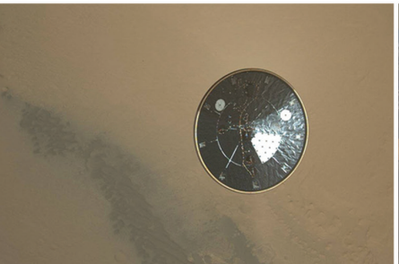



NASA
LANGLEY RESEARCH CENTER
ESTABLISHED 1917


14- by 22-Foot
Subsonic Tunnel

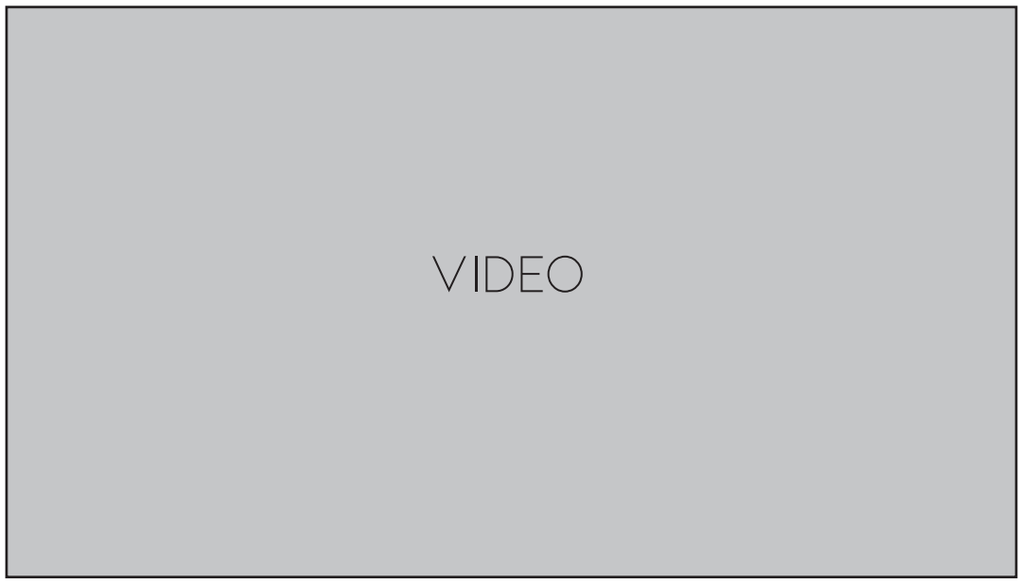





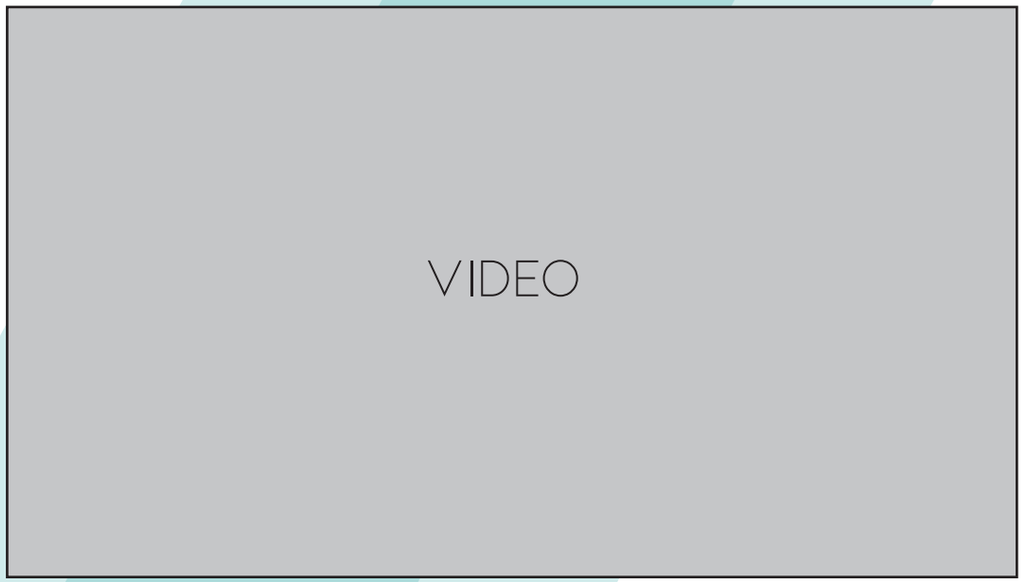






These video profiles offer examples of the remarkable men and women working at NASA's Langley Research Center.



LUCAS HORTA



KAREN TAMINGER

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