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X-57 wing tests complete

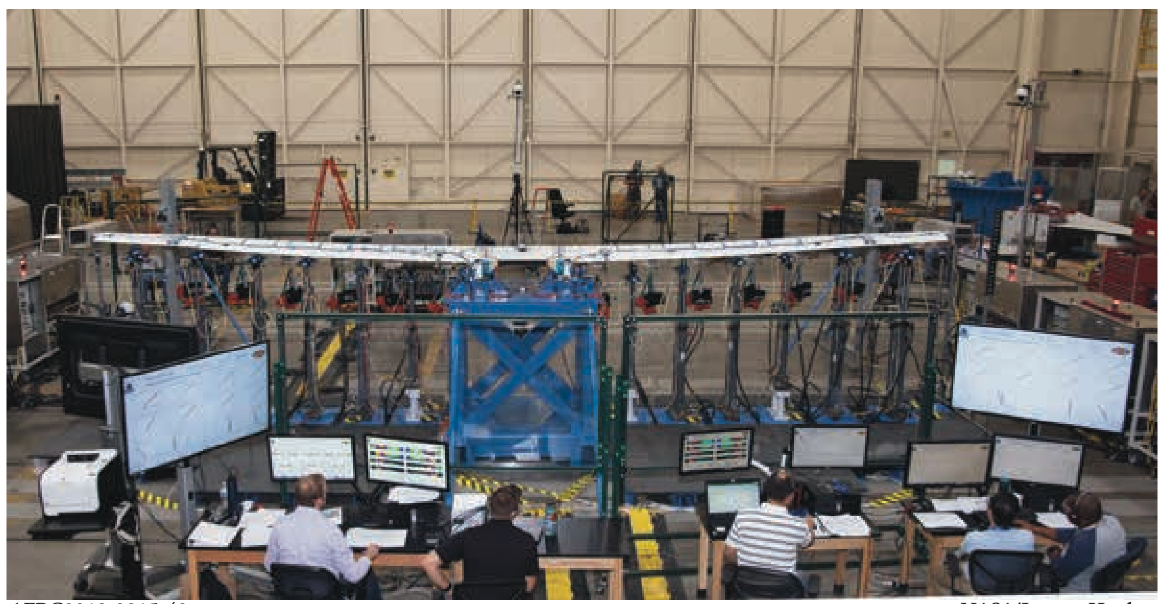
By Jay Levine
X-Press editor

As preparations continue for the X-57 Maxwell's arrival at NASA Armstrong in October, testing on the wing that will be integrated into the final configuration of the piloted experimental aircraft is complete.

NASA's first all-electric X-plane is intended to demonstrate the benefits electric propulsion may have for efficiency, noise and emissions. The aircraft set to arrive in the coming weeks will undergo verification, followed by taxi tests and experimental flight tests.

Armstrong pilots evaluated a standard P2006T Tecnam aircraft, considered the first of three configurations, in 2015 to compare with the electric versions. The aircraft set to arrive soon is X-57's Modification II configuration, or Mod II, which just had a successful engine run earlier this year at Scaled Composite's facility in California. Mod II, which is the X-57's first configuration as an electric aircraft, features electric cruise motors where two combustion motors originally were located.

Following the Mod II phase, modifications III and IV will feature a high-aspect ratio wing, compared to the wider, standard wing from the Mod II phase. The Mod III/IV wing was tested at Armstrong's Flight Loads Laboratory to calibrate installed strain gauges for real-time loads monitoring and to verify the wing has met design specifications.



AFRC2019-0215-40 NASA/Lauren Hughes

***Above**, the X-57 distributed electric aircraft wing that will fly in the final configuration of the flight tests completed its testing at Armstrong. The test above researched the wing's structure under stress of 120% of the design limit load. From left to right are Eric Miller, Tony Cash, Wesley Li, Shun-fat Lung and Ashante Jordan. **Below**, Wesley Li carefully watches real-time displays during wing proof load testing.*

The new wing will permit the repositioning of the electric cruise motors to the wingtips, which could significantly boost aircraft efficiency. The Mod IV configuration will include an additional 12 smaller high-lift motors to the two larger cruise motors on each end of the wing to produce distributed electric propulsion.

Built by Xperimental LLC in San Luis Obispo, the wing's major structural load tests involved

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AFRC2019-0215-25 NASA/Lauren Hughes

DC-8, ER-2 support FIREX-AQ

By Samson Reiny
NASA's Earth Science News Team

NASA's DC-8 flying laboratory returned in early September from a two-month investigation into the life cycles of smoke from fires in the United States. The goal was to better understand smoke impact on weather and climate and provide information that will lead to improved air quality forecasting.

A joint campaign led by NASA and the National Oceanic and Atmospheric Administration (NOAA), Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) is targeting broad questions about the chemical and physical properties of fire smoke, how it is measured and how it changes from the moment of combustion to its final fate hundreds or thousands of miles downwind. All of these have implications for public health.

"Ultimately, our goal is to better understand complex smoke-atmosphere interactions to improve the models for air quality forecasts, leading to increased accuracy and earlier notification, which are critical for communities downwind of fires," said FIREX-AQ co-investigator Barry Lefer, tropospheric composition program manager at NASA Headquarters in Washington. "That common purpose is what brought our agencies together several years ago when we started planning for this major effort."

The first phase of the campaign centered on observing smoke from wildfires in the western United States. Equipped with state-of-the-art remote sensing and in situ instruments, several aircraft based in Boise, Idaho, worked in unison to sample smoke plumes and their changing chemistry along with weather dynamics, tracking the plumes from combustion to destinations often several states away.

The DC-8 based at Armstrong's

NASA/Joe Atkinson

The DC-8 is prepared for flight on the tarmac at Salina Municipal Airport shortly before takeoff.

NASA/Franzeska Becker

The NASA ER-2 is seen at its home base in Palmdale prior to deployment in support of the FIREX-AQ mission.

Building 703 in Palmdale – a long-distance-traveling scientific workhorse – was joined by two NOAA Twin Otters. NASA's stratosphere-reaching ER-2 aircraft, also based at Armstrong, rounded out the science platforms.

"Armstrong hosted 163 scientists from 31 institutions and the team with their instruments are the foremost experts in the fields of atmospheric chemistry composition detection," said Chris Jennison, DC-8 mission manager. "The DC-8 flew 158 hours on 23 data acquisition flights and engaged fires in 18 states from Washington to Florida. We also had 36 instruments suites installed on the aircraft for the mission."

The ER-2 also was successful in completing 94% of its objectives.

"The ER-2 flew 12 flights in August to support FIREX-AQ totaling 63.3 flight hours," said Brain Hobbs, ER-2 project manager. "Missions covered eight states and included data collection over numerous wildfires in coordination with the DC-8, NOAA Twin Otters and satellite underpasses."

In mid-August, the base of operations moved to Salina, Kansas, with flights directed at smoke from agricultural fires in the U.S. southeast. There are hundreds of these fires every year and they are closely situated to population centers, but their small size relative to satellite observational capability means they often go undetected by the satellites that provide the basis for many estimates of smoke emission amounts. The aircraft observations also are critical for understanding small-scale plume dynamics and their scientific impacts.

Smoke forecasts are based on several different forecast models that use satellite and other data, such as the amount of area burned in agricultural fires. NASA and NOAA satellites provide information, such as fuel type, fire intensity and burn scar area, along with wind, temperature and other weather variables that feed into models that predict smoke amount, direction and speed.

Smoke chemistry starts with the fuel type, whether pine forests, oak forests or sage brush. In addition to gases such as carbon dioxide and carbon monoxide, burning will release different types and amounts of short-lived gases called volatile organic compounds (VOCs), which combine with other gases and sunlight to produce ground-level ozone – a gas that is harmful to humans and damages crops. Besides fuel type, the temperature of the burn also affects the resulting chemistry; in general, cooler, smoldering fires produce more VOCs, carbon monoxide and particulate matter, all of which are harmful to human health. Hotter, flaming fires produce less VOCs, carbon monoxide and total particulates, but more black

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AFRC2019-0180-42 NASA/Ken Ulbrich

Armstrong painting unveiled

Aviation artist Stan Stokes, left ,and Clay Lacy, who commissioned the new painting of Neil Armstrong, spoke to Armstrong employees Aug. 5 in the ISF as part of the event that featured the unveiling of Stokes' new portrait of Armstrong, featuring the center's namesake during his test flight career prior to his acceptance as an astronaut and the first man to walk on the surface of the Moon.

Students tour NASA Armstrong

NASA Armstrong opened its doors to 28 students from Hacienda Elementary School on Sept. 16. The California students are enrolled in the U.S. Department of Defense Starbase program, which focuses on elementary school students, primarily fifth-graders, to motivate them to explore science, technology, engineering and math.

The group toured Armstrong, viewed an aircraft hangar and "flew" aircraft in the simulation lab. Students sat in simulated cockpits of the F/A-18 and the X-57 Maxwell. The X-57 Maxwell simulator in the photo represents what it would be like to fly NASA's first all-electric X-plane.

AFRC2019-0194-1 NASA/Lauren Hughes

An elementary school student "flew" the X-57 Maxwell inside NASA Armstrong's simulator lab.

News at NASA

Turner named Langley director

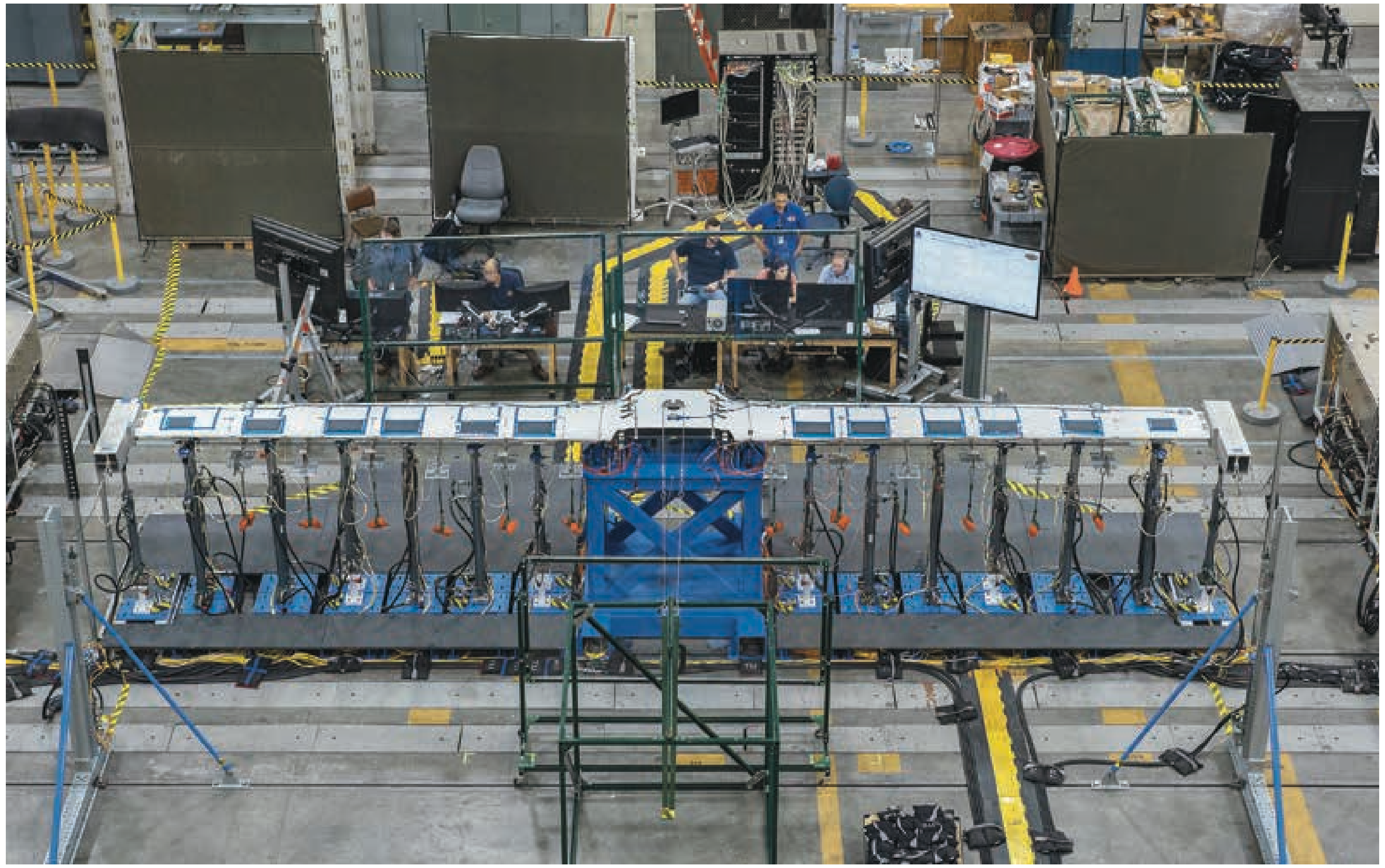
Clayton Turner is Langley Research Center's new director, following the retirement of David Bowles Sept. 30.

Turner had served as Langley's deputy director since 2015. As Center director, Turner will lead a diverse group of about 3,400 civil servant and contractor scientists, researchers and engineers.

Prior to his appointment as deputy director, Turner served as the associate director responsible for managing daily operations with a focus on center commitments. Turner also served as the director of the engineering directorate at Langley.

Turner began his career with NASA in 1990 by serving as a design engineer with the Lidar In-Space Technology Experiment project, where he spearheaded development of the laser aligning, bore-sight limit system. Over the next 29 years, Turner served in various roles with progressively increasing responsibility.

Turner has received many prestigious awards during his career including the Presidential Rank Award, the NASA Outstanding Leadership Medal, the NASA Exceptional Engineering Achievement Medal and the Paul F. Holloway Non-Aerospace Technology Transfer Award.



AFRC2019-0191-223 NASA/Ken Ulbrich

From left to right Jeff Viken, Wesley Li, Tony Cash, Larry Hudson, Kirsten Boogaard and Eric Miller conduct up load tests of the X-57 Modification III wing in the Armstrong Flight Loads Laboratory.

X-57 wing... from page 1

AFRC2019-0191-58 NASA/Ken Ulbrich

From left Eric Miller, Walter Hargis and Ted Powers load wing tip shot bags during wing loads calibration testing while Larry Hudson observes.

loading the wing to 120% of the design limit load (DLL) in positive and negative load conditions. Additionally, during 120% DLL testing, the control surfaces were activated through their rotational range to determine if they would bind during the maximum expected flight deflections. Testing revealed that the control surfaces rotated freely through their rotational range.

The test fixture designed to secure the wing for testing included 30 hydraulic actuators used to apply load to the wing, explained Eric Miller, Armstrong test conductor. In one test that took several hours to prepare, researchers positioned 26 hydraulic actuators – 13 per side – with pads to push up on the wingtip. At the same time, the wingtips were attached to four additional actuators to simulate the inertia and thrust forces caused by the 134 pound cruise motors that will be on the final wing configuration.

AFRC2019-0191-124 NASA/Ken Ulbrich

Ray Sadler, left, and Ronnie Haraguchi, right, load shot bags during loads calibration testing of the X-57 Modification III wing.

Shot bags were used as ballast to create opposing forces to simulate the conditions of about 3.4 g inertia that characterize a max design load case. These tests confirmed that the wing structure acts as predicted as it carries the approximately 3,000-pound aircraft through flight.

Larry Hudson, Armstrong Flight Loads Laboratory chief test engineer, said as is the case with many one-of-a-kind items the lab staff test, systems were set up, evaluated and monitored to ensure safety of the test and personnel. Testing on the X-57 wing marked the first time the lab has used a center-line reaction structure to perform a loads calibration test of an off-aircraft wing, where the entire wing was attached while loading the left and right sides of the wing. The reaction test fixture was conceptualized, designed and fabricated in about a year.

Wing testing also included weight and balance measurements and ground vibration testing. The weight and balance measurements determined the total mass and the center of gravity on the wing, which helped NASA verify that the aircraft will perform as expected during taxi and flight tests.

Ground vibration testing, or GVT, considers the engineering challenges of the relatively thin, high aspect-ratio wing, which could be prone to flutter and other vibration conditions in flight. The GVT lets NASA verify whether the structural properties built into the wing match what is expected for flight.

When the testing concluded, the wing underwent ultrasonic inspection to verify its health before it was shipped back to the project's prime contractor, Empirical Systems Aerospace Inc. of San Luis Obispo, California, or ESAero.

The wing will be integrated into a nearly identical Tecnam P2006T fuselage that came from the same assembly line as the one used in the research, said Trevor Foster, vice president of ESAero. The integration will provide firsthand experience with wiring and flight instrumentation before the integration into the X-plane following the Mod II flights.

"It allows us to practice first and develop a plan," Foster said. "We can work through many of the difficulties in advance to reduce risk and save time."

As all of the components are coming together, the question of efficiency and function will soon be answered.

AFRC2019-0191-144 NASA/Ken Ulbrich

Jacob Roepel operates the load control system in preparation for up load testing at the Armstrong Flight Loads Laboratory.

AFRC2019-0191-178 NASA/Ken Ulbrich

Ray Sadler, left, and Walter Hargis, right, set load pads prior to up load testing on the X-57 Modification III wing.

AFRC2019-0191-207 NASA/Ken Ulbrich

Ted Powers, left, and Chris Mount, right, adjust load pad position, while Larry Hudson observes.

Array tests part of X-59 prep

Matt Kamlet
NASA Armstrong Public Affairs

NASA has successfully tested a large microphone array in California's Mojave Desert as part of a flight series in preparation for the agency's quiet supersonic X-plane, the X-59.

Flying at speeds faster than Mach 1, the speed of sound, typically produces a loud sonic boom heard on the ground below. NASA's X-59 Quiet SuperSonic Technology X-plane, or X-59 QueSST, will fly over selected communities around the U.S. to demonstrate the ability to reduce the sonic boom to a quiet thump. The data from these flights will be turned over to the Federal Aviation Administration to possibly establish new sound-based rules for supersonic flight over land, possibly opening the door to future faster-than-sound commercial cargo and passenger air travel.

Before these community overflights take place, however, the X-59 will first undergo an acoustic validation phase, during which NASA will deploy an approximately 30-mile-long array of specially-configured microphones to measure the X-59's thumps to verify that they are as quiet as predicted.

The recently completed Carpet Determination In Entirety Measurements flight series, or CarpetDIEM, was NASA's "first practice" for the X-59's acoustic validation flights.

"The X-59 is designed to have quiet sonic booms that won't be disturbing to the people, but first we actually have to go out and prove it," explained Ed Haering, NASA's principal investigator for CarpetDIEM. "NASA will do that by flying the aircraft and taking real measurements on the ground before we eventually fly it over communities, to make sure that it is as quiet as it should be."

NASA will collect these sound measurements using a microphone array on the ground that covers the entire width where the X-59's quiet sonic thumps can be heard – a measurement area known as the "carpet." The goal of CarpetDIEM was to practice deploying a large-scale microphone array, and gain valuable lessons on the array's ideal configuration, instrumentation, and logistics.

The test microphone array for this flight series was deployed along an area of the Mojave Desert near NASA Armstrong from which NASA flew an F/A-18 aircraft to produce sonic booms under the designated supersonic corridor, which runs from Nevada toward Edwards.

"We chose this area of the Mojave Desert because it's a nice, wide area under our high-altitude supersonic corridor, where we are able to fly our F/A-18s at supersonic speeds routinely," said Haering. "Here we can learn how to best deploy a sensor array of this magnitude and the logistics of getting the hardware out here, using it for testing, and getting it back and logging the data."

The array featured high-fidelity microphones capable of measuring 50,000 samples per second, giving researchers the ability to obtain accurate sound data and assess the loudness of the sonic booms, just as they will measure the quiet sonic thumps from the X-59.

The flight series included engineers, researchers, and managers from NASA Armstrong and NASA's Langley Research Center in Hampton, Virginia, as well as participants from the Volpe National Transportation Systems Center in Cambridge, Massachusetts, and graduate students and professors from Brigham Young University (BYU) in Provo, Utah. Participants were spread out to cover as much of the wide microphone array as possible.

"We have a series of microphones set up, and the various sites have different configurations," explained Juliet Page, a physical scientist with Volpe. "We have microphones oriented in different configurations, including inverted, vertical, horizontal, some with different wind screens, and we're evaluating the acoustic performance and the difference between the different configurations in preparation of the X-59."

"It's cool to come out in the desert and just do all these measurements

Microphone array, page 8

EC02-0224-4 **NASA/Jim Ross**

NASA tested a large microphone array in the Mojave Desert of California by flying an F/A-18 aircraft overhead at supersonic speeds, or faster than the speed of sound, producing sonic booms as part of the Carpet Determination In Entirety Measurements flight series, or CarpetDIEM. The booms were picked up by multiple microphone stations, spread out over a 30-mile area and capable of capturing up to 50,000 samples of sound data per second, to assess the booms' sound levels.

AFRC2019-0181-18 **NASA/Lauren Hughes**

Juliet Page, a physical scientist with the Volpe National Transportation Systems Center, calibrates a microphone station during the CarpetDIEM flight series. The array featured high-fidelity microphones arranged in several configurations, giving researchers the ability to obtain accurate sound data and assess the loudness of the sonic booms, just as they will measure the quiet sonic thumps from the X-59.

Prandtl-D goes to Smithsonian

By Elvia Valenzuela
Armstrong Public Affairs

AFRC2019-0205-07 NASA/Ken Ulbrich

Prandtl-D1 will be displayed in an upcoming Innovations Gallery at the National Air and Space Museum, the Smithsonian Institution. From left are Robert "Red" Jensen, Logan Shaw, Christian Gelzer, Justin Hall, Al Bowers, Oscar Murillo, Brian Eslinger and Derek Abramson.

It's not every day that a research aircraft may possibly change the way we build future planes. A new method of wing efficiency was discovered at NASA Armstrong by an aircraft built with a twisted wing and no tail.

After years of research, data collection and flight tests, NASA Armstrong's Prandtl-D aircraft have demonstrated the ability to enhance controllability. One aircraft will be shipped to the prestigious National Air and Space Museum, Smithsonian Institution and another to the California Science Center in Los Angeles.

Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D, is a student driven project that was introduced by former NASA Armstrong chief scientist Al Bowers. The goal of the Prandtl-D program is to gather data and test Ludwig Prandtl's 1932 paper that details the best solution for aircraft wing efficiency. Prandtl proposed a non-elliptical bell-shaped curve by considering the strength of a wing rather than just the wingspan, which may produce a lift distribution with 11 percent less induced drag.

Traditional airplanes are designed to create an elliptical span load distribution, which means an aircraft's wings do not produce lift evenly. Instead, when an airplane is flying there is a lift distribution across the wings that is carried in the shape of half an ellipse. The new span load lift distribution would distribute the lift in the shape of a bell curve due to its twisted wing.

NASA personnel selected groups of student interns each year from high school through graduate school that conducted, tested and integrated research on proverse yaw based on the 1932 paper. The aircraft was built with a twisted wing and no tail to test the theory of wing design optimization.

The flight tests and data collected for Prandtl-D1 demonstrated that the new span load gave the outer part of the wing a higher pressure on top and a lower pressure underneath causing a positive thrust. Data collected from Prandtl-D's test flights demonstrated, by definition, proverse yaw.

Prandtl-D1 was requested by Russell Lee, chairman of the aeronautics department at the Smithsonian because it was the first aircraft in history to demonstrate and record data on proverse yaw. Mr. Lee plans to feature Prandtl-D1 in an upcoming Innovations Gallery at the Smithsonian.

The California Science Center also submitted a request for Prandtl-D3, a larger scale model of Prandtl-D1 that will be displayed in the near future.

AFRC2018-0310-06 NASA/Lauren Hughes

NASA Armstrong conducted its first formation flight with the Preliminary Research Aerodynamic Design to Lower Drag (Prandtl-D) aircraft Prandtl-D2 and Prandtl-3C.

The Prandtl program has become a high demand internship at NASA Armstrong for students across the nation. Since 2015 an average of 1,500 students apply each year and only 20 students are selected for a Prandtl summer internship.

The data gathered by Prandtl-D led engineers to also develop Prandtl-M, a concept for a Mars airplane that may collect and transmit valuable information back to Earth. Prandtl-M may be deployed and fly in the Martian atmosphere and capture high resolution topographic images as it glides down to inform scientists about the suitability of potential landing sites.

NASA Armstrong plans to continue the Prandtl program to gather research and data collection on proverse yaw through the non-elliptical bell-shaped span load distribution in the hopes to offer a new method of aircraft control and efficiency for future aeronautics.

FIREX-AQ... from page 2

carbon – an aerosol material with negative health consequences and additional climate warming potential.

"What's burning matters, but how it's burning matters maybe even more," said Carsten Warneke, University of Colorado and NOAA mission scientist for FIREX-AQ. In 2016, he and his colleagues at NOAA burned different fuels at varying temperatures in the Missoula Fire Science Laboratory to gain a more detailed understanding of those factors. "Now, with this campaign, we're taking our understanding from the laboratory to smoke from large fires happening in the field where the atmospheric dynamics change greatly over time and distance. From here, we can continue our work to improve the models."

Resolving those uncertainties in fuel chemistry also plays into another focus area for the campaign: plume injection height. Plume injection heights depend on a complex interaction of fire dynamics with the surrounding weather conditions and geography. Cooler fires, which more often occur at nighttime, inject smoke low in the atmosphere, where it poses a health risk to communities downwind. Hotter fires will inject smoke into higher altitudes, where it may travel farther laterally but is more likely to stay clear of populated areas.

Given the importance of their data to forecasting models, several satellites are used to retrieve plume injection heights. A few satellites with lidar instruments could be used to measure injection height directly, but these satellites do not observe the fires very frequently. Infrared instruments on other satellites are used to derive a measure of the fire's intensity, which is in turn used to estimate injection height as well as the amount of smoke emitted, but clouds and other smoke cover often hinder detection.

The aircraft observed plume injection heights directly and compared them to other direct measurements such as fire radiative power, smoke chemistry and atmospheric conditions at varying altitudes. The observations provided a clearer understanding of plume height as a function of chemistry and other factors such as weather. "We're growing the compendium of observations that can give us confidence that, when we estimate plume rise for the sake of smoke forecasting, we're going to create a more accurate model that will lead to better air quality forecasts," said NASA Langley's Jim Crawford, FIREX-AQ NASA mission scientist.

Longer-term improvement of air quality forecasting is a major focus of the campaign, but FIREX-AQ will also address broader impacts of smoke on weather and climate. For example, smoke particles can act to help initiate clouds. Smoke also affects how much sunlight clouds reflect back into the atmosphere. The optical properties of the smoke particles – how much light is absorbed and scattered by smoke – depends on their sizes and composition and determines their climate effects.

FIREX-AQ helped address one of the major uncertainties about fire emissions, namely the materials responsible for light absorption in smoke. Traditionally, all light absorption has been attributed to black carbon.

The improvements that FIREX-AQ brings to understanding the satellite retrievals of aerosol properties over North America will also improve the value of those observations over other areas of the globe.

Microphone array... from page 6

and just kind of geek out with this technology," Page added.

The data will now undergo analysis in preparation of furthering the technology for future flight tests.

CarpetDIEM was flown under NASA's Commercial Supersonic Technology project, which supports X-59's Low-Boom Flight Demonstration mission through conducting supersonic flight research and technology development.

"The Commercial Supersonic Technology project is responsible for measuring and validating the level of the acoustic signature from X-59 prior to our planned community overflight testing. We want to be sure we are fully prepared for that challenge," said CST project manager Lori Ozoroski. "This joint effort between NASA, Volpe, and BYU involved a number of early mornings and long, hot days to set up and record sonic booms generated by a NASA F/A-18. Lessons learned from this test will next be applied to the second phase of the CarpetDIEM testing, currently planned for summer 2020."

The CST project seeks to develop the tools and technologies needed to overcome the technical barriers to practical commercial supersonic flight. If you ask Ed Haering, who has spent 25 of his 35-year career at NASA researching sonic booms, overcoming barriers is what it's all about.

"It's been 70 years since Chuck Yeager broke the sound barrier," explained Haering, standing under the same skies where, in 1947, Yeager became the first pilot to fly faster than the speed of sound.

"Now we're trying to fix it."

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