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AFRC2019-0072-06 NASA/Ken Ulbrich

Shock Sensing Probe

Technology tested using classic flight test technique, page 2

Instrument design influenced by NACA

By Matt Kamlet
Armstrong Public Affairs

NASA recently completed flight testing of a state-of-the-art instrument designed to capture high quality measurements of shock waves created by supersonic aircraft in flight. The instrument is called the Shock Sensing Probe.

The probe's performance was tested in flight at Armstrong using an innovative technique originated by NASA's predecessor, the National Advisory Committee for Aeronautics.

Through the first half of the 20th century, those pioneering researchers led the world into a golden era of aeronautical breakthroughs and achievements, especially in the development of supersonic flight, or flight that is faster than the speed of sound.

Today, NASA is applying a 21st century twist to those early research methods as the Shock Sensing Probe flies to prepare for the planned 2021 delivery of the X-59 Quiet SuperSonic Technology aircraft.

Now under construction by Lockheed Martin in Palmdale, California, the X-59 is an experimental supersonic jet whose mission is to help enable a future in which commercial faster-than-sound flight over land is possible.

Before that can become a reality NASA will utilize its historic flight research expertise to observe, analyze and validate X-59 shock waves – waves of air pressure that occur whenever an aircraft flies at supersonic speeds and are heard on the ground as a loud sonic boom.

The key to the success of the X-59 will be its ability to fly at supersonic speeds without generating the standard shock waves that result in the loud sonic booms heard by people on the ground.

NASA will use the Shock Sensing Probe to accurately observe the various characteristics of X-59 shockwaves and confirm whether they match agency models to be able to reduce the sound of a sonic boom to a quiet thump.

"The X-59 is going to have specific shock waves that we

Shock Sensing Probe, page 7

AFRC2019-0072-11 NASA/Ken Ulbrich

Above, *the two NASA test pilots training to fly the X-59 Quiet SuperSonic Technology X-plane, Jim "Clue" Less, left, and Nils Larson, step toward a NASA F-15 research aircraft outfitted with the Shock Sensing Probe instrument. The instrument was mounted onto the end of an NACA-style nose boom, a pole extending from the nose of an aircraft to measure the shockwaves produced by an F-18 (background) when it flies supersonic. This method will help researchers validate the shock signature of the X-59 in flight.* ***Cover***, *a close-up view shows the Shock Sensing Probe on an NACA-style nose boom.*

Courtesy Lockheed Martin

The X-59 Quiet SuperSonic Technology X-plane, or QueSST, is designed so that people on the ground will hear a quiet sonic thump, if anything at all, when it is flying supersonic.

Navarro, Wellner recognized

AFRC2019-0283-01 NASA/Ken Ulbrich

Robert Navarro and Phil Wellner received 2019 NASA Engineering and Safety Center Awards in support of the NESC Pilot Breathing Assessment (PBA). Lance Richards, left, and David McBride, right, presented the awards to Navarro, second from left, and Wellner, second from right. Navarro was recognized for outstanding leadership and diligent advocacy, key reasons for the successful implementation of the PBA project. Wellner was recognized for engineering excellence. He and the Armstrong Life Support Team developed creative, first-of-a-kind solutions integrating aircrew flight equipment.

Military friends, family honored

Family can't always make it home for the holidays, especially when they are a member of the U.S. military.

Angela Ross knows that's true as her daughter Brittney Lasley will be serving in the U.S. Navy this holiday season in Japan as a fire controlman. Rather than dwell on missing her daughter, she came up with an idea – encourage Armstrong employees in a similar situation to come together to salute their family members who are serving or did serve.

It wasn't hard for her to find help. Kirstin Sharrer in the Armstrong Graphics Office gave her ideas, husband Jim Ross honored generations of his family dating back to World War I with the display and photographer Carla Thomas posted pictures of friends and family members who served.

The tribute outside the Armstrong Photo Lab in the first hall in Building 4800 encourages people to take a paper dog tag ornament, add a picture of a family member and attach it to the red, white and blue display with blue lights.

AFRC2019-0303-01 NASA/Ken Ulbrich

NASA pilot Nils Larson adds to a salute to U.S. military personnel serving over the holidays.

"We are so proud of Brittney, but it is not easy being without her," Angela Ross said. "It helps when people show support and shows our friends and family members that just because you're away doesn't mean you're forgotten."

News at NASA

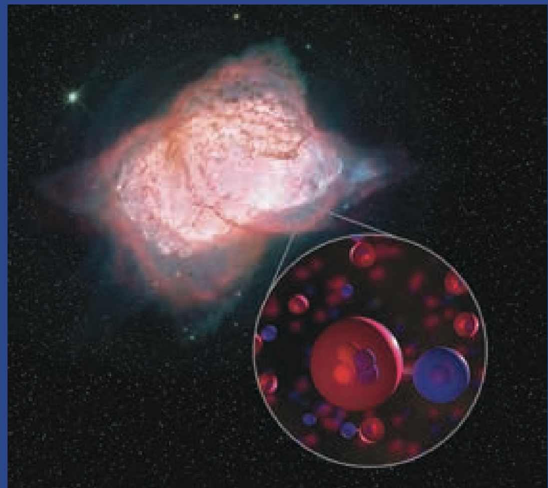
Pearce is ARMD AA

NASA Administrator Jim Bridenstine has named Robert Pearce as the associate administrator for the Aeronautics Research Mission Directorate (ARMD). Pearce replaces Jaiwon Shin, who retired from the agency Aug. 31.

"Bob is a visionary leader with a deep understanding of the current and future aeronautics environment," said NASA Administrator Jim Bridenstine. "He'll do a great job directing NASA in helping create a generational shift in air travel for the United States and the world."

Pearce served as the acting associate administrator for ARMD since Sept. 1. Prior to this appointment, Pearce was the deputy associate administrator for ARMD. He also has been ARMD director for strategy, architecture and analysis, as well as holding various strategic and program management positions within NASA. From 2003 until July 2010, he was the deputy director of the FAA-led Next Generation Air Transportation System (NextGen) Joint Planning and Development Office (JPDO). The JPDO was an interagency office tasked with developing and facilitating the implementation of a national plan to transform the air transportation system.

Pearce has been recognized for outstanding strategic leadership in aeronautics research. His honors include the NASA Exceptional Service Medal, NASA's Exceptional Achievement Medal and NASA's Outstanding Leadership Medal. He is also a recipient of a Presidential Rank Award.



NASA

This image of planetary nebula NGC 7027 also includes an illustration of helium (red) hydride (blue) molecules detected by SOFIA for the first time.

NASA

Ascent Abort-2 successfully launched July 2. Armstrong staff were in the control rooms when the agency successfully demonstrated the Orion spacecraft launch abort system at Cape Canaveral, Florida. The system is designed to take astronauts to safety during an emergency.

2019

Armstrong supported Artemis, X-planes and science missions

By Jay Levine
X-Press editor

Armstrong contributed to the agency's Artemis mission to return to the Moon and advanced preparation for research of experimental aircraft and systems to validate clean and quiet electric propulsion and advance commercial supersonic flight technology without the window-rattling boom.

The center also supported space science achievements such as the discovery of the first type of molecule ever formed called helium hydride and Earth science missions such as fire and smoke impact on regional and global environments. In addition, Armstrong was recognized for its key contributions to a system that has saved lives in the nomination and award of the Robert J. Collier Trophy.

Armstrong personnel supported the successful testing of the launch abort system as part of the Orion spacecraft that will enable the Artemis missions to the Moon, during which the first woman and next man will land on the surface. Once proven, the systems will eventually take astronauts to Mars.

Space technology was also advanced with the Flight Opportunities program, where NASA helped test a terrain relative navigation system for precise lunar landings and dozens of other technologies on commercial suborbital rockets, spacecraft, a parabolic plane and balloons. The program featured 48 opportunities to test new technologies on 15 successful flights by nine commercial flight providers.

X-planes

The Lockheed Martin Skunk Works began building an experimental aircraft for NASA known as the X-59 Quiet SuperSonic Technology, or QueSST. This aircraft will help researchers study how people react to quieter sonic boom noise in an effort to revisit the restrictions on commercial supersonic travel over land and potentially reduce travel times drastically for long flights.

Regarding sonic booms, the Carpet Determination in Entirety Measurements, or CarpetDIEM, flight series at Armstrong featured an array with high-fidelity microphones arranged in several configurations. The arrays gave researchers the ability to obtain

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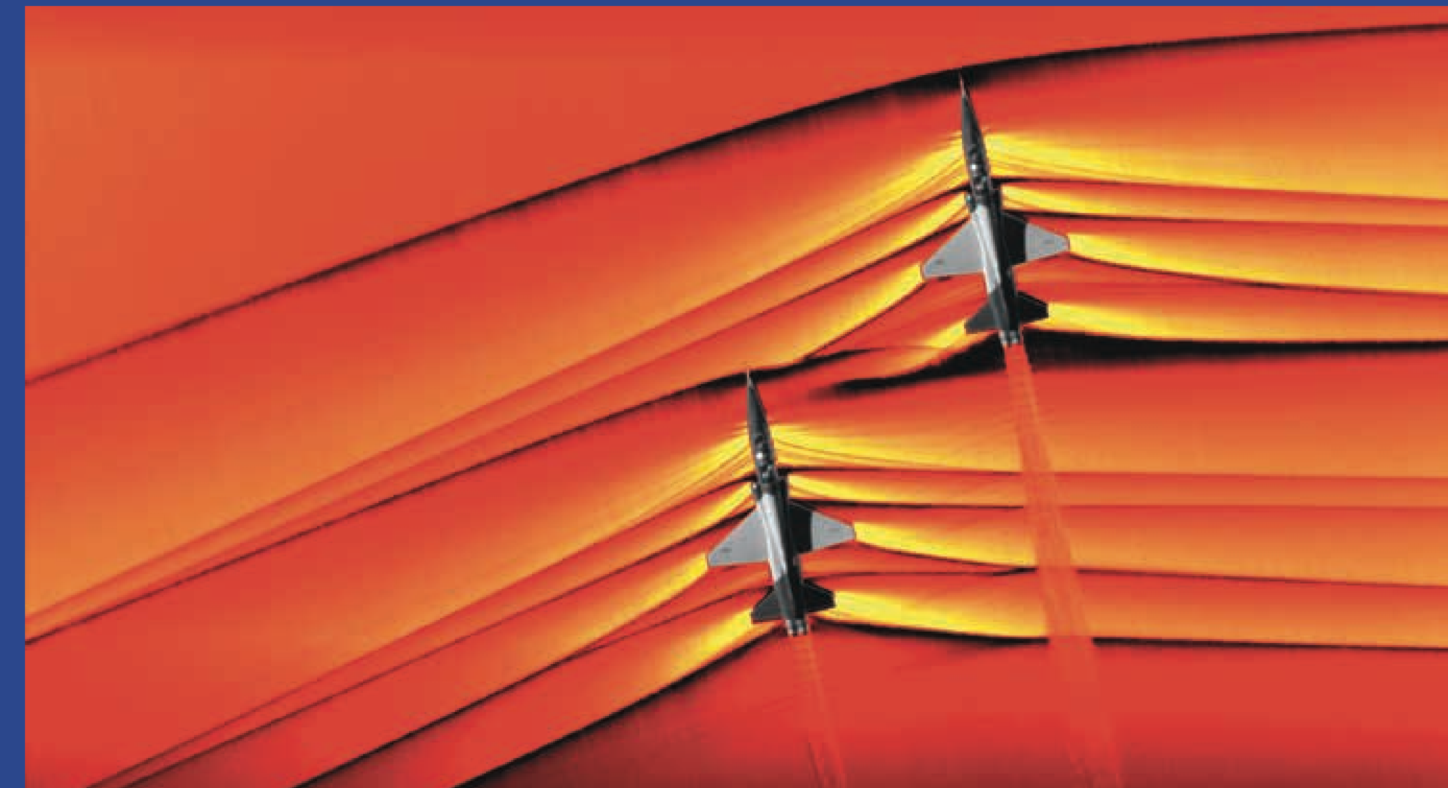

NASA

accurate sound data and assess the loudness of the sonic booms, just as they will measure the quiet sonic thumps from the X-59. How sonic booms look was a result of the first air-to-air images of the interaction of shockwaves from two supersonic aircraft during the Air-to-Air Background Oriented Schlieren flights earlier in the year.

Armstrong also accepted delivery of X-57 Maxwell Mod II, an experimental all-electric aircraft that will be used to collect data in support of enabling regulators to set certification standards for the emerging electric aircraft market. In addition, Armstrong prepared for future testing of the X-57 final configuration by testing the wing that will be used in later phases of the flight tests in the Armstrong Loads Laboratory.

Aeronautics

NASA was part of the team that developed the software system that will assume control of an aircraft upon imminent ground collision called the Automatic Ground Collision Avoidance System.

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NASA/Steve Parcel

AFRC2019-0289-15 NASA/Lauren Hughes

***Above**, when aircraft fly faster than the speed of sound, shockwaves travel away from the vehicle, and are heard on the ground as a sonic boom. NASA researchers use this imagery to study these shockwaves as part of the effort to make sonic booms quieter, which may open the future to supersonic flight over land.*

***In the middle,** the electric motors for the X-57 Mod II vehicle and their propellers were powered up and spun together for the first time as part of an integrated spin test.*

***At left,** Juliet Page, a physical scientist with the Volpe National Transportation Systems Center, calibrates a microphone station during the CarpetDIEM flight series.*

Armstrong staff honors peers

Mission Impossible: Joe Hernandez

Unsung Hero: Jeffrey Sutherland

Can-Do Attitude: April Kell

Engineer/Scientist/Pilot: Leo Gross

Mission Support - Administrative Professionals: Everlyn Cruciani

Mission Support - Financial / Resources Support: Lisa Logan

Mission Support - IT Support: James "Joe" O'Neill

Mission Support - Other Support Services: April Kell

Create Your Own Award: Mark Buschbacher

Steven B. Davis Coop / Student Award: Matthew Gray

Henry Arnaiz Mentor Award: David Nils Larson

NASA Pride In NASA (PIN) Award: Steve Parcel

Rising Star: Rose Blomquist

Technician/Mechanic: Todd Shaw

Facilities Personnel: Aleeza Griffin

James Harris Supervisor/ Manager/Leader Award: Michael Collie

Teamwork: Environmental Laboratory

AFRC2019-0289-15 NASA/Lauren Hughes

The Environmental Laboratory Team was honored with the Teamwork Peer Award. John Takas presents the award to Karen Estes, Nathan Rick and Roberto Oba Yoshymatan. Not pictured: Martin Munday.

AFRC2019-0289-03 NASA/Lauren Hughes

Ed Haering, left, received the Armstrong Center Director's Award from Armstrong Deputy Director Pat Stoliker.

AFRC2019-0289-04 NASA/Lauren Hughes

Steve Parcel receives the Pride in NASA Peer Award from John Takas.

Shock Sensing Probe... from page 2

predict will sound much quieter on the ground than your standard sonic boom," said Shock Sensing Probe Project Manager Kevin Weinert. "We've developed a system to be able to measure those shock waves and confirm they are what we're expecting. We're validating that we can collect this data when the X-59 flies."

Flying the Shock Sensing Probe now is giving engineers an opportunity to test the probe in conditions similar to what will be experienced during X-59 validation flights in the future.

To do this, NASA used a technique dating back to the 1940s and commonly used by the NACA – combining two instruments together and mounting them onto the nose of an aircraft to measure the pressure of shock waves from another aircraft.

During the recent flight tests the Shock Sensing Probe instrument was mounted onto the end of an NACA-style nose boom, which is a pole that extends from the nose of an aircraft – in this case a NASA F-15 research jet.

The F-15 joined a NASA F/A-18 research jet in the sky, with both aircraft flying at speeds up to Mach 1.3, or about 1,000 mph. The Shock Sensing Probe on the F-15 was then used to measure the supersonic shockwaves coming off the F/A-18.

"We were capturing pressure measurements, looking at the changes in pressure as we flew into and out of the shock waves," said Mike Frederick, NASA's Principal Investigator for Shock Sensing Probe.

"Essentially, we had the F/A-18 as the lead aircraft, flying supersonic so it was creating shock waves with the F-15 lined up off the F/A-18's wing. In that position, the F-15 is actually in front of the lead aircraft's shock waves, and we had the F-15 decelerate, and then reaccelerate, through the F/A-18's shocks back and forth multiple times, with the probe collecting measurements."

NASA researchers completed two probing flights, flying both aircraft at approximately 42,000 feet, with the F-15 taking multiple measurements at both 500 and 300 feet of separation.

This approach allowed the pilots to practice the maneuver at further distances and work their way closer. It also provided a rich set of data, as shock wave features change with distance from the shock-generating vehicle.

The next step is to compare the recorded data of the shock waves to existing computer models of the F/A-18 in flight, which predict how the shock waves will look. This comparison will help researchers determine how accurately the probe was able to measure the shock waves.

"We have the computational fluid dynamics models for the F/A-18, which is why we chose this aircraft for this flight series," said Frederick. "It gives us the ability to confirm how closely the shocks measured by the Shock Sensing Probe match our model for the F/A-18."

Basically, the closer the data recorded by the Shock Sensing Probe are to NASA's models, the more accurately the probe was able to capture that data.

The cone-shaped Shock Sensing Probe itself contains five "pressure ports" – holes that are in place to measure the pressure on the surface around the instrument.

As the F-15 flies through the shock waves coming off the F/A-18, the five pressure measurements are combined to calculate the changes in air pressure.

The Shock Sensing Probe effort is a continuation of previous research projects, including the 2016 Eagle Aero Probe flights, which provided valuable lessons learned leading to critical upgrades to the probe.

One such upgrade was to the quality of data, which was achieved by boosting the speed at which the probe was able to collect that data.

Previous probing booms featured up to 15 feet of pneumatic tubing, resulting in a lag in the time it took for the signal of the measurements to actually be transmitted through the tubing, which could negatively affect the data.

In comparison, today's Shock Sensing Probe features sensors that are within four inches of the pressure ports on the cone, resulting in the signal being transmitted nearly instantaneously and improving the quality of the data.

NASA's team is taking lessons learned from the first phase of Shock Sensing Probe flights to improve the design for the project's second phase, expected to happen in early 2020.

These improvements include enhancements to the team's ability to regulate the instrument's temperature, which can change based on flight conditions and speed, affecting the probe's ability to measure pressure. Keeping the probe at a stable temperature during flight should result in more repeatable and consistent data. Meanwhile, newly designed pressure transducers have improved data resolution.

"The X-59 will feature unique shock waves in which the changes in pressure are extremely small, so we need to have a very high resolution to be able to measure those," explained Frederick.

The ultimate goal of those pressure measurements, combined with others that will be taken after the X-59 begins its flight tests, is to be sure the aircraft is performing as expected by producing quieter sonic booms.

Today, aircraft are prohibited from flying at supersonic speeds over land, primarily due to the loudness of the resulting sonic booms.

The X-59 is designed to fly at supersonic speeds while producing shock waves in such a way that the typically loud sounds of sonic booms may sound no louder than a nearby car door being closed.

While the restriction on supersonic flight over land is currently based on the aircraft's speed, NASA research using the X-59 is intended to provide data that will enable regulators such as the Federal Aviation Administration to establish new rules that are based on sound.

The data will be created by flying the X-59 over several communities and recording public perception of the noise they heard, if any, through the use of official surveys.

Although the X-59 is not a prototype of a new commercial supersonic airliner, its sonic boom quieting technology will be shared with industry, which – along with potential rule changes by the FAA and others – could lead to a new era of faster-than-sound travel and substantially reduced flight times.

The Shock Sensing Probe flight series is flown under the Flight Demonstrations and Capabilities project, or FDC, within NASA's Aeronautics Research Mission Directorate. The FDC is one of three projects along with the Commercial Supersonic Technology and Low Boom Flight Demonstrator projects supporting the effort to demonstrate quiet supersonic flight. NASA's supersonic work through the current aeronautics programs can cahnge the way we fly like the agency has accomplished since the early days as the NACA.

"If there's a flight experiment involving complicated systems, or a flight test that's high risk, that's what FDC has set out to do," said FDC Project Manager Brent Cobleigh. "Our role is to increase the technology readiness level for new technologies and go out and fly them."

2019... from page 5

The system has been integrated into military aircraft and saved eight pilots since it was fielded about five years ago. The team was awarded the 2018 Robert J. Collier Trophy, which recognizes the greatest achievements in aeronautics or astronautics in the country each year.

Another key achievement was the Ikhana team acceptance of the 62nd Annual Laureate Award, in the category of Commercial Aviation, Unmanned Systems, by Aviation Week & Space Technology. The Ikhana team was chosen for the unmanned aircraft's first No Chase Certificate of Waiver Authorization flight in 2018 without the need of a chase plane or visual observers as it operated in various classes of airspace.

The Unmanned Aircraft Systems Integration in the National Airspace System project completed its Flight Test Series. The effort began in 2012 to inform the Federal Aviation Administration and RTCA Special Committee Detect and Avoid (DAA) Working Group on the minimum operational performance standards for DAA and air-to-air radar.

NASA Armstrong also completed its first phase of Pilot Breathing Assessments (PBA) to study how pilots breathe to make it safer for them to fly. PBA will help researchers and engineers understand how flight conditions may cause pilots to experience a physiological episode during flight and help determine methods that may prevent these in the future.

The X-56A remotely piloted aircraft concluded its flight series at Armstrong. The aircraft has lightweight, flexible wings and a system that suppresses a potentially destructive vibration called flutter. The successes of the project could allow future airline designers to use such wings to conserve fuel.

Science

The NASA DC-8 and ER-2 aircraft based at Armstrong participated in a joint campaign with the National Oceanic and Atmospheric Administration in a major campaign to improve its ground and satellite based forecasting models by taking a closer look at smoke. The joint Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) effort looked through the smoke and fire to bring scientists data to understand how fuel and fire conditions at the point of ignition influence the chemistry of smoke. The campaign also looked at what happens to smoke as it enters the atmosphere, and how the chemical transformation of smoke affects air quality and to a lesser extent downwind weather.

AFRC2019-0101-062 NASA/Ken Ulbrich

NASA's DC-8 flying laboratory transported the Fire Influence on Regional to Global Environments and Air Quality, or FIREX-AQ, science team and a suite of state-of-the-art instrumentation to observe different components of fire smoke in varying altitudes and weather. The NASA ER-2 also flew missions in the campaign.

The Moon is not just the focus of a future Artemis mission, a new sensor on NASA's ER-2 used the moon in an effort to improve Earth observations. The airborne Lunar Spectral Irradiance Instrument (air-LUSI) flew aboard the high altitude aircraft. The NASA-funded instrument is measuring how much sunlight is reflected by the Moon at various phases to accurately characterize it and expand how the Moon is used to calibrate Earth observing sensors.

Another breakthrough was the discovery of the universe's first type of molecule. Scientists believe that around 100,000 years after the Big Bang, helium and hydrogen combined to make a molecule called helium hydride for the first time. Helium hydride should be present in some parts of the modern universe, but it had never been detected in space until it was observed by the world's largest airborne observatory, NASA's Stratospheric Observatory for Infrared Astronomy, or SOFIA. Armstrong is SOFIA's home base.

Armstrong had a year of achievement in 2019. The center is preparing to make sure that 2020 will include new milestones, technology validation and science successes through flight.

The X-Press is published the first Friday of each month for civil servants, contractors and retirees of the NASA Armstrong Flight Research Center.

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