National Aeronautics and Space Administration

THE ARMSTRONG X-PRESS

Volume 60 Number 1 January 2018

Flight proves new tech

By Matt Kamlet
Armstrong Public Affairs

NASA has successfully applied a new technology in flight that allows aircraft to fold their wings to different angles while in the air.

The recent flight series, which took place at NASA Armstrong, was part of the Spanwise Adaptive Wing project, or SAW. This project aims to validate the use of a cutting-edge, lightweight material to be able to fold the outer portions of aircraft wings and their control surfaces to optimal angles in flight.

SAW, which is a joint effort between Armstrong, NASA's Glenn Research Center in Cleveland (GRC), Langley Research Center in Virginia, Boeing Research & Technology in St. Louis and Seattle, and Area-I Inc. in Kennesaw, Georgia, may produce multiple in-flight benefits to aircraft in the future, both subsonic and supersonic.

Photo courtesy Area-I Inc.

The subscale testbed PTERA flies over Armstrong with the outer portions of its wings folded 70 degrees upwards.

Folding wings in flight is an innovation that had been studied using aircraft in the past, including the North American XB-70 Valkyrie in the 1960s. However, the ability to fold wings in flight has always been dependent on heavy and bulky conventional motors and hydraulic systems, which can be cumbersome to the aircraft.

The SAW project intends to obtain a wide spectrum of aerodynamic benefits in flight by folding wings through the use of an innovative, lightweight material called shape memory alloy. This alloy is built into to an actuator on the aircraft, which plays a vital role for moving parts on the airplane, where it has the ability to fold the outer portion of an aircraft's wings in flight without the strain of a heavy hydraulic system. Systems with this new technology may weigh up to 80 percent less than traditional systems.

The recent series of flight tests at Armstrong successfully demonstrated the alloy application

SAW, page 8

Armstrong remembers the pilots who lost their lives

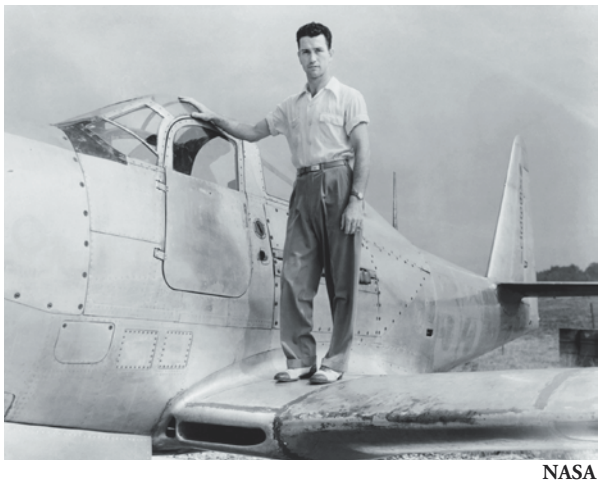
By Christian Gelzer
Armstrong Historian

NASA's Day of Remembrance Jan. 25 recognized astronauts who have perished in the efforts to advance the nation's reach into space. It's also a day to reflect on how to keep future astronauts safe and the need to remain vigilant on safety.

On the same solemn day, NASA Armstrong officials remembered three pilots in its history who died at the stick of a NASA or National Advisory Committee for Aeronautics (NACA) aircraft.

Howard C. "Tick" Lilly was the first NACA engineering pilot assigned to the Muroc Flight

Pilots, page 6



NASA

Howard C. "Tick" Lilly was the first NACA engineering pilot assigned to the Muroc Flight Test Unit, now known as Armstrong. He also was the first pilot who died on a research mission.

New Shepard launch successful

Technology could treat chest trauma in space

By Leslie A. Williams
Armstrong News Chief

Blue Origin successfully launched its New Shepard reusable space vehicle on Dec. 12 carrying a medical technology that could potentially treat chest trauma in a space environment.

The New Shepard reusable vertical takeoff and vertical landing space vehicle was launched with the experimental technology from Blue Origin's West Texas launch site. In addition to NASA funding non-government researchers to fly payloads, Blue Origin is a Flight Opportunities program launch provider for government payloads. The Flight Opportunities program is managed at Armstrong and funded by NASA's Space Technology Mission Directorate (STMD).

"This flight marks the first of many Flight Opportunities' flights of payloads with Blue Origin," said Ryan Dibley, NASA Flight Opportunities campaign manager for Blue Origin. "New Shepard brings new capabilities to the program. This launch platform allows for larger payloads, provides lower launch accelerations, and maintains a sealed pressure environment."

With NASA funding to support the flight cost, the Evolved Medical Microgravity Suction Device technology was developed by Charles Marsh Cuttino and his team at Orbital Medicine, Inc. in Richmond, Virginia.

The device could potentially assist in treating accidents such as a collapsed lung where air and blood enter the pleural cavity. The payload was constructed in collaboration with the Purdue University of Aeronautics and Astronautics in Indiana.

Photo courtesy of Blue Origin

Blue Origin's New Shepard booster rocket returns to its West Texas launch pad on Dec. 12 after completing a flight that tested the Evolved Medical Microgravity Suction Device technology. NASA funded the micro-gravity service on the flight.

Photo courtesy of Blue Origin

The Blue Origin capsule carried the Evolved Medical Microgravity Suction technology, which could potentially assist in treating chest trauma in space.

Currently astronauts and cosmonauts have to return to Earth quickly for medical treatment should an incident arise with chest trauma on the International Space Station. Collapsed lungs are treated on Earth with gravity-dependent collectors that will not work in space.

"My hope is that in the future, this type of medical device will be able to save the life of an astronaut, to continue their mission of exploration," said Dr. Cuttino. "These types of medical treatment options could be required to explore the Moon and Mars."

The new technology has a suction system that collects the blood in microgravity that can be used for transfusion and allows the lungs to continuously inflate. The device also has a pneumothorax simulator, which simulates an injured person and shows how the device removes the air and blood to promote healing.

Orbital Medicine's suction device technology was selected in Nov. 2015 under a NASA Research Announcement: Space Technology Research and Development, Demonstration and Infusion, or Space Technology REDDI-2015. The device has already flown on parabolic flights with past program funding.

Through the Flight Opportunities program, STMD selects promising technologies from industry, academia and government for testing on commercial launch vehicles. STMD is responsible for developing the crosscutting, pioneering, new technologies and capabilities needed by the agency to achieve its current and future missions.

Armstrong legend honored

The National Aviation Hall of Fame recently named former NASA Armstrong legendary pilot William H. "Bill" Dana as a 2018 inductee.

Each year, the NAHF Board of Nominations, a voting body comprised of over 120 aviation professionals nationwide, selects a handful of previously-nominated air and space pioneers to be recognized. Founded in 1962, the NAHF has honored 237 men and women.

Dana was a 40-year veteran of NASA, where he was a test pilot and aeronautical engineer. He died in 2014.

He was one of NASA's first employees, as he started work Oct. 1, 1958 – the same day on which the National Advisory Committee for Aeronautics (NACA) became NASA. The NASA facility was then called the High-Speed Flight Station.

Dana is best known as the project pilot for the rocket powered and hypersonic X-15 research aircraft that he flew to the edge of space. His flight of about 59 miles up later earned him his astronaut wings.

He also flew a number of research aircraft including the HL-10, M2-F3 and X-24 lifting body aircraft. He also flew advanced aircraft including the F-14, F-15, F-18 and the YF-12, the X-29 forward swept wing aircraft and the F-18 High Alpha Research Vehicle. He also served as the center's chief engineer toward the end of his NASA career.

His numerous awards and honors include the AIAA Haley Space Flight Award (1976), the NASA Exceptional Service Medal (1976), induction into the Lancaster Aerospace Walk of Honor (1993), the NASA Distinguished Service Medal (1997) and the Milton O. Thompson Lifetime Achievement Award (2000). He was honored in the "Salute to Test Pilots" at the Experimental Aircraft Association annual convention in 1996.

NASA

William H. "Bill" Dana is best known as the chief pilot of the X-15 rocket powered aircraft program.

DC-8 assists in Germany

DLR/NASA/Friz

NASA's DC-8 "Flying Laboratory" is in Germany for a joint flight campaign to sample clouds, contrails and aircraft emissions. The ongoing research looks at what happens with engine performance, emissions and contrail formation when different types of fuels in jet engines are used. The DC-8 is at left and at right is the Airbus A320-232 'D-ATRA,' the largest member of the DLR research fleet.

News at NASA

Warming trend is continuing

Earth's global surface temperatures in 2017 ranked as the second warmest since 1880, according to an analysis by NASA.

Continuing the planet's long-term warming trend, globally averaged temperatures in 2017 were 1.62 degrees Fahrenheit (0.90 degrees Celsius) warmer than the 1951 to 1980 mean, according to scientists at NASA's Goddard Institute for Space Studies (GISS) in New York. That is second only to global temperatures in 2016.

In a separate, independent analysis, scientists at the National Oceanic and Atmospheric Administration (NOAA) concluded that 2017 was the third-warmest year in their records. The minor difference in rankings is due to the different methods used by the two agencies to analyze global temperatures, although over the long-term the agencies' records remain in strong agreement. Both analyses show that the five warmest years on record all have taken place since 2010.

Because weather station locations and measurement practices change over time, there are uncertainties in the interpretation of specific year-to-year global mean temperature differences. Taking this into account, NASA estimates that 2017's global mean change is accurate to within 0.1 degree Fahrenheit, with a 95 percent certainty level.

C-20A tests hypersonic testbed

By Leslie Williams
Armstrong news chief

NASA and Generation Orbit Launch Services Inc. (GO) in Atlanta have completed the GOLauncher1 (GO1) Inert Test Article (ITA) captive carry flight test program. Under a public-private partnership with Armstrong, GO developed the GO1-ITA, a mass properties and outer mold line simulator for the GO1 hypersonic flight testbed and earned NASA's airworthiness approval for flight on NASA's C-20A.

The C-20A was modified to add a centerline hard point to carry the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) pod. A campaign of three flight tests was conducted, successfully completing all test objectives including clearing the operational flight envelope of the C-20A with the GO1 pod as well as demonstrating a unique launch maneuver designed for air launch of the GO1 on operational flights starting in 2019. Data collected during the campaign will be used to validate models and inform the ongoing design and development of GO1.

The GO-NASA partnership was conducted under a 2015 NASA Space Technology Mission Directorate Announcement of Collaborative Opportunity: Utilizing Public-Private Partnerships to Advance Emerging Space Technology System Capabilities entitled "Technology Maturation and Flight Validation for Air Launched Liquid Rockets." The non-reimbursable Space Act Agreement was signed in April 2016.

"I'm immensely proud of our team and what has been achieved in a very short timeframe," said GO CEO, AJ Piplica. "To go from concept to flight of our company's first flight hardware on a manned aircraft in under two years shows the talent, belief, and sheer force of will that are the trademark of the culture we're continuing to build at GO."

AFRC2017-0339-20 **NASA/Jim Ross**

In the skies above NASA Armstrong Generation Orbit's hypersonic pod is flight tested on the agency's C-20A.

AFRC2017-0339-34 **NASA/Jim Ross**

NASA's C-20A with Generation Orbit's hypersonic testbed attached is chased by the agency's F-18 jet for safety and photography.

He added, "Over the course of this collaboration with NASA, we've learned a great deal from working with the NASA Armstrong team, especially through the flight test operation portion of the collaboration. The culmination of this partnership in the successful flight test campaign has demonstrated the value of the NASA public-private partnership model for supporting the advancement of novel, commercial aerospace technologies."

Generation Orbit Launch Services Inc. is working toward offering fast and dedicated space transportation services for small payloads. The air-launch approach was developed by the company to provide flexible launch capabilities and to reduce fixed infrastructure needs, launch costs, and the time from contract signature to launch.

"This public-private partnership between NASA and Generation Orbit helped to advance a commercial air-launch system for delivering small payloads that will someday benefit the nation's space and hypersonic needs," said Ron Young, program manager for NASA's Flight Opportunities program. "Armstrong's rich heritage to safely fly unique aircraft

GO, page 6

Photography method can compare shockwaves of current aircraft to LBFD

BOOM!

Matt Kamlet
Armstrong Public Affairs

When NASA's next X-plane takes to the skies, it will produce some pretty cool images.

Thanks to the completion of a recent flight test series at Armstrong the agency is a step closer to being able to visually capture the shockwaves of NASA's future Low Boom Flight Demonstration aircraft, or LBFD.

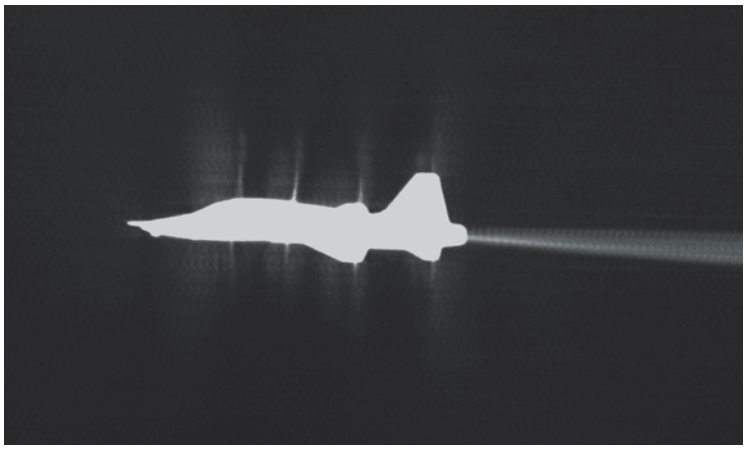
The LBFD will demonstrate the ability to fly at speeds beyond Mach 1 without creating the loud, disruptive sonic boom typically associated with supersonic flight. When this happens, around 2022, imagery to confirm that the future X-plane's shockwaves match NASA's predictions will need to be captured using a technique called schlieren photography.

The technique was used in a series of flights in 2016 called Background Oriented Schlieren using Celestial Objects, or BOSCO, at NASA Armstrong. BOSCO validated the use of a special hydrogen alpha filter and positioned cameras to use the sun as a background to visualize shockwaves from supersonic aircraft eclipsing the sun 40,000 feet from the camera. Placing the cameras on the ground enabled the use of full-sized telescopes, which were used to maximize the size of the sun image on the camera.

However, LBFD will be flying at higher altitudes around 60,000 feet. In order for shockwave data to be captured at a high quality, images will need to be taken at closer range by equipment onboard a chase aircraft. For that reason the photography equipment will need to be small enough to fit in a small wing pod, but still have the capability to take high-quality images of shockwaves.

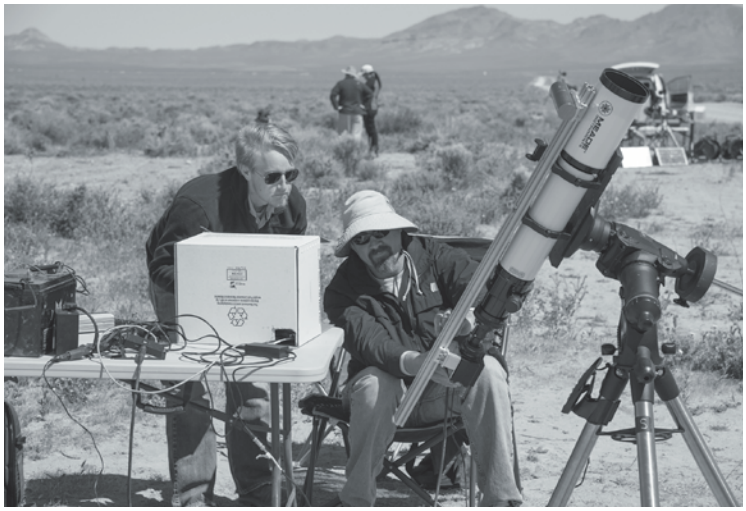
The recently completed second phase of BOSCO flights, or BOSCO II, accomplished just that.

In addition to validating the quality of smaller equipment, BOSCO II successfully applied this photography method from a range of 10,000 feet, similar to the range needed for an air-to-air system when LBFD flies, according to BOSCO II Principal Investigator Mike Hill.



NASA

This schlieren image shows an Air Force Test Pilot School T-38 in a transonic state, meaning the aircraft is transitioning from a subsonic speed to supersonic. Above and beneath the aircraft, shockwaves are seen starting to form. These shockwaves propagate away from the aircraft and are heard on the ground as a sonic boom.



AFRC2017-0084-31 NASA/Lauren Hughes

BOSCO chief engineer Brian Strovers and research engineer Paul Dees calibrate one of three cameras positioned to be able to capture images of supersonic research aircraft. Using a special hydrogen alpha filter, and positioning the cameras to use the sun as a background, NASA researchers are able to observe shockwaves coming off of the aircraft as it flies supersonically.

"The main objective here was to see what the image looks like at close range, including what kind of shockwave structure we can make out," Hill stated. "We needed to use our new compact camera system in order to get an idea of the quality of the images of those shockwaves using a smaller system."

Whenever an aircraft flies supersonic, or faster than the speed of sound, it produces shockwaves that we eventually hear on the ground as a loud sonic boom. This is the driving factor behind the Federal Aviation Administration restriction on supersonic flight over land. NASA, which has conducted decades of supersonic flight research, has worked with Lockheed Martin to complete an initial aircraft design called Quiet Supersonic Technology, or QueSST, which features a mitigation of those shockwaves to sound more like a quiet thump.

NASA intends to demonstrate quieter supersonic flight through the LBFD, and should the quiet thump of the shockwaves prove to be within acceptable limits to the FAA and communities on the ground, according to predicted sound levels, it may open the future to supersonic flight over land on a commercial level, potentially cutting flight times in half.

While NASA has used computational fluid dynamics to predict how those quieter shockwaves will travel through the air, validating these predictions will require researchers to visually observe the shockwaves through schlieren imagery.

"There are different concentrations of hydrogen atoms caused by varying magnetic fields on the sun's surface, and where there's a higher concentration of hydrogen atoms, we see more light, while lower concentration shows less light. The hydrogen alpha filter works by allowing only the wavelength of light emitted by hydrogen on the sun's surface through," Hill explained.

Boom, page 6

Pilots... from page 1

Test Unit, now known as NASA Armstrong. Lilly trained as a Naval aviator and joined the NACA's Langley Memorial Aeronautical Laboratory in Virginia (now known as Langley Research Center) in 1942. In 1943 he transferred to the NACA's Lewis Flight Propulsion Laboratory in Cleveland, (today NASA's Glenn Research Center) and then to Muroc in 1947.

At Muroc he flew the Douglas D-558-1 transonic research aircraft and the Bell X-1. Lilly was the fourth person to exceed the speed of sound. He died May 3, 1948, when components of the D-558-1's engine compressor failed, severing control cables and causing the airplane to crash. He was the first NACA pilot to die in the line of duty.

It was 18 years later when the center lost another pilot. Joseph A. "Joe" Walker was a chief research pilot at the NASA Flight Research Center during the mid-1960s.

During World War II Walker flew P-38 aircraft for the Army Air Force in North Africa. He joined the NACA's Lewis Flight Propulsion Laboratory in Ohio in 1945 (now known as NASA's Glenn Research Center) and transferred to the High-Speed Flight Research Station in 1951.

Walker made the first NASA-piloted X-15 flight March 25, 1960, and flew the aircraft 24 times, achieving its highest altitude (354,300 feet) Aug. 22, 1963; he made the first flight in the Lunar Landing Research Vehicle in 1964 that led to the Lunar Landing Training Vehicle used in Houston to train astronauts to land on the moon. Walker perished June 8, 1966, when his F-104 was caught in the wingtip vortex of a North American XB-70.

In the 1980s, a pilot proficiency flight claimed Richard E. "Dick" Gray.

Gray was an aerospace research pilot at NASA's Johnson Space Center (JSC) in Houston, from 1978 until he transferred to the Ames-Dryden Flight Research Center.

NASA

Joseph A. "Joe" Walker piloted such aircraft as the X-15. He died during a mission piloting the F-104.

NASA

Richard E. "Dick" Gray, seen above with the AD-1 oblique wing experimental aircraft, lost his life during a pilot proficiency flight.

At JSC he was the chief project pilot on the WB-57F high-altitude research aircraft and served as the prime chase pilot in the T-38 aircraft for video documentation of the landing portion of space shuttle orbital flight tests. A Naval aviator, he flew 48 combat missions in F-4s over Vietnam while assigned to squadron VF-111 aboard the USS Coral Sea in 1972.

Gray was fatally injured Nov. 8, 1982, in the crash of a Cessna T-37 aircraft.

X-Press editor Jay Levine contributed to this report.

Boom... from page 5

"This is what gives the sun's surface the granular texture we need to be able to get these images."

The BOSCO II flights were flown using a U.S. Air Force Test Pilot School T-38 aircraft, as well as a NASA F-15. In order to capture accurate images, pilots had to be in a precise location at a low altitude of 10,000 feet, directly between the cameras on the ground and the sun while flying faster than Mach 1.

"This wasn't an easy task for our pilots, but they hit the mark," Commercial Supersonic Technology Sub-project Manager Brett Pauer noted. "In the first series of BOSCO flights, we were trying to hit a spot that was about 300 feet in diameter. For these flights, however, since we had to shoot at a closer range, we needed to hit a spot that is one quarter of that. We're talking about a spot in the sky that's under 100 feet in diameter."

Now that flight tests have confirmed the quality of the images taken on a smaller photography system, and provided insight into how to optimally operate these imaging systems at close range, flightworthy hardware can be developed and integrated into a high-speed NASA chase aircraft to be able to capture similar images when LBFD takes flight.

BOSCO was flown under NASA's Commercial Supersonic Technology project, which operates under the Aeronautics Research Mission Directorate.

GO... from page 4

configurations and Generation Orbit's rapid ability to quickly deliver a flight test article allowed for a significant accomplishment advancement in this commercial capability in a short period of time."

NASA's C-20A is based at Armstrong's Palmdale campus. The aircraft supports missions under NASA's Science and Space Technology mission directorates.

Flights help advance tech to probe planets

By Leslie Williams
Armstrong news chief

How and why did the Earth evolve to be suitable for life, while other planets evolved to be distinctly inhospitable?

Researchers at Southwest Research Institute (SwRI) in Texas aim to address this question through their High-Altitude Electromagnetic Sounding of Earth and Planetary Interiors experiment by probing the crust and interior of the Earth and other planets from the sky.

"The answer to this question has become even more important in recent years, as exoplanets including Earth-sized planets are being detected," said SwRI principal investigator Robert Grimm. "And looking at those planets that are Earth-sized and seeing to what extent they may be Earth-like is going to be a big focus of future space research."

SwRI's experiment measures the electromagnetic waves known as the Schumann Resonances that circle the region between the Earth's ionosphere, an area of an atmosphere that is actively growing and shrinking depending on the energy it absorbs from the Sun, and just above the planet's surface, explained Grimm.

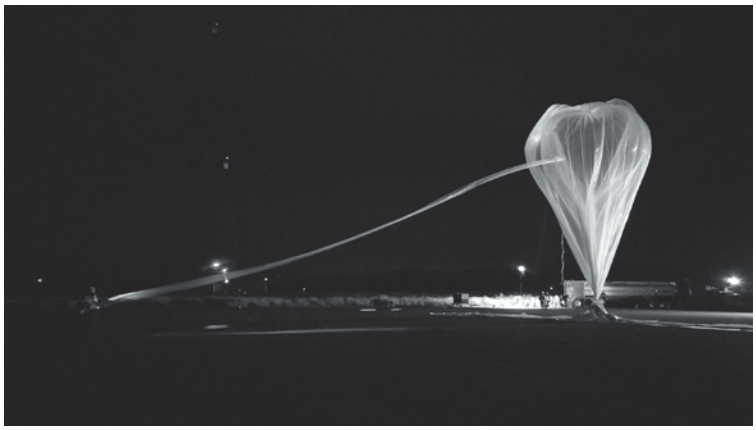


Photo courtesy of World View Enterprises

The World View team prepares their high-altitude balloon at McCall Idaho Municipal Airport to carry Southwest Research Institute technology that may probe other planets.

"By measuring how these electromagnetic waves penetrate into the ground, we can measure the electrical conductivity of the crust and infer its temperature," said Grimm. "And if we can determine the temperature inside Venus [and other planets], then we can understand how its internal heating works and how that might have affected its geological history."

SwRI's experiment is edging closer to this goal thanks to a successful balloon flight in October 2017 facilitated by World View in Arizona and supported by grants from NASA's Flight Opportunities and Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) programs. World View provides stratospheric balloon flights to the edge of space, approximating space-like conditions to give science payloads the relevant environment they need for testing.

Through the Flight Opportunities program, the Space Technology Mission Directorate (STMD) selects promising technologies from industry, academia and government, and provides opportunities for testing and technology demonstration on commercial launch vehicles. The program is managed at Armstrong.

Armstrong research featured in 3 publications

NASA Armstrong research led to new technical publications.

September 2017

John W. Kelly, Charles E. Rogers, Gregory T. Brierly, J. Campbell Martin, and Marshall G. Murphy collaborated on "Motivation for Air-Launch: Past, Present, and Future," AIAA-2017-5231, prepared for the AIAA Space and Astronautics Forum and Exposition, Sept. 12-14, 2017, Orlando, Florida.

Jason A. Lechniak and John E. Melton co-wrote "Manned Versus Unmanned Risk and Complexity Considerations for Future Midsized X-planes," NASA/TM-2017-219541.

November 2017

Tony Chen, Matthew R. Moholt and Larry D. Hudson collaborated on "Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Torus Mechanical Testing," NASA/TM-2017-219431.

Overholt, safety lead, dies

Warren Overholt, an Armstrong lead senior safety specialist, died Jan. 8. He was 63.

He had been employed at Armstrong since September 2013 following his retirement from the U.S. Air Force as a technical sergeant. He provided institutional and facility safety oversight mainly at Armstrong's Building 703 in Palmdale for the Stratospheric Observatory for Infrared Astronomy.

He was known for his professionalism and great sense of humor.

Ng, longtime engineer, dies

Howard Ng, a long time Armstrong engineer, passed Dec. 28. He was 58.

Ng was well known as the long time chief engineer of the F-15B, but he began his NASA career in 1985 on Space Shuttle Program Telecommunications Systems at NASA's Kennedy Space Center in Florida. In 1996 he transferred to Armstrong (then Dryden) to work as an aircraft instrumentation engineer. He retired in 2015 after more than 30 years with NASA.

People who knew him said he was one of the good guys, understanding, honest and displaying integrity and character. He had a good sense of humor, always smiled and never got angry. Ng was known for his professionalism, technical expertise and leadership.

Noterman, engineer, passes

Mark Noterman, a former Armstrong (then Dryden) software engineer, died Dec. 9 He was 65.

Noterman worked at the center for about two decades from the late 1970s to the mid 1990s. He worked for range support contractors Datamax Computer System Inc. and Computer Sciences Corp. as a software engineer supporting systems used for real-time missions.

People who knew him described him as giving, thoughtful, a hard worker, caring, helpful, willing to help others and a do-it-yourself enthusiast.

SAW... from page 1

and use by folding the wings between zero and 70 degrees up and down in flight.

"We wanted to see; can we move wings in flight, can we control them to any position we want to get aerodynamic benefits out of them, and could we do it with this new technology," said SAW Co-Principal Investigator Othmane Benafan. "Folding wings has been done in the past, but we wanted to prove the feasibility of doing this using shape memory alloy technology, which is compact, lightweight, and can be positioned in convenient places on the aircraft."

On subsonic aircraft such as commercial airliners, the potential aerodynamic benefit of folding the wings includes increased controllability which could result in a reduced dependency on heavier parts of the aircraft, including the tail rudder. This may result in a more fuel-efficient aircraft, as well as the ability for future long-winged aircraft to taxi safely in airports. Additionally, pilots may take advantage of a number of different flight conditions, such as wind gusts, by folding the aircraft's wings to adapt to any particular condition experienced in flight.

One of the most significant potential benefits of folding wings in flight, however, is with supersonic flight, or flying faster than the speed of sound.

"There's a lot of benefit in folding the wing tips downward to sort of 'ride the wave' in supersonic flight, including reduced drag. This may result in more efficient supersonic flight," SAW Principal Investigator Matt Moholt said. "Through this effort, we may be able to enable this element for the next generation of supersonic flight, to not only reduce drag but also increase performance, as you transition from subsonic to supersonic speeds. This is made possible using shape memory alloy."

The shape memory alloy is triggered by temperature, and works by using thermal memory in a tube to move and function as an actuator. Upon being heated, the alloy would activate a twisting motion in the tubes, which ultimately moves the wing's outer portion up or down.

NASA Glenn, which developed the initial alloy material, worked closely with Boeing to be able to use the alloy with an actuator in flight.

"The performance of this new alloy that we developed between NASA and Boeing really showed outstanding performance," said Jim Mabe, Technical Fellow with Boeing Research and Technology. "From the time we started initial testing here at Boeing, up to the flight tests, the material behaved consistently stable, and showed a superior performance to previous materials."

To test the technology, NASA turned to Area-I of Kennesaw, Georgia, to operate a remotely-controlled flight testbed called Prototype-Technology Evaluation Research Aircraft, or PTERA. PTERA was designed and built by Area-I, which was also involved in the design and integration of a shape memory alloy-actuated, wing-folding mechanism for the aircraft. The small-scale UAV features extensive flight instrumentation that is ideal for gathering data on SAW, as well as the ability to accommodate newly-designed wings for testing. Area-I personnel also conducted flight operations for the test, allowing NASA and Boeing to focus on the research during the flights.

"PTERA was developed as a flying laboratory, and was used in this flight series to host the SAW experiment," said Area-I CEO Dr. Nicholas Alley. "The intentional in-flight actuation of the outboard wing panels was a historic event, made all the more special as it took place over Rogers Dry Lake, where so much aviation history has been written."

Including a pair of system safety check flights, the SAW test flights were conducted over a two-day period. PTERA took off from the Rogers Dry Lake at Edwards Air Force Base with its wings at a level, zero-degree deflection. The testbed was flown in a large "racetrack" pattern, providing long legs of flight in which the necessary maneuvers for the research could be done. During these maneuvers, onboard controllers heated and cooled the SAW actuators, folding the wing panels to different angles between zero and 70 degrees.

For the first two flights, the wing tips were rigged to fold downward, while later flights featured rearranging the hardware to achieve 70-degree upward deflection. Wing-folding maneuvers were achieved in flight within three minutes each.

Follow-on SAW flights are planned for as early as summer 2018 that will expand the functionality of the SAW system, to be able to fold wings 70 degrees both up and down in a single flight. Tests are also expected to take place at Glenn, where engineers are working to scale up the technology flown on PTERA to be used on the wing of an F-18.

"We put the SAW technology through a real flight environment, and these flights not only proved that we can fly with this technology, but they validated how we went about integrating it," commented Moholt. "We will use the data from these flights to continue to improve upon the actuation system, including speed and smoothness of actually folding the wings, and we'll apply them as we get ready to fly again in 2018."

SAW is an effort within NASA's Convergent Aeronautic Solutions project under the agency's Aeronautics Research Mission Directorate.

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

**Address: P.O. Box 273,
Building 4800, MS 1422
Edwards, California, 93523-0273
Phone: 661-276-3449
FAX: 661-276-3167**

**Editor: Jay Levine,
Logical Innovations, ext. 3459**

Managing Editor: Steve Lighthill, NASA

**Chief, Strategic Communications:
Kevin Rohrer, NASA**

National Aeronautics and Space Administration

NASA Armstrong Flight Research Center
P.O. Box 273
Edwards, California, 93523-0273

Official Business
Penalty for Private Use, $300