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Collaboration

Work advances quiet supersonic technology

AFRC2020-0082-04 NASA/Lauren Hughes

A NASA F/A-18 is towed to the apron at NASA Armstrong during sunrise over Rogers Dry Lake. The F/A-18 was used to test a transmitter for an air navigation system, called the Airborne Location Integrating Geospatial Navigation System, or ALIGNS. This system, designed to allow pilots to position their aircraft at precise distances to each other, will be critical for acoustic validation efforts of the X-59 Quiet SuperSonic Technology demonstrator. *See story, page 2.*

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SCHAMROQ: Prepping the tools for supersonic research

Gracie Awalt
NASA Langley Research Center
Matt Kamlet
NASA Armstrong Public Affairs

Two NASA centers on opposite sides of the country are finding new ways to work together to support the agency's mission to develop quiet supersonic technology, in spite of thousands of miles of distance and a global pandemic.

Using their available labs, NASA's Kennedy Space Center in Florida is building tools in collaboration with NASA's Armstrong Flight Research Center in California, which NASA will use in support of the X-59 Quiet SuperSonic Technology X-plane, or QueSST.

Flying at faster-than-sound speeds over communities around the U.S., the X-59 will demonstrate technology to reduce the loud sonic booms typically heard below aircraft flying at supersonic speeds to a quieter noise similar to a car door closing in the distance. The X-59 will demonstrate to regulators through collected data that quiet supersonic flight is possible.

However, before the X-59 begins community overflights, NASA researchers need to validate the X-plane's acoustic signature through tests.

A project under NASA's Aeronautics Research Mission Directorate called SCHAMROQ, which stands for Schlieren, Airborne Measurements, and Range Operations for QueSST, is preparing the tools and test techniques to execute these tests at Armstrong. When a reduced capacity to develop these tools materialized during the COVID-19 pandemic, Armstrong turned to Kennedy to provide a helping hand, and to help ensure the project's progress.

AFRC2019-0072-06 **NASA/Ken Ulbrich**

A 2019 design of the Shock Sensing Probe, a cone-shaped aeronautical test instrument, extends from the nose of a NASA F-15 aircraft. As the aircraft flies through the shockwaves of a nearby F/A-18 aircraft, the probe, designed to capture high-quality measurements of shock waves created by supersonic aircraft in flight, used five "pressure ports" to measure the pressure on the surface around the instrument, which is shaped like a cone. This method will help NASA validate the acoustic signature of the X-59 Quiet SuperSonic Technology X-plane.

"It's neat working with a space center," said Matthew Moholt, deputy project manager for SCHAMROQ. "Their willingness and eagerness to help out a sister center is welcomed and appreciated. When you have another center willing to help out and do critical work that's critical to your schedule, that's really significant."

During supersonic flight, planes create shockwaves that merge together as they travel through the air to produce the sonic boom. Moholt says SCHAMROQ aims to build and test multiple tools to help researchers observe and validate these same shockwaves during quiet supersonic flight.

These tools include the Shock Sensing Probe, a device that will evaluate the characteristics of the X-59's shockwaves while in flight, a schlieren photography technique to visualize the X-59's shockwaves as they distort light through a camera, and a navigation software that will allow pilots to fly accurately during X-59 tests.

Moholt said all of this technology will be placed on a NASA F-15 research aircraft, which will take on the role of a chase plane, following the X-59 in the sky during flight tests to collect data.

"We have this big effort to instrument and put all the research systems into the F-15 that allows it to fly all of these technologies," Moholt said. "As the pandemic hit, it was right in the peak of getting instrumentation wiring put through it so that all of our instrumentation systems could get put in and our electronic fabrication shop was impacted by that."

This SCHAMROQ technology needs to be tested to ensure it can withstand the demands of supersonic flight while onboard NASA's F-15. Deputy instrumentation lead Matthew Waldersen said part of the testing process requires the usage of a network switch with cables – similar to an ethernet network, but for airplanes.

Waldersen explained to help ensure the project remained on schedule Kennedy Space Center was contacted to build cables for the network switch.

"We reached out to their branch chief and they said 'yeah, we want to take this work on,'" Waldersen recalls. "'We have the capacity, we've got the staff, we've got the ability to do it,' so this is fantastic."

Jeff Crisafulli, branch chief of testing and design in Kennedy Space Center Engineering, said Kennedy identified onsite subcontractors capable of building these cables.

"These are highly skilled technicians with 25-30 years of experience fabricating and designing the NASA way," he said. "They're part of the team."

Each center at NASA has their own unique skillsets that they bring to the table and that it is good to share knowledge, Crisafulli said. This collaboration between an aeronautics center like Armstrong and a space center like Kennedy reinforces one of NASA's goals – working together for the benefit of the future.

"This is a unique opportunity to help out our buddies at Armstrong by providing this fabrication service," he said. "It goes back to the 'One NASA' idea – we are 'One NASA.' This is a good example of pathfinding and opening up the door to some potential future work together."

F/A-18: Power and grace

AFRC2018-0287-070 **NASA/Carla Thomas**

The NASA F/A-18 aircraft, such as the one above, exudes power and grace in flight. Based at NASA Armstrong, the agency uses these aircraft to support research of all types. Sometimes the aircraft carry an experiment on board, such as when a radar system potentially destined for use by a Mars lander was tested. Other times the aircraft is used to "chase" different types of research aircraft to provide another set of eyes on what's happening and/or to capture images and video. In the case of this image, this F/A-18 is seen taking off from Ellington Field near NASA's Johnson Space Center in Houston. During a series of flights over Galveston, Texas in 2018, NASA's F/A-18 flew a number of well-scripted trajectories to generate sonic booms that were quieter than normal. The quiet sonic thumps were aimed at the Gulf Coast community to see if residents below could hear them. The research was part of NASA's Low-Boom Flight Demonstration Mission that will include use of the X-59 Quiet SuperSonic Technology airplane now being assembled in Palmdale.

Congratulations!

NASA Armstrong staff members were awarded NASA Awards at the virtual event Nov. 18. For a full list of the winning teams and individuals, checkout the details in the brochure developed by Kirstin Sharrer, with cover art by David Faust. It is located on the Xnet at https://afrcshare.ndc.nasa.gov/Shared%20Documents/HonorAwards2020EProgram.pdf

News at NASA

Dragon reaches station

SpaceX's upgraded cargo Dragon spacecraft was on its way to the International Space Station after launching atop a Falcon 9 rocket from Launch Complex 39A at NASA's Kennedy Space Center in Florida Dec. 6.

The first launch for SpaceX under NASA's second Commercial Resupply Services contract, CRS-21 will deliver supplies, equipment, and materials to directly support dozens of the more than 250 science and research investigations that will occur aboard the orbiting laboratory during Expeditions 64 and 65.

Included in this delivery is the Nanoracks Bishop Airlock, the first commercially owned and operated airlock that, once installed, will provide a variety of capabilities to the space station, such as payload hosting, robotics testing, and satellite deployment. It also will serve as an outside toolbox for crew members conducting spacewalks.

Dragon arrived at the space station Dec. 7. The spacecraft autonomously docked to the station's Harmony module – the first automated docking for a SpaceX cargo resupply mission. NASA astronauts and Expedition 64 flight engineers Kate Rubins and Victor Glover monitored docking operations.

Dragon, page 8

AAM Dry Run Tests begin

By Teresa Whiting
NASA Armstrong Public Affairs

Imagine air taxis, drones, cargo transports and package delivery services working in harmony in the National Airspace System with piloted aircraft. That's a vision NASA's Advanced Air Mobility (AAM) National Campaign and the Federal Aviation Administration (FAA) are working to achieve.

Over the next decade, the National Campaign will be researching, executing flight demonstrations, and establishing partnerships for urban air mobility (UAM) vehicles, or electric powered vertical takeoff and landing vehicles (eVTOLs) in order to safely enable eventual integration with existing air traffic.

NASA and the FAA intend to collaborate throughout all stages of the National Campaign, from planning and scenario validation to execution of flight demonstrations. The data and lessons learned from the National Campaign will help inform FAA policies and procedures that industry will follow to fly these various sized vehicles and diverse missions on a daily basis.

The purpose of the National Campaign (NC) is to eventually test vehicles and UAM airspace providers from various companies. Another focus is determining how cities, airports and overall infrastructure can support this type of passenger transport and cargo delivery.

This flight-testing series began the first week of December with the NC Integrated Dry Run Test using a helicopter as a surrogate UAM to develop a data baseline for future industry partnership flight testing. These flights will ensure a developmental test can be successfully conducted with a vehicle partner.

AFRC2020-0107-089 NASA/Ken Ulbrich

The Advanced Air Mobility National Campaign project conducted connectivity and infrastructure flight tests with a NASA TG-14 glider aircraft at NASA Armstrong Sept. 30-Oct. 1.

Flight Research Inc.

This Bell OH-58C Kiowa helicopter is owned by Flight Research Inc. in Mojave, California. It is scheduled to fly at NASA Armstrong during the Advanced Air Mobility project's National Campaign's NC Integrated Dry Run Test in December.

"The National Campaign is trying to verify the gaps in the current FAA standards that scaling eVTOLs operations can't yet meet," said Starr Ginn, AAM National Campaign lead. "We are putting these vehicles through the FAA standards for operations that currently exist. That is our measuring stick."

Flight Research Inc. in Mojave, California, will provide the Bell OH-58C Kiowa helicopter for the series of tests where FAA and Flight Research Inc. test pilots will fly different maneuvers to act as a "surrogate" UAM.

The data collected from the three series of flight tests at NASA Armstrong will be looking at overall challenges the urban environment will present for future vehicles. Included in this analysis are vehicle characteristics, the interactions with a third-party airspace service provider, wind conditions, flight path angles, heliports, vertiports, current FAA tools, and navigation systems. This flight test series will continue into early 2021.

"The dry run is NASA testing our flight test infrastructure which consists of range safety, instrumentation, airspace integration and data collection," Ginn said. "As the NASA subsystems mature, they will be tested at different phases of the dry run series where the final test in March will test the full end-to-end system."

The project describes the process as "anchor and evolve" – the helicopter represents the anchor of current FAA standards required for helicopters to fly today. Testing with industry will then evolve from these standards to mimic what an eVTOL will need to safely fly.

During the flight testing, test pilots will be flying the helicopter in ways based on how the project thinks eVTOLs will fly in the future. This includes flying terminal operations with representative real-time eVTOL flight plans and trajectories while testing interactions with a third-party airspace service provider.

"The industry and world will see we are not creating something new; we are evolving standards so urban air mobility can become a viable market," said Dave Webber, FAA research flight test engineer and vehicle characteristics principal investigator for this project.

In early October, the project conducted connectivity and infrastructure flight tests with a NASA TG-14 glider aircraft to prepare for December. In addition to assessing automatic dependent surveillance broadcast connectivity to the cloud and data processing system, these flights acted as a familiarization exercise for the test pilots who will fly the same routes during the helicopter test. The team also painted a vertiport and helipads at Armstrong to help understand the future infrastructure needs.

Alaka'i Technologies

Alaka'i Technologies' vertical takeoff and landing vehicle (eVTOL) air taxi called Skai is powered by hydrogen fuel cells.

Wisk

This is Wisk's autonomous all-electric vertical takeoff and landing vehicle (eVTOL) air taxi.

New partners join AAM National Campaign

By Teresa Whiting
NASA Armstrong Public Affairs

NASA's Advanced Air Mobility (AAM) National Campaign (NC) and the Federal Aviation Administration (FAA) are working to achieve harmony in the national airspace system by helping to integrate new aircraft.

The project is partnering with industry to test inventive urban air mobility (UAM) vehicles, or electric-powered vertical takeoff and landing vehicles (eVTOLs), to see how these industry-developed designs can safely interact with other air traffic in the future.

"Our vehicle partnerships are critical to NASA and the industry success in AAM," said Davis Hackenberg, AAM mission integration manager. "These partnerships are the cornerstone of our data collection that will support standardization, certification and eventually the operational approval for safe and scalable UAM operations."

Wisk and Alaka'i Technologies signed information exchange agreements with NASA this year, which establish mutually beneficial relationships to accelerate AAM operations as part of NASA's National Campaign. Both partners now join other industry partners to prepare for the first National Campaign (NC-1) beginning in 2022 with intent to assess operational safety scenarios focused on their respective automation and vehicle designs.

Wisk's all-electric eVTOL air taxi and Alaka'i's eVTOL air taxi called Skai, are intended to be demonstrated during this series of flight testing and evaluation. Wisk's partnership with NASA is designed to emphasize their experience in eVTOL vehicle development and flight test, with a focus on a safety-first mindset toward advancing autonomous flight. Alaka'i brings new technologies that are highlighted by an eVTOL aircraft powered by hydrogen fuel cells.

The NC Integrated Dry Run Test in December is the first step of this campaign, which will use a helicopter as a surrogate UAM to develop a data baseline for future flight testing.

Following this testing, the developmental test in 2021 using partner Joby Aviation's air taxi design will include activities such as designing flight scenarios for the participants to fly, exercising range deployment and data collecting protocols to prepare for NC-1 in 2022.

These partners will focus on demonstrating integrated operations through flight activities with vehicles and third-party airspace service providers at various locations in the national airspace system around the country. Both types of vehicle designs and propulsion systems will enable the National Campaign to continue its mission of engaging with diverse vehicle developers and manufacturers in emerging aviation markets for passenger and cargo transportation in urban, suburban, rural and regional environments.

Moving into December this series of helicopter testing will kick things off for the project and allow for the next building blocks of the National Campaign, the Developmental Test in 2021 and NC-1 in 2022.

The Developmental Test with partner Joby Aviation will include activities to prepare for NC-1 such as designing flight scenarios for the participants to fly, exercising range deployment and data collection protocols.

For NC-1, industry partners will focus on demonstrating integrated operations through flight activities with vehicles and third-party airspace service providers at various locations in the national airspace system around the country.

The integrated operations will allow collection of data from both the vehicle and airspace service providers as the aircraft performs approaches and departures in a number of conditions. In addition, these demonstrations will enable communities and local governments to further understand these operations through assessment of the noise footprint of these new vehicles.

This project includes members from three NASA aeronautics centers including Armstrong and Ames Research Center in California and Langley Research Center in Virginia with leadership by NASA's Aeronautics Research Mission Directorate.

AFRC2020-0107-089 NASA/Ken Ulbrich

A worker painted vertiports and helipads at NASA Armstrong Oct. 6-14. The Advanced Air Mobility project's National Campaign will use these areas for future flight testing.

NASA's vision for Advanced Air Mobility is to help create safe, sustainable, accessible, and affordable aviation for a number of uses at the local and regional level.

In the early phase of the pilot breathing research in 2018, NASA research pilot Jim Less is fitted with a VigilOX oxygen monitoring system. The NASA Jet Propulsion Laboratory in California prototype mask was tested in conjunction with this current VigilOX system, which measures the pilot's oxygen concentration, breathing pressures and flow rates at NASA Armstrong.

AFRC2018-0104-09 **NASA/Carla Thomas**

In the cockpit

It's a matter of life and breath

By Teresa Whiting
NASA Armstrong Public Affairs

The second and final phase of NASA's Pilot Breathing Assessment (PBA) program to analyze pilot breathing in high-performance fighter jet aircraft is now complete.

The program began with phase one in early 2018, and involved five pilots, four aircraft, two aircrew equipment configurations and approximately 90 hours of flight at NASA Armstrong.

Phase two started in fall 2019, and the program added an additional 50 flight hours. The research pilots primarily flew F-18 A/B aircraft to eliminate variables between jets, and the group refined data collection procedures, equipment and sensors.

"This study is focusing on how a pilot's physiology and the jet's oxygen system interact," said research pilot Jim Less. "There isn't a lot of data available on this and pilots are having an increased number of unexplained physiological incidents."

The NASA Engineering and Safety Center (NESC) at NASA's Langley Research Center in Virginia formed the group to gather missing pilot breathing data. The team believes this data collection is key to explaining the rising number of physiological challenges flyers experienced in the cockpits of U.S. Navy and U.S. Air Force jets since 2010.

When fighter jet aircraft like NASA's F-18 A/Bs and F-15Ds take to the skies, pilots wear oxygen masks and other equipment to help the pilots breathe at high altitudes and when making high g-force turns. While flying a variety of scenarios, the extent to how well the pilot's lungs are transmitting oxygen to the brain can fluctuate, which can sometimes result in a physiological episode (PE). A PE can include cognitive impairment, numbness, tingling, lightheadedness, behavioral changes and fatigue, which may be life threatening for a pilot.

Several milestones were added to phase two, which focused on refined methods to gather data from Navy and Air Force oxygen mask regulator systems and in testing cabin pressure in the F-18 A/B.

The PBA program uses two aircrew equipment configurations of oxygen mask regulator systems, one from the Air Force and the other from the Navy to gather appropriate data. The team was able to test both types with more flights on the F-18 A/B aircraft for direct comparison. The two configurations behave differently and when reviewing the data the team noticed several advantages to using the Air Force version.

In addition to oxygen regulators the pilot wears while flying, fighter jets have built-in cabin pressure regulator systems. These systems maintain the proper cabin pressure while in flight.

NASA research pilot Wayne Ringelberg wears a U.S. Air Force configuration of the NASA Jet Propulsion Laboratory in California prototype mask.

AFRC2020-0083-05 NASA/Carla Thomas

NASA research pilot Jim Less wears a U.S. Navy harness configuration with the NASA Jet Propulsion Laboratory in California prototype mask.

AFRC2020-0086-04 NASA/Carla Thomas

The pilots noticed fluctuations while flying and these changes in pressure on the pilot's body and regulator can cause unexpected interactions. An experiment was designed to de-pressurize the cabin to remove cabin pressure as a testing factor. Then the results were compared to a flight with the cabin pressurized to see how it affected the pilot.

Standardized Test for Pilot Breathing

As a result of the pilot breathing studies, the team is developing a standardized breathing system flight profile for other organizations to use in the future. The team hopes this can serve as a starting point for testing pilot breathing systems on new aircraft, for troubleshooting problems on existing aircraft, and for confirming systems are fixed after maintenance is performed.

Currently, individual components of a breathing system are checked separately on the ground, but there is no end-to-end check of the complete system to make sure it is delivering the proper pressure and concentration of oxygen to the pilot.

NASA's Jet Propulsion Laboratory (JPL) Oxygen Mask

JPL scientists in Pasadena, California, have been developing laser sensor systems for spacecraft to measure the concentration of different gasses in the atmosphere. The project partnered with JPL to see if this technology could be miniaturized and put into an oxygen mask.

This new mask uses laser sensors to determine levels of carbon dioxide and water exhaled inside the mask. The mask was tested in conjunction with the current VigilOX system, which measures a number of key parameters including the pilot's oxygen concentration, breathing pressures and flow rates. The VigilOX system data is collected in two small boxes, one at the beginning of the inhalation tube and the other at the end of the exhalation tube that connect to the pilot's mask. The mixing of gases in the tube inevitably leads to a less accurate data reading than measuring directly from a pilot's mouth. The JPL in-mask sensors gather data directly in the pilot's mask to get the most accurate readings possible.

Pilot Variables

Many variables go into one flight test. Pilot variables can include rest, exercise, diet, hydration, or how often the pilot flew that week, which can all affect the data outcome. During this study, research pilots were subject to pre-and-post flight surveys that ask questions such as what they ate for breakfast, if they exercised, and if they noticed breathing differences in flight.

In phase two, the team continued to rely heavily on the NASA Armstrong Life Support team to prepare pilots for flight with all equipment needs and to gather appropriate data. Life support continued to have the pilot complete spirometry, capnography, and pulse oximetry tests twice before and after each flight.

A spirometry test, measures how much air the pilot can breathe out by exhaling as forcefully and as long as they can. Capnography monitors the pressure of carbon dioxide. A separate device monitors the pilot's pulse, oxygen saturation in their blood, breathing patterns and blood hemoglobin. The tests are repeated post-flight to measure and compare breathing patterns to identify any changes.

Flight testing is complete and now the NESC will publish a report from the data from both phases. Researchers will compare data among pilots, flights, configurations, aircraft performance and look for patterns or unexpected results that may help researchers understand the causes of a PE. The team hopes others will use the results in the future and for more research to continue.

"About 100 flights or so is not a lot of data compared to the thousands of hours military aircraft are flying," Less said. "Our team learned a lot about pilot breathing needs and complex systems interactions, but we only scratched the surface with this study, and there is still work to be done."

Dragon... from page 3

Cargo Dragon's arrival at the space station marked the first time two Dragon spacecraft were docked to the orbiting laboratory at the same time. The Crew Dragon spacecraft, named Resilience, that brought the Crew-1 astronauts has been docked since its arrival on Nov. 16.

The cargo Dragon spacecraft will remain attached to the space station for about one month, after which it will return to Earth with 5,200 pounds of research and return cargo, splashing down in the Atlantic Ocean.

NASA/Kim Shiflett

A SpaceX Falcon 9 rocket lifts off from Launch Complex 39A at Kennedy Space Center in Florida on Dec. 6, carrying the uncrewed cargo Dragon spacecraft on its journey to the International Space Station for NASA and SpaceX's 21st Commercial Resupply Services (CRS-21) mission. Dragon will deliver more than 6,400 pounds of science investigations and cargo to the orbiting laboratory. The mission marks the first launch for SpaceX under NASA's CRS-2 contract.

Radish plants grown on space station

By Linda Herridge
NASA Kennedy Space Center

NASA astronaut Kate Rubins harvested radish plants growing in the Advanced Plant Habitat (APH) aboard the International Space Station Nov. 30. She meticulously collected and wrapped in foil each of the 20 radish plants, placing them in cold storage for the return trip to Earth in 2021 on SpaceX's 22nd Commercial Resupply Services mission.

The plant experiment, called Plant Habitat-02 (PH-02), is the first time NASA has grown radishes on the orbiting laboratory. NASA selected radishes because they are well understood by scientists and reach maturity in just 27 days. These model plants are also nutritious and edible and are genetically similar to *Arabidopsis*, a small flowering plant related to cabbage that researchers frequently study in microgravity.

"Radishes are a different kind of crop compared to leafy greens that astronauts previously grew on the space station, or dwarf wheat which was the first crop grown in the APH," said Nicole Dufour, NASA APH program manager at NASA's Kennedy Space Center in Florida. "Growing a range of crops helps us determine which plants thrive in microgravity and offer the best variety and nutritional balance for astronauts on long-duration missions."

The structure of the experiment will allow NASA to identify the optimum balance of care and feeding needed to produce quality plants. While growing inside the habitat, the radishes required little maintenance from the crew.

Unlike previous experiments in NASA's APH and Vegetable Production System (Veggie), which used porous clay material preloaded with a slow-release fertilizer, this trial relies on precisely defined quantities of provided minerals. Such precision allows for a better comparison of nutrients provided to and absorbed by the plants.

The chamber also uses red, blue, green and broad-spectrum white LED lights to provide a variety of light to stimulate plant growth. Sophisticated control systems deliver water, while control cameras and more than 180 sensors in the chamber allow Kennedy researchers to monitor the plant growth as well as regulate moisture levels, temperature, and carbon dioxide (CO2) concentration.

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