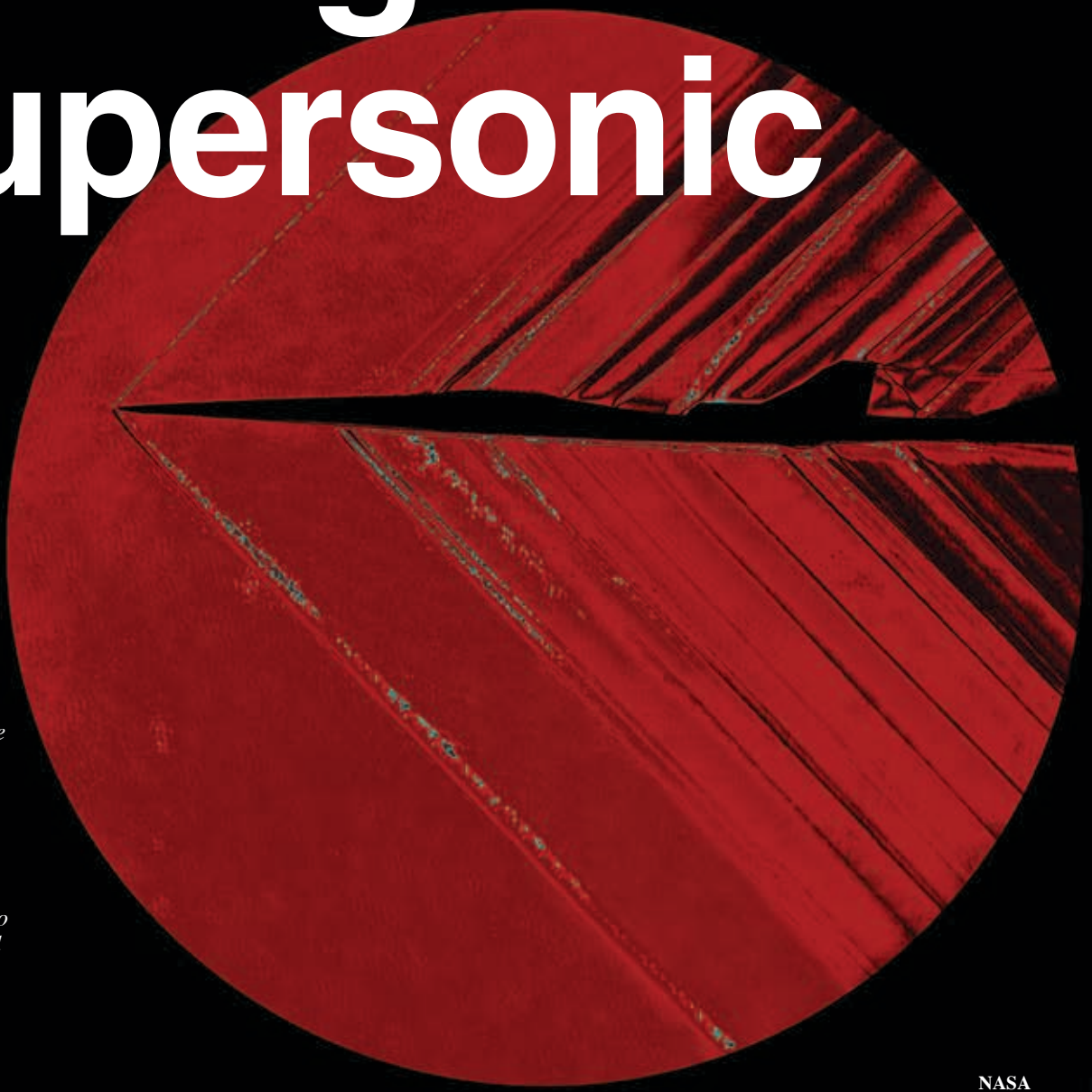
National Aeronautics and Space Administration

X-PRESS

Volume 64 Number 1 January 2022

Seeing Supersonic



This is a schlieren image of the X-59 small-scale model, captured inside the 8- by 6-foot Supersonic Wind Tunnel at NASA's Glenn Research Center in Cleveland. These images are used to predict sonic booms and verify computer-based modeling. *See page 2.*

Seeing shock waves

Wind tunnel helps visualize technology

By Doreen Zudell
with Jimi Russell
NASA Glenn Research Center

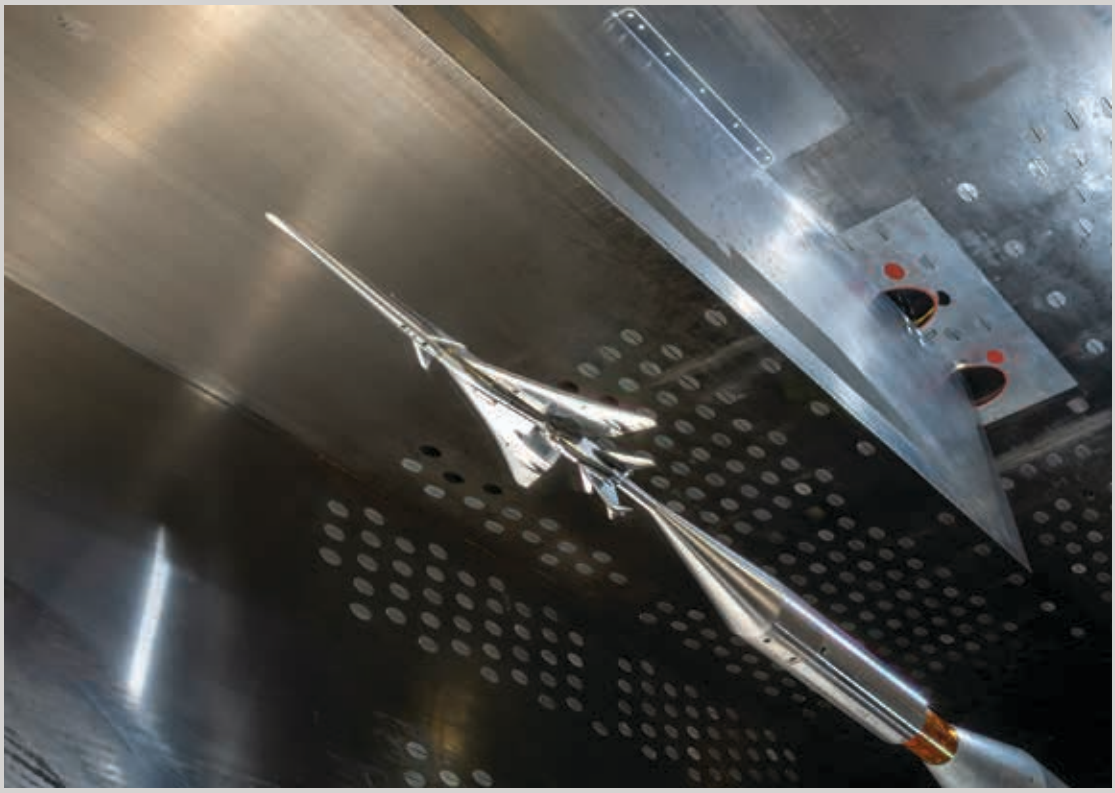
NASA hopes the ban on commercial supersonic flight over land can be lifted by replacing the loud sonic boom with a softer sonic "thump." A sonic boom happens when the shock waves from an object traveling through the air faster than the speed of sound merge together before they reach the ground. Sonic booms generate enormous amounts of sound energy, about 110 decibels, like the sound of an explosion or a thunderclap.

Through the unique design of the X-59 Quiet SuperSonic Technology (QueSST) airplane, NASA aims to reduce the sonic boom to make it much quieter.

Engineers with the agency's Commercial Supersonic Technology (CST) project recently used a small-scale model of the X-59 in NASA Glenn's 8- by 6-foot Supersonic Wind Tunnel to visualize the agency's boom-reducing technology and validate its boom-predicting capabilities.

"This is the team's opportunity to get data at the low sound levels produced in the tunnel," said Clayton Meyers, deputy project manager of the CST project. "It all comes down to our ability to measure the thump."

The model – measuring about a foot and a half in length – was subjected to weeks of testing in the tunnel, producing shock waves that were captured by special cameras mounted outside the test section and by a unique sensor array inside. The unique schlieren images from the cameras provide engineers with a visualization of the shock waves and their positions as air passes around the model. The sensor provides detailed measurement of the strength of the shocks. Results from the tests are encouraging, as the shock waves produced by the model were a match, in both position and strength, to those from earlier computer models for quieter supersonic flight.



NASA/Glenn Research Center

The X-59 small-scale model is seen in NASA Glenn's 8- by 6-foot Supersonic Wind Tunnel. The model was inverted with the shock wave sensor array mounted on the tunnel's ceiling.

Schlieren imagery and pressure measurement are critical to NASA's ability to compare wind tunnel data with computer modeling. These capabilities improve the team's capacity to understand and predict actual sonic thumps during future X-59 flights. NASA has developed schlieren imaging capabilities for flight that will also be used during upcoming flight campaigns.

"With the X-59, we want to demonstrate that we can reduce the annoying sonic booms to something much quieter, referred to as 'sonic thumps,'" said John Wolter, lead researcher on the X-59 sonic boom wind tunnel test. "The goal is to provide noise and community response data to regulators, which could result in new rules for overland supersonic flight. The test proved that we don't just have quieter aircraft design, but that we also have the accurate tools needed to predict the noise of future aircraft."

The model will travel to Tokyo in March for additional wind tunnel verification testing with the Japan Aerospace Exploration Agency and Boeing.

NASA and Lockheed Martin are currently finalizing the build of the X-59 at the Skunk Works facility in California. In late 2022, NASA and Lockheed Martin will begin initial flight tests to prove airworthiness. Following flight testing, NASA will then verify that the aircraft's quiet supersonic technology performs in flight as designed before transitioning to the community overflight phase.

Lockheed Martin

NASA's X-59 Quiet SuperSonic Technology aircraft (QueSST) is pictured here at Lockheed Martin Skunk Works in California, wrapped up in preparation for its move to Texas. The X-plane will undergo ground tests to ensure it can withstand the stresses of flight before returning to California for completion.

X-59 arrives in Texas for tests

By Matt Kamlet
NASA Armstrong Public Affairs

2021 saw significant milestones achieved in the assembly of NASA's X-59 Quiet SuperSonic Technology aircraft (QueSST), and all eyes now look forward to a pivotal 2022. Following the X-plane's temporary move from Lockheed Martin's Skunk Works in California to their facilities in Texas, the X-59 is set to start 2022 with critical ground testing, as progress continues toward NASA's target of the aircraft's first flight later this year.

While in Texas, ground testing of the X-59 will be done to ensure the aircraft can withstand the loads and stresses that typically occur during flight. The team will also calibrate and test the fuel systems before the X-59 makes the journey back to California for more tests and completion.

The X-59 is designed to reduce the loudness of the sonic boom, which occurs when an aircraft flies faster than the speed of sound, to a gentle, quiet sonic "thump." The X-plane will demonstrate this in flights over communities around the U.S. starting in 2024, as NASA collects data that could open the future to commercial supersonic flights over land.

Want to keep up? Subscribe to the NASA Explore newsletter and NASA specialty publications at: https://go.nasa.gov/3r20wkl

This artist's conception of the James Webb Space Telescope in space shows all its major elements fully deployed. The telescope was folded to fit into its launch vehicle, and then was slowly unfolded over the course of two weeks after launch.

NASA GSFC/CIL/Adriana Manrique Gutierrez

News at NASA

Drone provides 'volcano forecast'

By Abby Tabor
NASA Ames Research Center

The ability to provide a "volcano forecast" could help reduce the significant health, safety, and even economic impacts of eruptions; they regularly disrupt aviation and the global supply chain. Last fall, circling the summit of an active volcano, a small aircraft showed a future where remote but hazardous volcanoes are consistently monitored for signs that an eruption could be brewing.

This unmanned aircraft system, or UAS, commonly known as a drone, was specially designed for scientific uses in challenging environments and then upgraded to become an airborne volcano-observing platform. With flights to Makushin Volcano in Alaska's Aleutian Islands in September 2021, a group of federal scientists and industry engineers demonstrated the UAS could successfully fly without its pilots' eyes on the aircraft. That opens new possibilities for monitoring volcanoes and other hazards worldwide.

Out-of-sight flights

Sending researchers on foot or piloted aircraft to survey volcanoes up close can be dangerous and costly. It's also

Drone mission, page 7

Mentors guided my early career

What I learned influenced my approaches to work

Guest column

Paul Reukauf
Former center project manager

EC04-0095-38 NASA/Tom Tschida

Paul Reukauf, third from left, had a dynamic career for industry and NASA. He attributes a lot of his success to his early mentoring at the center.

In March 1967 I was hired by the NASA Flight Research Center (now Armstrong) as an engineering student trainee, or co-op, from the Northrup Institute of Technology. Three other co-ops from Northrup were Glenn Sakamoto, Alex Sim, and Louis Steers. A few days before I started, Glenn drove me out to the center and introduced me. The most important person I met that day was Dean Webb, who helped all the co-ops find housing and gave great advice on how to get along at the center.

I was initially assigned to the X-15 Project Office under Bill Grey. Bill was a retired test pilot and was the father of future NASA Dryden research pilot, Dick Grey. In the beginning, I spent most of my time reading material concerning the X-15 program.

NASA was getting ready for its first flight of the XB-70 triple sonic airplane, which took place on April 25, 1967, just 12 days after my 20th birthday. The XB-70 Project Office needed help, so I was reassigned to Bill Andrews, the project manager. The project office was located down the ramp near the weight and balance hangar. There was still a complement of North American Aviation and U.S. Air Force personnel seated in the same area as the project office. I worked mostly with Dick Klein, the project engineer. He had me hand-plotting the data from the first flight. The data were of great interest to the pilots, Fitz Fulton and Don Mallick, as well as the research engineers supporting the project.

Two of the more colorful characters were Tom Raczkowski, the crew chief, and Ron Waite, the operations engineer. They shared an office and would periodically get into rather heated discussions that could be heard all over the building. During one such interchange Tom, who was tall with a strong build, put an end to the conversation by stuffing Ron into a waste basket! I spent the rest of my three-month tour plotting data from that first flight. Automated data plotting was still years into the future.

My second co-op tour began in January of 1968, and I was again assigned to the XB-70 Project Office. I continued plotting data with Dick Klein, but I also started to keep track of the health of the propulsion instrumentation for the propulsion researchers. The XB-70 had a massive amount of instrumentation, with the mixed-compression inlet performance being of specific interest for the future U.S. supersonic transport (SST), which was under contract with Boeing. For this aspect of my job, an instrumentation technician, Bob Vieth, was a great help. He could be relied upon to troubleshoot and fix almost any problem with the static and total pressure ports in the inlet, as well as on the big rakes in front of the engine faces. The inlets were so large that I could stand up at the engine face. The propulsion research engineer I worked the most with was Ron Smith, a very genial and fun-loving person. He was highly interested in inlet air turbulence and the distortion it caused at the engine face. This was a high frequency phenomenon and required high response pressure measurements. Ron was able to explain the reasons why the data were important in a way that encouraged me to want to learn more about the fundamental science involved in mixed compression inlets. That experience certainly made obvious the importance of junior- and senior-level college courses in gas dynamics and propulsion.

Shortly after arriving for my second tour, I started dating Sharon McCartney, who worked in personnel. After a whirlwind romance, we were married in May of that year. Another propulsion engineer, Henry Arnaiz, became a good friend and convinced me that I should transfer to his alma mater, Cal Poly Pomona. Because there was not a co-op program at that university, I had to resign from NASA in September 1968. I then went to college full time and graduated in June of 1970 with a bachelor's degree in aerospace engineering. During my last quarter, I applied for employment at NASA and Propulsion Branch Chief Bill Schweikhard hired me.

By the time I graduated from college, the XB-70 Project ended and the airplane was delivered to Wright Patterson Air Force Base in Ohio. Meanwhile, a new joint project with the Air Force was

Paul Reukauf, page 7

It begins with a single step

The view from here

Jay Levine
NASA Armstrong X-Press editor

As it turns out, pizza, burgers, and chocolate are terrible companions for weight loss. I decided to meet some new friends called celery, carrots, and apples, and ramp up my exercise. I now have a winning team and I have shed more than 70 pounds.

On July 2, I became highly motivated when I woke up gasping for air in a dark hospital room following two procedures to dislodge and remove a large kidney stone. I was at the highest weight of my life, which added to my misery. It was the third surgery in six months, as I had my hands repaired from carpal tunnel damage.

As I recovered at home from the latest surgery, I struggled with intense pain walking across the room and an aviary was circling my head when the stars and planets were not. It was a low point in a year of low points. Then I did what I always do when adversity arises. I took a day to put my thoughts in order and then I came up with a plan.

I knew some of what I had to do to change my diet from a previous failed weight loss attempt. I also knew I had to start small with obtainable goals, and I began walking to the mailbox twice a day, every day. I was huffing and puffing, hunched over and sore. I paused at the mailbox before making what felt like a considerable journey back to the couch. As the days passed I went to the corner, then around the block and I added to the walk each week. I started to feel better.

Another trademark of mine is to do too much too soon. I had to reduce my steps a few times as I learned where my limits were following the surgery. I was beginning to lose weight, but it was slow. I knew that I was going to have to work on what I was eating to accelerate my weight loss.

Photo courtesy of Carla Levine

A journey of shedding more than 70 pounds began with a single step.

Through Carla's (my wife) insurance, we had access to weight loss programs, and we joined together. Many healthcare plans offer access to resources that educate and reinforce nutrition and portion sizes. These programs also provide a support network. For those who do not have that option, they can ask a friend or relative to walk. It is easier with a partner that provides encouragement and to consult when it is the hardest.

I knew I felt much better after losing the first 20 pounds. I was more agile, I stopped huffing and puffing, my balance was better, I had clarity of thought, and my clothes were loose. I didn't really think a lot about the changes until I returned home from a shopping trip. I was stretching to lift the heavy bags of groceries onto the counter when my previously tight shorts fell to my shoes. It was clear I was making progress.

I continued working hard each

Single step, page 8

Resources to help you

NASA Armstrong employees ready to take the first steps to better health don't have to do it alone. The Employee Assistance Program provides consultation, counseling, referral, and educational resources to all employees and their dependents.

- EAP is confidential and free of charge.
- For more information, or to schedule an appointment, contact Ashley Prueitt at 661-802-8359, or Ashley.D.Prueitt@nasa.gov
- Additional resources and information are available on the NASA Armstrong internal website: https://afrcshare.ndc.nasa.gov/Orgs/XM/EAP/Pages/Org2Layout_fw.aspx

NASA/Graphics

Several projects under NASA's Advanced Air Mobility, or AAM, mission are working on different elements to help make AAM a reality in emergency operations. This concept graphic shows how a future AAM vehicle could aid in disaster response.

AAM emergency role near

By Teresa Whiting
NASA Armstrong Public Affairs

Hurricanes, floods, fires, earthquakes – our planet faces many of these natural disasters each year that can quickly become emergency response and rescue efforts. NASA's Advanced Air Mobility, or AAM, mission is researching how AAM can help when disasters strike.

AAM has the potential to aid in disaster relief, assist in firefighting missions and provide supplies to hard-to-reach areas during an emergency event. This could look like a drone carrying supplies to local houses and hospitals when a city is flooded. Potentially, it's an air vehicle being used to rescue people trapped in a building or residential area after an earthquake that is otherwise difficult to reach. This could even look like firefighting teams using remotely piloted drones to drop fire retardant and spray water to fight fires in dangerous areas, along with moving people away from the fires quickly in emergency situations.

As part of the AAM Mission, NASA's Scalable Traffic Management for Emergency Response Operations, or STEReO, project is already looking at how drones can assist in wildfire management. Last year, the project sent drones into several California fires to collect thermal data about the fire for the firefighting teams and deployed tools to track the aircraft in real-world settings.

Firefighting teams across the state, like the California Air National Guard, already use technology like the remotely piloted MQ-9 aircraft with infrared cameras that can fly above a fire and see through smoke and ash. Several organizations also currently use helicopters for search, rescue, and fighting fires. The goal is to add new AAM aircraft into the mix for various uses and to increase safety for those in the communities and those fighting the fires.

Several projects under the AAM mission are working on different elements to help make AAM a reality in emergency operations. This includes work on automation, landing and take-off locations like vertiport and vehicle design, and airspace design to keep everyone safe while flying in the skies together. It's going to take an effort between government agencies, industry, and the public to build new highways in the sky.

NASA's vision is to map out a safe, accessible, and affordable new air transportation system alongside industry partners and the Federal Aviation Administration. Once developed, passengers and cargo will travel on-demand in innovative, automated aircraft across town, between neighboring cities, or to other locations typically accessed today by car.

Paul Reukauf... from page 4

initiated using two YF-12 aircraft for another high-speed research effort. I was assigned to this project under the supervision of Ron Smith. Many of the same people that had worked on the XB-70 were working on the YF-12. Fitz Fulton and Dan Mallick were the project pilots, Dick Klein was the project engineer, and Gene Matranga was the project manager. Gene and Bill Schweikhard were instrumental in defining the project. They then justified it to NASA and the Air Force. In later years I had occasion to speak at some length with Paul Bickle, then center director, and he was very complementary of Gene and Bill's efforts.

Our offices were in the Air Force YF-12 hangar near the Air Force Test Pilot School at Edwards Air Force Base. All project personnel were required to have special access security clearances, which contributed to very high morale. One of my first assignments was to assist Earl Montoya in the design of high response total pressure rakes to be mounted in the inlet near the engine face. Earl was an excellent designer and taught me a lot about the considerations that must be addressed during the design process. The YF-12 had a very complex axisymmetric mixed-compression inlet, with a fully automatic control system that kept it operating efficiently over a wide Mach number range. I was very interested in that system, and I spent most of the time that I was a research engineer analyzing the inlet performance. It gave me the opportunity to work closely with the contractor personnel who designed and built the system, so it was a great learning experience.

In 1971, the propulsion group hired a female co-op, Carol Bauer, from the University of Illinois. She was the first female co-op in the Propulsion Group. I knew she was very bright and resilient when she laughed at our jokes and put up with the usual office banter. Twenty-two years later, we were married. Carol worked with Ron Smith analyzing inlet turbulence and the resulting air flow distortion at the engine face.

During one of the many reorganizations, the Propulsion Group was split into two separate branches. I joined the new Propulsion Dynamics Branch, which was managed by Bill Burcham. Bill is a very skilled engineer and an excellent manager. We were both interested in the interactions between the flight control system, the engine control system, and the inlet control system on the YF-12. We began an effort to digitize the analog autopilot and the analog inlet control system. Glenn Gilyard headed the autopilot work, and I managed the inlet work, as well as leading an effort to have a Mach-hold auto-throttle installed. The ultimate goal of the effort, named Co-op Control, was to optimize the performance of the YF-12 over the supersonic portion of the flight envelope. The digital system was installed, and a number of flight tests were accomplished with the basic system. The Air Force SR-71 operators were very interested in the results and consequently had a similar system installed on all the operational SR-71s.

In 1975, Dick Klein left the project and I was named to replace him as project engineer. Shortly thereafter, Gene Matranga moved up the management ladder and was replaced by Berwin Kock. Berwin was a great project manager and I really enjoyed working with him. Then there was another reorganization, and the project engineers were moved back into the Research Directorate. The good news for me was that I, again, worked for Bill Burcham. In 1977 the YF-12 Program ended.

Then, Lockheed started a new classified program, and they invited me to join the effort. I had convinced myself it was going to be a hypersonic reconnaissance airplane to replace the SR-71. It turned out to be the F-117 Stealth Fighter, a challenging technical program with a top-notch team. I remained in private industry until 1996, when I was rehired by NASA – again working for Bill Burcham. I had a great career that later included the hypersonic X-43A, but it was my early experiences at the center that prepared me for success.

Drone mission... from page 3

just not realistic to do for a large number of volcanoes on a regular basis. But a sophisticated UAS could do the job, if it could fly beyond the visual line of sight of its operators. The capability marks a kind of threshold that, once passed, will make many more applications possible.

At NASA, using UASs for up-close monitoring of volcanoes was first demonstrated by researchers from the agency's Ames Research Center in California's Silicon Valley. In 2013, they collected science data by flying small, fixed-wing drones over Turrialba Volcano in Costa Rica.

Later, a long-term collaboration between NASA and Black Swift Technologies of Boulder, Colorado, resulted in the S2 UAS, which made the recent groundbreaking flights in Alaska.

"We needed it to be really rugged, to withstand flying in the turbulent conditions and corrosive gases around volcanoes," said Florian Schwandner, director of the Earth Sciences division at Ames and an early member of the project. "We also developed a gas-sensing payload the UAS could carry to look for signs of volcanic unrest."

When the U.S. Geological Survey joined the partnership, they brought an even more capable payload to detect additional gases and collect visual and thermal images.

The development path that led to the S2's flight demonstration was supported in part by NASA's Small Business Innovation Research and Small Business Technology Transfer program, whose management office is located at Ames. The program funds small businesses and research institutions for the research, development, and demonstration of innovative technologies with significant potential for successful commercialization. For all drones, achieving safe flight beyond the visual line of sight is the next big step toward wide commercial use.

To the summit and back

To demonstrate the S2 could fly this way – with no eyes on the aircraft, only on monitors displaying its flight path – one major requirement was a plan for integrating the UAS safely into the airspace. The Flight Operations division at Ames worked with the Federal Aviation Administration and Black Swift to develop the operations necessary to fly safely out of sight.

During the deployment, the team flew four beyond the visual line of sight missions to Makushin Volcano, 15 miles away. The S2 relied on its autonomous systems and a programmed flight plan to reach the summit, where the aircraft captured high-resolution visible-light and thermal images.

Bollinger, safety manager, dies at 62

Billy Bollinger, NASA Armstrong Safety and Occupational Health manager, died Dec. 27. He was 62.

Bollinger began his NASA career in 1982 at the Goldstone Deep Space Communications Complex. He supported the communications link for NASA and the Jet Propulsion Laboratory in Pasadena's piloted and uncrewed aircraft programs. In 2000, he came to NASA Armstrong to support the center's institutional safety programs, including Space Shuttle program landings and orbiter returns to NASA's Kennedy Space Center in Florida.

Bollinger became a government employee in 2010, when he was selected as the Safety and Occupational Health manager. Some of the significant efforts he led included becoming the center's fall protection manager, lifting device and equipment manager and had a key role in the safety office's oversight of the installation of the F/A-18 aircraft at the Lancaster Municipal Stadium, also known as "The Hangar." He also supported many projects during his NASA Armstrong career, including the Dream Chaser, the G-III aircraft wing loads calibration tests, the X-48 aircraft, the all-electric X-57, and the remotely piloted X-56.

People who knew him said he was a team player, key to resolving safety and technical issues, a mentor, a good friend and colleague, and able to identify the not-so-obvious challenges. He also went the extra mile to come up with solutions, had a great sense of humor, and his expertise ensured personnel safety and program success.

Tucker, FLL project manager, dies at 46

Kimberly Tucker, NASA Armstrong Flight Loads Lab project manager, died Dec. 27. She was 46.

Tucker began working at the center in July and was test project manager for the F/A-18E loads calibration test that is ongoing for the Naval Air Systems Command. Earlier in her career she worked at NASA Armstrong as an X-43A flight operations engineer during 2003-2004.

Prior to her current position, she worked for the U.S. Department of Defense for 17 years as a structures engineer on the F-22 and F-35 Lightning aircraft. For her work on those aircraft, she received recognition and awards.

People who knew Tucker said she was great to work with, witty, dedicated, smart, a problem solver, and had a fabulous laugh. She was a member of the Institute of Aeronautics and Astronautics, and a number of Texas A&M University and service organizations.

Single step... from page 5

week as the numbers on the scale dropped. My confidence increased as I began to believe that it was possible to lose more weight. When I surpassed 50 pounds, I was proud. Carla took a picture of me, and the photo shocked me. We do not have any full-sized mirrors in the house, and it was the first time I saw the results of my work like that. The victory of that moment tasted far better than the sweetest treat.

That's not to say I don't have a treat now or then, or that the holiday season was a snap. After putting exercise and diet together for the first time like I am now, it makes me want to use the strategies I have learned. For example, I prepare for when I will have an unhealthy food by having fewer calories starting days before the anticipated treat, or I have a plan for when I am going to be in a social setting that could offer a main course of temptation.

I still have a way to go to get to where I really need to be, but I have the confidence and knowledge to get there. For people who are ready to make that journey, start with a single step and see where it goes. It's possible and it feels great.

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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