National Aeronautics and Space Administration

THE ARMSTRONG X-PRESS

Volume 59 Number 1 January 2017

Grand success

Armstrong employees achieved much in 2016

By Anna Kelley
Armstrong Public Affairs

Armstrong celebrated its 70th anniversary in 2016 and continued its agency support with flight research, technology development and science flight operations to enable astrophysics and earth science missions as well as instrument validation.

Aeronautics

NASA Administrator Charlie Bolden announced the first NASA X-plane designation in a decade at the American Institute of Aeronautics and Astronautics forum and exposition in June. The X-57 Maxwell will be NASA's first X-plane to feature a distributed electric propulsion system, meant to demonstrate flight that is more efficient, quieter and more environmentally friendly. Now under the Aeronautics Research Mission Directorate's Flight Demonstrations and Capabilities project, the X-57 team is using data from the Leading Edge Asynchronous Propeller Technology project to begin integrating a Tecnam P2006T with an electric propulsion system.

After its July arrival in California, the aircraft was trucked to Mojave, where the baseline wing was integrated with the fuselage. While the aircraft is prepared for integration of

Year in review, page 6

NASA Langley/Advanced Concepts Lab, AMA Inc.

This artist's concept of NASA's X-57 Maxwell aircraft shows the plane's specially designed wing and 14 electric motors. NASA Aeronautics researchers will use the Maxwell to demonstrate that electric propulsion can make planes quieter, more efficient and more environmentally friendly.

Employees name NASA best place to work

By Jay Levine
X-Press editor

NASA was selected as the best place to work for the fifth straight year in a survey of federal government employees.

Armstrong ranked 28 in the list of best places to work in a large agency, which was 3.3 percent better than the previous year with a score of 77.5 percent. Center scores have been increasing every year since 2012 and are significantly better than the first survey tally of 60.7 percent in 2005.

"Thank you all for your feedback," Center Director David McBride said. "We take it seriously and we will use your responses to make Armstrong an even better place to work. NASA had the highest level of participation in the federal government for employee feedback. My challenge to you to participate in the survey caused all of the other NASA centers to take our challenge to increase their participation."

Employees awarded the highest marks to teamwork with a 77.2 percent mark, 2.2 percent better than last year. The next two highest areas of approvals were for innovation at 75.2 percent, on par with the previous total of 74.6 percent, and training and development at 72.1 percent, besting last survey's 70 percent.

The biggest increases from the previous survey were recorded for support for diversity at 69.6 percent, up from 66.7 percent, performance-

Survey, page 3

Display shows sonic boom location

By Matt Kamlet
Armstrong Pubic Affairs

NASA pilots flying supersonic aircraft now have a display that tells them exactly where sonic booms are hitting the ground.

A series of recent flights at Armstrong featured a display that allowed NASA research pilots the ability to physically see their sonic footprint on a map as the boom occurred. The series, which marked the second phase of the Cockpit Interactive Sonic Boom Display Avionics project, or CISBoomDA, continued from the project's first phase, when only a flight test engineer could see the display.

With the ability to observe the location of their aircraft's sonic booms, pilots can better keep the loud percussive sounds from disturbing communities on the ground.

Sonic booms occur when an aircraft's speed exceeds Mach 1, the speed of sound, causing an air density change to occur and sending shockwaves away from the aircraft. Upon reaching the ground, those shockwaves are perceived audibly as a sometimes loud, disruptive sonic boom. Civilian aircraft are currently prohibited from flying supersonically over land to prevent communities on the ground from being startled by sonic booms.

NASA has researched supersonic flight for decades and is working to identify and develop the methods and tools necessary to mitigate the sonic boom. Recent research projects, such as the Background Oriented Schlieren using Celestial Objects, or BOSCO, and Sonic Booms in Atmospheric Turbulence, or SonicBAT, are helping engineers and researchers accomplish this through further understanding of how supersonic shockwaves travel through the air.

CISBoomDA project manager Brett Pauer says the display will be a useful tool for supersonic-related projects in the future.

AFRC2016-0293-30 **NASA/Ken Ulbrich**

Flight test engineer Jacob Schaefer inspects the Cockpit Interactive Sonic Boom Display Avionics, or CISBoomDA, from the cockpit of a NASA F/A-18.

"The display is there to minimize the impact of sonic booms on the ground. Sonic booms generally don't cause damage at higher altitudes, but they can disturb people, and we want to make sure that we are good stewards to the public," said Pauer. "The use of this software allows pilots to maximize their flight and still not bother people on the ground."

NASA's supersonic research projects are helping engineers develop the means to design and build a proposed Low Boom Flight Demonstrator experimental aircraft, or X-plane, as part of the agency's New Aviation Horizons initiative. The X-plane would be designed to demonstrate what NASA believes could be a quieter sound in place of the louder sonic boom. This could in the future introduce the opportunity to permit supersonic flight over land.

The display used in the CISBoomDA Phase II flights is not limited to just the proposed X-plane, according to Pauer.

"This isn't just for the Low Boom Flight Demonstrator, it's for any supersonic aircraft. There are several companies that are looking to build supersonic aircraft that wouldn't produce a low boom, and would still be restricted from supersonic flight over land. This would give them a way to show their sonic boom footprint over water," explained Pauer. "So let's say you're flying from Miami to New York. You can see how far off the coast you need to be to not have that boom hit land."

The display used in CISBoomDA Phase II was operated by the flight test engineer in the backseat of a NASA F-18 research aircraft and was transmitted to the pilot's display in the front seat. The project team integrated a research-quality GPS to feed into the system, updating the positioning software from the aircraft's previous inertial navigation system, improving position accuracy to within 10 to 20 feet.

CISBoomDA principal investigator Ed Haering says the flights were designed to simulate boundaries on the ground, to help pilots practice monitoring the booms, and to keep the booms from impacting potentially populated areas.

"We flew in the High Altitude Supersonic Corridor, which is one place we're allowed to fly supersonically," Haering said. "The sonic boom carpet width, when you are 30,000 feet up, is about 30 miles wide. So we told the pilot to fly as if the boundaries represent places you can't boom past, and he flew to get the carpet to the edge of that boundary, but not past it."

The display is able to show the

Sonic boom, page 12

Armstrong part of two NIKS wins

By Jay Levine
X-Press editor

More accurate, immediate and economical information on severe weather phenomenon like hurricanes could one day be available thanks to the Weather Hazard Alert and Awareness Technology Radiation Radiosonde (WHAATRR) Glider.

Students and Armstrong staff have been developing the glider based on the Prandtl-M aircraft to fly in the atmosphere of Mars. The vehicle could potentially save the National Weather Service up to $15 million a year compared to current methods and with faster and more reliable data, said project manager Scott Wiley.

AFRC2016-0246-142 **NASA/Lauren Hughes**

The Preliminary Research Aerodynamic Design to Land on Mars, or Prandtl-M, flies during a test flight. A new proposal based on the aircraft recently won an agencywide technology grant.

Employees across the centers agree the idea could take off and voted for it during the NASA Agency Innovation Mission (AIM) Day Nov. 1 for a NASA Innovation Kick Start (NIKS) grant. Also winning a NIKS grant with Armstrong participation was the Agency Legal Enterprise Capability for Knowledge Sharing (ALECKS), the idea of a common NASA legal database including discussions, forums, news and updates.

From the 90 collaborative and visionary ideas submitted, 17 finalists were selected to present at the November event. Of those, 13 proposals were chosen by the panel of judges and agencywide votes from NASA employees to receive up to $10,000 in seed funding. Proposals were judged on innovativeness, cross-center collaboration, feasibility and relevancy, value and impact to NASA.

In addition to NASA and the National Weather Service, the WHAATRR Glider could benefit the National Oceanic and Atmospheric Administration and potentially serve as an airborne sciences platform, Wiley said. The data obtained from such gliders could reduce costs incurred from unnecessary airline delays and potentially save aircraft and lives, he added.

"It could fill a tremendous need in

Technology, page 11

Survey... from page 1

based reward and advancement at 60.2 percent from 57 percent and effective leadership increased 2.6 percent from 64.9 percent to an approval rating of 67.5 percent.

Across the agency, eight other organizations were recognized including NASA Goddard Space Flight Center ranked 10th with an 81.2 percent approval rating, NASA Johnson Space Center and Marshall Space Flight Center ties at 11th with an 80.2 percent favorable tally. Langley Research Center was 21st, with a 78.1 percent approval rating.

Rounding out the NASA selections representing the top 40 places to work were Glenn Research Center coming in at 32nd with a 76.8 percent favorable rating, Kennedy Space Center at 34th with a 76.5 percent approval rating, Ames Research center at 39th with a tally of 75.5 percent and NASA Headquarters at 40th with a 75.4 percent approval rating.

The annual results of the Employee Viewpoint Survey are published by the Partnership for Public Service. It ranks nearly 400 federal organizations by overall employee satisfaction and commitment and also evaluates key workplace focus areas such as innovation, training and development, leadership and diversity. Participation increased at all NASA centers in this recent survey.

NASA Administrator Charlie Bolden said he knows why job satisfaction is high at NASA.

"Your passion and dedication to our missions and each other is evident in the results, because every single question increased in favorability," he said. "This commitment to continuous innovation – whether applied to our missions or to improving our work environment – is what makes NASA so special and is the fuel for our journey to Mars and all of our cutting edge missions in air and space.

News at NASA

Dust never settles here

When your house gets dusty, the dust settles, falling down to lower surfaces, awaiting your attention with the vacuum cleaner or duster. Not so on the International Space Station. Like any home, it gets dusty, but the particles don't settle…they float.

And that's a problem for astronauts living and working there. Dust can get in their eyes and nose causing irritation and allergic reactions.

Although high-efficiency filters are installed on the space station and the astronauts vacuum regularly, there has never been a thorough investigation of airborne particulates until now.

NASA Glenn research scientist Dr. Marit Meyer is leading an experiment to sample airborne particles on station to help improve astronaut health and wellness. The experiment involves samplers designed by the RJ Lee Group, which are portable collection devices.

"Collecting this data will help us to ultimately build a particulate matter monitor so NASA can improve the environment for astronauts on station and other long term missions in deep space," says Meyer.

The first collection device is an electric sampler placed on the wall near where the astronauts work. A pump draws air through a cartridge containing a heated channel and across a very small disk. The airborne particles are drawn inside and get stuck to the surface of the disk.

When the samplers return to Earth, the cartridges and other samples will be analyzed in a variety of light, laser and electron microscopes.

Center artifacts

Lunar Landing Research Vehicle and shuttle era astronaut transport loaned to Air Force Flight Test Museum

Marshall Murphy
NASA Armstrong Public Affairs

NASA Armstrong lent its Lunar Landing Research Vehicle, or LLRV, and a space shuttle crew transport vehicle, or CTV, to the Air Force Flight Test Museum.

The LLRV is a bedstead-shaped vertical takeoff and landing testbed that pilots used to practice lunar landings for NASA's Apollo program. Armstrong's LLRV, the second of two LLRVs constructed, was delivered to the center in 1964.

The aluminum-alloy-framed vehicle is built around a central vertical jet engine that simulated a lunar lander's descent rocket engine. The LLRV once included rocket-powered control thrusters and an ejection seat.

The LLRV's controls and cockpit configuration were modified to match the three Lunar Landing Training Vehicles, or LLTVs, which were newer vehicles that incorporated design changes enabled by LLRV flight data. By the Apollo program's conclusion, one LLRV and two LLTVs had crashed, leaving Armstrong's LLRV as the sole survivor of its type.

NASA used the Space Shuttle Program's crew transport vehicle, or CTV, to transfer astronauts landing at Edwards from shuttle orbiters to Armstrong's medical facilities.

Flight surgeons performed basic medical checkups on astronauts inside the CTV. The vehicle, acquired in 1990, is a former people mover from Dulles Airport in Virginia. The mover's interior was modified to accomplish its role as a mobile medical facility.

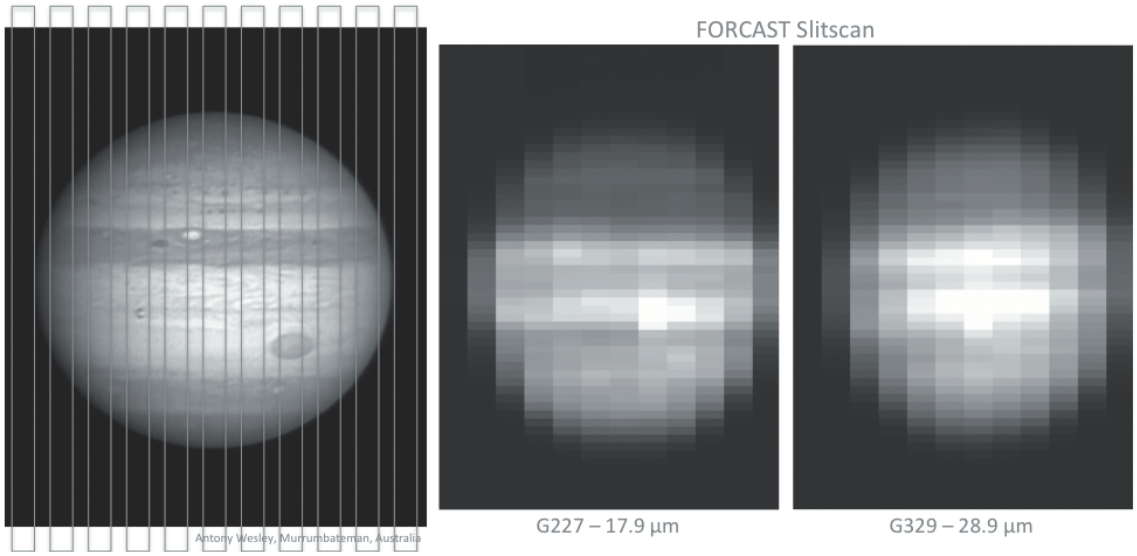
The Air Force Flight Test Museum is free to people with Edwards Air Force Base access, including visitors on monthly public tours.

AFRC2016-0259-68 NASA/Lauren Hughes

AFRC2016-0259-21 NASA/Lauren Hughes

***Above**, a crew moves the Lunar Landing Research Vehicle, or LLRV, into the Air Force Flight Test Museum for temporary display.*

***At left,** workers drive the space shuttle crew transport vehicle to the Air Force Flight Test Museum for display.*



Visible light image: Anthony Wesley. FORCAST slitscan: NASA/SOFIA/Fletcher et al.

Jupiter was observed with SOFIA by stepping the FORCAST spectroscopic slit across the planet. The left-hand panel shows a visible-light image of Jupiter with blue rectangles illustrating the orientation and size of the FORCAST slit. For each pointing of the telescope, the spectrum was made at every position along the slit. The two right-hand panels show SOFIA images of Jupiter made from combining the wavelengths in two of the slits. Jupiter's Great Red Spot is evident and has rotated between the different observations. The total information content is full images of Jupiter at all wavelengths between 17.9 and 32.9 microns, or equivalently, spectra at each position.

Amazing views

Jupiter observations captured from SOFIA were previously possible only from space

NASA

The Stratospheric Observatory for Infrared Astronomy arrives at Christchurch International Airport on June 6, 2016, to begin observations in the Southern Hemisphere.

By Kassandra Bell
SOFIA social media specialist

For the first time since the twin Voyager spacecraft missions in 1979, scientists have produced far-infrared maps of Jupiter using NASA's Stratospheric Observatory for Infrared Astronomy, or SOFIA. These maps were created from the researchers' studies of the circulation of gases within the gas giant planet's atmosphere.

Far-infrared observations provide details not possible at other wavelengths. When gas planets like Jupiter are studied with visible light, scientists can only see the light reflecting from the top of the gas clouds that make up the atmosphere. Using infrared light allows scientists to see past the clouds and into the deep layers of the atmosphere, providing a 3D view of the planet and the ability to study how gases circulate within the atmosphere.

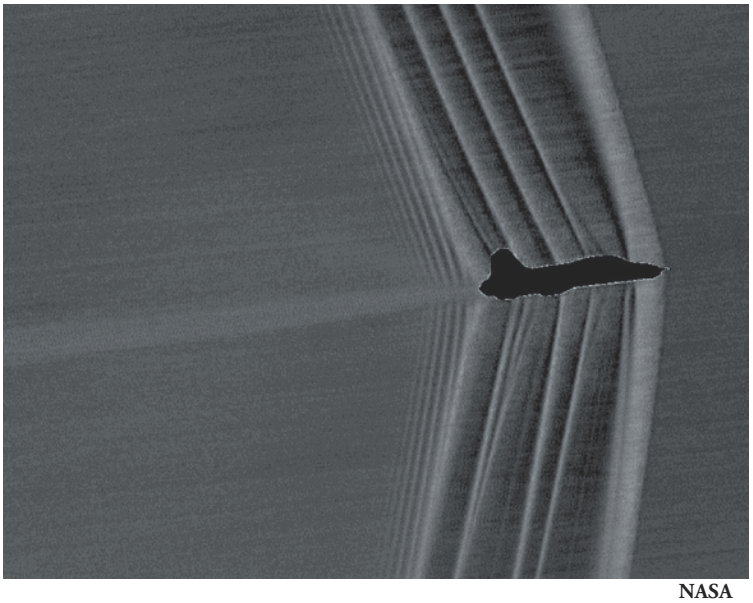
Leigh N. Fletcher from the University of Leicester, England, led a team of researchers that used the SOFIA telescope and data from the Faint Object Infrared Camera for the SOFIA Telescope, known as FORCAST, to make these observations. Fletcher's team was looking for the two types of molecular hydrogen, called "para" and "ortho" – differentiated by whether their protons have aligned or opposite spins. The fraction of hydrogen in the "para" flavor is a good indicator for gases upwelling from deep within the planet's atmosphere. These two different flavors of hydrogen were observed at infrared wavelengths between 17 and 37 microns, a spectral range that is largely inaccessible to ground-based telescopes.

Much of the current understanding of Jupiter's circulation patterns are based on results from space-based missions of the past, including the Voyager mission, Galileo mission (1989–2003), and the Cassini spacecraft, which flew past Jupiter in 2000. SOFIA's airborne location, above more than 99 percent of Earth's

Jupiter, page 11

Lockheed Martin

Artist's concept of a possible Low Boom Flight Demonstrator X-plane design for Quiet Supersonic Technology.



NASA

Shockwaves produced by a U.S. Air Force Test Pilot School T-38 are captured by a camera to study flow patterns.

Year in review... from page 1

an initial phase of the electric propulsion system, pilots and engineers have developed a simulator designed to give pilots the practice necessary to fly the X-plane.

Bolden also announced Feb. 29 that the agency had awarded a contract to Lockheed Martin for the preliminary design of the Low Boom Flight Demonstrator, or LBFD, as part of the New Aviation Horizons initiative. The announcement marked a critical milestone in NASA's efforts to demonstrate a supersonic aircraft that would produce a quiet sound in place of the disruptive sonic boom. Levels of noise from supersonic aircraft perceived as acceptable by communities on the ground could open the door to supersonic flight over land on a commercial level.

NASA's supersonic flight research included Background Oriented Schlieren using Celestial Objects, or BOSCO, which helped researchers obtain images of supersonic shock waves coming off a T-38C aircraft, used an improved image-processing technology that used the sun as a background. In doing so, data was obtained that will help engineers validate tools used to develop the LBFD.

In addition, NASA Armstrong performed a series of flights designed to study how sonic booms travel through the air. The Sonic Booms in Atmospheric Turbulence, or SonicBAT, flights were flown in July to help researchers measure the effect of low-altitude turbulence on supersonic shock waves reaching the ground. Progress was also made in further developing a cockpit display that allows pilots of supersonic aircraft to see where sonic booms are hitting the ground.

The second phase of Cockpit Interactive Sonic Boom Display Avionics, or CISBoomDA, continued work from 2015's first phase, now providing the display for the pilot in addition to the flight test engineer. This tool will assist current and future supersonic research projects by helping to make sure sonic booms are kept away from areas of population on the ground.

NASA researchers performed a key aeronautics project with the Gulfstream III Subsonic Research Aircraft Testbed, or SCRAT, for a series of flights to examine the readiness of the aircraft to review integrated test operations required for acoustic research measurement flights. The series, which took place in August and September, provided practice maneuvers for a forthcoming flight test series that will examine the acoustic benefits of landing gear noise reduction and the Adaptive Compliant Trailing Edge, or ACTE. A separate production G-III was introduced into the flights to provide comparative data between the two aircraft.

In December, researchers began flying a follow-up to 2015's ACTE research, called ACTE II. These flights began flying at Mach 0.85, demonstrating the morphing wing technology at a higher, more typical aircraft cruise speed. The flights also provided insight into the ability to twist the flap to permit different inboard and outboard angles, which may lead to a means of weight reduction on future aircraft wing designs.

In addition, continuing 2015's successful efforts in testing sensors and algorithms for Detect and Avoid, or DAA, NASA engineers completed Flight Test Series 4, or FT4, which supported Phase 1 Minimum Operational Performance Standards validation for the Federal Aviation Administration. Leveraging lessons learned from 2015's Flight Test Series 3, FT4 sought to further develop key concepts and technologies that would allow routine airspace access to Unmanned Aircraft Systems, or UAS. Nineteen flights during a two-month period saw NASA's Ikhana UAS perform 321 scripted encounters with several manned aircraft "intruders" testing and validating DAA technology designed to provide a tool for UAS pilots to observe proximate traffic, and maneuver as necessary to maintain safe separation from other aircraft.

Also of note, in preparation for its next round of taxi and flight testing, the X-56A Multi-Utility Technology Testbed, or MUTT, underwent several phases of testing in NASA Armstrong's Flight Loads Laboratory. Engineers performed ground vibration testing on the vehicle, suspending it in the air using a bungee system and subjecting it to sensors placed throughout the aircraft to measure responses from stimuli. The ground vibration tests are helping engineers to better understand motion patterns imposed by outside forces, as well as overall structural behavior. Other testing was concluded, including moment

AFRC2016-0195-196 NASA/Lauren Hughes

NASA pilot Nils Larson and flight test engineer and pilot Wayne Ringelberg head for a mission debrief following a SonicBAT flight.

AFRC2016-0246-135 NASA/Lauren Hughes

Derek Abramson, from left, Justin Hall, and Alexander Flock position the Prandtl-M glider onto the Carbon Cub that drops it from 500 feet altitude.

of inertia testing, which involved swinging the vehicle to determine how easy or difficult it is to pitch up or down. Data from these tests are going toward updating a finite element model, which will bring the team closer to flight testing.

Armstrong engineers continued work on an aerodynamic wing concept, called the Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D, which features a wing twist that could reduce fuel consumption by 11 percent. Following the March publishing of a NASA Technical paper, Prandtl received the first of two applied patents for the wing. Additionally, a team of student interns were instrumental in the first successful flights of the smaller scale Preliminary Research Aerodynamic Design to Land on Mars, or Prandtl-M, aircraft.

Airborne Science

The airborne science aircraft at NASA Armstrong supported environmental and Earth science research missions under the Airborne Science Program of the agency's Science Mission Directorate. From glaciers to air pollution, Armstrong's aircraft were used for a variety of different missions to help further NASA's research on Earth's climate.

NASA

The two NASA AFriSAR research aircraft: the B-200 (left) and the C-20A (right) collected measurements of surface topography and vegetation structure, creating 3D maps of its targets.

NASA airborne instruments and scientists on the ground joined colleagues from space agencies in Gabon and Europe in February to study the dense African tropical forests in Gabon. During the two-week campaign, a collaboration with a European Space Agency (ESA) mission called AfriSAR, researchers collected measurements of plant mass, distribution of trees, shrubs and ground cover, and diversity of plant and animal species. Armstrong's C-20A played a large role by carrying the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) beneath it. UAVSAR collected measurements of surface topography and vegetation structure, creating 3D maps of various targets.

Also in February was the Observations of Aerosols Above Clouds and their Interactions (ORACLES) mission, when Armstrong's ER-2 aircraft deployed to the Atlantic coast of southwest Africa. These flights were to validate current satellite observations of aerosols and clouds, and test instruments that may fly on future satellites, by making detailed observations that are impossible to make from space with current capabilities.

In May, NASA and the Republic of Korea participated in a cooperative field study of air quality to advance the ability to monitor air pollution accurately from space. The Korea U.S.-Air Quality study (KORUS-AQ) assessed air quality across urban, rural and coastal areas of South Korea. Armstrong's DC-8 aircraft carried a payload containing five South Korean instruments and conducted eight-hour flights to make direct measurements of the atmosphere from altitudes up to 25,000 feet.

The DC-8 aircraft flew on a 26-day trip around the world in July including stops at Kona, Hawaii, Christchurch, New Zealand and Chile for the Atmospheric Tomography (ATom) mission. The scientists aboard were measuring more than 200 gases as well as airborne particles from the remotest parts of the atmosphere to better

2016 page 8

NASA

NASA's DC-8 takes off from the Punta Arenas airport during its fourth Operation IceBridge science flight.

AFRC2016-0329-09 NASA/Ken Ulbrich

NASA's Global Hawk prepared for deployment to Florida to study Hurricane Matthew during the SHOUT mission.

2016... from page 7

understand the processes that govern how various greenhouse gases cycle around the world.

Also in July, Armstrong's Global Hawk gathered data for the Sensing Hazards with Operational Unmanned Technology (SHOUT) mission. SHOUT is a three-year research project with NOAA to evaluate the benefits of using the unmanned aircraft to improve severe storm forecasts. In October, NOAA's National Weather Service National Hurricane Center used real-time weather from our Global Hawk unmanned aircraft to upgrade tropical storm Gaston to a hurricane.

In November, the DC-8 carried a team of scientists and a sophisticated instrument suite to study ice in Antarctica for the final science mission in 2016 called Operation IceBridge (OIB). For the past eight years, OIB has been on a mission to build a record of how polar ice is evolving in a changing environment. For the first time in the Antarctic, OIB used an infrared camera to measure the surface temperature of the ice.

SOFIA

NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) program added a new instrument, completed observing flights from Christchurch, New Zealand and NASA Armstrong and published new findings.

Courtesy of U.S. Embassy New Zealand/Ola Thorsen

NASA Deputy Administrator Dava Newman flies aboard the Stratospheric Observatory for Infrared Astronomy.

In April, the observatory (a Boeing 747SP jetliner modified to carry a 100-inch [2.5-meter] diameter telescope), added a new instrument, an infrared camera and Polarimeter called the High-resolution Airborne Wideband Camera-Plus (HAWC+). This is the only currently operating astronomical camera that makes images using far-infrared light, allowing studies of low-temperature early stages of star and planet formation.

In June, NASA and the German Aerospace Center, DLR, extended their agreement to continue SOFIA science observations until the end of 2020.

SOFIA deployed for eight weeks to New Zealand in June to study objects that are best observed from the Southern Hemisphere. Deputy Administrator Dava Newman flew aboard the observatory in July. Newman was able to observe several targets in space such as a nova and a newly forming star.

Researchers published many new findings made while observing from New Zealand and NASA Armstrong, including that nova eruptions create elements that can form rocky planets, much like Earth. SOFIA's powerful instruments were also used to detect atomic oxygen in the atmosphere of Mars for the first time since the 1970s and to map Orion's Horsehead Nebula. This map is available to the greater scientific community.

In addition to the scientific achievements of the SOFIA team, 18 educators from across the United States and Germany flew on the observatory as part of the Airborne Astronomy Ambassadors (AAA) program. This professional development program strives to inspire students to pursue careers in science, technology, engineering and math, or STEM. Aboard SOFIA the educators have the

Recognized, page 9

Recognized... from page 8

unique opportunity to interact with researchers and aircraft crew, and to witness scientific research. After the STEM immersion experience, ambassadors took what they learned into their classrooms and communities to relate the scientific discovery process and its value to society.

In November, SOFIA shared the ramp at Armstrong's Building 703, with Pratt and Whitney Canada's (PWC) 747SP flying testbed aircraft. PWC's maintenance team and development offices discussed challenges posed by the limited number of Boeing 747SPs. During the visit, the PWC team planned to host regular user group meetings to continue the discussion of how the programs can aid each other.

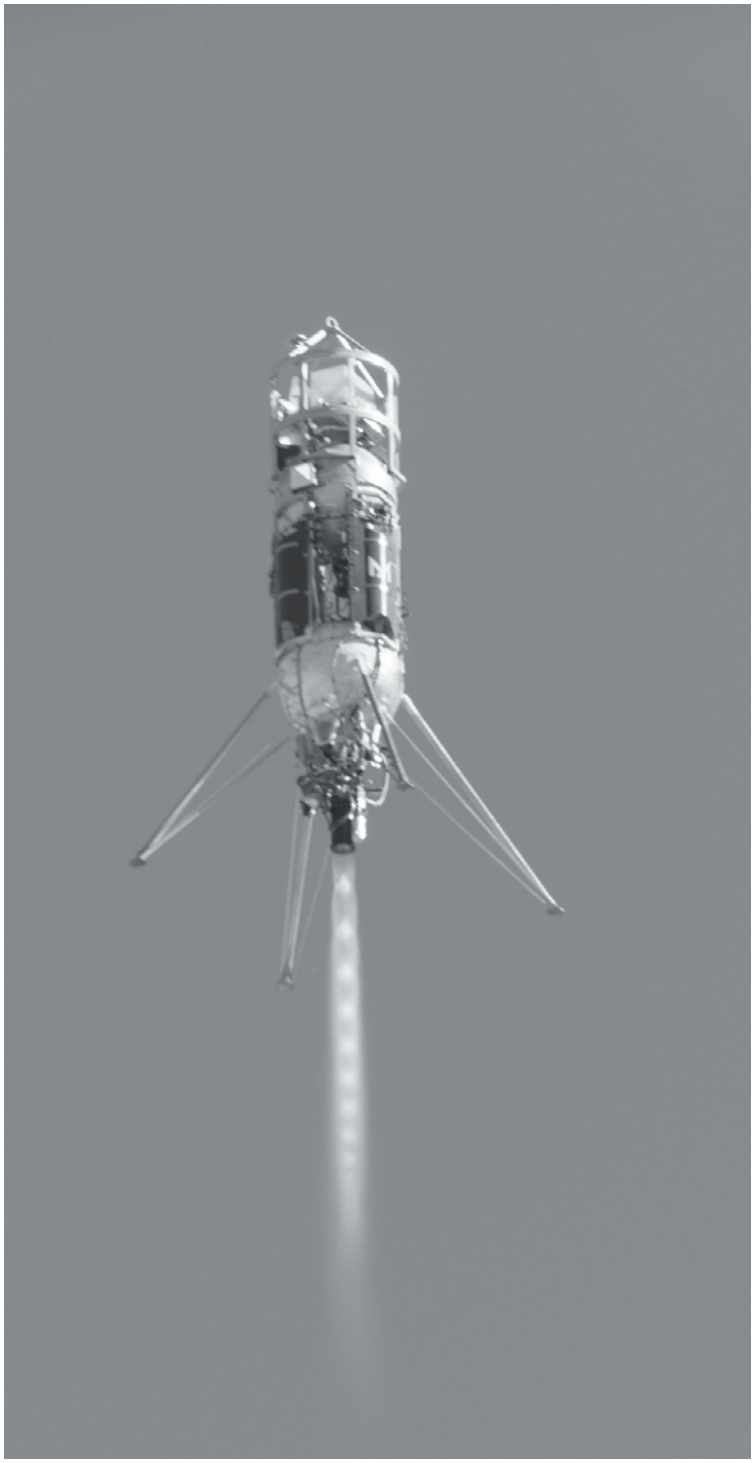
In 2017 the flying observatory will continue to expand frontiers in the solar system and beyond. Observations planned for 2017 include studying Neptune's moon Triton, the center of the Milky Way Galaxy and possible water plumes on Jupiter's moon Europa.

SOFIA is a joint project of NASA and the German Aerospace Center. The aircraft is based at NASA Armstrong's Building 703. NASA's Ames Research Center in Moffett Field, California, is home to the SOFIA Science Center that is managed by NASA in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute at the University of Stuttgart.

Flight Opportunities Program

The Flight Opportunities program is designed to mature space technologies, as was demonstrated with the successful flight test of a Lander Vision System flown on Masten Space Systems' rocket from California, which will now be on NASA's Mars 2020 rover.

Another program accomplishment is a 3-D printer by Made in Space Inc. in California, which was flown on a parabolic flight that was later installed on the International Space Station. The printer technology manufactures parts such as wrenches.



NASA

Masten Space Systems' rocket flight tests John Hopkins University's experiment for suborbital spacecraft carrying multiple payloads to determine their function and if they interfere with each other.

An additional program success is the technology known as the Gecko Grippers that are now on the station, which is flying 17,000 mph in orbit around Earth. The grippers have sticking power that is not affected by the harsh environment of space. The technology was based on the bottom of a gecko's feet that have tiny hairs to cling to surfaces.

The Flight Opportunities program also added Blue Origin's New Shepard rocket from Van Horn, Texas, as a new launch provider tentatively scheduled for a Flight Opportunities flight in 2017.

FO's other high-altitude balloon flight provider, Near Space Corp. in Oregon, recently carried a drone to 70,000-feet altitude with a Federal Aviation Administration communication system technology aboard that could detect commercial spacecraft entering the National Airspace, or NAS, as it descends from space in an effort to have accurate tracking of vehicles.

Through the Flight Opportunities program, NASA's Space Technology Mission Directorate, STMD, selects promising technologies from industry, academia and government, and tests them on commercial launch vehicles. The Flight Opportunities program is funded by STMD, and managed at NASA Armstrong. STMD is responsible for developing crosscutting, pioneering new technologies and capabilities needed by the agency to achieve its current and future missions.

Education

Armstrong's Office of Education supports activities at the pre-college and higher education levels. The Educator Resource Center at the AERO Institute provided nine professional development workshops for 250 K-12 formal and informal educators.

NASA's Beginning Engineering, Science and Technology (BEST) provided educator professional development and instructional guides on the engineering design process. Education Specialists collaborated with school district and informal education agency partners providing over 50 workshops and

Education, page 12

Mini Mars rovers

Student teams make, compete vehicles

Marshall Murphy
Armstrong Public Affairs

College students built Mars rovers at a competition Oct. 16 through 19 at NASA Armstrong's Office of Education at the AERO Institute in Palmdale.

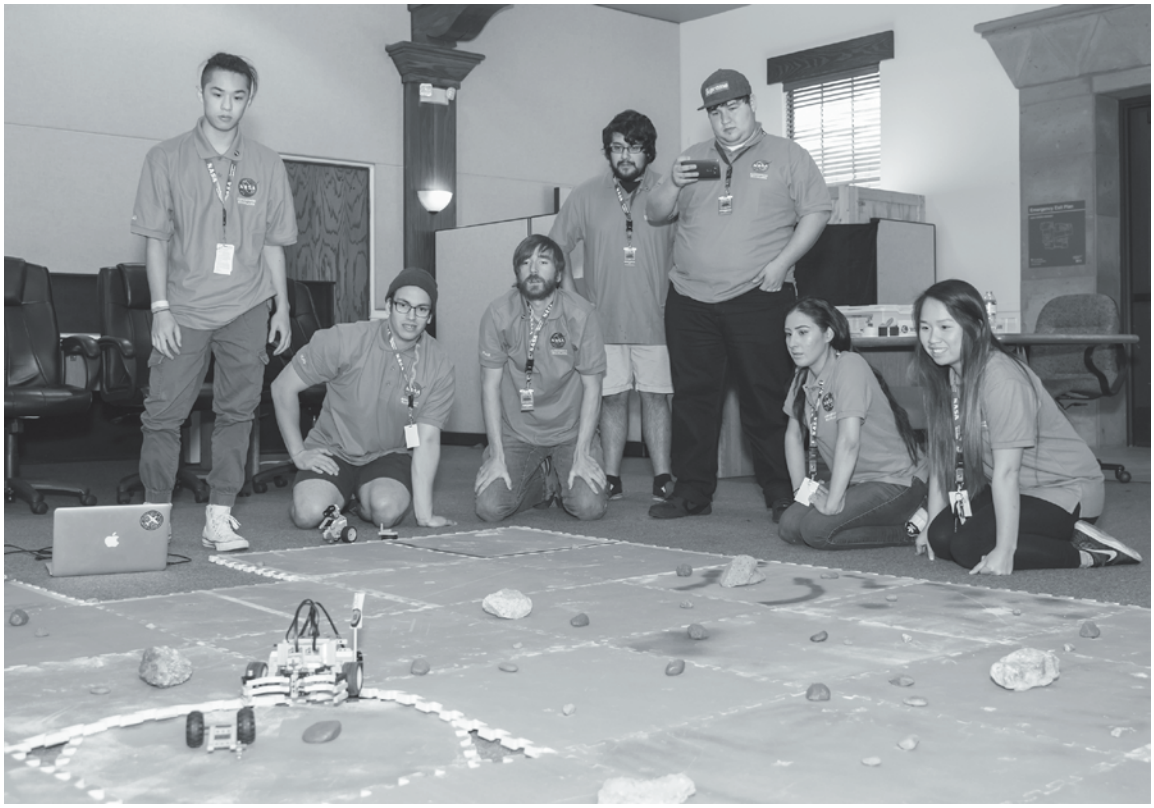
The competition was a workshop coordinated and implemented by Armstrong through the NASA Community College Aerospace Scholars, or NCAS program. It gathered 40 community college students from around the nation to learn about engineering, practice teamwork and complete simulated Mars missions using miniature, programmable robotic rovers.

The students split into four teams: Red, Green, Gold and Blue. Each team received a mentor from NASA and a small set of snap-together components to build their rovers. The teams had a simulated budget for their components, which required them to be lean and efficient with their designs.

The rovers completed two challenges. In the first challenge, they retrieved rocks from a mock Martian boulder field. Retrieving larger rocks earned higher scores. The most valuable rock was a smooth pebble placed atop a model of Olympus Mons, thought to be the largest volcano in the solar system.

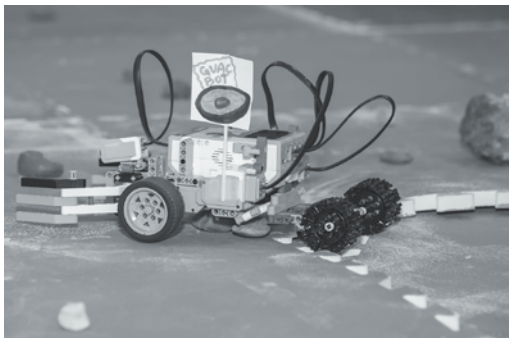
The teams designed a range of contraptions to retrieve the rocks. Some designs attempted to scoop underneath the rocks, while others used claws to grab the targets and drag them away. Regardless of their design, each rover had to automatically drive to their targets, retrieve them, and then automatically drive back to a home base. Rocks dropped outside home base were not scored.

Although teams could not physically alter their rovers between retrieval runs, they could reprogram them. Some rovers went too far and tumbled off the course, but others drove to and from their targets successfully, which made their teams erupt in cheers.



AFRC2016-0310-50 NASA/Lauren Hughes

College students from around the country built small prototype Mars rovers at a competition Oct. 16 through 19 at NASA Armstrong's Office of Education at the AERO Institute in Palmdale. The competition was a workshop coordinated and implemented through the NASA Community College Aerospace Scholars, or NCAS program. Forty students from around the nation participated.



AFRC2016-0310-56 NASA/Lauren Hughes

Guacbot, a student-built miniature Mars rover, attempts to reach a stranded rover component.

The Red Team won the rock retrieval challenge using its rover *Surmount 1*.

Red Team member Lauren Gilmore, a chemical engineering student from Salt Lake City, said participating in the challenge gave her valuable engineering insight.

"It was a once in a lifetime opportunity," Gilmore said. "I felt like being part of a team like that was just a great experience. This was a small glimpse of the real world of engineering."

For the next challenge, rovers rescued stranded rovers from the boulder field. Various rover components large and small were scattered across the field. Smaller components and those attached to wheels proved especially challenging to capture, while teams typically retrieved larger components within one or two attempts.

The Green Team, with its rover *Guacbot*, won the rescue challenge – nearly retrieving the Olympus Mons rock in the process.

Armstrong's Michelle Haupt, the

Rovers, page 11

Jupiter... from page 5

infrared-blocking water vapor, combined with the powerful FORCAST instrument, provides one of the only current facilities capable of studying Jupiter's overall atmospheric circulation. These new SOFIA observations allow comparisons of how Jupiter's atmospheric circulation has changed over time.

Images from SOFIA reveal several interesting features. The Great Red Spot appears as a large, cold feature in the Southern Hemisphere indicating an upwelling of gas. The belt zone structure near the equator shows that the equator is cold and surrounded by warm belts of sinking gas. Bright, warm features near the North Pole reveal heating of the planet's upper atmosphere by powerful auroras.

SOFIA's unique observations of the comparison between ortho and para hydrogen reveal a gradual trend from the equatorial to polar regions. Fletcher's research team found that significant upward mixing at low latitudes was responsible for the presence of "para-hydrogen" in the tropics, whereas the atmosphere appeared more sluggish at high latitudes. Downwelling over the poles may be further affecting the distribution of para-hydrogen, but further observations from SOFIA are necessary to better understand the processes over time. The results from the Fletcher team's observations were recently published in the journal Icarus.

"These results demonstrate that from Earth we can now capture a similar quality of spatially resolved infrared observations as we can obtain from space missions like Voyager," said Fletcher. "These SOFIA observations will fill the gap in the wavelength coverage of current and future space-based observatories and provide spatial and temporal context for them."

SOFIA is a Boeing 747SP jetliner modified to carry a 100-inch diameter telescope. It is a joint project of NASA and the German Aerospace Center, DLR. NASA's Ames Research Center manages the SOFIA program along with science and mission operations in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute at the University of Stuttgart. The aircraft is based at Armstrong.

Technology... from page 3

the weather community," Wiley said.

Another expected contribution of such vehicles is the ability to gather research to improve weather forecast models on Earth and in space. The glider development also could bolster a the goal of flying on Mars to collect atmospheric information to inform exploration decisions.

Once molds are made for the aircraft expected to have a wingspan of about 3 feet, and the double ply, carbon fiber aircraft is fabricated, one of the first tests will be an air launch from 20,000 feet from a weather balloon, Wiley explained. Simultaneously, sensors, instrumentation and flight control software and hardware will be prepared for the aircraft's ultimate test in the early development phase – a drop from 100,000 feet altitude and remotely piloted to a predetermined destination.

The multi-center team consists of Armstrong's Luke Bard, Scott Wiley, Al Bowers, Dave Berger, Robert "Red" Jensen, Derek Abramson and Justin Hall; NASA Goddard Space Flight Center's Antti Pulkkinen; and NASA's Wallops Flight Facility's Geoff Bland.

For ALECKS, Armstrong's Brett Swanson is co-leading the team with Donna Shafer, the deputy chief counsel at NASA's Johnson Space Center. Shafer and Andrea Warmbier, from NASA Langley Research Center's legal office, spearheaded the idea. The ALECKS team is comprised of representatives from each of the agency's centers and NASA Headquarters. The ALECKS proposal ranked first in the employee vote cast across the Agency.

"NASA's legal community has been working for some time to develop a common system for more efficient sharing of legal knowledge across the centers," Swanson explained. "Each center's legal office currently has its own system for tracking legal actions, storing legal documents, templates and practice manuals."

"Although coordination of information within the NASA legal community is good, we were looking for a better way to share knowledge in real time and in one virtual location," he said. "The ALECKS team goal is to create a common information technology resource across Agency legal offices to replace redundant processes and systems. The idea is designed for our legal community, but it could translate to other NASA organizations."

A dedicated enterprise legal knowledge management capability will improve the quality and consistency of the legal community's work product, capitalize on best practices, increase efficiency and attract and retain talent, Swanson added.

Rovers... from page 10

NASA mentor for the Green Team, said the experience was rewarding for her team and herself.

"It was exciting to see that their hard work paid off and that they worked well as a team," Haupt said. "I love being a mentor. It's my passion to help inspire the next generation, so it was a lot of fun to talk to students and encourage them to work at NASA."

Throughout the competition, the teams promoted their rovers on social media and created presentations about why their rovers should win the overall best in competition. Judges from NASA picked the winners of each overall category. The Blue Team won best social media presence, while the award for overall best in competition went to the Green Team.

In addition to the competition, the students toured Armstrong facilities, including the center's hangars, mission control rooms and subscale aircraft laboratory, and attended multiple career advisement presentations.

Armstrong's Chief of Strategic Implementation Steve Schmidt and Chief Scientist Al Bowers presented personalized achievement certificates to each student at the workshop's finale.

Blue Team member Rohan Vohra, a Cal Poly Pomona business major, said the workshop was a solid route to gain NASA experience.

"This experience is invaluable," Vohra said. "You can't learn the lessons they teach you here anywhere else. If you might want to work for NASA, this is the perfect opportunity."

NCAS is a national program organized as a NASA and Oklahoma State University partnership. NCAS is based at NASA's Johnson Space Center and provides NASA engineering experiences to community college students at workshops nationwide. Students complete a five-week online learning course prior to the workshops.

Armstrong's Office of Education plans and implements all the center's educational activities, including workshops for students and educators.

Education... from page 9

reaching over 1,500 educators.

The AERO Institute managed the Library Initiative for Teachers and Students (LIFTS) project establishing partnerships with five libraries in California and Arizona to integrate NASA content. LIFTS partners receive NASA aeronautics books, high-quality NASA aeronautics-themed educator guides, and library display materials.

Office of Education's Antelope Valley Educate to Innovate (AVETI) provided the Armstrong workforce with K-12 presentations that inspire the next generation of innovators and explorers. The program offered its first course for employees to learn about strategies for engaging students in science, technology, engineering and mathematics. The office provided 21 AVETI presentations and events.

This year, education had 92 student interns, including eight high schoolers, nine community college students and 75 students from four-year universities. Students were represented in 13 center organizations and eight of those students transitioned into NASA's Pathways internship program.

From across the country, 88 community college students attended the NASA Community College Aerospace Scholars (NCAS) workshops at the AERO Institute. The workshops culminated with students engaged in team engineering design competitions.

Education manages both the NASA Flight Scholars (NFS), a community college hands-on research experience, and the Education Unmanned Aerial System (EduUAS), which is a platform for partnering on research and education activities in the field of unmanned aircraft. A major accomplishment was the first stable controlled Prandtl-M flight series.

NASA

Students use an infrared camera to understand the composition and temperatures of their classmates.

Sonic boom... from page 2

location of sonic booms based on tracking the aircraft's trajectory and altitude. The display is founded on an algorithm designed by Ken Plotkin of Wyle Laboratories who died in 2015.

That algorithm is also being used by two companies contracted by NASA to develop similar displays with more of a predictive element.

Honeywell Aerospace in Phoenix and Rockwell Collins in Cedar Rapids, Iowa, are both working in collaboration with NASA's CISBoomDA project to develop displays with predictive capabilities. While the CISBoomDA display in NASA's F-18 shows the real-time location of sonic booms, the displays being developed by Honeywell and Rockwell Collins, using the same algorithm, are looking to see where sonic boom locations would be on the ground, based on a planned flightpath.

"What Rockwell Collins and Honeywell are developing actually runs on the same algorithm as our display, but uses a predictive capability to show the booms on a proposed flightpath," said Haering. "The pilot can adjust a proposed flightpath to avoid sonic booms in a particular spot, and then lock it in and fly that path."

The display will ultimately be used to help NASA proceed with supersonic research in a way that minimizes disturbance on the ground and provides practice with the future of supersonic technology for pilots such as NASA research pilot Nils Larson.

"Flying with the CISBoomDA display was really interesting," Larson stated. "It was great to have it in the cockpit, and I think it's a valuable tool for the future. As a matter of fact, I've asked to be allowed to start using the display on my proficiency flights, just so I can keep practicing with it."

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