National Aeronautics and Space Administration

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ED15-0076-26 NASA/Jim Ross

The Adaptive Compliant Trailing Edge Flight Research project involves replacement of both of the G-III's conventional 19-foot-long aluminum flaps with advanced, shape-changing flaps that form continuous bendable surfaces.

ED15-0201-07 NASA/Ken Ulbrich

NASA researchers Martin Hoffman, from left, John Freudinger, and Ed Koshimoto observe one of the third phase tests with the Ikhana remotely piloted aircraft from NASA Armstrong's Research Ground Control Station.

2015: NASA Armstrong advanced aeronautics, science and technology through flight

By Peter W. Merlin
Armstrong Public Affairs

Armstrong helped advance the agency's overall missions of aeronautics research, Earth and space science and aerospace technology during 2015.

Aeronautics

Adaptive Compliant Trailing Edge Flight Experiment

In April, NASA researchers completed initial flight-testing of a radically new morphing wing technology that has the potential to save millions annually in fuel costs, reduce drag and airframe weight and decrease noise during takeoff and landing. A total of 23 research flights were flown with experimental Adaptive Compliant Trailing Edge (ACTE) flight control surfaces that offer significant improvements over conventional flaps. NASA's Environmentally Responsible Aviation project teamed with the Air Force Research Laboratory to equip a Gulfstream III jet with ACTE flaps designed and built by FlexSys Inc. of Ann Arbor, Michigan with AFRL funding under a Small Business Innovation research contract. The test team exceeded expectations by completing all primary and secondary objectives on schedule and within budget.

UAS Integration in the National Airspace

Armstrong is the host center for the Unmanned Aircraft Systems Integration in the National Airspace System project, one of the nation's most important research efforts for improving safety and reducing technical barriers and operational challenges associated with flying unmanned aircraft in airspace shared by commercial and civil air traffic. Technical challenges include development of detect-and-avoid (DAA) standards to assure safe separation from other nearby air traffic, safety-critical command and control system standards, human

2015, page 2

2015... from page 1

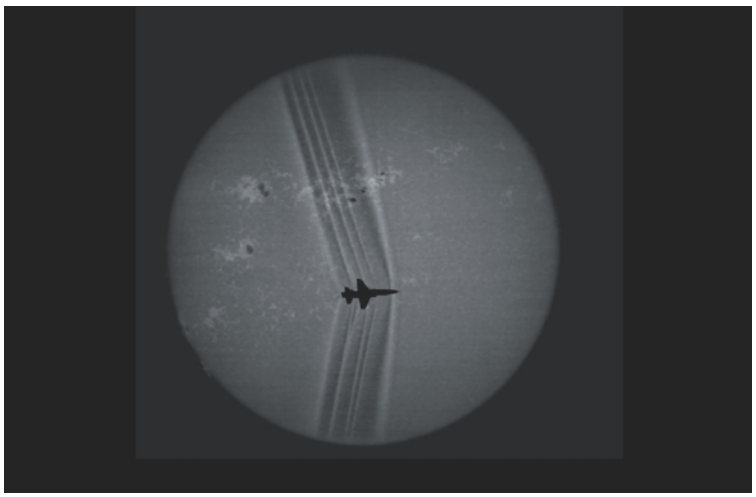
systems integration issues and integrated test and evaluation to verify and validate UAS technologies in an integrated and relevant test environment. The third phase of flight testing was completed this year. Equipped with a prototype system of DAA sensors working in concert with airborne and ground-based computers, Armstrong's Ikhana UAS made 11 flights involving more than 200 scripted encounters with approaching aircraft.

DC-8 High Ice Water Campaign

Future aircraft may be equipped with radar capable of warning of a certain type of potentially hazardous icing conditions at high altitude thanks to NASA's High Ice Water Content (HIWC) research campaign. The goal for this NASA-led effort, which also involved the FAA, The Boeing Company and other industry partners, was to record both instrumented weather and standard radar data as the plane flew in known HIWC conditions, and then see if by comparing the data a potential HIWC radar signature could be identified. Current weather radar can detect rain or hail, but is limited in its ability to discerning smaller sizes of ice crystals in the atmosphere. Ice crystals ingested by aircraft engines start to melt and evaporate, cooling the engine core surfaces to temperatures below freezing and causing ice to form inside the engine. This may cause temporary power loss or engine blade damage. For the 2015 campaign, which ran from Aug. 10-30, researchers aboard Armstrong's DC-8 flying laboratory collected almost 72 hours of in-flight meteorological and radar data associated with adverse weather and thunderstorms over the Atlantic Ocean and the Gulf of Mexico. The HIWC research team included principal investigators from NASA's Langley Research Center in Hampton, Virginia, and Glenn Research Center in Cleveland.

NASA/Peter Merlin

Mission managers Matt Berry, left, and Tim Moes work at the operations console aboard NASA's DC-8 research aircraft.



NASA

Using the solar disk as a backdrop, this image processed by researchers reveals shock waves created by a supersonic T-38C. The details of the image are revealed by using a calcium-K optical filter.

Commercial supersonic technology

Researchers continue to refine techniques for capturing images of shock waves generated by supersonic airplanes using schlieren photography. Flow visualization is one of the fundamental tools of aeronautics research, and schlieren methods with a speckled background have been used for years to visualize air density gradients caused by aerodynamic flow. While this has been easy to accomplish with scale models inside a wind tunnel, capturing schlieren images of a full-scale aircraft in flight was more challenging. In February, researchers used a technique called Air-to-Air Background-Oriented Schlieren (AirBOS) to photograph a supersonic T-38 against a tumbleweed-studded desert backdrop using special cameras mounted on the underside of a subsonic King Air twin-prop aircraft. Following each flight the AirBOS team used NASA-developed image processing software to remove the desert background and reveal rough shock wave images. Next, researchers combined and averaged multiple frames to produce clean and clear images of the shock waves. The team also demonstrated a ground-based method called Background-Oriented Schlieren Using Celestial Objects, or BOSCO. Viewing the sun through a calcium-K filter provided a satisfactory speckled backdrop for the supersonic target aircraft and, once again, the patent-pending method for imaging shock waves was made possible through advanced image processing technology.

Armstrong researchers are also testing Cockpit Interactive Sonic Boom Display Avionics, or CISBoomDA, a revolutionary software system capable of displaying the location and intensity of shock waves caused by supersonic aircraft. Developed by aerospace engineer Ed Haering, technical lead for supersonic aerodynamics research at NASA Armstrong, and Ken Plotkin of Wyle Laboratories in El Segundo, California, this application calculates an airplane's sonic boom footprint and provides real-time information, enabling pilots to make the necessary flight adjustments to control the impact of sonic booms on the ground.

Electric aircraft propulsion

The arrival of a unique experimental demonstrator at Armstrong Feb. 26 may herald a future in which many aircraft are powered by electric motors. The Leading Edge Asynchronous Propeller Technology (LEAPTech) project tested the premise that tighter propulsion-airframe integration, made possible with electric power, will deliver improved efficiency and safety, as well as environmental and economic benefits. Over the

2015, page 4

Dance, dance, dance

At the NASA Armstrong holiday party Dec. 12, revelers were invited to learn the Charleston dance.

NASA/Lauren Hughes

NASA/Ken Ulbrich

A ho-ho-ho time for kids

The NASA Armstrong holiday party for kids was Dec. 13 at the Mulligan Family Fun Center. In addition to games, go-carts and pizza, children had a chance to let Santa know what they wanted for Christmas. Maya and Hannah Spivey had their photo taken with Santa during the event.

Songs for the holidays

The NASA Armstrong Holiday Choir performed at the center director's open house Dec. 16. Center Director David McBride thanked staff for a productive year and refreshments were served.

ED15-0372-13 NASA/Ken Ulbrich

News at NASA

El Niño is on its way

The strong El Niño brewing in the Pacific Ocean shows no signs of waning, as confirmed by the latest satellite image from the U.S./European Ocean Surface Topography Mission (OSTM)/Jason-2 mission.

El Niño 2015 has already created weather chaos around the world. Over the next few months, forecasters expect the United States to feel its impact.

The latest Jason-2 image bears a striking resemblance to one from December 1997, by Jason-2's predecessor, the NASA/Centre National d'Etudes Spatiales (CNES) Topex/Poseidon mission, during the last large El Niño event. Both reflect the classic pattern of a fully developed El Niño.

El Niños are triggered when the steady, westward-blowing trade winds in the Pacific weaken or even reverse direction, triggering a dramatic warming of the upper ocean in the central and eastern tropical Pacific. Clouds and storms follow the warm water, pumping heat and moisture high into the overlying atmosphere. These changes alter jet stream paths and affect storm tracks all over the world.

Forecasters at the National Oceanic and Atmospheric Administration predict an El Niño-induced shift in weather patterns in the U.S. to begin in the near future, ushering in several months of relatively cool and wet conditions across the southern United States, and relatively warm and dry conditions over the northern United States.

ED15-0137-65 NASA/Tom Tschida

NASA researchers test a wing with 18 electric motors on a specially instrumented truck, effectively turning the surface of Rogers Dry Lake at Edwards into an outdoor wind tunnel.

ED15-0188-006 NASA/Carla Thomas

NASA researchers prepare to run volcanic ash through an F117 engine mounted on a C-17 cargo transport at Edwards. Ground testing of improved sensors could identify changes in vibration, speed, temperature and emissions that are symptomatic of engine problems before they become serious safety concerns.

2015... from page 4

span of several months, NASA researchers performed ground testing of a 31-foot-span, carbon composite wing section with 18 electric motors powered by lithium iron phosphate batteries. The experimental wing, called the Hybrid-Electric Integrated Systems Testbed (HEIST), was mounted on a specially modified truck. Testing on the mobile ground rig assembly provided valuable data and risk reduction applicable to future flight research. The HEIST wing section remained attached to load cells on a supporting truss while the vehicle was driven at speeds up to 70 miles per hour across a dry lakebed at Edwards. The LEAPTech project began in 2014 when researchers from Langley and Armstrong partnered with two California companies, Empirical Systems Aerospace (ESAero) in Pismo Beach and Joby Aviation in Santa Cruz. ESAero is the HEIST prime contractor responsible for system integration and instrumentation, while Joby is responsible for design and manufacture of the electric motors, propellers and carbon fiber wing section. The truck experiment is a precursor to development of a small X-plane demonstrator proposed under NASA's Transformative Aeronautics Concepts program that may fly within the next few years.

NASA/Lori Losey

Scott Howe performs a task with the Fused Reality system, which displays virtual objects such as runways or other aircraft over what is really there.

Vehicle Integrated Propulsion Research

This past summer, researchers from NASA's Transformational Aeronautics Concepts Program, Convergent Aeronautics Solutions project, completed the third phase of the Vehicle Integrated Propulsion Research (VIPR) effort to test and evaluate new aircraft engine health management technologies. This research incorporated smart sensors and advanced diagnostic techniques designed to improve safety and reduce costs. Over the past several years VIPR researchers have conducted experiments that introduced foreign material – liquids and particulates – into a high-bypass turbofan engine and simulated engine faults to test the effectiveness of the new sensors. To reduce risk, all such testing was conducted on the ground under controlled conditions with an Air Force C-17 aircraft. This third phase of testing focused on the characterization of high bypass jet engines that have encountered low-concentration volcanic ash plumes in the atmosphere. For the VIPR III tests, NASA partnered with the Air Force Research Laboratory, Federal Aviation Administration, Boeing Research & Technology, Pratt & Whitney, General Electric Aviation and Rolls-Royce Liberty Works, with assistance from the U.S. Geological Survey. Researchers from four NASA centers – Armstrong, Glenn, Langley and Ames – were involved in various aspects of research and testing. The Air Force provided the C-17 cargo transport plane and NASA Armstrong provided two F117 engines – military versions of

2015, page 5

ED15-0325-18 NASA/Jim Ross

NASA Armstrong's PTERA remotely piloted research aircraft made its first flight on Oct. 22, 2015.

ED15-0352-35 NASA/Lauren Hughes

Student interns from NASA Armstrong launch the Prandtl-D No. 3 on a research flight at Rosamond Dry Lake.

the commercial PW2037 used on the Boeing 757.

Fused Reality

In January, several NASA Armstrong pilots evaluated a new technology known as Fused Reality that combines elements of flight simulation with actual flight experience.

The patented technology combines real world video with interactive computer generated environments to create a highly immersive training experience for practicing complex tasks such as landing, flying in formation and aerial refueling.

The pilot wears a special helmet in flight with an optical system that combines the real out-the-window view from a camera with computer-generated graphics of an airfield or another aircraft. During nine flights in a Gippsland GA-8 Airvan research aircraft owned by the National Test Pilot School in Mojave, California, each evaluation pilot performed a series of tasks generated by the Fused Reality system and subjectively rated the airplane's handling qualities.

X-56A MUTT

The Multi-Utility Technology Testbed (MUTT) project marked a milestone in August when researchers at Armstrong completed a series of performance envelope expansion flights. These sorties, the first of which took place April 9, represented the first flights of the second of two X-56A air vehicles built by Lockheed Martin under a contract from the Air Force Research Laboratory. Although the airplane has thus far only been flown with conventional, stiff wings, these flights were the first tests of NASA-developed control laws that will eventually allow researchers to actively control the dynamic behavior of lightweight, flexible wings. This control technology will hopefully lead to lighter, and therefore more efficient, flexible airfoil designs. The airplane, on loan from Lockheed Martin, is currently undergoing maintenance and modification in preparation for the next phase of flight-testing.

PTERA

On Oct. 22, researchers from Armstrong and Area-I Inc. of Kennesaw, Georgia, successfully conducted the maiden flight of a remotely piloted test bed for cutting edge aviation and space technologies. The Prototype-Technology Evaluation and Research Aircraft (PTERA) is a versatile flying laboratory bridging the gap between wind-tunnel experiments and crewed flight-testing. The PTERA aircraft is configured to resemble an 11 percent-scale Boeing 737 with a wingspan of 11.3 feet and 200-pound gross weight. Powered by two 50-pound-thrust JetCat P200 engines, each PTERA has a semi-modular airframe designed to accommodate a variety of configurations and technologies.

Prandtl

Engineers at Armstrong are working on an increasingly complex remotely piloted aircraft concept called the Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D. The aircraft design features a new method for determining the shape of the wing with a twist that could lead to an 11-percent reduction in fuel use. The concept may also lead to enhanced controllability that could eliminate the need for a vertical tail and potentially to new aircraft designs. Several radio-controlled models of increasing size have been tested over the past few years. The largest, Prandtl-D No. 3 with a span of 25 feet, completed initial flights in November. Work on the Prandtl-D also led to a concept for a future Mars airplane. If the Preliminary Research Aerodynamic Design to Land on Mars, or Prandtl-M aircraft, is successful, it could be deployed from a CubeSat flying as ballast on a Mars Rover. It would then be released into the Martian atmosphere to collect and transmit valuable information back to Earth. Albion Bowers, NASA Armstrong chief scientist and Prandtl project manager, has led the NASA effort with help from student interns.

2015, page 7

SOFIA

2015 was successful and 2016 is looking strong for new science opportunities

Kassandra Bell
SOFIA Science Center at NASA Ames

2015 was an exciting year for the Stratospheric Observatory for Infrared Astronomy, or SOFIA. By flying at altitudes of more than 40,000 feet, above more than 99 percent of the water vapor in Earth's atmosphere, SOFIA can make observations with its 2.5-meter diameter infrared telescope and crew of pilots and scientists that no other current ground or space observatory can. Here are some highlights:

Racing into Pluto's shadow

As Pluto passed in front of a distant star, it cast a faint shadow on Earth. By flying in that shadow SOFIA was able to study the dwarf planet and its atmosphere. SOFIA was the only observatory able to observe this event directly from the center of this shadow, which fell over the Southern Pacific Ocean. This observation was timely, helping to validate similar data collected by the New Horizons spacecraft as it made its nearest approach to Pluto two weeks later on July 14.

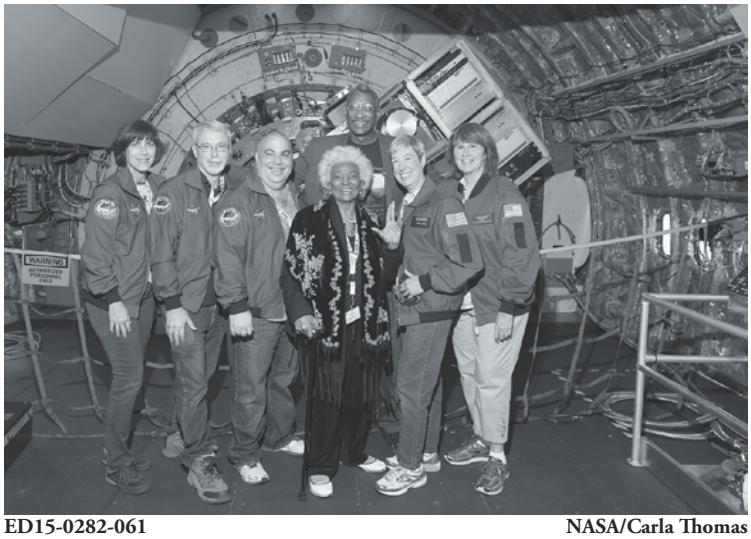
Inspiring the next generation

More than thirty educators flew on SOFIA as part of the Airborne Astronomy Ambassador (AAA) program in 2015. These educators partner with SOFIA astronomers aboard flights and take what they learn about the scientific discovery process and all facets of SOFIA's mission into their classrooms and communities to inspire students to pursue careers in science, technology, engineering and math fields.

Actress and science education advocate Nichelle Nichols flew with a group of Airborne Astronomy Ambassadors. Nichols played Lt. Uhura on Star Trek and used her role to recruit women and other underserved populations for NASA and into various science careers. During the flight she answered questions about SOFIA online and sent messages to students, continuing to inspire the next generation of scientists.

ED15-00187-236 **NASA/Carla Thomas**

This photo of the Stratospheric Observatory for Infrared Astronomy (SOFIA) was captured just before sunset at the Christchurch International Airport in Christchurch, New Zealand, while aircraft crews were preparing for a nighttime observation flight.



ED15-0282-061 **NASA/Carla Thomas**

Actress Nichelle Nichols and Airborne Astronomy Ambassadors pose in front of the observatory telescope during their SOFIA pre-flight safety training on Sept. 14. Front from left: Susan Oltman, Michael Shinabery, Jeffrey Killebrew, Nichelle Nichols, April Whitt and Jo Dodds. Back: Ivor Dawson.

Clues to how Earth got its water

SOFIA made the first detection of water vapor in gas ejecting from a newly forming star, protostar AFGL 2591, demonstrating the potential for SOFIA and its Echelon-Cross-Echelle Spectro-graph instrument to help scientists understand how water was incorporated into Earth and other planets.

Missing link between supernovae and planet formation

A team using SOFIA discovered that supernovae can produce a substantial amount of the material from which planets, like Earth, can form. Until now, scientists were unsure if the dust particles produced by supernovae would survive the subsequent inward "rebound" shock waves. The SOFIA observations reveal that the dust survived the shock wave and may eventually form new stars and planets.

SOFIA's first exoplanet observations

SOFIA observed a planet outside of our solar system (an exoplanet) as it passed in front of a star. This type of mini-eclipse is called a "transit." Transits are difficult to observe, but these findings indicate that SOFIA can measure the sizes of transiting giant planets with remarkable accuracy.

Observing the southern skies

SOFIA spent five weeks flying out of Christchurch, New Zealand, to study celestial objects that are more easily observed from southern latitudes. Observations included examining star formation and evolution processes in the Milky Way and nearby galaxies such as the Magellanic Clouds, and studying the atmosphere on the dwarf planet Pluto.

The flying observatory is scheduled to return to Christchurch in 2016 for another series of southern sky observations.

Coming in 2016

A number of observations are planned for next year including studying the water on Mars, star formation processes and searching for signs of planet formation around stars.

2015... from page 5

Earth Science

Airborne Science

The airborne science aircraft at Armstrong spanned the globe in 2015 looking for answers to important questions about Earth's climate. Each team studied a wide variety of weather phenomena, atmospheric conditions, and ground formations such as volcanoes, glaciers and deltas. Flights took place at various locations in the United States, as well as overseas in Iceland and Chile.

Winter and spring highlights included the CalWater mission, a multi-agency campaign supported by NASA's ER-2, designed to improve understanding of when and how California is on the receiving end of precipitation caused by atmospheric rivers. The Global Hawk program continued its support of the Airborne Tropical Tropopause Experiment (ATTREX) mission, that tracked the transport of water vapor into the upper atmosphere and helped researchers understand how greenhouse gases affect Earth's climate.

The summer months brought ongoing flights over the Louisiana Coast by NASA's C-20A carrying the Jet Propulsion Laboratory managed Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) instrument, which observed ground subsidence and sediment transport in deltas. NASA's DC-8 also traveled to Salinas, Kansas, for the Plains Elevated Convection at Night (PECAN) mission, which studied atmospheric conditions that form nighttime thunderstorms across the Midwest.

The year ended strong with the Global Hawk program supporting the NOAA-led mission called Sensing Hazards with Operational Unmanned Technology (SHOUT), aimed at improving how well weather models forecast significant events such as tropical storms, winter storms and major floods. There was also an opportunity for collaboration between the DC-8 and ER-2 aircraft as they participated in the Olympic Mountain Experiment (OLYMPEX), a comprehensive field study focus on tracking precipitation over mountainous terrain that is difficult to measure. The information will be used to validate data being tracked by the Global Precipitation Measurement satellite systems, which will help scientists more accurately predict atmospheric conditions that contribute to our daily weather and global climate.

Combined, the airborne science aircraft teams completed over 1,600 science flight hours in 2015.

Spaceflight Technology

Flight Opportunities Program

NASA's Flight Opportunities Program, part of the agency's Space Technology Mission Directorate, funded flights through two commercial suborbital space companies and two balloon companies, and six parabolic campaigns on NASA's C-9 aircraft for researchers developing technologies of interest to NASA.

The program flew 30 technology payloads in 2015 over 21 parabolic flights, four suborbital reusable launch vehicle test flights and four balloon flights. The technologies tested included a sensor package from Carnegie Mellon University of Pittsburgh that was flown on a vertical launch, vertical landing rocket from Masten Space Systems of Mojave, California. This sensor package can analyze large pits in the surface of the moon or Mars that may lead to openings of caves.

Another successful suborbital test flight was conducted by UP Aerospace Corporation of Highlands Ranch, Colorado, with the launch of its SpaceLoft-10 sounding rocket. The flight demonstrated a new capability for that vehicle to eject a payload in space and re-enter separately for testing descent and landing technologies.

ED15-0079-22 **NASA/Carla Thomas**

NASA's DC-8 aircraft takes off from the operations facility in Palmdale on a mission aimed at studying polar winds in the Arctic region.

ED15-0249-24 **NASA/Carla Thomas**

NASA's Global Hawk No. 872 soars over Edwards during a check out flight on Aug. 17 for the NOAA-led Sensing Hazards Operational Unmanned Technology (SHOUT) mission.

The program's newest commercial near-space balloon provider World View of Tucson, Arizona, successfully launched its Tycho balloon to flight test two university experiments. One of these experiments was the University of Central Florida's mid-infrared, intra-cavity laser absorption spectrometer. This lightweight and low-power device can be used to detect trace gases in Earth's atmosphere and in atmospheres of other planets or moons during future planetary missions.

The Flight Opportunities program also selected six technologies for flight demonstration grants through the STMD SpaceTech Research

2015, page 8

2015... from page 7

Development, Demonstration and Infusion, or REDDI-15 NASA Research Announcement.

During an open call for companies that can provide suborbital flight services, NASA awarded an indefinite delivery, indefinite quantity contract to New Space Corporation, Tillamook, Oregon. Near Space Corporation joins four other commercial firms that Flight Opportunities has on contract to provide test flights for new technologies.

The program also released an announcement for public-private partnership opportunities to assist in the development of technologies for suborbital and nano-launchers. The Flight Opportunities Program is managed at Armstrong.

Education

Armstrong's Office of Education provided eight educator professional development workshops in 2015 at the Educator Resource Center in the Aerospace Education Research Operations, or AERO, Institute in Palmdale. Examples of workshops are NASA is With You When You Fly: Principles of Flight, Journey to Mars: Rocketry, and Earth Right Now: Atmosphere.

Education held numerous K-12 student events throughout the year such as: Rockets to the Rescue for Arizona 4H and Southern California's 4H as well as the Boys and Girls Clubs. Journey to Mars was presented to K-6 students at Gregg Anderson Academy in Palmdale.

Armstrong's education office manages the Minority University Research and Education Project (MUREP) Institutional Research Opportunity (MIRO) for the agency. MIRO provides funding for minority serving institutions (MSIs) for research and to assist students in attaining degrees in NASA STEM related fields. Ten new MSIs received awards totaling nearly $47 million.

The office provided internships through the AERO Institute and the Universities Space Research Association with a record high of 90 student interns, which almost doubled the total annual number of student interns from 2014.

In October, the Office of Education, with AIAA and the AERO Institute, held a Mars Airplane live event for high school and college students, educators, industry representatives and the public. Participants learned about Mars and how Prandtl-M may one day be the first airplane to glide through the Martian atmosphere.

ED15-0293-077 **NASA/Ken Ulbrich**

Kristy Mar, a teacher at J.H. Hull Middle School in Torrance, California, peers through a microscope to examine moon rocks encapsulated in clear Lucite.

Clyde Bailey, NACA/NASA pioneer, dies at 99

Clyde Bailey, a pioneer of the NACA research center on Muroc Army Air Base (Now NASA Armstrong on Edwards Air Force Base), died Dec. 18. He was 99 and just weeks from what would have been his 100th birthday Jan. 6

He began his career at the NACA Langley Aeronautical Laboratory (now the NASA Langley Research Center) as the head aircraft mechanic. In 1947 he was sent to Muroc Dry Lake to work on the X-1 project. Working with Chuck Yeager and other pioneers of aviation, the X-1 program proved that aircraft could fly faster than the speed of sound.

Bailey was a consultant on the movies "The Right Stuff" and "Apollo 13".

He retired from NASA in 1975 as chief of Aircraft Maintenance at the high desert NASA center and became a field representative for California Sen. Newt Russell and then for California Sen. Don Rogers.

Bailey also served on several airport directorships and he helped start the Air Force Flight Test Museum.

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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