



# The Dryden X-Press

Volume 56 Number 1 January 2014

## 2013 Dryden contributed to aerospace, technology, Earth and space sciences

By Peter W. Merlin

Dryden Public Affairs

Dryden helped advance NASA's missions in Aeronautics, Earth and Space Science and Space Technology in 2013.

### Aeronautics

#### X-48 Blended/Hybrid Wing Body

The subscale X-48C remotely piloted aircraft completed an eight-month flight research campaign last April to evaluate the low-speed stability and control characteristics of a proposed future Hybrid Wing Body aircraft design. NASA's Aeronautics Research Mission Directorate and Boeing funded the technology demonstration effort, which supported NASA's goals of



ED13-0056-01

NASA/Carla Thomas

*The X-48C Hybrid Wing Body aircraft flew over Rogers Dry Lake on Feb. 28. The long boom protruding from between the tails is part of the aircraft's parachute-deployment flight termination system.*

reduced fuel burn, emissions and noise.

#### UAS in the NAS

Dryden is spearheading the Unmanned Aircraft Systems Integration in the National Airspace System, or UAS in the NAS, project that focuses on reducing safety and technical barriers and operational challenges associated with flying unmanned aircraft in the same airspace shared by commercial and civil air traffic.

Five sub-projects focus on assurance of safe separation of unmanned aircraft from manned aircraft when flying in the same airspace; safety-critical

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## Dryden busy in 2014 Center renamed

By Jay Levine

X-Press editor

It was a year where continuing resolutions, sequestration, a federal shutdown and aircraft maintenance records offered complex challenges. However, one fact is undisputable – Dryden staff came through with big achievements in 2013 and



David McBride

will do so again in 2014, Dryden Director David McBride said.

"I'm pleased with the general direction of the center and the list of what we've accomplished in 2013," he said. "We've demonstrated again our ability to overcome adversity and deliver for NASA."

McBride recalled key events in

2013, including 3,271 flight hours without an accident. That total includes 972 sorties in 25 different modified and unique aircraft, science missions around the world and two aircraft that took flight for the first time from Dryden.

In 2013, there were first flights of the Lockheed-Martin X-56 Multi-Use Technology Testbed and the

Busy, page 7

President Barack Obama signed a bill into law Jan. 16 redesignating NASA's Hugh L. Dryden Flight Research Center as the Neil A. Armstrong Flight Research Center. The bill also renames Dryden's Western Aeronautical Test Range as the Hugh L. Dryden Aeronautical Test Range. More details on Armstrong and Dryden will be in the February X-Press.

# SOFIA studied ISON comet

**Nicholas A. Veronico**

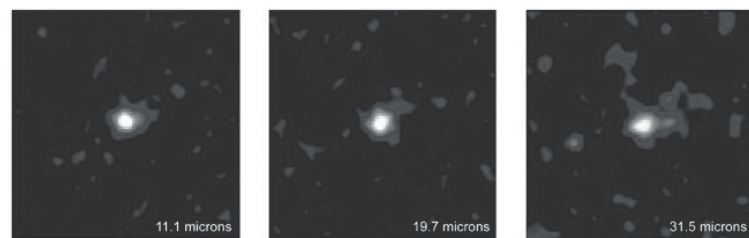
SOFIA Public Affairs  
NASA Ames Research Center

NASA's Stratospheric Observatory for Infrared Astronomy, or SOFIA, embarked on a "target of opportunity" flight recently that included study of the Comet ISON.

The lengthy mission was SOFIA's second opportunity to capture data on a comet. The observatory previously studied Comet Hartley 2 in 2010.

NASA's highly modified 747SP carrying a high-tech German-built 2.5 meter infrared telescope departed its home base at Palmdale on the evening of Oct. 24. The comet ISON observations began south of the Canadian border, above the border of Idaho and Montana while SOFIA was flying at 43,000 feet altitude. The entire non-stop flight took nearly 10 hours to complete.

Comet ISON, a pristine chunk of primordial material from the Oort Cloud, recently entered the inner solar system for the first time and was heading toward a close encounter with the sun. On Thanksgiving Day, Comet ISON reached perihelion –



*SOFIA's FORCAST camera was used to take these images of the Comet ISON at wavelengths of 11.1, 19.7, and 31.5 microns. Measurements at 31.5 microns, crucial for determining the temperature and other characteristics of the comet's material, cannot be made using ground-based telescopes.*

the orbital point of closest approach to the sun – passing within 730,000 miles of the sun. The comet was discovered in September 2012, by researchers Vitali Nevski and Artyom Novichonk using the International Scientific Optical Network's (ISON) 0.4-meter (16-inch) telescope. It was then named in honor of the institution.

## Comet studied at Three Wavelengths

Principal investigator Diane Wooden of NASA's Ames Research Center, who had proposed that Comet ISON be studied at three infrared wavelengths – 11.1, 19.7,

and 31.5 microns, was aboard the Oct. 24 SOFIA flight. Two of those wavelengths, 19.7 and 31.5 microns, cannot be seen from Earth-based telescopes because water vapor in Earth's atmosphere blocks infrared energy from reaching the ground. The 31.5-micron wavelength was detected simultaneously with the 11.1 and 19.7-micron images.

The 11.1-micron wavelength allows the SOFIA observations to be tied to ground-based measurements with the Subaru Telescope on Mauna Kea, Hawaii, and the Great Canary Telescope on the island of La Palma, in Spain's

Canary Islands. Currently, there are no space-borne telescopes operating at wavelengths longer than 4.5 microns, making SOFIA the only telescope able to see these limited wavelengths.

Wooden, who made more than 75 flights on SOFIA's predecessor, the Kuiper Airborne Observatory, is working with a diverse team that will combine its numerous observations to better understand the composition of Comet ISON. Her observations aboard SOFIA were to measure the thermal emission from small and large dust grains in the coma of Comet ISON by measuring the mid-infrared wavelengths with the Faint Object Infrared Camera for the SOFIA Telescope, or FORCAST, instrument. FORCAST collects infrared photons at wavelengths between five- and 40-microns.

"The long wavelength photometry, only possible from SOFIA, will allow us to measure the thermal emission from larger grains, which cannot be seen in scattered light at visible wavelengths," said Wooden.

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# ER-2 completes airborne campaign

**By Beth Hagenauer**

Dryden Public Affairs

NASA's ER-2 high-altitude research aircraft wrapped up the fall 2013 series of flights during the first week in December for the Hyperspectral Infrared Imager, or HypsIRI, airborne campaign.

The Airborne Visible / Infrared Imaging Spectrometer, or AVIRIS, developed by NASA's Jet Propulsion Laboratory and the MODIS / ASTER Airborne Simulator, or MASTER, developed jointly by JPL, NASA Ames Research Center and the Earth Resources Observation and Science Center, were mounted in the ER-2 to collect early datasets for the future HypsIRI satellite mission. When launched into low Earth orbit, the satellite mission will study the world's ecosystems and provide critical information on natural disasters.

AVIRIS and MASTER are collecting data under cloud-free daylight conditions during the spring, summer and fall of 2013 and 2014 over six diverse areas of California from San Francisco to near the Mexican border.

JPL scientist Robert Green is leading the effort to use imaging spectroscopy to capture a unique set of reflected wavelengths to learn about Earth's ecosystems, how they function and vary from season to season.

The aircraft flew the missions from the Dryden Aircraft Operations Facility in Palmdale.



ED10-0383-08

NASA/Tony Landis

*One of NASA's high-altitude ER-2 environmental science aircraft descends on final approach to the runway at Air Force Plant 42 in Palmdale. The aircraft is based at the Dryden Aircraft Operations Facility.*

## Songs of joy

*The Hallway Holiday Choir performed at a number of events, including the Center Director's Open Houses at the Dryden Aircraft Operations Facility Dec. 17 and on Dryden's main campus on Dec. 18. The open house also included a video that showcased Dryden successes in 2013.*



ED13-0397-01

NASA/Tom Tschida

## News at NASA

### Rocket is named for Fullerton

A private U.S. spacecraft named for C. Gordon Fullerton flew to the International Space Station Jan. 9. Fullerton is the late NASA astronaut and research pilot who helped to deploy air-launched Pegasus rockets built by Orbital Sciences Corporation while he was a Dryden pilot.

Orbital Sciences Corp. launched the Cygnus unmanned spacecraft to the station from the Mid-Atlantic Regional Spaceport at the NASA Wallops Flight Facility in Virginia. The flight is the first of eight resupply missions the company is scheduled to fly under a \$1.9 billion contract with NASA.

Orbital launched its first Cygnus spacecraft in September on a demonstration mission that proved it could safely fly the unmanned freighter to the orbiting outpost. Orbital officials named their maiden Cygnus in honor of G. David Low, a former astronaut and a former Orbital employee who was involved in the early days of NASA's Commercial Orbital Transportation Services program.

"Gordo, as most of us knew him, was a two-time shuttle pilot, a long-time test pilot and research pilot at Dryden, but his connection with Orbital was that he was the pilot of the NB-52B that dropped our Pegasus air-launched rocket several times," said Frank Culbertson,

**Gordo, page 8**



*The Dryden Holiday Dinner and Dance event on Dec. 7 featured more than just dinner. Attendees of the event at the Embassy Suites in Palmdale also had the opportunity to mingle with co-workers, play games and, of course, dance the night away.*

ED13-0383-48

NASA/Tom Tschida

## Family fun time

*Dryden's Children's Holiday Party at Mulligan's Family Fun Center in Palmdale Dec. 12 offered a variety of activities for parents and their sons and daughters to do from rock walls and motorized go carts to laser tag and video games. Eric Boyden and his son Hayne work together to meet the challenges posed by a number of terminators.*



ED13-0390-15

NASA/Tom Tschida

## 2013... from page 1

command and control systems and radio frequencies to enable safe operation of UAS; human factors issues for ground control stations; airworthiness certification standards for UAS avionics, and integrated tests and evaluation to determine the viability of emerging UAS technology. Dryden is planning integrated human-in-the-loop testing with a piloted aircraft acting as a surrogate UAS in 2014.

### Supersonic Research

In September, researchers used a ground-based telescope and digital camera system to capture images of shock waves emanating from airplanes traveling at supersonic speeds. Images taken with the Ground-to-Air Schlieren Photography System will help validate computer simulations and wind tunnel test data used in designing future supersonic aircraft.

In partnership with Aerion Corporation of Reno, Nev., Dryden studied supersonic airflow over a small experimental airfoil design on its F-15B test bed aircraft last spring in the second phase of the Supersonic Boundary Layer Transition project. Testing the airfoil at actual supersonic speeds enabled engineers to capture data that will allow more precise refinement of supersonic natural laminar flow airfoil design.

### Active Compliant Trailing Edge Flight Experiment

NASA and the Air Force Research Laboratory, or AFRL, are conducting the Adaptive Compliant Trailing Edge flight research project to determine if flexible trailing-edge wing flaps can both improve aircraft efficiency and reduce airport-area noise generated during takeoffs and landings. Researchers are preparing to replace the conventional 19-foot-long aluminum flaps on a modified Gulfstream III business aircraft with advanced, shape changing flaps that form continuous bendable surfaces.



ED13-0108-13

NASA/Carla Thomas

Dryden's F-15B research test bed roars aloft from the Edwards Air Force Base main runway for a Supersonic Boundary Layer Transition project mission.



NASA/Wallops Flight Facility

NASA's Global Hawk unmanned aircraft project celebrated a flight milestone on Sept. 17. The two Global Hawks reached a combined total of 100 NASA flights during the deployment at the Wallops Flight Facility.

### Vehicle Integrated Propulsion Research

The Vehicle Integrated Propulsion Research program is a joint project of NASA, the Air Force, and jet engine manufacturer Pratt & Whitney to test a number of engine health monitoring sensors. These include an emissions sensor system to monitor the output of carbon, oxygen and other gases; a self-diagnostic accelerometer; high-frequency vibration sensors;

inlet-debris monitoring sensors, and a high-fidelity fuel flow measurement system. Engineers are putting the sensors through a series of ground tests at Dryden on the engines of a retired C-17 on loan from the Air Force.

### X-56A MUTT

The remotely piloted X-56A Multi-Use Technology Test bed was developed by the AFRL and Lockheed Martin to test active

aeroelastic control technologies for flutter suppression and gust-load alleviation of thin, lightweight flexible wings. It was first flown with a stiff wing in August and will soon fly with one of three sets of flexible wings. After completing tests for AFRL, the X-56A will be transferred to Dryden to support research on flexible wings for future transport aircraft. By using active control to suppress the flutter of slender, flexible wings, NASA is hoping to achieve a 25 percent reduction in wing structural weight, and enable a 30 to 40 percent increase in aspect ratio to reduce drag.

### Earth and Space Science

#### Global Hawk Earth Science Missions

NASA sent an autonomous Global Hawk UAS over the Pacific Ocean to study climate change in January during the Airborne Tropical Tropopause Experiment multi-year airborne science campaign. In August, two Global Hawks were deployed to NASA's Wallops Flight Facility in Virginia for the Hurricane and Severe Storm Sentinel (HS3) mission. This was the first simultaneous deployment of both aircraft and the first use of a new permanent Global Hawk operations center constructed recently at Wallops.

Dryden and Northrop Grumman Corporation extended a no-cost Space Act Agreement that enables NASA to conduct Earth science research with the Global Hawk for an additional five years through April 30, 2018, while providing a platform for the company's further development testing of upgrades for the Global Hawk fleet.

#### DC-8 Flying Laboratory

A series of flights in March used NASA's DC-8 flying laboratory to study the effects of alternate biofuel on engine performance, emissions and aircraft-generated contrails at altitude. The Alternative Fuel Effects on Contrails and Cruise Emissions



ED12-0143-21

NASA/Lori Losey

The DC-8 flew up to 40,000 feet in March to research the effects of alternative biofuel on engine performance, emissions and aircraft-generated contrails at altitude.

effort involved flying the DC-8 as high as 40,000 feet while an instrumented HU-25 Falcon aircraft trailed behind at distances ranging from 300 feet to more than 10 miles.

In June and July, more than 30 undergraduate students participated in NASA's Student Airborne Research Program. While flying aboard the DC-8, the students measured pollution and air quality in the Los Angeles basin and in California's San Joaquin Valley and used remote sensing instruments to study forest ecology in the Sierra Nevada and ocean biology along the California coast.

#### ER-2 Missions

For the Polarimeter Definition Experiment mission in January, the ER-2 carried an instrument that provides detailed information about aerosols and clouds. A few months later, the ER-2 flew the Hyperspectral Infrared Imager campaign that used spectrometers to collect data under cloud-free daylight conditions during the spring, summer and fall over six diverse areas of California. During August and September, the ER-2 and NASA's DC-8 flying laboratory were deployed to Ellington Field in

Houston for the Studies of Emission, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys mission to learn more about how vertical air pollution and natural emissions affect climate change in the U.S.

#### C-20A and UAVSAR

In March, NASA's C-20A that carries the Uninhabited Aerial Vehicle Synthetic Aperture Radar completed a mission that studied the dynamics of Earth's crust, glaciers and the lives of ancient Peruvian civilizations over the U.S. Gulf Coast, Arizona, and Central and South America. The aircraft flew the Glacier and Ice Surface Topography Interferometer – Airborne mission over the Sierra Nevada, Beaufort Sea and Alaska in April. The project studied surface movement of Japanese and Hawaiian volcanoes in November.

#### SOFIA Airborne Observatory

NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) was deployed to New Zealand for three weeks in July, taking advantage of the Southern Hemisphere's orientation



ED13-0362-84

NASA/Jim Ross

An F/A-18 research jet simulated various flight conditions that NASA's Space Launch System may experience as it makes its way from the launch pad to space.

to study celestial objects that are difficult or impossible to see in the northern sky. Astronomers used SOFIA to observe a disk of gas and dust orbiting the black hole at the center of our galaxy, and two nearby dwarf galaxies, the Large and Small Magellanic Clouds.

Earlier in the year, the SOFIA program provided an opportunity for 26 educators from across the U.S. to interact with scientists conducting infrared astronomy aboard the flying observatory as part of the Airborne Astronomy Ambassadors program.

### Space Technology

#### Commercial Crew Program

Following tow tests and a captive carry flight in August, NASA partner Sierra Nevada Corporation of Louisville, Colo., accomplished the first free-flight approach and landing test flight of the Dream Chaser engineering test vehicle Oct. 26. Although an anomaly with the left landing gear deployment occurred, automated flight controls steered the craft to its intended glide slope, a smooth flare and touchdown on runway centerline.

#### Flight Opportunities Program

NASA's Flight Opportunities Program, part of the agency's Space Technology Mission Directorate, funded several commercial suborbital space companies under contract to provide flights for researchers whose technologies are of interest to NASA to help meet the agency's research and technology needs.

Masten Space Systems' Xombie rocket-powered, vertical-landing technology demonstrator reached its highest altitude and furthest distance to date March 25 at the Mojave Air and Space Port in Mojave, Calif., using Draper Labs GENIE developmental navigation system designed to land a space vehicle on other celestial bodies. This kind of experiment allows NASA to test prototype instruments for future Moon or Mars missions under realistic conditions without leaving Earth.

Masten's Xombie again rose above the desert this past summer to test NASA Jet Propulsion Laboratory's G-FOLD, or Fuel Optimal Large Divert Guidance, algorithm for planetary pinpoint landings. This

## Steady as she goes



ED13-0387-049

NASA/Tom Tschida

*The retired NASA F/A-18A aircraft that has served as an iconic landmark in front of “The Hangar” – the Lancaster Municipal Stadium – for the past 17 years, was demounted from its pylon at the stadium entrance Dec. 12. It was transported overland to the DAOF in Palmdale for temporary storage. The City of Lancaster is planning on refurbishing the exterior of the stadium and the mounting pylon in the near future, and that work required removal of the aircraft. The F/A-18, which is on loan to Lancaster from NASA, is scheduled to return to its perch prior to the first Lancaster JetHawks California League baseball game in mid-April.*

### Passings

## Barto, former quality control officer, dies

Leroy Ernest “Bart” Barto, a former Dryden employee when the center was known as the NACA High-Speed Flight Station, died Nov. 7, 2013. He was 93.

Barto worked at Dryden for 28 years as a quality control officer and retired in 1986.

## Huxman was mechanic, technician, dies at 87

Joseph D. Huxman, a former Dryden employee, died Sept. 16, 2013. He was 87.

He worked at Dryden when it was known as the National Advisory

Committee for Aeronautics, or NACA, High-Speed Flight Station. The NACA was the precursor to the National Aeronautics and Space Administration, or NASA.

He began his career here as a mechanic in 1956 and retired in 1983 as a life support technician.

## Warehouseman Shively, 29-year employee, dies

Wayne J. Shively, a retired Dryden contractor employee, died Nov. 20. He was 84.

Shively had been employed for 29 years at Dryden, most recently in the Dryden warehouse, prior to his retirement in 2009. He had previously served in the U.S. Air Force for 26 years, including assignments at Edwards Air Force Base, prior to his retirement from that service in 1974.

Services were Dec. 5 at the Community Church of California City. Interment followed at the Bakersfield National Cemetery in Arvin, Calif.

## Busy... from page 1

Sierra Nevada Corporation's Dream Chaser engineering test spacecraft. Also flown were the first flight of a DC-8 with a new alternative fuel, the first flight of Ikhana in a new configuration, the first Southern Hemisphere deployment of SOFIA to New Zealand and the first dual deployment of NASA Global Hawks to the Wallops Flight Facility.

"We had one of our best years for flight. It shows the resiliency and the hard work of everybody here and their abilities to get the job done," McBride said.

Dryden's stability in 2013 and 2014 originates with the more than decade-long effort to diversify its work, McBride explained. Those efforts to move from an aeronautics-based portfolio have strengthened the center's ability to maintain its workforce and a steady budget. As a result, the center is positioned to assist the agency in answering big questions, such as those in astrophysics.

"When you look at what SOFIA is doing, as it moves to operational observatory status, it is helping provide clues to answer the, 'Where do we come from?' questions," McBride said. 'Where did the chemistry in the cosmos originate? Where did water come from? How did the chemistry required for life begin? We are part of watching star birth and stars dying.'

One major change in the SOFIA program as it moves from a developmental program toward full operational capability in 2014 is the planned move of the SOFIA Program office from the Dryden Aircraft Operations Facility in Palmdale to the Ames Research Center, Moffett Field, Calif. SOFIA aircraft operations will remain in Palmdale. The management of SOFIA science is based at Ames.

Some challenges from 2013 are forecast to remain so in 2014. For example, the Center Maintenance and Operations budget will remain constrained.

"We will look for opportunities to gain from efficiencies. That won't



ED13-0220-178

NASA/Carla Thomas

*The Stratospheric Observatory for Infrared Astronomy NASA 747SP successfully completed its first deployment to the Southern Hemisphere in 2013. The observatory is expected to be fully operational in 2014.*



ED12-0162-447

NASA/Tom Tschida

*The Facilities Support Center is expected to be occupied in 2014, which in addition to being environmentally friendly, is expected to save on energy costs.*

be easy and it won't be without pain to live within the budget," he said.

It is anticipated that the full operation of two facilities projects will help bring some budget relief. The Consolidated Information Technology Center, or CITC, will have its renovations complete and the Facilities Services Center, or FSC, will be occupied in 2014. It is expected the efficiencies of those facilities will bring significant savings in utilities and an increase in the quality of life for the Dryden workforce, McBride said.

The \$8.8 million CITC in 2013 was nationally recognized

for its features that make it an environmentally friendly building. The \$11.2 million FSC is expected to have an even greater level of sustainability. That and other planned facilities work follows NASA's move to eliminate old, inefficient buildings for new structures that are environmentally friendly and energy efficient.

Concerning aircraft work, there is a full slate in 2014.

"In Earth Science, we are part of the campaigns providing opportunities for scientists concerned about the health of the Earth and its fragile ecosystem,"

McBride added. "We also continue to partner with NASA aeronautics to work to improve aircraft safety and performance," he explained.

From the start of 2014 Dryden will be busy when the Global Hawk travels to Guam for the first time. The Global Hawk will be a part of the Airborne Tropical Tropopause Experiment, or ATTREX, to study moisture and chemical composition in the upper atmosphere in January and February, McBride said.

For the Aeronautics Research Mission Directorate, Dryden is expected to complete integration of the Adaptive Compliant Trailing Edge, or ACTE, flap on the modified Gulfstream-III research aircraft. The experimental flight research project, which is expected to fly toward the end of 2014, is a joint effort between NASA and the U.S. Air Force Research Laboratory to determine if advanced flexible trailing-edge wing flaps can improve aircraft aerodynamic efficiency and reduce airport-area noise generated during takeoffs and landings.

ARMD planning in 2014 could also lead to additional work for Dryden.

"Dryden's primary competency is flight and integration of complex systems," McBride said. "In the planning stages in NASA Aeronautics are concepts like more efficient civil transport and quiet supersonic (aircraft), but those plans are not mature enough yet for us to lay out long-term plans for those future vehicles. I expect to see more progress in these directions during 2014."

In the meantime, Dryden also is involved with outside customers to assist with a number of aeronautics-related projects.

For example, The Boeing Company's Phantom Eye also is set to continue flights from its current base at Dryden. It is scheduled to expand its flights from the local area to high-altitude flights in the larger 2508 test range, he said.

No doubt 2014 will bring new questions and McBride said when they come up, "Please ask."

## Year-in-review... from page 5

algorithm could revolutionize how we land future rovers on other planets by optimizing fuel usage in selecting where the vehicle will land.

Oregon's Near Space Corporation launched several Flight Opportunities technologies on their high-altitude balloon, reaching heights of nearly 102,000 feet.

Another vendor, Colorado's UP Aerospace, launched two of its SpaceLoft rockets from New Mexico's Spaceport America in 2013 that carried a variety of technology payloads for the Flight Opportunities Program. The two sounding rockets provided several

minutes of microgravity conditions for the experimental payloads.

The Flight Opportunities Program was not limited to rockets and balloons, as it also funded flights on Zero-G Corporation's modified Boeing 727 on parabolic flights. One technology, Made in Space's 3-D printer, was flown on the 727, demonstrating the technology worked in near-space conditions preparatory to being launched to the International Space Station.

### Space Launch System Development

The Launch Vehicle Adaptive

Control experiment used a Dryden F/A-18 aircraft to evaluate an Adaptive Augmenting Controller developed by engineers at Marshall Space Flight Center for the agency's Space Launch System rocket.

The system has been designed to autonomously adjust to unexpected environmental or vehicle conditions during actual flight rather than to preflight predictions. The ability to make real-time adjustments to the autopilot provides enhanced performance and increased crew safety.

## Comet... from page 2

"Compared with smaller submicron grains, larger grains have cooler temperatures and emit at longer wavelengths.

"Only the FORCAST instrument on SOFIA can obtain the longer wavelength photometry measurements that sample the thermal emission of the larger grains," she explained. "By modeling the FORCAST photometry, we can constrain the grain size distribution and the dust mass. The mass and loss rate of the dust are one of the fundamental characterizations of a comet."

### Making the Observations

"When we got onto the comet leg of the flight, we clearly saw the

extended coma in the fine guiding camera but not in the wide-angle camera," Wooden said. "We acquired images at 11.1 microns and immediately saw the comet was faint. We then shifted to the 19.7-micron filter, where the comet was expected to be brighter.

"Soon we could see the comet was about as weak at 19.7 microns as it was 11.1 microns, consistent with the expectations of a typical grain-size distribution, Wooden continued. "If the 19.7-micron images had a stronger signal, that would have meant there were more, larger grains."

Wooden said these measurements are important because they serve as constraints or upper limits on the

flux of thermal emissions from larger dust grains in the coma.

"Studying the dust's thermal emission from SOFIA enables us to derive the grain size, its distribution, and the mass of the amount of dust coming from the comet," she said. "This is a critical complement to studying the gases that are released, and thereby contributes significantly to understanding the origins of comets.

"We learned that the comet is dust-poor not only for small grains, as already known by the weak scattered light at visible wavelengths, but also for larger grains detectable at these mid-IR wavelengths from SOFIA," Wooden concluded.

## Gordo

... from page 3

Orbital executive vice president and former astronaut.

Fullerton died Aug. 21 at the age of 76, three years after suffering a stroke that left him partially paralyzed.

After flying Enterprise, NASA's original prototype space shuttle, on atmospheric test flights, Fullerton launched into space twice. He piloted the space shuttle's third mission in 1982 and, three years later, commanded shuttle mission STS-51F. Fullerton followed up his 16 days orbiting the Earth with 22 years of service as a research pilot at Dryden. It was in this capacity that he worked with Orbital Sciences.

Orbital introduced the Pegasus in 1990 as the first commercially developed launch vehicle. Used to deploy small satellites, the winged Pegasus' first stage is launched from an aircraft, initially NASA's now-retired NB-52B and now a modified L-1011 commercial transport. Fullerton flew NASA's NB-52B aircraft from Dryden on the first six air launches of the Pegasus.

The Cygnus Spaceship C. Gordon Fullerton delivered during the mission approximately 3,217 pounds of science equipment, spare parts and supplies to the space station for NASA.

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

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