National Aeronautics and Space Administration

The Dryden X-PRESS

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# UAS

## A big future is in store for these aircraft, but there's a lot of work to do first – integration, technology and FAA regulatory changes

**By Jay Levine**
X-Press editor

Medicine and supplies might be delivered into remote areas of the world where terrain and access are difficult. People in areas hit by natural disaster could be assisted in finding survivors. An item purchased online could be on its way to a customer's door in mere hours.

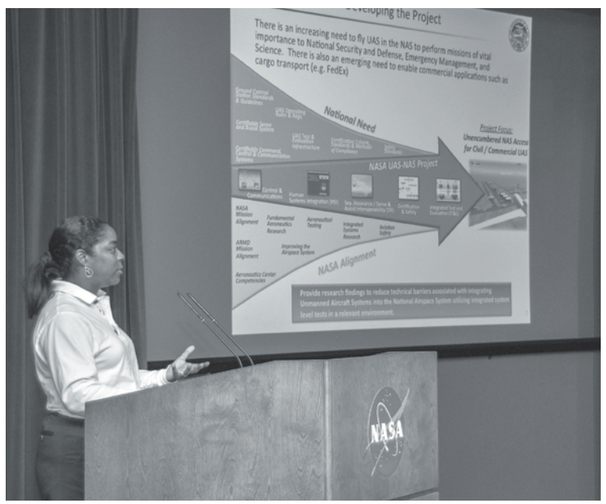
These are some of the visions for how unmanned aircraft systems, or UAS, might be used one day when such vehicles have routine access to the National Airspace System, or NAS. Dryden has for more than four decades had a hand in the development of unmanned aircraft systems and continues to have a role in the critical steps needed to incorporate them into the same airspace as piloted aircraft.

Big potential is how Laurie Grindle, Unmanned Aircraft Systems Integration in the National Airspace System project manager at Dryden, sums it up.

"For example, for a search and rescue mission you could have a bunch of small UAVS looking in several places," she suggested.

"The Ikhana (NASA's Predator B) fire missions are another example," she added. "They were not putting a pilot at risk, but they were able to use sensors to collect information from above to help the firefighters figure out where to focus their resources to put out the fire."

NASA uses UAS for development of new concepts and potentially dangerous science missions like hurricane and volcano research. NASA missions also have proven the utility of UAS in crop management and coastline studies. But in order for a commercial market to flourish for UAS, a number of Federal Aviation Administration requirements must be met.




**ED13-0341-031** **NASA/Ken Ulbrich**

*Laurie Grindle, Unmanned Aircraft Systems in the National Airspace System project manager, explains some of the work required for unmanned systems to gain access to the National Airspace System.*

Many of these FAA integration requirements are still in development and NASA and Dryden have a major role in that process. The UAS in the NAS project will provide recommendations to the FAA to establish rules, regulations and limit risks, Grindle explained. NASA is working at investigating the major impediments to routine UAS access to the NAS, checking those results with simulated flight tests and offering real solutions, she said.

Components of a successful system will include ground control stations, sense and avoid systems to guarantee safe separation between aircraft, unmanned aircraft certification and safety. UAS can range in size from tiny vehicles just inches long to as large as a commercial jetliner.

NASA plans integrated research activities to validate technology and develop recommendations, Grindle said.

"The first one is in 2014 and it is an integrated human-in-the-loop simulation that will utilize a live, virtual, constructed-distributed environment," she said.

In other words, NASA centers, FAA technical centers and potentially other partners will be connected together for a simulation that includes handing off a UAS from one ground transmitter to another hundreds of miles apart.

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# Knutson, former site manager, dies

**By Peter W. Merlin**
Dryden Public Affairs

Former NASA Ames-Dryden Flight Research Facility site manager Martin A. "Marty" Knutson died on Dec. 11. Knutson led the center for six years from 1984 through 1990 while Dryden was managed as a satellite facility of NASA's Ames Research Center, Moffett Field, Calif.

Knutson joined NASA as a research pilot and manager of U-2 flight operations at Ames in 1971 and was instrumental in the acquisition of two U-2C aircraft for the agency's Earth resources science program. He also served as one of several NASA U-2 pilots, and later flew the ER-2, an updated model introduced in 1981 that remains in service at NASA Dryden's Aircraft Operations Facility in Palmdale, Calif.

In May 1984, Knutson was appointed Director of Flight Operations for Ames, and was also assigned additional duty as site manager of the Ames-Dryden Flight Research Facility. During his six years at Dryden he maintained the facility at operational readiness for space shuttle landings and provided leadership for numerous flight research programs.

After the Air Force announced the impending retirement of the SR-71 Blackbird, Knutson successfully sought to acquire three of the airplanes for Dryden. In late 1990 he returned to Ames where he served as chief of flight operations until his retirement in 1997.

Knutson was honored with NASA's Outstanding Leadership Award and the Presidential Rank of Meritorious Executive. He was an Associate Fellow of the Society of Experimental Test Pilots.

A memorial is scheduled for 1 p.m. on Jan. 25 at Ames Research Center, Mountain View, Calif.

NASA photo

*Site manager Martin A. "Marty" Knutson led the facility from 1984 through 1990.*

# Mach 2 first achieved 60 years ago

**By Peter W. Merlin**
Dryden Public Affairs

Sixty years ago, A. Scott Crossfield, a talented young engineering research pilot for the National Advisory Committee for Aeronautics (NACA), became the first human to fly faster than twice the speed of sound in the Douglas D-558-2 Skyrocket in the skies over Edwards Air Force Base.

Dryden celebrated the 60th anniversary of the milestone Nov. 20 during colloquium presentations by Dr. Richard P. Hallion, a research associate in aeronautics for the Smithsonian National Air and Space Museum, former Edwards base historian and author of "On the Frontier," Dryden's official history.

During his "Rocketing Through Mach 2" presentations at Dryden and at Antelope Valley College in nearby Lancaster that evening, Hallion emphasized that the event's purpose was threefold: to recognize Dryden as a center of excellence for aeronautics research; to pay tribute to a remarkable aircraft, the Douglas D-558-2 Skyrocket; and to honor Crossfield, who flew the Skyrocket to a speed of Mach 2.005 – roughly 1,300 mph at 62,000 feet altitude – on Nov. 20, 1953.

NASA photo

*The D-558-2 Skyrocket streaks above the skies of Edwards Air Force Base. The aircraft recorded the first time Mach 2 was exceeded.*

The Skyrocket was one of several aircraft flown in the Rocket Airplane Research Program, a joint NACA, Air Force and Navy project established in 1944 to explore the problems of transonic and supersonic flight. Civilian participants included research scientists, engineers, pilots, mission planners, maintainers, and data-reduction specialists from the NACA High-Speed Flight Research Station, which later became today's Dryden Flight Research Center. They tested innovative design concepts based on shapes known to be capable of exceeding the speed of sound.

"The initial designs for transonic research airplanes were very simple," said Hallion. "Fuselage shapes were typically based on the .50 caliber bullet."

Three Skyrockets – NACA No. 143, 144 and 145 – were built and flown with various combinations of jet and rocket propulsion. When powered by a single 3,000-pound-thrust jet engine, the D-558-2 required a takeoff roll as long as three miles unless augmented with auxiliary rocket thrusters. The airplane was later equipped with both the jet plus a 6,000-pound-thrust, four-chambered, liquid-fueled rocket engine, and some flights were flown solely under rocket power.

Researchers made the most of the Skyrocket's limited fuel supply, extending flight duration by carrying the research airplane aloft beneath a specially modified B-29 bomber –

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# Bennett accepted into HR leaders program


*Brian Bennett*

Dryden Human Resources specialist Brian Bennett has been accepted into the Partnership for Public Service's Emerging HR Leaders Forum, a yearlong leadership training program for human resources professionals.

Bennett is one of only six NASA human resources professionals to be accepted into the prestigious program for 2014, according to Dryden Human Resources Director Dana Askins.

The Emerging HR Leaders Forum is focused on high-potential human resources employees who are in the early stages of their federal careers. It is designed to help participants develop the skills and perspective necessary to take on future leadership roles in government through a combination of peer learning and collaboration, facilitated dialogue with subject matter experts and hands-on activities.

The program involves monthly meetings totaling 30 classroom hours. In advance of monthly meetings, participants are expected to complete short readings and activities. Each emerging leader is also required to participate in at least one extra program element, which may include a team project, peer presentation or leading one or more activities, Askins noted.

All sessions take place at the Partnership for Public Service's offices in Washington, D.C., with participants from outside the Washington commuting area able to participate via on-line "virtual" accommodations.

The Partnership for Public Service is dedicated to improving government performance by strengthening federal leadership.

ED13-0314-18 NASA/Tom Tschida

## Room to think big

*Engineers Stephanie Andrade, from left, Travis Covert and Seth Trey work on algorithms together in a recently established collaboration area in the Dryden Research Aircraft Integration Facility. The collaboration area was set up apart from the typical office cubicle areas in order to encourage technical work-related interaction between engineers and researchers.*

## Safety is the focus

*Jim Smolka, director of Flight Operations, makes a presentation during a maintenance safety day at Dryden Dec. 9. A similar event was previously conducted at the Dryden Aircraft Operations Facility in Palmdale.*


ED13-0353-22 NASA/Ken Ulbrich

# News at NASA

## Deep Space Network still on task

NASA's Deep Space Network, the world's largest and most powerful communications system for "talking to" spacecraft, will reach a milestone on Dec. 24: the 50th anniversary of its official creation.

Over the past 50 years, antennas of the Deep Space Network have communicated with just about every mission that has gone to the moon or beyond. The historic communiqués include "That's one small step for [a] man, one giant leap for mankind;" numerous encounters with the outer planets of our solar system; images taken by rovers exploring Mars; and the data confirming that NASA's Voyager spacecraft had finally entered interstellar space.

The Deep Space Network has been critical to so many missions over the decades, the network's team members like to use the phrase "Don't leave Earth without us."

More information about the Deep Space Network is online at: http://www.jpl.nasa.gov/dsn50/

## NSSC News is available

The latest issue of the NASA Shared Services Center quarterly publication, the NSSC News, has the results of the NASA Shared Services Center Customer Satisfaction Broad-Based surveys.

It is available at www.nssc.nasa.gov/customerservice. Click on the newsletter icon for the latest issue.

X-Press December 2013

# NASA Global Hawks continue hurricane work

**Rob Gutro**
Goddard Space Flight Center

NASA's Hurricane and Severe Storms Sentinel airborne mission, or HS3, wrapped up for the 2013 Atlantic Ocean hurricane season at the end of September. HS3 is expected to resume from NASA's Wallops Flight Facility in Wallops Island, Va., for the 2014 Atlantic hurricane season.

During the 2013 mission, two unmanned Global Hawks flew from Wallops for the first time. The Global Hawks are based at Dryden, but for the hurricane missions the aircraft were based at Wallops from mid-August to the end of September.

The mission highlights included studying the Saharan Air Layer, following the genesis of a tropical storm, finding a unique hybrid core or center circulation in a redeveloped storm, obtaining measurements on the strongest side of one of this season's few hurricanes, an investigation of a storm that was almost certain to develop but didn't and a landmark 100th flight for the Hawks.

"We were able to obtain some excellent data on the Saharan air layer; multiple flights covering the life cycle of Tropical Storm Gabrielle; and an excellent flight for a system in the southern Gulf of Mexico that, despite having about a 70 percent chance of forming, failed to form," said Scott Braun, HS3 principal investigator at NASA's Goddard Space Flight Center in Greenbelt, Md. "However, from a science perspective, it was disappointing because of the low amount of tropical cyclone activity."

NASA photo

*Global Hawk No. 871 rolls out on the runway at NASA's Wallops Flight Facility after a sortie for the 2013 hurricane formation and intensification mission.*

**Examining the Saharan Air Layer**

One of NASA's Global Hawks flew over the remnants of Tropical Storm Erin and captured data on the Saharan Air Layer or SAL in the Eastern Atlantic Ocean on Aug. 20 and 21. Known as HS3's environmental Global Hawk, the aircraft carries a payload of instruments that include the CPL or Cloud Physics Lidar, S-HIS or Scanning High-Resolution Interferometer Sounder Instrument, and NOAA's dropsonde system.

A sonde is a device that measures winds, temperature and humidity as it falls through the atmosphere. Sondes were dropped out of the tail of the Global Hawk during the mission.

The CPL instrument analyzed the SAL and showed an elevated dust layer between about 1.5 and 2.8 miles/2.5 and 4.5 km overrunning the remnants of Erin. The low-level clouds associated with what was left of Erin were located below 1.2 miles/2 km. Data showed that the SAL moved right over Erin's remnants. HS3 conducted a second flight into a large SAL air mass on Aug. 24-25 that provided a unique combination of data from the dropsonde system and CPL. The data captured the tremendous variability in dust layer structure that occurs within the broader air mass.

**Identifying a Unique Hybrid Core**

HS3's environmental Global Hawk gathered data from Tropical Storm Humberto on Sept. 16 and 17 after it was reborn from the original storm's remnants. Braun combined dropsonde data with a satellite image from NOAA's GOES-East satellite. The dropsonde data

**Monitoring page 6**

## UAS... from page 1

That work, which includes testing of components and simulation, is expected to be complete by this summer. Modeling and simulation is part of that continuing work, but the emphasis will be shifting to integrated flight research.

"In 2015 and 2016 we have flight tests that are integrated events, which take into account all of the different research," Grindle explained.

UAS integration will be incremental, she said.

"I think the path the FAA is going down will be to allow small unmanned aircraft systems first to have access into the National Airspace System. Safe access might include a finite part of the national airspace at first," Grindle said.

"The key word is *routine* access, the same kind of access a manned aircraft has to the National Airspace System. You won't have to plan six months in advance the exact path you want to fly, or exactly the mission you want to fly," she added.

Ultimately, filing a flight plan will be the process and eliminate the need for the special agreements (called certificates of operations, or COA's) used now that require lengthy lead time of up to six to eight months for a single flight, she added.

ED12-0082-17 NASA/Tony Landis

*The Ikhana is prepared for the first checkout flight of the Automatic Dependent Surveillance-Broadcast, or ADS-B, device.*

When the project is complete in 2016, it is expected the FAA will use those recommendations in developing rules and policies for making UAS access to the NAS happen.

"Individual technologies we are working on and technology development that we are doing as well as the flight tests that we will do, and the results that we will get – will all feed into the ability to give them more information so they can make more informed decisions," Grindle said.

"You have to be able to write regulations for things that are different from what we have right now," she said.

An example is the difference in having a pilot in the cockpit.

"There is a person in the cockpit that can see an aircraft and avoid it. But with the pilot being in the ground control station, and not in the aircraft, you don't have someone who is seeing and avoiding all the other aircraft. Now you have to come up with a new definition of 'well clear,' i.e. maintaining an appropriate distance from other aircraft, but a definition that is one a system can achieve," she said.

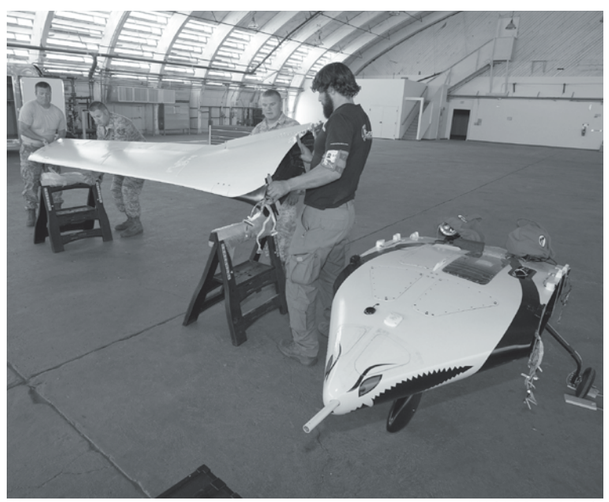
It is complex.

"Sense and avoid algorithms that use sensors on board the aircraft and transmit that information down to the pilot on a display in the ground control station would allow the pilot to make some of those decisions, but it still requires you to know how close is too close?" Grindle explained. "Also, if the pilot loses connection with the aircraft, those algorithms must handle that scenario as well."

Technologies are being tested to meet other challenges as well.

"You need things like a collision avoidance system in case there is a problem and a pilot is not able to react," she said.

Other considerations include human systems integration in air traffic control, contingency management and certification processes for validating airworthiness of UAS. As part of that effort, Dryden has been using the Ikhana unmanned aircraft to validate a technology that will be common on all aircraft in 2020 called Automatic Dependent Surveillance-Broadcast, or ADS-B.



ED13-0091-21 NASA/Tom Tschida

*Preparations continued for test flights of the Lockheed Martin X-56 for the Air Force Research Laboratory. Once those tests are complete, it is planned that Dryden researchers will have use of the remotely-piloted aircraft for a number of flight research projects.*

ADS-B is a technology used for tracking aircraft. An aircraft using the systems can track itself, relay that information to other aircraft in the area, and track other aircraft. ADS-B is part of the FAA's NextGen air traffic control system that will move from ground-based systems to satellite-based systems.

"ADS-B is considered a next gen technology. We proved out the ADS-B capabilities. I wouldn't say it's complete. The objectives we are trying to achieve are complete, but we might want to make use of ADS-B in the future flight tests," she said.

All of NASA's aeronautics research centers are involved with the Integrated Systems Research program, which includes the UAS in the NAS effort. Those centers are Dryden, Ames Research Center, Moffett Field, Calif., Langley Research Center, Hampton, Va., and Glenn Research Center in Cleveland. In addition to NASA, small business innovative research agreements, industry and other government agencies are working together on this project.

The current effort builds on past Dryden work such as the Environmental Research and Sensor Technology, or ERAST, program and the Access 5 effort that followed. ERAST was a technology development program managed by Dryden for about a decade starting in 1994 that provided seed money for technologies and development of a number of new prototype unmanned aircraft.

> "The key word is routine access, the same kind of access a manned aircraft has to the National Airspace System. You won't have to plan six months in advance the exact path you want to fly, or exactly the mission you want to fly."
>
> **Laurie Grindle**
> **Unmanned Aircraft Systems Integration into the National Airspace System project manager**

Access 5 followed that effort in 2004 to develop a path toward routine access to the National Airspace System led by industry and supported by NASA. This latest effort builds on that work, Grindle said.

While the exact shape of the future air traffic control system is still in development, one thing is for sure – UAS will be part of it.

# UP Aerospace launch successful

**By Leslie Williams**
Dryden Public Affairs

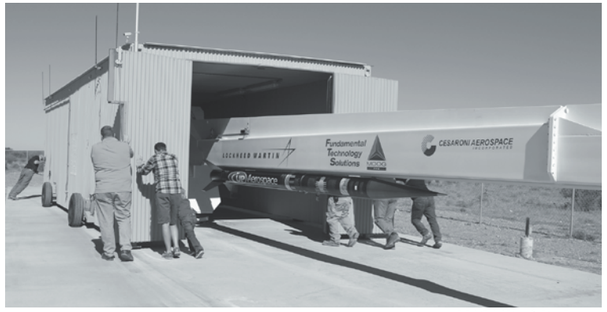
An enthusiastic group of suborbital space researchers arrived at Spaceport America in New Mexico in early November to prepare and load their experiments on an UP Aerospace rocket that would place their technologies in a space-like environment where they will eventually operate.

All of the payloads carried on the Nov. 12th launch of UP's SpaceLoft-8 sounding rocket were NASA-funded research technologies chosen by NASA's Flight Opportunities Program, which is part of the agency's Space Technology Mission Directorate.

The rocket reached an altitude of approximately 73 miles – roughly 385,000 feet – and provided the technologies with nearly four minutes of microgravity. All payload teams indicated they were satisfied with the flight, and a couple of researchers were excited with the preliminary data received.

"The SL-8 launch was a complete success," said NASA campaign manager Paul De Leon at NASA's Ames Research Center, Moffett Field, Calif. "The UP Aerospace team provided an outstanding service, and the launch vehicle performed exceptionally well, just as planned. All of the payload teams were extremely happy with the flight and anxious to get their payloads back and analyze their data."

The Flight Opportunities Program, which is managed at Dryden, released another Announcement of Flight Opportunities Nov. 21 for proposals to test crosscutting technologies in space-like environments, using NASA contracted commercial suborbital companies. NASA will fund those proposals selected by paying the commercial vendor for the cost of the flight.




NASA/Paul De Leon

*UP Aerospace ground crew members roll back the moveable garage and payload integration facility to expose the launcher with the SL-8 sounding rocket mounted underneath.*

## Monitoring... from page 6

on Sept. 17 revealed that Humberto was a hybrid storm. Humberto's hybrid structure was the result of a union of the low-level warm-core tropical storm with an upper-level cold low, so it had a structure that was more of a hybrid, or combination, of a tropical and extra-tropical system.

**Measuring a Hurricane's Heavy Rain and Strong Winds**

HS3's over-storm Global Hawk, which focuses on measurements of storm internal structure, carried the Hurricane Imaging Radiometer or HIRAD, the High-altitude Imaging Wind and Rain Airborne Profiler or HIWRAP, and the High-Altitude Monolithic Microwave Integrated Circuits Sounding Radiometer or HAMSR, on a flight over Hurricane Ingrid on Sept. 15 as the storm moved through the extreme southwestern Gulf of Mexico and traveled west-northwestward along Mexico's east coast. HIRAD identified an area of heavy rain and likely strong winds on Hurricane Ingrid's eastern side by measuring energy coming from the rough ocean surface caused by the rain and strong winds.

"HIRAD data definitely saw most of the strong wind and heavy rain on the northern and eastern sides of Hurricane Ingrid in the area generally near 23 degrees north latitude and 95 degrees west longitude," said Daniel J. Cecil, the principal investigator for the HIRAD instrument at NASA's Marshall Space Flight Center in Huntsville, Ala.

**The Storm That Didn't Develop**

On Sept. 19-20, HS3's environmental Global Hawk was sent to investigate and gather data from a low-pressure system designated Invest 95L, located in the Bay of Campeche. The National Hurricane Center gave Invest 95L a 70 percent chance for development into a tropical depression, but that never occurred. While HS3 data indicated the occurrence of a weak closed circulation at the surface and somewhat stronger circulation just above the surface, rain shower and thunderstorm activity was largely suppressed, preventing development.

"Dropsonde data suggested a layer of sinking air motions in the upper half of the troposphere, the layer of the atmosphere containing most weather. Such sinking motions typically suppress cloud development and dry out the air and likely contributed to the lack of development," said Braun.

**National Hurricane Center Uses HS3 Data from Tropical Storm Gabrielle**

NASA's Global Hawk dropsonde data assisted forecasters at the National Hurricane Center when they analyzed the environment of Tropical Depression 7 that became Tropical Storm Gabrielle on Sept. 4.

The NHC discussion at 11 p.m. EDT on Sept. 4 noted: *Dropsonde data from the NASA Global Hawk aircraft suggest that the circulation of Gabrielle is tilted to the northeast with height...with a mid-level circulation seen in data from the San Juan WSR-88d Radar. This tilted structure is consistent with southerly to southwesterly vertical shear of 5 to 10 knots shown over the cyclone by the University of Wisconsin Cooperative Institute for Meteorological Satellite Studies and other analyses.* In addition the dropsonde data showed dry air in the mid-levels of the atmosphere around Gabrielle that led NHC forecasters to note that not much strengthening was expected in the short term.

**Milestone Flight for Global Hawks**

NASA's Global Hawk unmanned aircraft project celebrated a flight milestone on Sept. 17. The two Global Hawks reached a combined 100 NASA flights during the deployment at the Wallops Flight Facility. NASA's environmental Global Hawk returned to Wallops on Sept. 17 after making its 75th flight and the over-storm Global Hawk departed from Wallops marking its 25th flight.

Although tropical activity was unusually low and there were no major hurricanes, scientists were able to gather a large amount of data on several storms and explore the Saharan Air Layer using the two Global Hawks and their unique suites of instruments.

# Dryden has key ISS role

**By Sam Smith**
Dryden Public Affairs

It was whom Houston called when they had a problem.

As the International Space Station, or ISS, celebrates the 15th anniversary of the launch of its first element, the Russian Zarya module, Dryden continues its vital role as an emergency communications relay for the station.

The communications relay was originally set up in support of the Mir space station, a Russian predecessor to the ISS, in 1995. The Dryden communication team developed a low-cost system consisting of modified commercial equipment to provide inexpensive communications support for the Mir when U.S. astronauts were on board. The system was then installed at two other NASA sites, the White Sands Test Facility in New Mexico and the Wallops Flight Facility in Virginia, to expand the ground network coverage. The three sites continue to support communications between mission control at the Johnson Space Center in Houston and the space station today.

Michael Yettaw, Dryden's communications facility work leader, recently recalled an intense instance when Dryden provided critical communication to the station in 2002.

The positioning systems on the ISS went down putting the station in a free-drift state. The station started to slowly rotate, disabling the primary means of communications. Also, the solar arrays were no longer charging the station's power systems and the station would have gone dark if nothing was done.

During those critical moments, mission control used Dryden's Western Aeronautical Test Range's emergency communications link to transmit the instructions to the space station's crew.

With only 20 minutes notice, Justin Thomas, a communications technician, was able to set up the space communications link in 10 minutes. Dryden was able to relay the repair instructions before the other two emergency sites because of the location of the ISS.

**ED13-0365-07** **NASA/Tom Tschida**

*Communications technician Richard Batchelor and team lead Mike Yettaw of Dryden's Range Operations Branch use a complex array of equipment to monitor and relay data telemetry to and from the International Space Station and voice communications with its crew.*

Despite the potential danger the space station and crew were in, the calm and professional demeanor of the ISS crew and Johnson Space Center's ISS support team during the situation impressed Yettaw.

"It was like something out of the 'Right Stuff' movie," he said. "Hours and hours of routine operations punctuated by moments of intense activity. Matter of fact, they could teach actors how to act calm under duress."

Dryden provided similar emergency support to the Mir. Yettaw recalls a time when the Russian space station lost all power after a docking crash with a Progress cargo spacecraft. The cosmonauts moved into the Soyuz spacecraft to initiate an emergency undocking and return to Earth. The Russian mission control center in Moscow was able to uplink repair instructions through Dryden to the cosmonauts to restore the Mir.

"That 10 minutes of Mir emergency support was one of the highlights of my 30-year career at NASA," Yettaw said.

In early 2007, the Dryden range communications team was again contacted to resolve an ISS issue. Astronauts were installing new cables routing communications for spacecraft dockings, and Houston needed a way to test them from the ground before the next space shuttle mission to the station.

"When the ISS chief engineer advised me that new UHF cables were being installed on-board and (they) needed a way to verify it, he asked if there was anything on the ground that could be used to verify the installation prior to the space shuttle getting in vicinity of the station or astronaut EVA (extra-vehicular activity) outside," said Joe Whitney of the Ground Control Office at Johnson Space Center's Mission Control Center in a follow-up e-mail to Larry Schilling, Dryden's associate center director for Operations at that time.

"I immediately thought of DFRC. DFRC always provides top notch communications support for both the Space Shuttle Program and ISS, and I knew that if it could be done, DFRC could do it," Whitney continued. "I began a few chats with Yettaw and once it sounded doable, we proceeded with … the support."

Yettaw expanded the frequency range of the Dryden directional antennas during a routing upgrade that allowed Dryden to be uniquely qualified to support the new requirement.

The Dryden team combined the existing antennas and spectrum analyzers with a $29 TV amplifier to field a low-cost transmitter test system. Dryden successfully validated the ISS modifications during several orbital engineering support passes in time for the next space shuttle launch.

The Dryden communications support team has received numerous awards including the Exceptional Service Award, the Exceptional Engineering Award, the Manned Spaceflight Support Award, the STS Silver Snoopy and the STS Orbit and Landing Group Achievement Award.

"It's a good feeling," Yettaw said, "to be recognized for what our team does."

# Mach 2... from page 2

re-designated P2B-1S by the Navy – and releasing it at altitudes of about 35,000 feet. Designed by Douglas Aircraft Company's Ed Heinemann, the D-558-2 had an Art Deco profile that made it, in Hallion's opinion, "one of the most elegant research airplanes ever built."

"If we look at the Skyrocket, we really see the genius of one of America's great aircraft designers," said Hallion. "This is an extremely streamlined, highly refined design."

*A. Scott Crossfield*

Although the Skyrocket was only designed to reach Mach 1.5, the NACA team was confident that it could reach Mach 2 under certain conditions. In preparation for the attempt, Skyrocket No. 144 was cleaned and polished to reduce drag, and the fuel was cold-soaked to minimize its volume and maximize the amount that could be stored in its tanks.

Following launch from the P2B-1S, Crossfield ignited the rocket motor and climbed to 72,000 feet altitude. He then nosed the Skyrocket over into a shallow dive and gradually accelerated, edging through Mach 2 at about 62,000 feet. After the engine's fuel was expended the airplane slowed, easing back through the transonic region into a subsonic glide. Crossfield ended the 12-minute flight with a 360-degree roll followed by a smooth landing on Rogers Dry Lake, Hallion related.

Crossfield's record speed in the Douglas Skyrocket would not last long. Only 22 days later, Air Force Capt. Charles E. "Chuck" Yeager flew the Bell X-1A rocket plane to 1,612 mph, almost Mach 2.5.

Following completion of the D-558-2 Skyrocket research program in 1956, Skyrocket No. 144 was placed on display in the Smithsonian Institution's National Air and Space Museum in Washington, D.C. The other two Skyrockets remained in California, No. 145 on exhibit at Antelope Valley College in Lancaster and No. 143 on display at the Planes of Fame Museum in Chino.

Crossfield, who died in the crash of his private plane in 2006, joined the NACA in June 1950 and spent five years flying numerous research jets and rocket planes. During that time he logged 100 rocket-powered flights, making him the single most experienced rocket pilot in the world.

He then joined North American Aviation in 1955 to serve as both test pilot and design consultant on the X-15 rocket-powered research airplane. He made 16 captive-carry and 14 free flights in the X-15, reaching Mach 2.97 – almost three times the speed of sound – on one flight.

After leaving North American in 1967 he remained a vital member of the aerospace industry, working with Eastern Air Lines and then as a technical consultant to the House Committee on Science and Technology until his retirement in 1993. He received numerous awards for his work, including the Harmon Trophy in 1960 and the Collier Trophy in 1961, and was awarded the NASA Distinguished Public Service Medal in 1993.

Throughout his life, Crossfield advocated aerospace education and created the A. Scott Crossfield Aerospace Education Teacher of the Year Award to recognize and reward teachers for outstanding accomplishments in aerospace education. Although revered for his flying exploits, Crossfield preferred to emphasize his role as a scientist.

"I am an aeronautical engineer, an aerodynamicist, and a designer," he explained in a 1988 interview. "My flying was primarily because I felt that it was essential to designing and building better airplanes for pilots to fly."

## Learning and insight

**ED13-0381-26** **NASA/Ken Ulbrich**

*Capt. Carlos "Yardman" Pinedo, above, was one of more than 25 students from United States Air Force Test Pilot School who helped Dryden researchers evaluate potential tow vehicles for the Dream Chaser spacecraft. Pilots evaluated handling qualities of a lifting body in tow using the HL-20 simulator that Pinedo is piloting and performance qualities in the simulators of the C-17 and F-15 as lifting body tow vehicles. The HL-20 simulation was linked to the C-17 and F-15 simulators for real-time tow operation.*

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

Address: P.O. Box 273, Building 4839
Edwards, CA 93523-0273
Phone: 661-276-3449
FAX: 661-276-3566

Editor: Jay Levine, Jacobs/Tybrin, ext. 3459

Managing Editor: Steve Lighthill, NASA

Chief, Strategic Communications:
Kevin Rohrer

National Aeronautics and Space Administration

**Dryden Flight Research Center**
P.O. Box 273
Edwards, CA 93523-0273

Official Business
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