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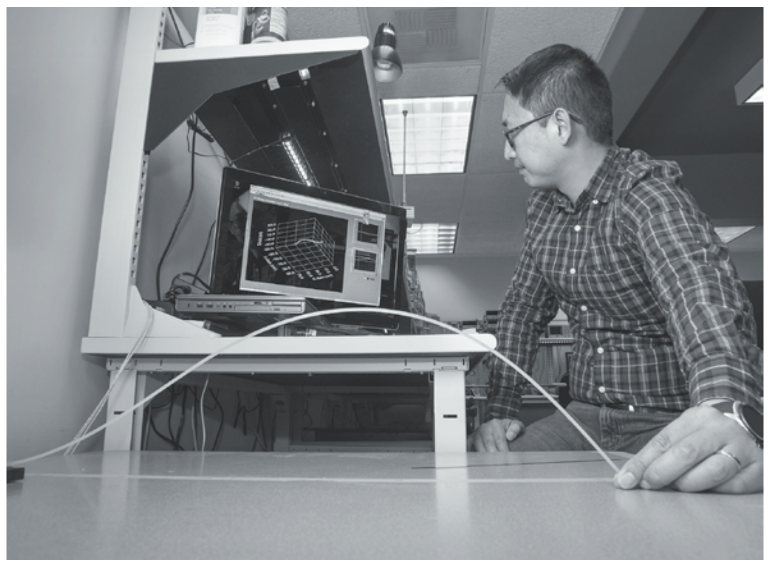

AFRC2017-0092-04 NASA/Ken Ulbrich

Patrick Chan demonstrates one way that the Fiber Optic Sensing System is used by bending a fiber with a 3D representation of the fiber's shape as it bends.

FOSS

System could be valuable to a number of varied industries

By Jay Levine
X-Press editor

A Fiber Optic Sensing System (FOSS) developed through NASA Armstrong research has the potential to change the way flight instrumentation is envisioned.

The light-weight system is capable of monitoring thousands of measurements and relaying that data in real time. It is that ability that led to incorporating FOSS on the X-56 experimental airplane.

Researchers at Armstrong continuously work to improve the system that started as table sized and soon will fit in a container the size of a box of cookies, said Allen Parker, Armstrong's FOSS lead.

The FOSS team is also working with NASA Marshall Space Flight Center in Alabama to refine the system for launch vehicles, he said.

In addition, refinements to simplify FOSS will make it cost effective for use by industries as diverse as medical, power, beverage and automotive that have expressed interest.

"What we can do is only limited by imagination," Parker said.

Experimental aircraft

The system is intended to soon take flight on the X-56 Multi-Utility Technology Testbed aircraft, Parker said.

The X-56 is tasked with investigating flexible wings to improve safety, efficiency and ride quality. FOSS will enable researchers to see the wing shape and strain as it flies to determine how it is working, Parker said.

In addition, NASA's Aeronautics Research Mission Directorate's Flight Demonstrations and Capabilities (FDC) project is funding elements of FOSS work to increase the technology readiness level for other uses.

For example, it is envisioned that a FOSS system could collect information on how aerodynamic forces are affecting an aircraft in real time and loop that information directly into the aircraft's control system for fuel efficiency, safety and a more comfortable ride for passengers.

"To stick FOSS on an airplane, we have to know that it will work with confidence," Parker said. "We will decrease the complexity of the systems for the next generation of this technology and leverage as much as we can from commercial off-the-shelf components."

Spacecraft

The technology is out of this world, as evidenced by the request for FOSS research on rockets to monitor liquid fuel levels and the temperatures and the strain on spacecraft.

In partnership with United Launch Alliance, the Cryogenic Orbital Testbed (CRYOTE) 3, which is anticipated for test later this year at Marshall, will examine the effectiveness of the system. Information gathered from that research could improve models and the design of rocket systems. In addition, a cryogenic sensor would monitor liquid fuel temperatures.

The NASA Engineering and Safety Center also is interested in using a FOSS in the construction of composite fuel tanks to gather data through a FOSS for models and to see the physics of what is actually happening in real time to the tanks. The FOSS could monitor for strain and temperature in the unforgiving environment of space. These tanks consist of pressure vessels with a metallic liner and layers of composite material externally. FOSS could also be embedded in each layer for a ship-in-a-bottle method to continuously monitor the structure, Parker explained.

Why FOSS?

In the past, collecting aerodynamic data and transmitting it required miles of wires, harnesses to keep the

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wires in place and bulky sensors that added weight and complexity to aircraft systems.

The Fiber Optic Sensing System developed through NASA Armstrong research has the potential to be game changing in the way flight instrumentation is envisioned. High-speed monitoring and sensing technology is enabled with efficient algorithms for use in determining strain, shape deformation, temperature, liquid level and operational loads – in real time.

A 40-foot hair-like optical fiber provides up to 2,000 data points and the system processes information at rates up to 100 times per second, representing a sizable improvement compared to conventional data acquisition systems.

When the FOSS and the number of wires required for robust aircraft and spacecraft systems are simplified, it is anticipated that industry interest will grow for the FOSS technology. Industries such as oil, gas and dairy have inquired about a simpler system that can help with a number of different applications.

Along those lines, NASA's FDC and Transformative Tools and Technologies projects have funded development work to advance FOSS technology. "We are constantly looking at how to solve NASA's technical challenges," said Jeff Bauer of the Armstrong Projects Office. "In addition, the Technology Transfer Office is leveraging those solutions to benefit a wide range of non-aerospace industries."

Technology transfer efforts

The FOSS team works with the Armstrong Technology Transfer Office's Janeya Griffin and Laura Fobel to lead industry partnerships that are advancing the readiness level and university agreements, such as one with UCLA, to pursue specific FOSS-related research questions.

For example, two licenses have been granted and five more are pending for evaluation of liquid level sensing in the beverage industry, liquid level and cryogenic liquid level testing, evaluation for 3-D shape sensing for robotic surgery applications and strain and shape measurements for the automotive industry.

In addition, college students at California Polytechnic State University in Pomona are tapped to look at the business case for commercial products from the FOSS. Fobel explained NASA's mission is to develop technology and then to commercialize it for widespread use.

NASA also provides grants to small businesses for technology development. For example, a current Phase 2 Small Business Innovative Research award to Freedom

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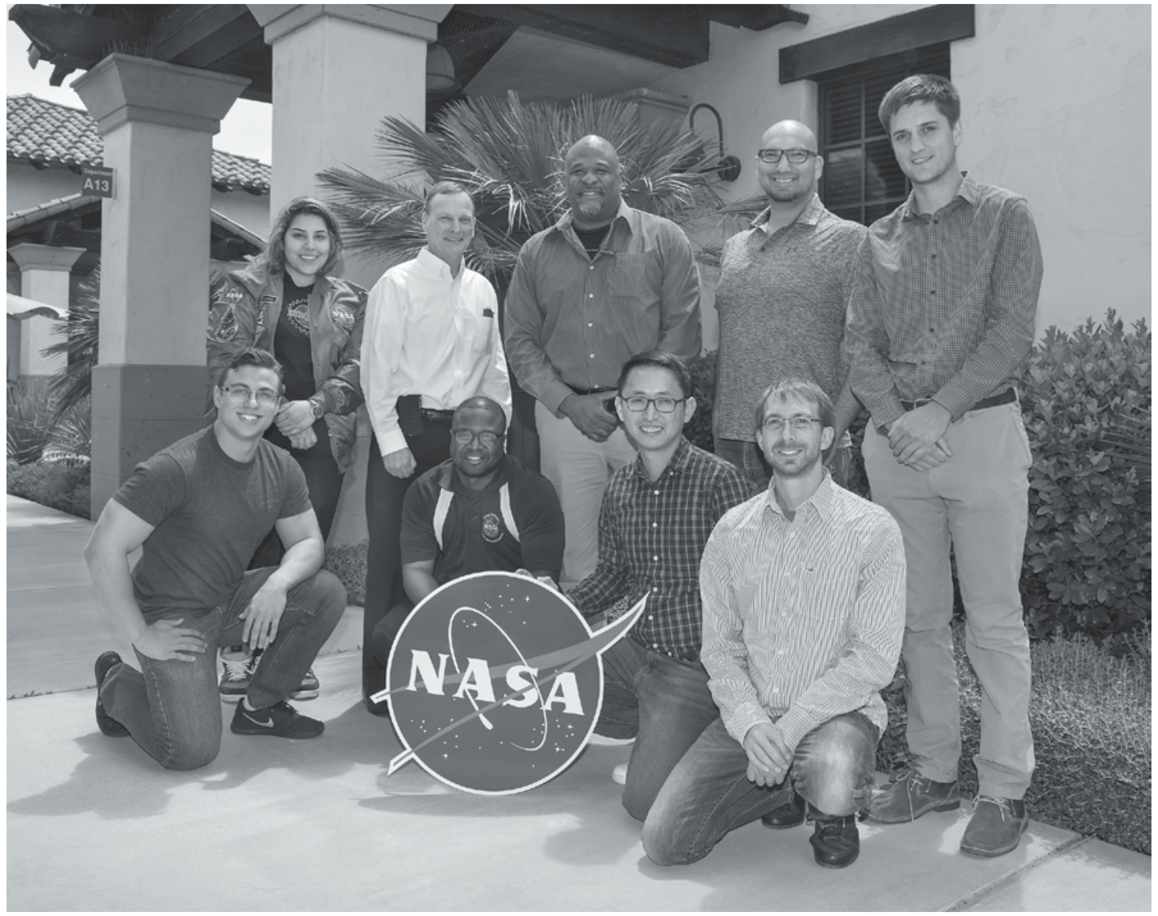

AFRC2017-0092-07 NASA/Ken Ulbrich

The Fiber Optic Sensing System team includes in the front from left Nick Finks, Ryan Warner, Patrick Chan and Paul Bean. In the back row from left are Shideh Naderi, Jeff Bauer, Allen Parker, Frank Pena and Nathan Perreau. Lance Richards, Anthony Piazza and Phil Hamory are current FOSS team members who are not pictured.

AFRC2017-0092-02 NASA/Ken Ulbrich

Shideh Naderi works on designing the electronics for the next generation Fiber Optic Sensing System.

Iliff honored by Iowa State

By Jay Levine
X-Press editor

Ken Iliff , who was chief scientist here from 1994-2002, was recently inducted into the Iowa State Aerospace Engineering Hall of Distinguished Alumni.

Iliff passed Jan. 4, 2016. The Ken Iliff Knowledge Center in Building 4800 was dedicated in his honor in November.

Iliff was key in X-15 rocket plane and lifting body flight research, but his methodology for parameter estimation remains one of the most significant analytical advances in flight research and testing. His codes are used by virtually all flight test organizations. The codes are also used for identification of other dynamic systems, including submarines and economic and biomedical models.

He spent much of his career applying his methodologies to aircraft in flight regimes from low subsonic through hypersonic, including more than 15 years of research on NASA's space shuttles.

Iliff published more than 100 technical reports during his 40-year career, was an AIAA Fellow, and was an inductee to the National Hall of Fame for Persons with Disabilities. He also received the NASA Scientific Achievement Medal in 1976 and the Kelly Johnson Award from the Society of Flight Test Engineers in 1989.

Iliff earned mathematics and aerospace engineering degrees from Iowa State University in 1962, a Master of Science degree in mechanical engineering from USC in 1967, a doctorate in electrical engineering from UCLA in 1973, and a Master of Science degree in engineering management from UCLA in 1975.

Former Center Director Kevin Petersen is also a past inductee.

Submitted photo

Mary Shafer Iliff accepts the Iowa State Aerospace Engineering Hall of Distinguished Alumni Award on behalf of Ken Iliff, her late husband, who passed in January 2016.

Serving up a heaping helping of gratitude

Armstrong's Executive Leadership Team and the Armstrong Exchange joined forces to present an employee lunch following the Safety Day presentations. Safety Day coverage begins on page 4.

AFRC2017-0082-071 NASA/Ken Ulbrich

News at NASA

SOFIA aids in discovery

NASA's flying observatory, the Stratospheric Observatory for Infrared Astronomy, SOFIA, recently completed a detailed study of a nearby planetary system. The investigations confirmed the nearby planetary system has similar architecture to Earth's solar system.

Located 10.5 light-years away in the Southern Hemisphere of the constellation Eridanus, the star Epsilon Eridani is the closest planetary system around a star similar to the early sun. It is a prime location to research how planets form around stars like Earth's sun.

With new SOFIA images, Kate Su of the University of Arizona and her research team were able to ascertain that the warm material around Eps Eri is in fact arranged in at least one narrow belt rather than in a broad continuous disk.

These observations were possible because SOFIA has a large telescope diameter of 100 inches (2.5 meters), which allowed the team onboard SOFIA to discern details that are three times smaller than what could be seen with the Spitzer space telescope. Additionally, SOFIA's powerful mid-infrared camera, called FORCAST, the Faint Object Infrared Camera for the SOFIA Telescope, allowed the team to study the strongest infrared emission from the warm material around Eps Eri, at wavelengths between 25-40 microns, which are undetectable by ground-based observatories.

For more information on SOFIA, go to http://www.nasa.gov/sofia

Stay Safe

Everyone needed to improve solid record

By Jay Levine
X-Press editor

NASA Armstrong had a solid safety record in 2016 that included an 18-percent reduction in serious incidents from the previous year and marking the first time since 2009 that there wasn't a single major injury, illnesses or mishap, said Glenn Graham, director of Safety and Mission Assurance.

The total number of events resulting in property damage decreased from 27 in 2015 to 20 in 2016. Some people are still getting injured at work, he added, during Armstrong's annual Safety Day presentation. Slips, trips and falls are main personal safety challenges, followed by back injuries. Minor injuries dropped from 30 to 26, he said.

Close calls, incidents that under different circumstances could have led to an accident or injury, are another category that the center tracks. About 90 percent of the close calls involve one or more human factors like complacency, inattention to detail, failure to follow procedures, normalization of bad practices, poor communication or coordination and cutting corners or rushing.

"We are irreplaceable and one deep in many areas," Graham said. "Additionally, all of our research airplanes are one-of-a-kind with hard-to-find parts. Safety Day provides a way for us to pause from routines, reflect on areas we can improve and refocus and recommit to safety."

Center Director David McBride focused on lessons learned from the Apollo 1, Challenger and Columbia losses noted by Wayne Hale, a former NASA flight director and Space Shuttle Program manager.

It can happen to you and it takes a team to get things done safely, McBride said. Focusing, speaking, listening, comprehending and taking action are required for a good safety culture.

"We need you all to participate," McBride said. "All of our aircraft are unique. If you see something you are not comfortable with, we need you to speak up."

Dissention has value in a good safety culture. Sometimes it is appropriate to challenge conventional wisdom in order to raise

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AFRC2017-0082-36 NASA/Ken Ulbrich

***Above**, Armstrong employees focus on Safety Day presentations. **Bottom left**, David McBride talks about lessons learned from some of NASA's biggest programs. **Bottom right**, Glen Graham explains the center's safety statistics.*

AFRC2017-0082-010 NASA/Ken Ulbrich

AFRC2017-0082-014 NASA/Ken Ulbrich

At work and away safety is a concern

By Jay Levine
X-Press editor

Work can present hazardous situations, but so can leisure activities – just ask Lily Buth and Tiffany Titus.

The two NASA Armstrong employees explained during Safety Day how some of their favorite activities led them into dangerous situations.

Buth was hiking in a remote area near the Montana and Canadian border when she and her partner were caught in a hail storm. Without cell service, water or protective clothing, the two hikers quickly found themselves in trouble, as hail, rain and increasingly cold weather caused them to lose feeling in their fingertips.

Lily Buth

Clothed only in shorts and a T-shirt, the likelihood of their survival began to diminish, Buth said. Five hours into the hike they saw another person who was heading back because a bear and her cubs where ahead on the trail. A quick risk assessment led the couple to decide they would perish from hypothermia if they turned back, so they risked being mauled.

The temperature was dropping and the rain provided some cover from the bears and the couple passed without incident. Buth and her companion then found garbage bags and used them as makeshift ponchos in order to provide protection from the storm.

A key lesson – no matter what a person is doing during a leisure activity like hiking, or at work, a person must not be complacent, Buth said.

Tiffany Titus recalled a skiing trip that went awry and forever changed her life.

Titus enjoyed the outdoors and was excited about a ski trip in February 2013. The weather was overcast with a few inches of fresh powder, good conditions for skiing.

However, the chair lift also had a dusting of snow hiding ice on the seats that had no restraining bars. Titus began to slip out of the seat and fell screaming 20 feet resulting in a landing flat on the frozen ground.

Tiffany Titus

Her first memory was of a dull aching sensation in her back and being fastened into a neck and back brace. She thought her legs were broken because of the "insane amount of pain" that she felt.

"An X-ray of my spine showed the impact burst my L1 vertebra; I broke my back," Titus said.

A fragment of the vertebra was lodged in the spinal column, requiring two surgeries. Two sets of rods and screws also were inserted.

"I went from being completely active to needing help with everything," Titus said. "It was devastating to me. Standing to brush my teeth was hard. It was a long road to recovery."

She worked hard and she was walking unassisted in 2 ½ months and hiking again three months after the accident. She had been told it would be at least six months before she would be walking unassisted. She said she continues to do all of her favorite outdoor activities, but she still has nerve damage and lingering challenges.

"I didn't give up," she said. "I went backpacking the following summer, 16 months after the accident. I was skiing again 21 months after the accident, and I had a backpacking wedding. You never know what is going to happen to you. A split second changed my life."

AFRC2017-0082-067 NASA/Ken Ulbrich

Jack Trapp, right, received the 2017 Safety Civil Servant of the Year Award from Glenn Graham. As aircraft support fleet manager, he identified, reported and facilitated the remedy of hazardous conditions within the flight and facility operations that averted potential serious injury and equipment damage.

AFRC2017-0082-068 NASA/Ken Ulbrich

Karen Richards, right, received the 2017 Safety Contractor of the Year Award from Graham. She provided attention to detail as an invaluable link between the principal investigators and the mission managers to ensure the safety and success of the lab and ground integration activities.

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safety concerns, McBride said. In addition, imagination and vigilance are keys to success.

"We have to take risks sometimes, but we have to manage those risks," McBride said. "The trends show accidents are coming down, but the costs of accidents are high. Even at our current rate of injuries, 10 to 12 of you might not go home in the same condition that you came to work at some point this year. That is too many. Zero is the appropriate number."

A presentation by Rogers Smith, a former Armstrong test pilot on research aircraft such as the X-29, X-31 and the SR-71, focused on safety culture.

"A safety culture is one that has trust, discipline, competence and passion that allows room for good leadership in the face of periodic stress," Smith said. "If you think safety is expensive, think about the cost of an accident. Safety is like an insurance policy."

Fighting what he calls a global war on error, safety challenges have to be weighed as if they were based in the department of wishful thinking or the department of reality. "We need both, but they have to work together."

An enemy of the safety culture is the normalization of bad habits, the idea that if something works people keep doing it, even if it might not be safe. People also have to think under pressure and be aware of their environments

"You can do something right 99 times, but the one time you do it wrong, maybe you die, someone else dies, perhaps high-value damage results," Smith said. "We work in high-risk environments where you have to do it right all of the time."

"In fact, mistakes are made by people with the most experience and who are gifted," Smith said. "For that reason, checklists are invaluable. In our world, we need to read them and do them because

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AFRC2017-0082-069 NASA/Ken Ulbrich

Kevin Mount and Juan Salazar, middle and right, received the 2017 Safety Team of the Year Award, from Graham. In response to a close call incident on the G-III Subsonic Research Aircraft Testbed project, the team devised a brake fluid capture vessel that prevents exposure to potentially hazardous hydraulic fluid.

AFRC2017-0082-070 NASA/Ken Ulbrich

Eric Huffmaster right, received the 2017 Safety Representative of the Year Award from Graham. He brought unsafe working conditions to light, improved the safety awareness of branch employees, briefed new employees on emergency response procedures and ensured fire response was accurate and timely.

Biofuels significantly reduce emissions

By Kathy Barnstorff
NASA Langley Public Affairs
and Jim Banke
NASA Headquarters Public Affairs

NASA/SSAI Edward Winstead

The DC-8's four engines burned either JP-8 jet fuel or a 50-50 blend of JP-8 and renewable alternative fuel of hydroprocessed esters and fatty acids produced from camelina plant oil.

Using biofuels to help power jet engines reduces particle emissions in their exhaust by as much as 50 to 70 percent, in a new study conclusion that bodes well for airline economics and Earth's environment.

The findings are the result of a cooperative international research program led by NASA and involving agencies from Germany and Canada, and are detailed in a study published in the journal Nature.

During flight tests in 2013 and 2014 near NASA Armstrong, data was collected on the effects of alternative fuels on engine performance, emissions and aircraft-generated contrails at altitudes flown by commercial airliners. The test series were part of the Alternative Fuel Effects on Contrails and Cruise Emissions Study, or ACCESS.

Contrails are produced by hot aircraft engine exhaust mixing with the cold air that is typical at cruise altitudes several miles above Earth's surface, and are composed primarily of water in the form of ice crystals.

Researchers are most interested in persistent contrails because they create long-lasting, and sometimes extensive, clouds that would not normally form in the atmosphere, and are believed to be a factor in influencing Earth's environment.

"Soot emissions also are a major driver of contrail properties and their formation," said Bruce Anderson, ACCESS project scientist at NASA's Langley Research Center in Hampton, Virginia. "As a result, the observed particle reductions we've measured during ACCESS should directly translate into reduced ice crystal concentrations in contrails, which in turn should help minimize its impact on Earth's environment."

That's important because contrails, and the cirrus clouds that evolve from them, have a larger impact on Earth's atmosphere than all the aviation-related carbon dioxide emissions since the first

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we can't make that one mistake, especially in the air."

Flight research operates in an unforgiving environment and Todd Ericson, Virgin Galactic vice president for safety and tests, talked about a bad day for Space Ship Two.

A serious inflight anomaly happened 13 seconds into the flight and resulted in the pilot's death and serious injuries to the co-pilot on the fourth powered flight of the vehicle. The co-pilot unlocked the aircraft's "feather" system at the worst time in the flight resulting in the vehicle's inflight breakup.

"Managing risk on complex vehicles is difficult," Ericson said. "Risk is impossible to eliminate, but we have to be mindful of unintended consequences."

As a result of the incident and the ensuing comprehensive safety review, the spaceship's procedures were amended so that the "feather" is now controlled automatically. The solution can prevent the same situation from unfolding.

Dave Walker, who is a member of the safety directorate at Building 703 in Palmdale, recounted a F-16 ejection that was necessary after an engine failure.

As a pilot at Luke Air Force Base in Arizona, he was flying an aircraft with a poorly-manufactured engine turbine blade. The engine failure on this flight was nearly fatal as a blade from the engine flew into the aircraft's fuel tank and exploded.

Walker said he was forced to eject, a decision that resulted in spinal injuries that he continues to suffer. A contributing factor to his injuries was a normalization of deviance from procedures in which one of the seatbelt straps was not worn tightly because it impeded the pilot's ability to see completely behind the aircraft.

"We were doing stuff wrong for so long it became the norm. Now I need pain killers 25 percent of the time."

Tracy Dillinger, NASA's manager for Safety Culture and Human Factors in Mishap Investigations aims to disrupt the chain of events leading to injuries.

"Safety incidents are a chain and they build like dominos," Dillinger said. "The idea is to stop the chain."

About 80 percent of mishaps and other safety events are attributed to humans for reasons like memory, violation of the rules and incompetence, she said.

"Each one of you has a part of this," Dillinger said. "We are all vulnerable to human factors. We have to work at it all the time."

Maj. Gen. Larry Stutzriem, director of research for the Mitchell Institute for Aerospace Studies and a 30-year U.S. Air Force veteran pilot and commander, offered a different perspective.

When he served in Korea on an investigative board, a member felt there was something not right about the engine they were reviewing.

"We went back to where they worked on the engines," Stutzriem said. "We met with the two-star general, who said, 'I fix, you fly. Major, I think your job is done here.'"

Not satisfied with the responses, he decided to break into the turbine assembly area. What he found was distressing, he said. There were tools all over, areas of the engines were partially exposed that shouldn't have been, and other violations were obvious.

He was taking pictures when he was discovered. Despite the trouble, the safety board changed its findings because talented people looked beyond the surface.

"Becoming a believer beyond the structured environment is a characteristic of top performing teams," Stutzriem said. "The workforce is a commodity. Speak up and say something isn't right."

FOSS... from page 2

Photonics of Santa Barbara, California, funds testing of a laser that could provide a smaller and more robust system at a cost far less than the current laser technology applied in the FOSS.

"If the laser can solve some challenges, we can make a smaller and cheaper system – then the sky is the limit," Parker added.

The goal for the FOSS technology is to become a reliable, plug-and play, commercial off-the-shelf product.

"It will be robust and earn safety critical certificates to make it truly commercial and ready for use," Parker said.

History lesson

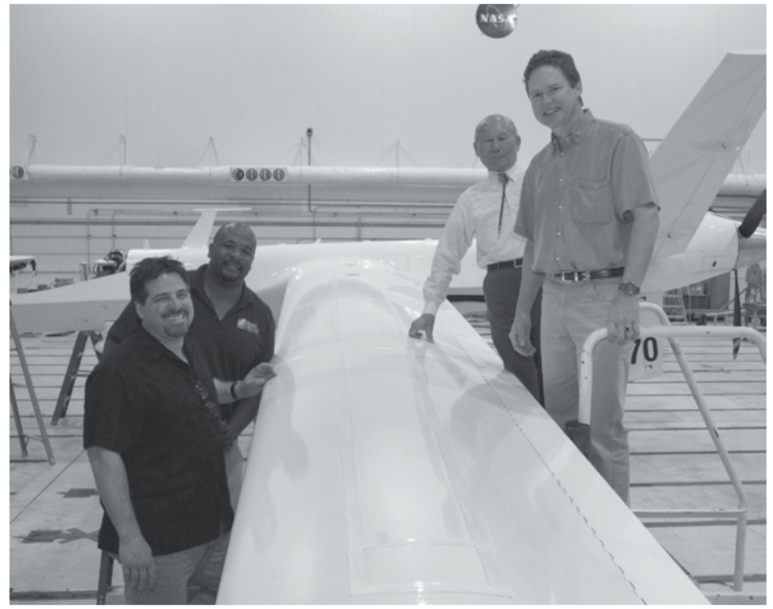
Armstrong's Lance Richards began to consider fiber optic applications to aerospace in the 1980s and saw potential in work at NASA's Langley Research Center in Virginia in the mid 1990s.

Along with William Ko, Anthony "Nino" Piazza and Parker, the team at Armstrong began to adapt the work to aerospace and develop the algorithms, hardware, software and ideas to make it functional.

The FOSS and traditional sensors were used in 2008 for the first time in flight on the center's remotely piloted Predator B, called Ikhana. Those flights validated the FOSS worked as well in the sky as it had in the laboratory. Since then, Parker and a team of researchers have worked to simplify the system, while improving reliability.

"We knew once we saw this fiber react to the environment, we knew this had the potential to change the way we do structural health monitoring, but we also knew we had a long road ahead," Parker said of early research. "We saw the potential and with Ikhana, the dream came true."

The work to refine the dream continues.



ED08-0109-08 NASA/Tom Tschida

The Fiber Optic Sensing System (FOSS) technology was used on NASA's Ikhana (Predator B) aircraft to validate fiber optic sensor measurements and real-time wing shape sensing predictions. The FOSS team during the research included, clockwise from left, Anthony "Nino" Piazza, Allen Parker, William Ko and Lance Richards.

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powered flight by the Wright brothers.

The tests involved flying NASA's workhorse DC-8 as high as 40,000 feet while its four engines burned a 50-50 blend of aviation fuel and a renewable alternative fuel of hydroprocessed esters and fatty acids produced from the oil of the Camelina sativa plant. A trio of research aircraft took turns flying behind the DC-8 at distances ranging from 300 feet to more than 20 miles to measure emissions and study contrail formation as the different fuels were burned.

"This was the first time we have quantified the amount of soot particles emitted by jet engines while burning a 50-50 blend of biofuel in flight," said Rich Moore, lead author of the Nature report.

The trailing aircraft included NASA's HU-25C Guardian jet based at Langley, a Falcon 20-E5 jet owned by the German Aerospace Center (DLR), and a CT-133 jet provided by the National Research Council of Canada.

"Measurements in the wake of aircraft require highly experienced crew members and proven measuring equipment, which DLR has built up over many years," said report co-author Hans Schlager of the DLR Institute of Atmospheric Physics. "Since 2000, the DLR Falcon has been used in numerous measurement campaigns to investigate the emissions and contrails of commercial airliners."

Researchers plan to continue studies to understand and demonstrate the potential benefits of replacing current fuels in aircraft with biofuels. NASA's goal is to demonstrate biofuels on its proposed supersonic X-plane.

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