The National Aeronautics and Space Administration

The Dryden X-Press

AEROVATIONS

Desert Thunder!

Masten Flight Systems works toward first launch of a NASA payload for Flight Opportunities office

Inside Aerovations

Cover Story
Flight Opportunities

News

SBIR

Fiber optic systems

People

Concepts

The Masten Flight Systems tethered rocket test on the cover was photographed by Tom Tschida (NASA Photo ED11 0139-49)

Stories by X-Press Editor Jay Levine except where noted.

Welcome to Aerovations

This is an exciting time within NASA for innovation and technology. With the creation of the NASA Office of the Chief Technologist, and the selection of its chief, Bobby Braun, a new agency champion has emerged to re-vitalize NASA as a preeminent research and development organization. Expanding on initiatives of the former Innovative Partnerships Program, new models are nurturing innovations inside and outside of NASA. In fact, as part of the OCT, all of the IPP – now called the Innovative Partnerships Office – has been adopted and its work continued.

Competitive partnership opportunities such as the successful Small Business Innovative Research and Small Business Technology Transfer programs continue as part of the OCT Space Technology programs. Ten such programs are organized under three divisions: early-stage innovations, game-changing technologies and crosscutting technology demonstrations. The individual programs are detailed elsewhere in this publication.

The Innovative Partnerships Office is managing all former IPP responsibilities for the Space Technology programs. David Voracek, Dryden center chief technologist, provides oversight and serves as a representative to Braun's office. Center chief technologists guide their respective center's participation in the Space Technology programs, and will provide each center's "bottom-up" input to the agency's innovation and technology strategies and goals.

Selecting and investing in a large number of highly creative activities with potential for disruptive, or game-changing, technology breakthroughs will generate excitement about NASA's work. Drawing from private industry, colleges and universities, a wave of creative ideas will foster innovations that will engage a new generation of researchers and technologists. Partnerships such as those available through SBIR and STTR are models for other collaborations aimed at reinvigorating technology for NASA as well as at stimulating commercial applications, market expansion and investment in future technologies.

Dryden also was selected to manage the Space Technology's Flight Opportunities program under NASA Headquarters program executive Laguduva Kubendran, a former member of Dryden's technical management staff. Dryden's John Kelly is the Flight Opportunities program manager. The Flight Opportunities

Resources

Ronald Young, Dryden Innovative Partnerships Office 661-276-3741

The Office of the Chief Technologist: http://www.nasa.gov/offices/oct/home/index.html

SBIR and STTR information: http://sbir.gsfc.nasa.gov/SBIR/SBIR.html

Dryden IPP website: http://www.nasa.gov/centers/dryden/about/Organizations/Technology/

ED11 0115-05 NASA Photo by Tom Tschida

The Innovative Partnerships Office staff includes, from left, Jason Hanson, Ron Young, Julie Holland, Greg Poteat and Elizabeth Newcamp.

office is formulated from two previous projects. Ames Research Center, Moffett Field, Calif., began the Commercial Reusable Suborbital Research, or CRuSR, activity for the agency's Science Mission Directorate. A second project is the Facilitated Access to the Space Environment for Technology, or FAST, which originated in the former IPP office. Flight Opportunities officials will seek and foster capabilities and services from the commercial sector, initially for suborbital flight services.

As with all change, some has been seamless and some has been challenging. At Dryden, a valued member of the IPO staff, Russ Barber, recently passed away. Barber participated in analyzing and assessing emerging commercial space markets that would foster a viable commercial industry, bringing these data into NASA's Space Technology strategy and selection process. Additionally, in work with a nascent commercial flight-service community, Barber's many years of NASA project management experience and insights were greatly respected on Flight Opportunities programmatic challenges. Russ will be sorely missed in a number of ways.

It also is expected to be a year of achievement. The Xaero launch of the first NASA payload by Masten Flight Systems of Mojave, Calif., for the Flight Opportunities program will be a major step toward demonstrating reliable flight services for additional technology demonstrations and scientific payloads. The flight also marks a new era of cooperation with our commercial partners.

Although the name of the office has changed, its mission has not. Partnerships are still part of the office name and a key part of what we do. We seek out partnerships with industry, academia and other NASA and government entities to continue raising the readiness level of emerging technologies, identifying new sources of innovation to address NASA's technology needs that will not only resolve the agency's technical challenges, but also benefit the nation and the general public through technology transfer for new commercial applications.

Ron Young, Dryden Innovative Partnerships Office

Seeding innovation

Dryden Center Innovation Fund selectees named

A new Center Innovation Fund seeded through the NASA Office of the Chief Technologist became available when the federal 2011 fiscal year budget passed in April. The goal of the new initiative, funds from which are being offered to agency researchers at each of NASA's field centers, is to stimulate new ideas and encourage pursuit of promising technologies.

Dryden researchers submitted their proposals at the beginning of the fiscal year to David Voracek, Dryden Chief Technologist. So selections could be made from the submissions as soon as funding became available, a group composed of two members from each Dryden directorate ranked the proposals on technical merit, Voracek said.

"The Center Innovation Fund will allow researchers to investigate ideas they would not be able to fund any other way to see if a concept has merit for further study. We hope the research funded by the CIF will lay the groundwork for future NASA investments in developing these emerging technologies, which will leverage Dryden's talents and capabilities," said Voracek.

Four projects were selected to receive funding and are expected to reach established milestones by September. Project researchers are listed alphabetically below with brief descriptions of the projects they will lead.

Jonathan Barraclough

Two-seat and, soon, six-seat aircraft powered entirely by electricity are closer to becoming reality. The trend is moving toward electrically powered commercial aircraft, and Dryden researcher Jonathan Barraclough wants Dryden to be a driver of this new revolution in technology advancement and integration.

Ideally, an X-plane that integrates all-electric components or a hybrid aircraft with many electric components would be developed and flown at Dryden to validate and verify the concepts and integration, which the commercial sector would then incorporate into new generations of airplanes. Toward that goal, Barraclough earned funding for electric aircraft system technology development that dovetails with Aeronautics Research Mission Directorate visions for less noisy, more fuel efficient and environmentally friendly future aircraft.

Jonathan Barraclough

Barraclough, an electrical engineer, is specifically interested in electric propulsion, which he said he believes can dramatically increase overall efficiency and reduce environmental impact. Development of new aerodynamic, structural, control and powerplant technologies will be required, but preliminary steps could lead to new breakthroughs to make future visions possible, he said.

His task will be to seek out partners in industry and academia with expertise that can be leveraged in electrical aircraft technologies, combining benefits of related technologies to help surmount technical hurdles in creating all-electric aircraft. A report he will write when his research is complete will focus on partnering possibilities, required test infrastructure for electric aircraft systems development and integration and, potentially, conceptual drawings for test systems.

Marty Brenner

Algorithms will be needed for moving aeronautics- and physics-based information from sensors to an aircraft's flight control computer in real time and success will open a new frontier in controls

See Innovation, page 5

Center chief technologist has a vision

David Voracek has a vision for Dryden in which technology developed here collaboratively through partnerships nationwide will cut across a number of needs for NASA and the nation. More important, the technology will be ready for use when it is needed.

David Voracek

As the newly named Dryden Chief Technologist, Voracek has begun to chart a course to realize that vision. First, he will have to determine the range of technologies at the center and how they fit into the key goals of the agency's Office of the Chief Technologist.

"We will develop strategies to get to a technology portfolio that we really want – including flying technology demonstrations. Fortunately, we have NASA Center Innovation Funds to help some people bring their ideas from napkins and paper to start implementing them," Voracek said.

His vision and his task extend across Dryden.

"The Center Chief Technologist represents technology in all of the different codes across a NASA center. I am trying to encourage innovation in everything we do here, from a procurement process to a flight technology. Innovation can help us do everything better," he added.

The agency Office of the Chief Technologist, which also was recently established, seeks to coordinate all technology efforts across the agency into a cohesive plan for elevating the readiness level of key technologies, while helping to foster partnerships to maximize resources and more rapidly move technology to products that can

See Voracek, page 5

Innovation ... from page 4

and aircraft efficiency.

New aerospace vehicle designs will depend on such an integrated system that can gather information from an aircraft's sensors and feed it into the flight control computer. What's potentially revolutionary is then having the flight control system use new algorithms in harnessing that information to alleviate aerodynamic forces and achieve different system goals, said Dryden researcher Marty Brenner. The research focus will alternately be on handling quality performance, gust-load alleviation and aerostructural stability.

Marty Brenner

Brenner equates the sensors and their information on an aircraft, feeding back into a fly-by-feel flight control system, to the human nervous system. In the body, signals to the brain from the central nervous system allow a person to react to what is happening, as it's happening. If Brenner is successful, as an aircraft flies, information from the sensors will be fed into the flight controls and allow the aircraft to adapt to flight conditions.

Called Distributive Adaptive Aeroservoelastic Control Utilizing Physics-Based Aerodynamic Sensing, the new technology will be used in pinpointing flow bifurcation points – areas where the airflow characteristics change significantly – to define a relationship between different key parameters.

For example, information on the leading-edge stagnation point, with angle-of-attack or flow separation point and aerodynamic lift coefficient, could be used in the control system for decisions on how to control the aircraft. The system also would help minimize transitions on the aircraft, such as those from laminar-to-turbulent and attached-to-separated airflow, and shock waves.

See Innovation, page 29

Voracek ... from page 4

benefit the nation.

A chief technologist was appointed at each NASA center to represent the centers on the Office of the Chief Technologist staff. As such, Voracek will be expected to serve as the principal advisor to Dryden leaders on center-wide technology development efforts and communicate Dryden technology capabilities to the NASA Center Technology Council. The council is comprised of the center chief technologists and NASA Chief Technologist Robert D. Braun.

Voracek will also serve as the point of contact for the NASA Center Innovation Fund, when the appropriations process is complete, and for fund reporting and management. Proposals already have been requested, collected and are in the process of being prioritized for when funding does become available (see article p. 16).

Other duties include being the center focal point for Space Technology Research Fellowships and leading technology transfer, Small Business Innovation Research and Small Business Technology Transfer and commercialization opportunities at Dryden.

In addition, Voracek is tasked with serving as center change agent in aiding the workforce's capacity to innovate, document, demonstrate and communicate societal impact of center technology accomplishments and encourage partnerships and inter-center collaborations.

Voracek first worked with the Office of the Chief Technologist in April 2010, when he took a temporary assignment at NASA Headquarters to help with OCT formulation. In May 2010, he was appointed Dryden center chief technologist and was permanently appointed to the position in October.

Voracek began his Dryden career in 1987 as a research engineer in structural dynamics working on flight research programs such as F-16XL, X-29 and the F/A-18 High Angle of Attack Research Vehicle, doing ground-vibration testing and flight-flutter testing. His research included developing flight-flutter techniques, active structural damping and piezoelectric systems tests.

In 1995, Voracek was chief engineer for the F/A-18 Systems Research Aircraft. He was responsible for working with technologists from NASA and the Air Force Research Laboratory on integrating experiments onto the aircraft and coordinating technical engineering staff and technical briefings.

The technology included electromechanical actuator and electrohydrostatic actuator systems, fiber optic engine sensors, the integrated structural antenna, and structural excitation systems. Voracek's duties included serving as mission controller and flight test engineer for the flights. He accumulated 25 flight hours in the back seat of the F/A-18 aircraft as SRA chief engineer.

From 1998 to 2002, Voracek was chief engineer for the Active Aeroelastic Wing project, a joint project of the AFRL, The Boeing Company and NASA. Voracek led the formulation team that developed the research objectives and requirements for the flight project. He led the technology and engineering staff from development of requirements through the first flight and aircraft characterization phase of the project.

In addition, Voracek worked five years in the Dryden Business Development office with officials from other government agencies and private industry to formulate technology development programs. He managed the $1million Dryden Flight Research and Productivity Tools project, a competitive technology development effort.

In 2008 he was appointed deputy director for Dryden Research and Engineering, where he helped to supervise a 143-person directorate and managed the research budget.

Voracek received his aerospace engineering degree from Iowa State University, Ames, in 1986, a Master of Science in aerospace engineering from Northrop University in Los Angeles in 1991, and a Master of Science in systems architecture and engineering from the University of California, Los Angeles, in 2008.

Fiber optic sensors

Parker's algorithm shatters a technology barrier

Dryden researcher Allen Parker recently developed an algorithm that permits information from fiber optic sensors to move exponentially faster. In other words, information from fiber optic sensors can now be viewed in real time.

"Sitting at my workbench, a light came on," said Parker, who works from the NASA Advanced Technology Laboratory located at the Aerospace, Education, Research and Operations, or AERO Institute in Palmdale, Calif. "I saw the problem with a different perspective and, shortly afterward, submitted a New Technology Report, and it took off from there."

A key impediment to widespread use of fiber optic sensor technology was the speed at which information from the sensors travelled to the individual needing the information. With his new mathematical equation, or algorithm, that is no longer a problem.

As a result of the breakthrough, Parker has a patent pending for his algorithm, which is called Method for Reducing Rate of Fiber Bragg Grating Sensors. In addition, with removal of a key stumbling block that was holding the technology back, the commercialization possibilities are growing. Dryden's Innovative Partnerships Office recently announced that a licensing agreement is now in place with Texas-based company 4DSP to commercialize the technology, making it readily available for others to use (see related article).

To put Parker's fiber optic sensing development in perspective, the rate of information transfer from fiber optic sensors in the past was one sample every 30 seconds; Parker's algorithm increases that to 100 sweeps of the laser that reads the sensors per second.

Parker also has worked on miniaturization of fiber optic sensor systems. When he first saw a fiber optic sensing system – one developed at Langley Research Center, Hampton, Va. – it took an entire table to contain a system capable of transferring just one

See Fiber optic sensors, page 7

ED10 0223-01 NASA Photo by Tony Landis

The metallic panel has both conventional and fiber optic sensors. The white bundle of cables contains 100 conventional strain gages, the single yellow cable about 350. Dryden aircraft have been used in validation of fiber optic sensors. Fiber optic sensors may also have applications in a number of different fields.

Dryden, 4DSP enter licensing agreement

A single fiber thinner than a human hair may one day enable systems that can monitor aircraft health, detect cracks and assess damage from natural disasters in bridges and infrastructure as they occur, support the gas and oil industries and be used in medical equipment.

Pierrick Vulliez

Pierrick Vulliez, president of the company 4DSP, thinks that day is near. Vulliez's company recently entered into a licensing agreement with Dryden to begin commercializing Dryden-developed fiber optics work. Through use of Dryden researcher Allen Parker's patent-pending algorithm (see main article), information now can move from the fiber optic sensing system to the people who need it as events being monitored unfold, he said.

"Under the licensing agreement, 4DSP is allowed to engage in the design, manufacturing, promotion and commercialization of fiber optic sensing products," Vulliez said.

Vulliez and Parker began talking and working together in 2007 and the Texas-based 4DSP has developed some of the components of Dryden's fiber optic sensing system. Now the challenge will be to package the technology into commercial, off-the-shelf products that can be customized by users.

See 4DSP, page 8

Fiber optic sensors ... from page 6

scan every 30 seconds.

"Wow, this is neat, but how realistic is it?" Parker said of his first look at a fiber optic sensing system.

Since seeing the Langley system, Parker has worked to reduce the size of the fiber optic sensing system by more than 75 percent. Parker, who was part of a team with William Ko, Anthony Piazza and Lance Richards, first instrumented a Dryden aircraft in 2008 to prove that the accuracy of the fiber optic sensing system was as good as traditional sensors. Flights on the Ikhana unmanned air system validated that point.

With the combination of smaller size and faster data transfer, the fiber optic sensing system is now ready to go and has been proven so through flights on both the Dryden Ikhana Predator B and AeroVironment's Global Observer.

As so often happens, breaking through one technological barrier has led to a new one, Parker said. Now, the limitation will be the capability of the laser. Parker has ideas for how to eventually resolve that problem, too, but for now the algorithm will be expanded; fiber optic systems that now can gather 100 sample per second as a result of this algorithm can be improved to obtain as many as 250 samples per second, he said.

Though aeronautics, space, medicine and drilling have been mentioned as some of the industries with an interest in fiber optic sensing system technology, Parker said there are no limits to how it can be used.

For example, Parker said he believes a day will come when aircraft are fabricated with fiber optics and have systems that tell maintainers exactly what is wrong, without extensive – and expensive – maintenance down periods.

"One direction is for it to become a large-scale system – instrument an entire large-scale aircraft with a single, relatively small system, putting fibers all over the surface of the vehicle to perform comprehensive vehicle health monitoring," he said. "Like a human nervous system, which has 'sensors' embedded throughout the body from the legs, arms, back and all areas, determines the state of the body then feeds that information to the brain – the same is true for this next-generation aircraft system."

Sensing is not limited to strain; other parameters such as temperature, pressure, shape and loads can be measured with a fiber optic sensing system.

For that reason, the oil and gas industries are interested in using fiber optics in specialized drill heads that can sense shape as well as temperature and pressure. A drill operator needs to know exactly how a drill head is positioned, which can be determined by knowing its shape. Temperature and pressure can also tell the operator about the health of the drill.

Closer to home, fiber optics will be added to the F/A-18 No. 853 for flight experiments that could have implications for aero and space vehicles, as well as for structures in space. Fiber optics can be used to take measurements on wing and other aerodynamic surfaces that could be fed into flight control computers for what researchers call a "fly-by-feel" system. The system would be able to compensate for conditions and would therefore use less fuel.

Another result of using fiber optic sensing systems as part of a control system is managing aircraft structural components anticipated to be made of lighter, more flexible materials, Parker explained.

The fiber optic sensing system on F/A-18 No. 853 will include shape as one of the parameters to be measured, fed back into the flight control system and used to control the shape of its wings.

"We hope to have the fiber optics sensing system on the aircraft and start making measurements by end of the year," Parker said.

Meanwhile, a fiber optic sensing system is in development for the Dryden G-III, for a new type of composite flap. The Air Force Research Laboratory wants NASA to design and build a fiber optic sensing system to monitor the strain distribution and shape of the new flap.

Also of interest is how a fiber optic sensing system could be used in assessing the nation's aging infrastructure. Fiber optics can be used on bridges to sense cracks or assess damages from natural disasters such as earthquakes, he said.

During the next several years, Parker envisions working with components such as lasers and optics to greatly reduce the size and cost of the next-generation system. Originally, researchers saw large-scale systems as being able to fit on a rack mount on an airplane. But Parker said building small, rugged systems with four to eight fibers for small, unmanned aerial systems has become a priority. Particularly in new and smaller craft, involving situations in which a vehicle is performing near its structural limits, a fiber optic sensing system could be critical, he added.

The capability of having thousands of sensors to measure strain, temperature or pressure also represents a paradigm shift. New ways of looking at information – and determining what is important – are becoming a new area of interest. An adaptive "smart sensor" is the answer, he said. The new fiber optic sensor systems will be developed with the capability of focusing on what the researcher wants, or where the action is, he added. In other words, researcher would not have to sort through large amounts of data during post analysis to extract important data features.

Regardless of what the next advancement will be in fiber optic sensing technologies, one common thread is that Allen Parker and Dryden researchers will be looking to lead it.

Dryden fiber optic sensor work honored

Dryden's work with fiber optic sensor systems has garnered agency-wide attention. The following are awards earned by Dryden researchers:

• Jaiwon Shin, Aeronautics Research mission directorate associate administrator, named Dryden researcher Allen Parker a 2010 recipient of an honorable mention in the technology innovation category for his fiber optics work.

"An expert in fiber-optic instrumentation, Parker has led the development of miniaturized fiber-optic based strain measurement

See Honors, page 8

Honors ... from page 7

technology that can be used in flight capable systems, and that provides sample rates appropriate for research data gathering and for possible use in aircraft control systems and other non-aerospace technologies," the wording of the award reads.

"His work on miniaturizing the system's electronics and streamlining algorithms running on those electronics resulted in small suitcase-sized systems that can acquire data from thousands of individual sensors. NASA is exploring these systems for active control of extreme lightweight airframe structures. The medical device industry is exploring use of this technology in advanced medical instruments."

• Parker also was part of the NASA Composite Crew Module Non-Destructive Evaluation and Test team, which also included Patrick Chan, Anthony Piazza and Lance Richards. The group was recognized with a group achievement award at the 2010 NASA Engineering and Safety Center Honor Awards.

The honor was in recognition of outstanding contributions in the field of Non-Destructive Evaluation and test execution on the Composite Crew Module Project at Langley Research Center, Hampton, Va. The crew module was instrumented with fiber optic sensors along the hatch and windows to monitor high-strain areas during a loading test on the structure.

• The NASA Composite Crew Module Non-Destructive Evaluation and Test team also received a NASA Group Achievement Award "for achieving excellence through design and fabrication of a full-scale composite crew module."

• Dryden's Fiber Optic Shape Sensing team, which included William Ko, Parker, Piazza and Richards, captured a NASA Group Achievement award.

In 2009, the group won the team award for successfully demonstrating fiber optic wing shape sensing on the Ikhana unmanned aerial system. The citation reads, "For the development and flight testing of fiber-optic strain measurement systems and algorithms that enabled lightweight deformation measurement of flight vehicles."

4DSP ... from page 6

The company's name, 4DSP, is an abbreviation for "for digital signal processing," Vulliez explained. "Our expertise is in performing signal processing and data acquisition using field, programmable gate array, or FPGA, technology."

Vulliez recalled his first conversation with Parker.

"At the time, we had some off-the-shelf products that he [Allen] thought were suitable for his application. We [4DSP] didn't know anything about fiber optics; it was a foreign concept to us. We delivered a signal processing system and Allen hooked up the fiber optics to it," he said.

Opportunities followed as 4DSP was asked to assist Parker and Dryden researchers in dreaming up the next-generation fiber optic sensing system. That led to an exponentially smaller, compact system, which Vulliez said will be further minimized in size and power consumption.

Signal processing and data acquisition, or moving information from one point to another in real time, have moved fiber optics from an interesting novelty to a potentially game-changing technology, Vulliez said. Because of Vulliez's contacts with large aerospace and defense contractors, who make up about 80 percent of his current business, Vulliez said he believes those will be some of the first customers for the fiber optic sensing technology.

Opportunities with fiber optics are without boundaries, Vulliez said, and he jumped at the opportunity to show Dryden what 4DSP brings to the table and why they were the right company to begin commercializing this technology, he said.

"The prospects of bringing this technology to market and making it available to industry were too appealing for us to pass up," Vulliez said. "Some elements of the [fiber optic] system technology that Dryden has developed delivers about a 20-fold improvement over what is available."

What Vulliez said 4DSP is uniquely qualified to commercialize the Dryden-developed fiber optic technology because of the company's involvement in the system's creation, its experience in signal processing and its relationship with major aerospace and defense contractors.

"Because we are a small business, our flexibility and expertise allow us to solve problems in an unconventional manner," he said.

During the next year, 4DSP will roll out a number of products that will be showcased on the company's website. Vulliez said he will introduce the latest developments to customers who might be able to make the best use of it.

The cost of obtaining the technology, however, remains a roadblock for smaller companies.

"The items we sell are on the high end of the technology market. These systems can costs hundreds of thousands of dollars. If we want this technology to be available to a number of industries, we need to reduce the cost," he said.

To make the system more attractive, he said, the next generation of it will need to be increasingly compact and lightweight. Fiber optic sensing systems already have an advantage over traditional systems that use transducers and heavy bundles of wire to collect information. But as fiber optic systems become more compact, weigh less and establish a record of reliability, their use will grow exponentially.

"Credit goes to many people, but this licensing agreement would not have happened without [Dryden partnership-development manager] Julie Holland. She walked us through the licensing process and she really made it a breeze. Her help goes far beyond the agreement – Julie worked with us to define whom we are and where we want to go.

"From our perspective, her input was of tremendous value."

Fiber optic sensing solutions bring benefits that are hard to ignore, he said. For that reason, while it may take a decade for the technology to become mainstream, "it will surely happen."

SBIR

Nine Dryden Small Business Innovative Research projects approved for Phase II

NASA has chosen nine Phase II Small Business Innovative Research agreement proposals submitted by Dryden. The following list looks at the concepts:

• Systems Technology of Hawthorne, Calif., earned an SBIR agreement for its Smart Adaptive Flight Effective Cue, or SAFE-Cue, proposal. Piloted simulation studies conducted under a previous SBIR agreement prevented loss of a simulated aircraft's control by providing tactile cues to the pilot through the control stick. Simulation tests also verified the ability to prevent adverse pilot interaction with adaptive control laws used to allow a damaged aircraft to be flyable in conditions such as the failure of a flight control surface. An STI partner, Barron Associates, developed the adaptive control laws used in Phase I, which will also be used in Phase II work.

Phase II work will advance this technology for a prototype system that will be evaluated with a series of flight tests using a Learjet provided by another STI partner, Calspan. SAFE-Cue can be applied to any modern flight control system regardless of whether it uses an adaptive controller. It is envisioned that SAFE-Cue software will significantly and economically increase safety for commercial transport and military aircraft.

• Systems Technology also was awarded an SBIR agreement for another safety enhancement, real-time methods for adaptive suppression of adverse aeroservoelastic dynamics. Adverse aeroservoelastic interaction is a problem on aircraft of all types causing repeated loading, enhanced structural fatigue, undesirable oscillations and catastrophic flutter.

The developed adaptive aeroservoelastic suppression algorithms and subsequent real-time piloted validation simulations will benefit NASA flight test programs by providing a solution for rejecting adverse aeroservoelastic dynamics. Such conditions include flight condition changes, configuration changes and damage and failure scenarios. Potential benefits also include adverse dynamic suppression in manned and unmanned spacecraft systems.

• The Numerica Corp. of Loveland, Colo., was awarded an SBIR agreement for the company's estimation and prediction of unmanned aerial vehicle trajectories, a potential element of integrating Unmanned

See Technology, page 10

New launch technology idea gains ground

A team including members from multiple NASA centers has been formed to examine the feasibility of an electromagnetic-catapult concept as a key component for new launch technologies.

December 2010 Edition

Stanley Starr, a Kennedy Space Center, Fla., physicist, and engineers Paul Bartoiotta at Glenn Research Center, Cleveland, and Dryden's Kurt Kloesel are developing a proposal for the launch system. The proposal is being developed for NASA's Exploration Systems Mission Directorate and the Office of the Chief Technologist.

Engineers at Langley Research Center, Va., also are becoming interested in the concept because it could potentially satisfy gross takeoff weight and wing loading requirements for a future two-stage-to-orbit vehicle with a staged ramjet or scramjet engine, Kloesel said.

Popular Science magazine ran an article and cover graphic in the December issue to draw interest in the technology. That published account sparked more interest from a number of NASA researchers across the agency. Those researchers then decided to joined together to develop the current feasibility study.

Kloesel began work on the concept of what he calls a highly reliable reusable launch system with the help of Innovative Partnerships Program seed funds in 2008. Since then, his idea of packaging technologies to develop an electromagnetic launch assist vehicle has continued to generate interest.

In practice, such a vehicle would use the equivalent of an electromagnetic catapult for a first stage. The propulsion from the electromagnetic forces would move a spacecraft along a rail system, with a secondary stage completing the job of propelling the vehicle into space, Kloesel explained.

This technology could be matured from a concept into a launch capability that will take spacecraft to low Earth orbit at lower cost, in a more environmentally friendly way and with greater reliability, he added.

Kloesel is quick to add that he didn't originate all of the elements of the electromagnetic launch assist vehicle and that he continually seeks help from people he thinks can help evolve the concept. His key contribution is combining the electromagnetic launch concept with a hybrid air-breathing system.

With the need for new launch technologies growing, the team of NASA researchers looking into this concept may be able to contribute a key component to the development of a next generation launch system.

Technology ... from page 9

Aerial Vehicles, or UAVs, into the national airspace.

A key goal of NASA's NextGen Airspace plans is to add UAVs safely into the national airspace. Many UAV aircraft lack a sense-and-avoid capability to mitigate collision risk, a challenge that prevents government and private contractors from using these platforms for routine operations in the national airspace. Development of target-state estimation and trajectory prediction algorithms could be a step toward routine use of UAVs for missions such as homeland security, Earth science and disaster assessment.

• VIP Sensors of San Juan Capistrano, Calif., was awarded an SBIR agreement for a fiber optic pressure sensor array. VIP Sensors proposes a fiber optic pressure sensor array system for measuring airflow pressure at multiple points on the skin of aircraft for flight-load test applications. The proposed technology is applicable to such different types of sensors as accelerometers, pressure and strain gages. Each sensor in the array is designed to work at discrete optical wavelengths.

Testing of aircraft requires a large numbers of sensors, each requiring four to six interconnecting wires. For large systems, this means large numbers of wires that add weight and occupy space. The proposed system not only has the potential to significantly improve pressure measurements for flight load testing, but its micro-miniature networking optical sensors will benefit many other aircraft ground and flight testing applications and aircraft, satellite and ship monitoring.

• Aries Design Automation of Chicago is funded for additional work on its reconfigurable very-long instructional word, or VLIW, processor for software-defined radio. The company's technology could have applications to radiation-hardened flight-control computers that NASA uses in many space missions, including Deep Impact, the Mars Reconnaissance Orbiter and the Mars Rovers.

The VLIW processor will have reconfigurable functional units and specialized instructions that will be optimized for Software Defined Radio applications. The radiation hardening will be done at the micro architectural level with a mechanism that will allow the detection and correction of all timing errors – caused not only by radiation, but also by variations in voltage, frequency, manufacturing process and chip aging. The work will result in technology that allows for very quickly designing and verifying radiation-hardened and reconfigurable VLIW processors that are binary-code compatible.

• Firestar Engineering of Mojave, Calif., intends to advance the technology readiness level of its Nitrous Oxide fuel blend, or NOFBX, monopropellant Mars ascent vehicle, or MAV, engine. A compact, three-engine cluster provides thrust-vector control passively with its fixed, canted engine nozzles and flow control valves. The concept is intended for use on planetary ascent vehicles but could also be used for the upper-stage engines on a launch vehicle.

The clustered engine concept coupled with an NOFBX monopropellant and feed system will allow the company to provide a single-stage-to-orbit MAV engine. Success could significantly simplify the MAV architecture. The technology could also be applied to planetary-sample-return rocket engine stages, upper-stage launch vehicle and kick motors and small launch-vehicle engines.

• Busek Company of Natick, Mass., will continue development work on its magnesium-based rockets for Martian exploration. Busek will test multiple metal fuel and oxidizer combinations and then will design, build and test an integrated rocket and propellant management system.

The company has validated that magnesium can be combusted with carbon dioxide, water and hydrogen peroxide, all of which may be obtained from the Martian surface or atmosphere. Methods for storing, delivering and igniting the propellant have been identified, and combustion experiments have been carried out.

This "green" technology could be used for Martian payload ascent vehicles, Martian rocket-propelled transports, lunar transit and ascent vehicles and satellites and service modules. The technology also has applications to satellite station-keeping, repositioning, attitude control, rendezvous, docking and separation, multi-mode propulsion systems, launch vehicle upper stages, and air, surface and submarine applications on Earth.

• Ultracor of Livermore, Calif., will advance work on its C-SiC and SiC-SiC honeycomb materials for advanced flight structures, which are capable of operating at 2,700 degrees Fahrenheit with reduced oxidation that occurs with carbon-carbon materials. It is anticipated the C-SiC and SiC-SiC honeycomb materials for advanced flight structures are materials that could be produced more economically than can other available materials and could enable construction of future hypersonic flight vehicles.

A C-SiC honeycomb for advanced flight structures project Phase I SBIR effort demonstrated the feasibility and efficacy of a lightweight, C-SiC high-temperature core system capable of operating at the temperatures experienced during hypersonic flight. These results demonstrate that this material is a good candidate for use in building an aircraft for the extreme temperatures of hypersonic flight. Further validation of the C-SiC material, to demonstrate its longevity, and the development of a SiC-SiC material is what this research is expected to achieve.

• Zona Technology of Scottsdale, Ariz., will pursue research to develop a comprehensive on-line flutter prediction tool for wind-tunnel flutter testing using parameter varying estimation, or PVE, methodology. Specifically, this tool will be applied to rapidly evaluate parameters, such as modal damping and frequency, which are required to assess the flutter boundary of a wind-tunnel model in pre-flutter test conditions. The tool can also be applied to the flight flutter test for envelope expansion prediction to help ensure the safety of the pilot and aircraft.

Zona envisions that the proposed Phase II research effort will result in a commercial product called the PVE Toolbox. The PVE Toolbox will be a crucial technology for the flight flutter test of next-generation aircraft, such as the NASA Hybrid Wind Body Configuration and Quiet Supersonic Transport.

Springing toward a novel solution

Dryden researcher submits winning idea for future space treadmills

NASA needs to improve its treadmills on Earth and in space and offered a prize to NASA researchers who could help with the technologies to make it happen.

Dryden researcher Christine Jutte answered this "NASA@Work Challenge" with a new technology, for which NASA awarded her an Innovation Award of $200. In a nutshell, Jutte proposes a new spring design that, unlike coil springs, maintains a constant force over a large deflection.

The NASA challenges are intended to find answers to research questions within NASA using a collaborative, problem solving, Web-based approach. Cash awards were offered to the researcher with the best solution for each of 20 posted challenges. The NASA@Work Challenge is one of the incentive programs developed by InnoCentive, a Waltham, Mass., company NASA has contracted to spark innovation through a series of challenges.

Gail P. Perusek of Glenn Research Center, Cleveland, is the Exercise Countermeasures project manager who issued the treadmill challenge. Perusek's project is part of NASA's International Space Station and Human Research project offices. She notified Jutte by e-mail.

"Congratulations, Christine. Your contribution, 'Customized constant-force spring' stood out as an intriguing new avenue that we had not considered," Perusek wrote.

Jutte welcomed the news.

"I am excited to see that my previous research in nonlinear spring design is useful to this challenge. There are many applications out there that can be improved with non-traditional, customized springs; the fulfilling (and fun) part is discovering these applications," she said.

The new concept is a customized constant-force spring design and was judged the best idea for meeting the challenge of minimizing force fluctuations over a person's maximum gait displacement of 18 inches, while also minimizing mass, volume and power requirements. It replaces gravity so that someone exercising in a simulated zero gravity environment on Earth, such as on a horizontal suspension treadmill, or someone who is exercising without gravity in space would still feel the effects of gravity with every footstep taken on the treadmill.

To achieve the goal, Jutte suggested simulating gravity with the constant-force springs she developed. The springs, which look like flattened wires, would work by pushing the person toward the treadmill to feel the effects of gravity during exercise. The springs could be designed for each individual user to accommodate different sizes and weights and also so that it can simulate both gravity conditions on Earth as well as lunar gravity, which is one-sixth that of Earth.

Though some additional engineering could improve the function of the constant-force spring for use in space or zero gravity treadmills, a prototype for proof of concept showed the merit of Jutte's ideas. Coincidently, Jutte's doctoral thesis was on non-linear springs, including constant-force springs, and how to create them. It was on her work at the University of Michigan, where she also earned a mechanical engineering master's degree in the same area, that she based the foundation for her NASA challenge work.

Jutte said she was delighted when her doctoral work culminated in a computer program that created nontraditional spring designs from specifications provided by the user and algorithms to scale the springs for different applications.

Applications for the constant-force spring, or nonlinear springs in general, could go far beyond space treadmills to more terrestrial uses such as improving artificial implants and prosthetics since many biological materials have a nonlinear stiffness, she said. The springs might also help reduce injuries by making heavier objects feel almost weightless while a person performs a task. In that case, the springs are used to counterbalance the heavier object. When using the same concept in machines, smaller motors can replace larger ones, potentially leading to energy savings.

Regardless of how it will be used, Jutte's constant-force spring was judged to be a new approach that merits further investigation.

NASA Photo

In the background, *astronaut Edward Lu, Expedition 7 NASA ISS science officer and flight engineer, exercises on the station's Treadmill Vibration Isolation System.* ***Above,*** *a test subject runs in a zero gravity simulator on Earth in the Exercise Countermeasures Laboratory at Glenn Research Center, Cleveland.* ***Below,*** *Christine Jutte shows a prototype of her spring design.*

Photo courtesy Christine Jutte

Under Control

Flight experiments validated ‘hot film’ sensors. Now, the challenge is to move the technology to the next level.

A flight on the F-15B Aeroelastic Test Wing 2 test fixture has validated that new “hot film” sensors could one day be used to help aircraft avoid conditions that lead to flutter.

In addition, the sensors could be a part of the solution to a number of aeronautics challenges ranging from laminar flow control and sonic boom suppression to aircraft safety.

“The sensors worked as advertised. They can measure flow angularity and they measure critical aerodynamic parameters like stagnation point, which was predominantly what we wanted to see,” said Marty Brenner, Dryden principal investigator for the project.

The hot film sensors measure flow angularity through the stagnation point as measured by angle of attack or sideslip. A stagnation point is a point in the airflow field where the local velocity of the fluid is zero. In this flight condition static pressure is at its maximum value and the streamline at the stagnation point is perpendicular to the surface of the aircraft, Brenner explained.

“Stagnation point is a more critical parameter than angle of attack in controlling performance of the wing. You could improve the performance of the wing by measuring and controlling where these critical aero parameters are, such as [at] stagnation point and flow separation. Supersonically, you could reduce the shockwave coming from the wing and alleviate a sonic boom on the ground,” he said.

There could be additional benefits.

“If we can adjust the lift distribution, we can maximize the performance of the wing more to improve maneuverability or fuel efficiency,” he added.

The F-15B flight marked the culmination of work on a new system that combines the hot film sensors with advanced signal processing techniques and is the first of its kind to measure unsteady aerodynamic loads, or forcing

See Hot film sensors, page 14

ED10 0223-01 NASA Photo by Tony Landis

Dryden researcher Marty Brenner, left, and Tao Systems president Arun Mangalam are working together on advanced technology that has been validated and verified in flight on a Dryden F-15B. They hope to see development of their ideas continue with the F/A-18 research aircraft pictured at left.

Fly-By-Feel systems represent the next revolution in aircraft controls

A “fly-by-feel” system could measure the aerodynamic forces directly on aircraft surfaces and use that information in a physics-based adaptive flight controls system to increase maneuverability, safety and fuel efficiency.

As a step in that direction, Dryden researcher Marty Brenner was selected to receive a NASA Innovation Fund award for a project that would begin investigation of components that could be used in such a system. Brenner envisions state-of-the-art sensors that could be candidates for wind-tunnel or flight-test applications and determine guidelines for further development.

In fact, Brenner also received more good news on June 22, when it was announced he had been chosen for an Aeronautics Research Mission Directorate Seedling Fund award for his Fly-By-Feel research. The new award builds on Innovation Fund awards he received previously, but the new funding will subsidize work concentrated on modeling controls.

NASA is interested in the fly-by-feel concept to meet its goals for increased fuel efficiency and improved reliability and ride quality through managing gusts and flutter (vibration on aircraft surfaces) suppression and load alleviation.

Brenner looked at the materials and process needed to fabricate state-of-the-art sensors and transduction mechanisms to see which might work best for the challenges of a fly-by-feel system. Additionally, a number of available sensors were tested for potential use.

The research was successful and future work could include testing other transduction mechanisms to identify the best fit for the concept, as well as selecting a sensor array for wind-tunnel tests and then for flight research, to track key aerodynamic information and develop a real-time signal-processing algorithm for the new sensor array.

“The hot film sensors can be put on an aircraft right away and then the additional sensors could be added later,” Brenner said.

The research has promise, he said.

“Fly-by-feel is geared toward designing airplanes and control systems with distributed sensing. It puts

See Fly-by-feel, page 14

Hot film sensors ... from page 13

function, in real time and correlate those data with how the structure responds to the loads.

The system as a whole is called the distributed aerodynamic sensing and processing, or DASP, toolbox. The project was accelerated with a 2007 Innovative Partnerships Program seed fund project. TAO of Systems Integration, Hampton, Va., has been a key partner in development of the DASP Toolbox (see related article).

"With the hot films, from what we have looked at so far, it was very successful. It is another measurement system that, along with accelerometers and strain gauges, can monitor the aero forces that go into the wing. It is a good technology to demonstrate because we never get the forces in the wing; we usually just get a response from the wing. This was the first demonstration in flight of getting these forces from these critical aerodynamic parameters," Brenner said.

The single flight also produced another valuable validation.

"The other aspect of this was the signal processing of the sensors. The toolbox part is on-board signal processing. We want to take this technology to the F/A-18 no. 853 and demonstrate it on full-scale aircraft wings. We want to see the signature of the forcing function going into the wing as well as the response of the structure due to the forces," he said.

The technology has intriguing potential uses.

"Ideally, you could feed this information to a control system and use these parameters you get from the hot film sensors in a feedback mechanism. That's one of our next objectives," he said.

The advantages could be revolutionary for control systems.

"Now you can control where these critical aero parameters are and, by doing that, you can control the forces on the wing going into the structure. You can change the force distribution on the wing so you can reduce loads on the wing, or with a combination of other sensors, adjust the wing twist or the performance of the wing by adjusting the force distribution and alleviating the stresses," he added.

In addition, controlling aerodynamic forces could help with other key technology developments NASA is pursuing. Some of the applications could improve aircraft performance in areas such as load alleviation, wing twist, gusts and maneuvering loads in flight.

The next step is determining whether the F-18 no. 853 Full Scale Advanced Systems Technology, or FAST, aircraft is available and when.

"We are planning on installing theses sensors and system this year. Eventually, we want to get it connected to the flight control computer and then start using it for control. We might use it locally for a wingtip, but somehow we are going to try to put it in a feedback control scheme," he said.

Initially the system will look at the same basic parameters, but on a larger scale and the goal is to put it in a control-oriented context with similar objectives.

"We can even look at a supersonic flight and see if we can monitor the shock. We may be able to control aero parameters the way we want them to, to optimize the performance of the wing in some way and also to alleviate the loads, or suppress vibration," Brenner said.

The DASP Toolbox may piggyback on adaptive controls work being conducted with the FAST aircraft and will not interfere with the aircraft's primary mission for aviation safety, he said.

"We can augment some of their goals with these sensors. If you have some adverse flow condition and you have to accommodate for it, this would be one way to think about doing that. If you detect something you don't expect, you can try to accommodate for it with the controllers. If there is a fault in one of the surfaces, then they try to recover from it with some adaptive rescheduling scheme. That is where the DASP can potentially be helpful," Brenner said.

Installation on the F/A-18 is expected to take a few weeks and then experiments with on-board processors will begin. Distributed sensing is a goal for performance and aviation safety, he stressed, where distributed sensing for distributed controls can happen.

The emerging technology might one day mean safer airplanes capable of avoiding conditions that lead to accidents, maximizing fuel economy and potentially even reducing the impact of sonic booms on the ground. What is known for sure is the DASP Toolbox and its components have proven through flight research that they work and merit further research and development – a signature of success.

Fly-by-feel ... from page 13

distributed sensing in the aircraft design and helps meet challenges with flight control. As part of the design of the structure and a complement for how the control system is going to be designed, using the distributed design for multi-objective problems can maximize aero-structure performance," Brenner said.

Arun Mangalam, president of Tao of Systems Integrated of Hampton, Va., is a partner in the research. His company developed the hot film sensors and the Distributed Aerodynamic Sensing and Processing, or DASP, toolbox on which Brenner has been principal investigator (see lead story).

"This allows you to really look at the aerostructure-design space," Mangalam said.

The fly-by-feel concept could enable a vehicle to autonomously react to changes in aerodynamic and structural conditions through the use of distributed sensors that don't just obtain sensor information as it is happening, but also convert it into aerodynamic coefficients that can be used for flight control, Brenner explained. Also of importance is the fact that knowledge of aerodynamic loads across the span of the wing and flight-control surfaces enables a controller to redistribute the loads for optimum performance.

Accurate real-time aerodynamic load and moment sensors also could enable a number of revolutionary capabilities across a wide speed range, including but not limited to shorter takeoff and landing, safe and reliable supersonic operation and larger passenger and cargo capacity. Fly-by-feel also has the potential of becoming one of the key new technologies to opening the door not only to aeronautics, but also to monitoring the health and increasing the range and endurance of future planetary exploration vehicles.

Though the concept of fly-by-feel has a number of steps that must be validated before it is fully proven, Brenner said he will continue to take steps today to ensure that technologies of tomorrow will be ready when they are needed.

Tao of systems

Mangalam brings Dryden ideas, technology

Tao of Systems Integration of Hampton, Va., has developed technology that will revolutionize aircraft control. Small Business Innovative Research funds were among the factors that have enabled the company to pursue concepts and build on them for decades.

Arun Mangalam, Tao Systems president, continues to mature technology validated and advanced through 11 SBIR agreements. Mangalam was principal investigator and collaborator for a number of those advancements. Some of those breakthroughs were from proposal requests from Dryden that resulted in the Distributed Aerodynamic Sensing and Processing, or DASP, Toolbox (see related story).

During the past decade, working toward using flow physics to determine lift and drag to seek aero efficiencies has been the heart of Tao Systems' business. To that end, the company has earned 14 patents for sensors and signal processing. The payoffs for gaining aero efficiencies are reflected in increased fuel efficiency and range and improved safety.

Mangalam also is at Dryden working on the Aeronautics Research Mission Directorate Environmentally Responsible Aviation experiments with the G-III aircraft. That aircraft is being used for in-flight research of a new laminar flow glove on the wing and new composite actuators.

He will be assisting with sensors and signal processing to assess the aerodynamics of the actuators on the G-III – essentially, an SBIR phase III agreement, he said. (Phase I agreements are commonly paper studies, Phase II agreements are funded and Phase III is the point at which a technology has been the object of interest and has received capital for further research.) In addition to looking at the transition from smooth to turbulent air, Dryden partners at the Air Force Research Laboratory are looking at the efficiency of the new actuators.

"How do you get loads and moments from these flow characteristics? That's the question we are trying to answer," Mangalam said. "It's much faster to measure the flow physics than to look at the response on the structure. To do that, we will be looking for surface flow measurements and will be obtaining critical features from those measurements, like stagnation point, effective flow angularity and flow separation point."

In addition to earning undergraduate and graduate degrees in physics and computer science from the College of William and Mary, Williamsburg, Va., Mangalam is working on a doctorate at Virginia Polytechnic Institute and State University, Blacksburg, in mechanical engineering with a specialization in aeroelasticity. Essentially, everything involving flow physics and structural dynamics and control are his key interests.

"My interest is in the physics of flows and structures and how to use and exploit that to achieve whatever objective you are seeking," he said. "In the case of aircraft, you are trying to achieve aerodynamic efficiency, structural reliability, safety and performance."

ED10 0223-01 NASA Photo by Tony Landis

Arun Mangalam, Tao Systems president, is working on several Dryden projects, including one involving the G-III aircraft behind him.

He is enthusiastic about his work at Dryden.

"I enjoy what I do, but this is going to take it closer to the action. Flight testing is where it all happens," Mangalam said.

Work furthered with SBIR funding helped enable his current opportunities at Dryden.

"SBIR is sort of like seed funding for an idea. Sometimes these ideas in aeronautics cost a lot just to implement because testing facilities are very expensive, materials are very expensive and the time required to do a good job is quite intensive. So I think SBIR funding allows you to commit resources," he added.

SBIR agreements can also lead to resources that have more than a dollar value, he said.

"We work with a lot of organizations – agencies and industry as well as academia – from the U.S. and Europe. A lot of products are being sold internationally and [SBIR support] helped in refining those products. Even now we are collaborating with people from

See Tao of systems, page 27

Flight Opportunities

OCT's new office seeks to match NASA and science community launch needs with companies capable of getting the experiments aloft to flight conditions

NASA Photo

University of Florida students maximize their exposure to zero gravity to conduct a flight experiment aboard the Zero-G parabolic aircraft.

When Masten Flight Systems of Mojave, Calif., launches a NASA payload later this year with its Xaero reusable launch vehicle, it will mark the beginning of a new era in NASA-industry partnership as the Flight Opportunities program takes flight.

The Flight Opportunities program is one of ten programs organized under three divisions comprising the Office of the Chief Technologist's Space Technology program (see accompanying article). The Space Technology program is focused on foundational research and technology advances to be made in a wide range of future missions.

Masten won the NASA-funded Lunar Lander Challenge in October 2009 and demonstrated the first-ever vertical takeoff and landing vehicle in-air engine re-light in May 2010. Masten plans for initial flights to take place at the company's 200,000-square-foot test area at the Mojave Air and Space Port. The Xaero vehicle is a reconfiguration of the company's Xoie platform, which won the Lunar Lander Challenge.

Masten officials are confident they will meet the conditions of the $250,000 contract NASA awarded them for launching NASA payloads to required test conditions, said John Kelly, Dryden Flight Opportunities program manager. In fact, NASA has guaranteed payment for launch services only when they have been successfully rendered.

Armadillo Aerospace of Heath, Texas, with its SuperMod launch vehicle, also was awarded a $250,000 contract for launch services. Earlier Mod vehicles were successful competitors in NASA's Lunar Lander Challenge, the earlier version taking first prize in 2008 and the SuperMod version winning second place in 2009.

SuperMod was severely damaged during a flight test in June. Company officials decided that rather than continue with a vehicle that is now part of the company's legacy, they would put all attention and resources into development of a Suborbital Transport Inertially Guided reusable rocket program, which is "going very well," said Neil Milburn, Armadillo vice president of program management.

Success in the development of the STIG family of rockets – STIG A-II is under construction and an inaugural flight is anticipated later this summer – will make the company competitive in future Flight Opportunity contracts, Milburn said.

Challenges have delayed both Masten and Armadillo, but that's to be expected in a nascent industry experiencing many of the same growing pains that characterized early development of the airplane, Kelly said.

The program is fashioned after the successful Kennedy Space Center, Fla., launch services contract. Both contracts rely on companies to have the ability to provide the services NASA needs.

"We are like a broker in that we are looking for payloads and flight platforms for achieving the technical benefits we want," Kelly said.

Meeting of the minds

Before the first request for proposals had been fully developed, Flight Opportunities officials met at Dryden in January with suborbital reusable launch vehicle providers and payload integrators during an Industry Day. The goal of the event was to determine which companies were interested in providing services and to convey

ED10 0226-05 NASA Photo by Carla Thomas

Patrick Chan, second from left, explains components of the Dryden-developed fiber optic strain-sensing technology to Bobby Braun, second from right. Also pictured are Tom Horn, left, and Robbie Schingler.

OCT structure is focused on tech

NASA Administrator Charlie Bolden created the Office of the Chief Technologist in 2010 and named Bobby Braun to head it.

Since then, that office has been tasked with focusing NASA's technology efforts across the agency, eliminating duplication and creating a new structure in which to advance the agency's technology-development goals. Three divisions, each representing a higher technology-readiness level, and their key elements, are listed.

Early Stage Innovation

The Early-Stage Innovation Division sponsors a range of efforts aimed at advanced concepts and emerging technologies across academia and industry, at NASA field centers and at other research institutions. The Early-Stage Innovation programs include:

- NASA Innovative Advanced Concepts – focused on visionary aeronautics and space system concepts
- Space Technology Research Grants – focused on innovative research in advanced space technology and fellowships for graduate student research in space technology
- Small Business Innovative Research, also known as SBIR, and Small Business Technology Transfer, or STTR, programs – intended to engage small businesses in aerospace research and development for infusion into NASA missions and the nation's economy
- Centennial Challenges – provides prize incentives to stimulate innovative solutions by citizen inventors

See OCT, page 18

to the industry NASA's intended direction on acquiring commercial launch services, Kelly said.

Representatives of more than 20 aerospace firms met with Flight Opportunities officials. In addition to companies learning about NASA's plans, company representatives were given an opportunity to comment on the request for services that NASA planned to issue.

"We considered the feedback from industry, and we clarified a few items and made a few adjustments prior to releasing the request for proposals," he said.

Photo courtesy of Armadillo Aerospace

Armadillo Aerospace sees its Suborbital Transport Inertially Guided reusable rockets, pictured in this image, as an answer to getting scientific payloads to flight conditions.

Also at that event, Steve Meier, director of the Cross-Cutting Demonstrations Division of NASA's Office of the Chief Technologist, stressed the partnership approach that NASA seeks to take with commercial launch vehicle firms. Michelle Murray of the Federal Aviation Administration Office of Commercial Space Transportation outlined FAA licensing and the commercial-launch approval process.

A new paradigm

Officials said they hope the new approach will lead to significant cost savings to NASA as reusable launch vehicle technology matures. In addition, they hope the research that will take shape is inspiring to students and will result in technology development of benefit to the nation.

Unlike past development efforts, in which NASA has contracted for a vehicle and then paid for its operation to achieve agency goals, the Flight Opportunities program is structured to enable NASA to use commercially available vehicles for its own research and provide opportunities for researchers across the nation, Kelly said.

Dryden was selected to manage the Space Technology's Flight Opportunities program under NASA Headquarters program executive Laguduva Kubendran, a former member of Dryden's technical management staff.

The Flight Opportunities program incorporated two existing projects. Ames Research Center, Moffett Field, Calif., began the Commercial Reusable Suborbital Research activity for the agency's former Innovative Partnerships Program office. The second project, Facilitated Access to the Space Environment for Technology, also originated in the former IPP office. Flight Opportunities officials will seek and foster capabilities and use services from the commercial sector, initially for suborbital flight services.

Flight-testing is expected to reduce risk inherent in the use of emerging technologies, procedures and overall space operations by demonstrating application in a relevant environment. A measure of program success will be the extent to which it can infuse

OCT ... from page 17

and independent teams outside the traditional aerospace community

• Center Innovation Fund – stimulates creativity and innovation at NASA field centers

The Early Stage Innovation programs are an incubator for a multitude of high-risk, high-payoff ideas that, if successful, will result in further development as part of higher-level technology-development programs or adoption into other government or commercial efforts. Participation in all of these programs is based on competitive selection.

Game-Changing Technology

The Game-Changing Technology Division focuses on maturing advanced space technologies that may lead to new approaches for NASA's future space missions and solutions to significant national challenges.

The two programs in this division, the Game-Changing Development Program and the Small Satellite Subsystems Technologies Program, determine the feasibility of novel ideas and approaches that have the potential to revolutionize future space missions.

Through significant ground-based testing and/or laboratory experimentation, the Game-Changing Technology Division matures technologies in preparation for potential system-level flight demonstration. Those demonstrations could be within the Crosscutting Capability Demonstrations Division, other NASA mission directorates or other government agencies.

The focus on game-changing technologies is that over time, despite expected challenges pushing the limits of new ideas, the overall investments are expected to result in dramatic advances in space technology. Those advancements will enable new NASA missions and potential solutions for a wide variety of society's technological challenges and will be measured. In this division, more than 70 percent of funds are competitively awarded.

Crosscutting Capability

One of the greatest challenges NASA faces in incorporating advanced technologies into future missions is bridging the mid-technology readiness level gap between early conceptual studies and infusion of new technologies into the planning of a science or exploration mission. Maturing a space technology to flight readiness status through relevant environment testing present a significant challenge in management of cost and risk. The Crosscutting Capability Demonstrations Division matures a small number of technologies that are beneficial to multiple customers. Technology considered too risky or too costly for a mission can be proven mission-ready.

The Crosscutting Capability Demonstrations Division consists of three programs that will demonstrate technologies in a relevant environment:

• Technology Demonstration Missions Program
• Edison Small Satellite Demonstration Missions Program
• Flight Opportunities Program

new technologies into NASA missions while encouraging development of commercial space services as well as a customer base for the emerging industry.

The commercial suborbital flight services offer access to a flight environment that provides 3-4 minutes of microgravity during which technology payloads can be tested. Also as part of the program, technology payloads will be tested on parabolic aircraft flights that can simulate microgravity and the reduced gravity environments of the moon or Mars, with the goal of maturing applications for future space missions.

The Flight Opportunities program leverages Dryden's experience and expertise in planning and conducting flight tests of new aeronautical and spaceflight concepts, Kelly said.

ED11 0021-14 NASA Photo by Tom Tschida

Michelle Murray of the FAA Commercial Space Transportation office spoke to representatives of aerospace firms Jan. 25 during a Flight Opportunities Program Industry Day at Dryden.

Launch services

About a dozen companies make up the commercial suborbital launch industry. The industry's capabilities are evolving, however, and a much smaller group stands ready to provide commercial payload service in the immediate, Kelly said.

To make it easier for NASA to broker deals with scientists and researchers seeking launch services and the companies that provide them, the agency issued a request for proposals, which closed in June, seeking companies to provide future launch services for the next two years.

Each company chosen is guaranteed minimum funding of $10,000 and will be able to compete for launch payloads provided through NASA's Flight Opportunities office. Total funding to be made available through the two-year program is $10 million and will center around three flight

Laguduva Kubendran

John Kelly

levels, all of which are suborbital, Kelly said.

It's expected the first contract awards will be made before the end of September. Some of the flight opportunities that will be funded will include experiments aimed at advancing science, technology and education.

Payloads announced

In May, Flight Opportunities officials announced the selection of 16 payloads for flight on the commercial Zero-G parabolic aircraft and two suborbital reusable launch vehicles. The flights provide opportunities for space technologies to be demonstrated and validated in relevant environments.

Payloads and teams from 10 states and the District of Columbia were selected from among applications received in response to a NASA call issued in December. Of the payloads, 12 will ride on parabolic aircraft flights, two on suborbital reusable launch vehicle test flights and two on both platforms.

The commercial Zero-G aircraft payloads will be flown during a weeklong campaign from Houston's Ellington Field in mid-July and another flight series in September. The suborbital reusable launch vehicle payloads will be flown on Masten's Xaero.

Proposals for payloads to be flown on the commercial vehicles will be accepted until Dec. 31, 2014. Dryden's Flight Opportunities office manages the commercial suborbital reusable launch vehicle contracts. Payload activities for the program are managed at Ames Research Center. A complete list of the 16 proposals chosen and more information on the Flight Opportunities program are available at http://flightopportunities.nasa.gov.

Four more parabolic aircraft flight opportunities are set for 2012. These flights will include microgravity experiments in environments that simulate near zero gravity, the gravity of the moon and the gravity of Mars.

Pilots will fly the parabolic profiles for brief periods of reduced gravity while the researchers tend to their experiments in the aircraft cabin. Each flight will permit as many as 60 reduced-gravity opportunities.

Regardless of whether the opportunity is provided on a new launch vehicle or on an aircraft, the Flight Opportunities office strives to break new ground in technology development as it forges new partnerships with commercial flight providers.

Early warning

Dryden helps determine whether sonic booms will create false alarms

By Gray Creech
Dryden Public Affairs

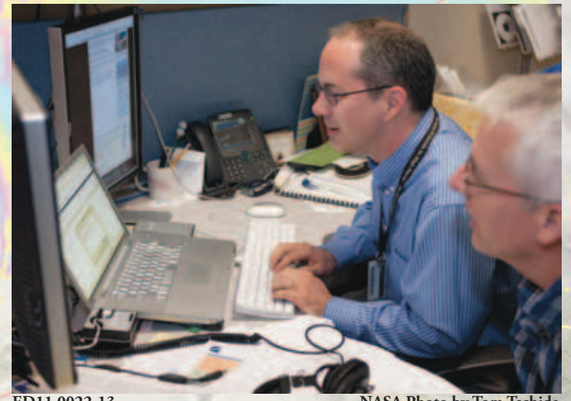
Dryden and Seismic Warning Systems Inc., Scotts Valley, Calif., are evaluating the company's QuakeGuard earthquake warning system to determine whether sonic booms cause the system to register false alarms.

Under a NASA Space Act agreement, the company has installed two of their QuakeGuard warning seismometers at Dryden. With the system in test mode, not warning mode, devices were installed in Dryden's main office building, spaced about 100 feet apart and tied into the building's foundation. Vertical accelerometers in the devices, using the company's proprietary algorithms, are designed to detect precursor, or "P," waves that travel ahead of the primary, destructive "S" shockwaves generated by earthquakes.

Dryden's Innovative Partnership Program Office, which is now known as the Innovative Partnerships Office, helped establish the Space Act Agreement that is the foundation for the partnership. In addition, the IPO Office and NASA's Airborne Sciences program funded the purchased of seismometers.

Also as part of the Space Act Agreement, Seismic Warning Systems loaned Dryden additional seismometers for the flight research.

So far, normal sonic booms are not causing the system to generate false alarms. But Dryden, in an effort dubbed SonicBREWS, or Sonic Boom Resistant Earthquake Warning System, put the system to the test with three flights during which an F/A-18 aircraft made sharp dives to generate sonic boom shockwaves directly on the building, thereby better mimicking the P waves.



ED11 0022-13 NASA Photo by Tom Tschida

Dryden sonic boom researcher Ed Haering answers questions on NASA sonic boom research during a Jan. 25 NASA.gov Web chat. At right is Gray Creech from Dryden public affairs.

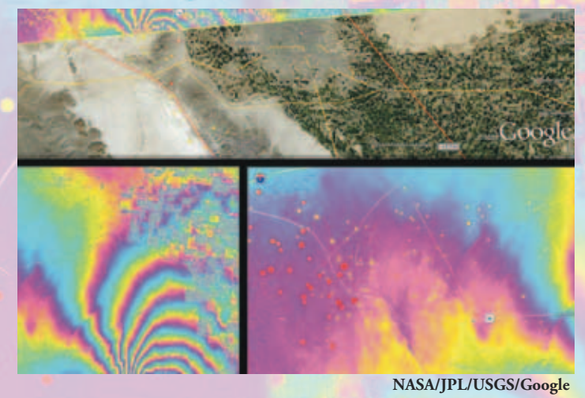
Such a system is currently in operation in California's Coachella Valley, with warning devices installed in several schools and fire stations. The system worked during one of California's most recently felt quakes, the 7.2-magnitude Baja California earthquake that occurred April 4, 2010, the strongest in the region in 18 years. The earthquake was larger than the devastating 7.0 Haitian earthquake of last January.

The QuakeGuard system successfully detected the Baja quake's P wave 90 seconds before arrival of the S waves and set off alarms that included the automatic raising of local fire station doors, which are integrated into the system. During earthquakes, fire station doors are frequently jammed shut, interfering with local fire department response.

Depending on the geographic distance from an earthquake epicenter, officials estimate such warning systems could provide up to five minutes warning prior to the arrival of a distant quake, but only seconds ahead for a device located near the epicenter. Though 90 seconds may sound like little warning, that much time or less is enough to allow people to take shelter, for automated valves on gas company pipes to shut gas off and for fire station doors to open.

Plans are being developed for installation of such a system in the Lancaster-Palmdale area, which lies adjacent to the San Andreas Fault about 70 miles northeast of Los Angeles. Due to the frequency of sonic booms in the area from flight test aircraft operating out of Edwards Air Force Base, Seismic Warning Systems must determine whether sonic booms need to be filtered out of the system.

Additionally, Dryden is working with the company on a white-paper study of the technology and the effects of sonic booms, or lack thereof, on its capabilities.



NASA/JPL/USGS/Google

The UAVSAR aboard NASA's Gulfstream III research aircraft captured this interferogram of the magnitude-7.2 Baja California earthquake that struck on April 4, 2010. The interferogram is overlaid atop a Google Earth image of California's Coachella Valley-Salton Sea region. Dryden is evaluating Seismic Warning Systems' earthquake-warning seismometers to determine whether sonic booms could create false alarms.

Fasteners of the Future

Hyper-Therm High Temperature Composites of Huntington Beach, Calif., has developed a low-cost ceramic composite mechanical fastener system that may become an enabling technology for the next generation of propulsion systems and hypersonic and space vehicles.

As a result of NASA Small Business Innovative Research work Hyper-Therm completed with Dryden oversight, the company developed and validated the high-temperature fasteners. Currently, the company is in discussions with several large aerospace companies about potential uses for the technology.

For example, interest in Hyper Therm's high-temperature fastener has resulted in a partnership with a major turbine engine manufacturer. That company has invested more than $170,000 for continued development of the fasteners and fastening methods, said Wayne Steffier, Hyper-Therm president and principal investigator for the high-temperature fastener project. The partnership, which constitutes Phase III SBIR work and a technology development success story, also might result in a dual patent.

Hyper Therm received $650,000 from NASA for Dryden SBIR Phase II work, for development and validation of the high-temperature fasteners. The new fasteners are considered economical compared to alternative fasteners and fastening techniques, Steffier said. In addition, though metallic fasteners are incapable of withstanding the extreme temperatures of high-speed flight or combustion environments, Hyper-Therm fasteners can join load-bearing structures capable of withstanding high temperatures.

"What makes our two-dimensional, ceramic, mechanical fastener so unique is it is fabricated out of flat, laminated, plate-stock material. It does not look like a traditional bolt that you buy in a hardware store. We are able to greatly reduce the cost of a typical fastener because we are using flat, plate, laminated material and we don't need to machine threads into the ceramic composite element of this fastener," Steffier said.

"Because the fastener is fabricated with the same materials as the adjoining structure it is being used to fasten together, it is essentially thermal-stress free. This reduces a lot of the complexity associated with joining high-temperature structural assemblies."

How valuable was the SBIR work in advancing this concept?

"It would still be sitting on the back burner if it were not for NASA funding the effort," Steffier said.

Dryden was helpful as the overseer of the work, he added. More specifically, he said Dryden contracting officer Craig Stephens helped focus the concept on applications NASA has interest in, such as hypersonic vehicles. That direction led to Lockheed Martin's interest in using the technology in development of a potential future hypersonic vehicle, Steffier said.

Stephens oversaw SBIR Phases I and II work.

"The original premise of the SBIR effort was to develop a high-temperature fastener that was lower-cost than traditional methods. Traditional high-temperature fasteners are usually made from three-dimensional, woven, high-temperature, composite materials, which are expensive to begin with and then you have to machine specific bolts or fasteners where the cost per bolt becomes fairly significant," Stephens said.

Hyper-Therm proposed a more cost effective, high-temperature fastener for SBIR Phase I work, which the company was awarded.

"The company developed a design based on plate material, making it a high-temperature fastener that is much more cost-effective. Phase I was to develop the concept and conduct initial mechanical testing of the fastener design.

"In Phase II the company began to acquire more data on the fastener's capability. Hyper-Therm completed planned room temperature and high-temperature testing of the fastener and ceramic composite lap joint sub-elements at different orientations relative to the primary orientation of the two-dimensional fastener. The research enabled them to characterize how the fastener would function under complex loading conditions," he said.

NASA is interested in high-temperature fasteners for joining sections of thermal protection systems, hypersonic engines and flight control surfaces, Stephens added.

Working with Hyper-Therm has gone well.

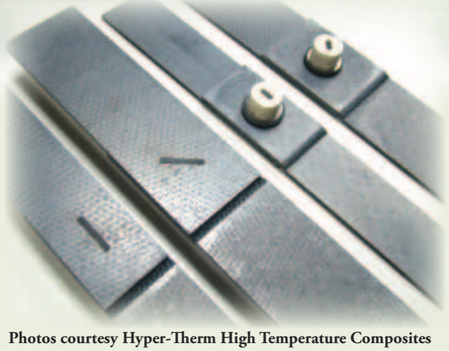
"Hyper-Therm is a good company and Wayne Steffier was very excited about this effort. He was very interested in the concept and spent a lot of time coming up with analysis techniques," Stephens said. "It is exciting to see an SBIR [project] that has this kind of business potential."

The SBIR program is an important tool for allowing businesses to explore new ideas and for NASA to determine if these ideas can be matured into new technologies, he added.

"Knowing that the NASA SBIR process is available provides NASA opportunities, when we are talking to companies, to direct them to the program and help them mature a potential technology that may be beneficial to both organizations," Stephens said.

This SBIR work has benefited the company.

See Fasteners, page 29



***In the background** is the high-temperature fastener system. **At right** are composite lap joint test articles.*

Photos courtesy Hyper-Therm High Temperature Composites

Partnerships

Students contribute to Dryden researcher's work and gain insight into engineering careers

When Dryden researcher Sunil Kukreja assembled a team for an Innovative Partnerships Program Seed Fund effort to begin looking at health monitoring of composite material airframes, he did so with partners from the University of Michigan, Ann Arbor.

Kukreja, who holds a doctorate in nonlinear system identification, forged the partnership with his long-time University of Michigan colleague Dennis Bernstein, who has a doctorate in control engineering, and Bernstein's students. Recently, Amy Wu and Tony D'Amato, two of Bernstein's students involved in that research, visited Dryden to share the results of the collaboration.

ED10 266-05 NASA Photo by Tom Tschida

Craig Stephens, right, makes a point during a tour of the Dryden Flight Loads Laboratory. From left are Dryden researcher Sunil Kukreja and two University of Michigan students with whom he worked on a recent project, Tony D'Amato and Amy Wu.

The collaboration took the team steps closer in the theoretical mathematical formulation and development of algorithms required for on-line health monitoring of next-generation aircraft made from composite materials. The work could ultimately allow for greater passenger safety and cost savings for airliners, enabling users of the technology to learn from the aircraft when and where maintenance is required and reducing the need for long inspections currently required, Kukreja said.

The way the team was looking at achieving the goal was by development of a sensors-only, fault-detection approach using pseudo-transfer function identification, Kukreja explained. The latter refers to identifying the pseudo-transfer function – a type of mathematical representation – between two sensors in the presence of variations from the baseline operation and external factors during ambient conditions. Validation of the fault detection architecture could allow health monitoring in real time on board with the addition of the proposed algorithm and software to existing cockpit computers.

The work has been a success and Kukreja and his team learned June 22 that they were awarded an Aeronautics Research Mission Directorate Seedling Fund award for new reearch on multiple input multiple output, or MIMO, formulation and the nonlinear effects on sensor-only system identification. This award advances the team's previous work.

Wu, a second-year graduate student in aerospace engineering, worked on the system identification research part of a sensor-only fault detection. It was a positive learning experience, she said.

"It's good to work your problems with someone who gives you really good advice," she said. "When I came to Dryden to present my work, I found out that the math and theory had application not only to what I am doing, but that there are all of these unsolved problems out there that this research might make a difference in. Dryden researchers brought up things we had not thought of, and we went back and thought about it."

The research project directly related to Wu's controls studies.

"Sometimes you don't quite know how what you learn in class fits into the real world. Now I can see how they relate. I learned about some of the questions Dryden engineers asked me

See Partnerships, page 23

Partnerships ... from page 22

about in class, but I think more about it now that I've heard it from them [the researchers]. Sometimes you get lost in the research. What you are trying to achieve, getting the codes to work – it can be frustrating. But I learned it's the nature of research and you just have to deal with it and keep at it," she said.

During the visit and tour of Dryden, she had a favorite part.

"I worked on the 747-8 at Boeing and I liked seeing the Shuttle Carrier Aircraft. It had a special meaning for me. Being in the aircraft and knowing it carried the shuttle was pretty cool. I know people who have been to Dryden, but now I have seen it for myself. I really appreciated the level of questions from the engineers and their interest and what they shared with me," she said.

D'Amato's work focused on the development of structural-health monitoring techniques based on system identification and estimation methods.

"Thus far we have developed techniques for the linear case and several nonlinear models. The goal of the research is to use models obtained with identification and estimation to facilitate damage detection and localization in aerospace structures," he said.

D'Amato said he learned much from the project.

"The most important concept that I learned from this project so far is the difference between practical application and the theoretical world," he said. "Most of our ideas start in the theoretical world under a specific set of assumptions, specifically, that the world is linear. Under this assumption we have many theoretical tools at our disposal to prove ideas and demonstrate concepts.

"The problem is that the world is nonlinear and, worse yet, most of the assumptions we impose on our methods and algorithms are violated when operating in the real world. Through this project, I had the opportunity to work with real data gathered from experimental setups. This gave me the chance to reflect critically on my work so far and determine which assumptions were valid and which were unrealistic," he said. The hard work paid off.

"The most rewarding aspect of the work so far has been the presentation of our results at national and international conferences. Meeting other researchers interested in the same types of problems, discussing the complications and possible resolution helps to give the project perspective. When I get stuck, I think back to these conversations and realize that I am not the only one struggling to solve these issues. Sometimes a simple informal discussion about the work has led to great ideas, which helped to push the project forward," D'Amato said.

Working with researchers helped focus his efforts.

"The overall goal of the project is fairly clear, namely, to detect and find damage in aerospace structures. The problem is that this is really an interdisciplinary subject, specifically, structures, dynamics and modeling with many potential routes and just as many dead ends. I have found it easy to get discouraged. However, working with experienced researchers has helped me tackle issues under the simplest conditions and then expand on these ideas until the issue is resolved. I have learned how to conduct research in a scientific fashion and then communicate my ideas and results in a clear and concise fashion to other researchers," D'Amato said.

There were challenges to overcome.

"The greatest challenge so far was recognizing the multidisciplinary nature of the work and learning how to incorporate advice and guidance from my peers and mentors. I was challenged to function as a team member to solve a complicated problem. As a senior student in our research group, I am expected to act as a mentor to incoming students. This perspective helped me realize that engineering is fundamentally a team effort and the unique experiences and backgrounds of the individual team members are what make the group more capable of solving difficult problems," he said.

D'Amato said he enjoyed the tour of Dryden facilities.

"We were offered great explanations and discussion on the various projects and experiments. I enjoyed the static aircraft displays, especially the SR-71 and the X-15. I had never seen these aircraft in person, but had read extensively about the programs. Without a doubt, it was projects like these that influenced me from early on to become an aerospace engineer. It had also been a dream to work with NASA, so getting the opportunity to visit and tour the facility was something very meaningful for me," he said.

He would recommend other students take advantage of working with Dryden.

"Working with the researchers at Dryden has helped me make the connection between the fundamental tools we learn as students in engineering and real-life problems faced by researchers advancing the state of the art," D'Amato said.

Kukreja said the students worked hard on the project and he enjoyed working with them.

In fact, Kukreja enjoys sharing his knowledge with students and peers. For example, last summer he shared his specialties in non-linear system identification as the keynote speaker at the International Conference on Non-Linear Problems in Aerospace World Congress in Brazil.

With the University of Michigan students, Kukreja said, solid work was accomplished.

"We developed good algorithms for a sensors-only approach. That means we don't need inputs to excite the system to determine the health of a structure," he said.

With the revolution under way with fiber optics, determining structural health will be possible in the future. Kukreja is already analyzing real flight data from accelerometers, as well as strain and loads data obtained from fiber optic sensors, in preparation for in-flight research to obtain critical information about aircraft health and or performance in real time, as it is being collected on an aircraft in flight. Such an algorithm could then be fully developed, paired with the mathematical estimation work and packaged for commercial use.

"The algorithm will work in a simulation environment such as Simulink in Metlab," he said, referring to the software used in testing, "but does it work in reality with interaction and complications in real-world situations? Will the flight test data validate the algorithm for structural health monitoring?"

In time, progress on the algorithms and mathematical framework for the concept could lead to a new day in safety and maintenance of composite structures. For now, researchers such as Kukreja will continue to work and collaborate with students and peers for the benefit of increasing the technology readiness level of these new concepts.

ED10 0042-16 NASA Photo by Tom Tschida

A software-development team prepares for a flight with a new research tool. In the aircraft, from left, are Ryan McMahon and David Marten. Outside the cockpit, from left, are Katherine Ryan, an unidentified technician, Gianmarco Di Loreto, Jade Lemery and Bruce Cogan.

The Art of Prediction

New tool could accurately gauge how an aircraft will fly when a flight control surface is damaged and adaptive flight control software compensates for the loss

Research and software being developed at Dryden could provide future aircraft designers with a better prediction tool that will accurately gauge how an aircraft would fly when a flight control surface is damaged and adaptive, or "intelligent," flight control software is used to compensate for the loss.

Ample handing-quality metrics are available for standard areas of the flight envelope. However, damage to a flight control surface may require the aircraft to operate in regimes for which there currently are no handling-quality scales or tools that can predict how the aircraft will fly or if it is flyable, explained Bruce Cogan, a Dryden researcher and lead on the project.

One example is cross coupling, which causes an unexpected response to the aircraft when the pilot moves the control stick. If the pilot pulls back on the control stick to climb the aircraft may climb, but it will also roll to the left or right. That left or right motion could make the aircraft hard to control. This situation is generally not a concern, except in a case where the aircraft has been damaged.

This research is intended to provide a metric for use by future designers in measuring cross coupling and building control laws to eliminate it, Cogan said. The tool could eventually be part of standard engineering software that aircraft designers use. Somewhat ironically, research with one of the few fixed-wing aircraft where cross coupling applied also was done at Edwards Air Force Base. The AD-1 research aircraft, which was flight tested at Dryden, exhibited heavy cross coupling due to the ability to change the angle of the wing in flight.

The concepts were developed initially through Small Business Innovative Research work with Hoh Aeronautics Inc. of Lomita, Calif., and are based on a metric developed for helicopters. Unlike fixed-wing aircraft, helicopters exhibit cross coupling in routine flight. The overall concept is to apply helicopter cross-coupling metrics to a damaged fixed-wing aircraft.

The end result is software that predicts how an aircraft would fly when damage occurs in flight and how well an adaptive controller compensates for cross coupling. That software recently took flight in a U.S. Air Force Test Pilot School simulator and on the F-16 variable-stability in-flight simulator test aircraft, or VISTA.

"The VISTA is a good test bed for the research because the aircraft software is easy to modify and the aircraft is able to 'fly' like different aircraft," Cogan explained. "In this case, the software was modified to fly like an F-16 and simulate effects of various degrees of simulated cross-coupling damage to the flight control surfaces."

For the flight tests, the aircraft took off under student control and in the air the instructor pilot would switch to one of 25 pre-programmed configurations, changing it to enable the student to fly the new configurations, Cogan said. Also, safety trips were in place to ensure that flight controls reverted to those of a standard F-16 in case the aircraft

See Prediction tool, page 27

SBIR opportunities help tech innovation

Dave Mitchell of Hoh Aeronautics doesn't have to be sold on the value of participating in Small Business Innovative Research agreements.

What began as a series of code under two SBIR agreements with the Air Force has been refined into an algorithm to detect pilot-induced oscillations, or PIO, with two SBIR agreements with Dryden. It now also is a commercially viable product used by The Boeing Company.

The Realtime Oscillation Verifier algorithm for detecting PIO, which Mitchell calls ROVER, uses control input and aircraft response to determine if a PIO is occurring. The phenomenon occurs when a pilot overcorrects for perceived changes from normal control of the aircraft.

As part of SBIR contracts with the Air Force at Wright-Patterson Air Force Base in Ohio, the ROVER was used to post process simulation and flight-time histories to look for PIO. It was not user-friendly and was a small part of the work performed on those contracts, Mitchell said. However, the idea showed promise and under Phase I and II SBIR agreements with Dryden – Tim Cox was the contracting officer – the ROVER was optimized.

"We improved the algorithms, worked out a logic structure, wrote new versions of the algorithms for its various uses and implemented the code in a Dryden simulator and a simulator at Hoh Aeronautics. We also performed piloted evaluations of ROVER as a PIO detection tool," he said.

That work has paid dividends. "We have sold two copies of the executable code to Boeing for use on C-17 control law improvement and advanced transport aircraft control law development efforts," he added.

In addition, Mitchell worked with Dryden on a follow-on SBIR Phase III agreement earlier this year. Bruce Cogan, the project lead, worked with Air Force Test Pilot School personnel to see if research and software developed at Dryden could provide future aircraft designers with a better prediction tool. The tool is intended to accurately gauge how an aircraft would fly when a flight control surface is damaged and adaptive, or "intelligent," flight control software is used to compensate for the loss.

The ROVER was intended to identify PIOs within the unusual flight regimes the aircraft flew as a result of the in-fight simulations. Although there were no indications of PIOs during those research flights, Mitchell assisted with designing the experiment. The project represents the follow-on work that can be available through successful SBIR agreements and the partnerships that are developed through that work, Mitchell said.

Mitchell is pleased with the concept's development and he enjoys working with Dryden.

"It's been wonderful. I was a co-op at Dryden in the 1970s.

See Hoh Aeronautics, page 29

Filling a need

Chief test pilot says partnership engaged students and offered an example of what flight test is all about

X-Press editor Jay Levine recently talked with William Gray, the U.S. Air Force Test Pilot School chief test pilot and staff advisor for Project Icarus: A Limited Handling Qualities Evaluation of Cross-Coupling. Gray talked about the value the project had for students in their partnership with Dryden researcher Bruce Cogan.

What was the biggest benefit to the TPS with this research project?
Every student in every class is involved in a student test-management project. It's always a real-world test project. We want it to be something that is important, valuable and new. There is a wide variety of these projects. This particular one was really good for us because this kind of research had never been done with fixed-wing aircraft and it needed to be done. It was a chance for our students to be involved in a project that would, no kidding, affect future planning and design of aircraft.

For them, it's just a fascinating project and they get the additional motivation of "it matters." It's not a make-believe thing. We don't do many make-believe things, but some things are more interesting than others and this is a particularly interesting one."

How were students selected for this project?
Students have opportunities to request the projects they work on, and this one was a match for several who were selected for it. It was a chance for them to work with engineering and sciences for which they had a lot of education. There was a lot of benefit to bringing home their education and a lot of benefit in terms of bringing home some of the stuff we teach them here about aircraft flying-and-handling-qualities testing.

What were the biggest challenges?
From my point of view, the biggest challenge on any project like this is scoping it. Because to really, fully answer the questions that [Dryden researcher] Bruce [Cogan] had, that NASA had, and that we had, would have taken easily 10 times more flight hours and man hours to do. We had to scope it into something the students can do while they were still attending school eight hours a day. This is something that they do in addition to their regular schoolwork. We had to scope it [the project] to the point where they had a chance to get good, solid answers and not be overwhelmed with the amount of data or preparation. Nevertheless, they had to work hard. This was not a simple subject.

What was the biggest success from a TPS standpoint?
There were problems they had to solve and whenever they are solving problems, they are learning. From the standpoint of the school, once again, we are producing information that is adding to the body of knowledge on how aircraft fly and how pilots interact with aircraft. We learn a lot when we put together a project like this.

How did the aircraft fly with the algorithms?
We had to build these algorithms so that we could change the way the airplane flew in predictable ways. The big question was, if a pilot is controlling the pitch by pulling back on the stick to raise the nose, what if the airplane also rolls? So now the pilot would have to control that, too. It could roll a little bit, or it could roll a lot. It could roll so much that the pilot would lose control of the airplane. Vice versa, what if the pilot goes to roll the aircraft and it pitches too? Same thing. If it pitches a little bit, the pilot may not notice it. If it pitches a lot, it may give the pilot problems. If it pitches too much, the pilot may lose control of the aircraft. We looked at both of those factors from [the standpoint of] how much any given change would affect the flyability of the aircraft.

There were numerous times where we would run the algorithm on the NF-16D VISTA control laws, and students who were doing the flying in the front seat would lose control of the aircraft and the safety systems in VISTA reverted back to standard controls. It was very physically demanding.

How did it fly?
Sometimes it flew really well, sometimes really, really bad. They needed those data to see how the aircraft would fly with a certain amount of cross control.

What do you think about the prospects of the flight experiment?
Data obtained from the flights resulted in development of a credible preliminary [flight] envelope. In a nutshell, designers could use the information in determining how an aircraft would fly with certain damage and the extent to which it could be controlled.

We understand the problem better now. A lot of times, when you are just starting out research, you sometimes create more questions than you answer but it just brings you that much closer to solving the original problem. With the guidance they have come up with, I think we are pretty far down the path toward having useful information for future designers.

Prediction tool ... from page 25

approached dangerous conditions. Then, TPS students flew and rated the controllability of the aircraft in about 230 flight scenarios during nine research flights.

As a whole, the software predicts cross coupling and the controllability of the aircraft, which were then compared to the students' experiences. Students used the Cooper-Harper scale, a recognized pilot rating system for flying qualities, to judge the aircraft performance. A tracking task was designed by the students to evaluate the aircraft. Early results showed a good comparison between predicted and actual handling qualities for varying degrees of cross coupling.

The enthusiasm and contributions of the student pilots added to the positive results, Cogan said.

"We listened to their comments, and they thought of things we didn't about introducing cross-coupling challenges," Cogan said. "They wanted to get good results for us on what was a very tight, compact schedule. It was a win-win."

The Air Force Test Pilot School team included project pilots Maj. Dail Fields, Maj. David Marten and Italian Air Force Capt. Gianmarco Di Loreto. Project engineers included Robert Koo, Jade Lemery and Katherine Ryan. Bill Gray was staff advisor for the project, which the Test Pilot School called Project Icarus: Limited Handling Qualities Evaluation of Cross Coupling.

The work wasn't accomplished without a lot of perseverance and patience, as the concept originated in 2004.

Proposals originally were written for testing the ideas on the F-15 Intelligent Fight Control Systems aircraft. Dryden researcher Peggy Hayes first saw the need for this information when she was working on intelligent flight control systems on the F-15 and began looking for a solution to the problem.

The ideas were developed with help from Dave Mitchell through the Dryden SBIR agreement with Hoh Aeronautics. Mitchell was the principal investigator and used his experience in handling qualities and helicopters to make the program a success. Early simulation tests proved successful and led to the current effort. When Hayes moved on to another project, Cogan took on the work. Cogan hopes to analyze the information and refine it for potential use on Dryden test aircraft, such as the F/A-18 no. 853.

Now that the concept is proven through flight the development process will continue, leading to validation for its use in helping make aircraft safer.

Tao of systems ... from page 15

Canada, France and some in the United Kingdom, so that we can come up with a better result in the United States. We are also working with U.S. researchers and SBIR definitely helps in that process."

However, there is no environment like that of flight to determine if everything works as planned.

"In wind tunnels, flow angularity is not well defined, especially near and past stall angles. In the linear small flow regime, there are good solutions available from computational methods.

"Once you get enough flow separation, predicting the static and especially the dynamic test results becomes very challenging. When you get near stall, there is a high degree of uncertainty in terms of prediction. And where do you think nature is optimizing – it's near stall. Everything is near stall and past stall.

"We also see the problem when you try to scale test results from wind tunnel to flight. It doesn't match, because it's hard to match boundary conditions like the effective flow angularity in the presence of flow separation."

Some aircraft are sensitive to gusts, and gust load alleviation is another of Tao Systems' interests.

"We tested out a gust load-alleviation controller under an Air Force program at NASA Langley's Transonic Dynamics Wind Tunnel. Those technologies could very well be used on aircraft right now. An issue that needs to be addressed is the environmental effect on sensors.

"The Air Force is working to come up with a more rugged solution to the sensors. We are collaborating with companies to make the transition to military aircraft first and ultimately on civilian aircraft," he said.

Determining the aerodynamic loads on the tail and wings by gusts in real time is a first step. Then a controller would need to be developed to automatically adjust for the loads. These concepts have led Tao Systems to a different vision of what controls of the future should look like.

"Would it be useful to have a system where you could 'fly by feel,' just like birds at various flight conditions? Fly-by-feel means you are able to sense the aerodynamics in a very quantitative way. An aircraft could react immediately to suit mission objectives, like being able to loiter for a long time and focus on range and endurance, or dash not unlike rapid maneuvering of insects.

"In order to do that you have to have a flow physics model that works – validated for angles well beyond stall and including flow separation – numerically and experimentally and numerically. Through our collaborations, we have the beginnings of that and we would like to extend that further," Mangalam said.

And there would be other benefits to the fly-by-feel concept.

"Fly-by-feel is physics-based control not just for subsonic and transonic flows, but for supersonic flows, where you can sense the loads in real time and react. What nature is very good at is exploiting the energy available in the environment.

"For example, take crosswinds or atmospheric turbulence. We generally avoid these conditions, but insects use them to generate thrust for themselves or gain altitude. The fly-by-feel concept and implementation enables aircraft to sense and exploit the environment regardless of flight regime."

Regardless of what the controls of the future look like, one thing seems certain – Tao Systems will have a role in developing it.

DIMM is a bright idea

Mass-properties measurements for large structures may be safer, more accurate, efficient and less costly

Three Dryden researchers are studying the Dynamic Inertia Measurement Method, or DIMM. DIMM could augment ground-vibration tests with additional software and hardware to make mass properties measurements for large structures more accurate and efficient, less costly and safer.

Claudia Herrera and Leonard Voelker were awarded a NASA Innovation Fund Program grant last summer to use the DIMM to calculate mass properties on large structures. It had previously been proven that the DIMM could be used effectively to measure mass properties on desktop-sized objects. The latest research was completed last fall in the Dryden Flight Loads Laboratory.

"Conventional methods for measuring mass properties are an incredibly big production," said Herrera, principal investigator on the project.

"It takes a lot of people and it exposes the vehicle to a lot of risk because for just about every setup you have to do a critical lift. You usually have to design some big, expensive test fixtures and then you have to analyze and test those fixtures to show they are structurally sound for support of the test article.

"In addition, for just about every mass property value you are trying to measure, you need a different configuration, which adds risk to the test article."

Not so with the DIMM, she said. Because most of what is required for its use is available during ground-vibration testing, mass properties measurements could be taken with just a little more effort.

As an example, it took a month to obtain information on seven of 10 mass properties measurements required to construct a full mass properties matrix on the crew module used as part of the May 6 Orion Pad Abort 1 test at White Sands Missile Range, N.M., Herrera said. With the DIMM, all the mass properties could have been obtained in about one quarter of the time "with one configuration and just one critical lift."

Because of the ease of use, Herrera said using the DIMM for large objects could make it valuable for a number of different design projects, especially in the aerospace and automotive worlds.

"People don't complete a lot of mass properties measurements because of the complexity. However, with this method, people would look at the magnitude of difference in obtaining that information, compared to traditional methods, and use it," she said.

Traditional methods and the DIMM concept were compared with separate evaluations of a 17,000-pound test article built for the research. DIMM test methods were evaluated with sensors, including six-degree-of-freedom load cells to measure the support force, or the force on the structure that is supporting the test article. The excitation, or force input to the structure to make it vibrate, was achieved through use of an impact hammer and a shaker and measured through use of a tri-axial force transducer. Seismic accelerometers were used to measure the response from the structure as a result of the excitation.

Hardware issues during the tests limited the analysis window, Herrera said. For that reason, further study is needed for DIMM application on large test articles for the full-analysis window, which can reduce uncertainty in results before moving on to the next step: proving and demonstrating the method on a full-size aircraft.

The research showed promise and additional investigation could validate use of the DIMM, Herrera said. Success could lead to a day when the DIMM is used for measuring mass properties that are more accurate, less expensive and time intensive and with less risk.

Photo courtesy Claudia Herrera

Dynamic Inertia Measurement Method, or DIMM, team members are, from left, Kevin Napolitano, Ralph Brillhart and William Fladung of ATA Engineering; Dave Brown of the University of Cincinnati; and Dryden team members Starr Ginn, Claudia Herrera and John Bakalyar. The team is working to validate and verify that augmenting ground-vibration test hardware and software can improve the accuracy, affordability and safety of mass properties measurements for large structures.

Innovation ... from page 5

Chan-gi Pak

The capability for flexible motion control will help increase design options for lighter-weight aircraft, which can lead to increased fuel efficiency and reduce noise. Reducing aircraft weight usually means reducing stiffness and increasing flexibility. Increased flexibility translates into an aircraft being more susceptible to aeroelastic phenomena such as flutter, divergence, buzz, buffet and gusts.

Chan-gi Pak

For lighter-weight aircraft and spacecraft, use of the new materials and structures, coupled with the new control methodologies, could lead to drastic weight reduction and corresponding cost savings, said Dryden researcher Chan-gi Pak.

In the past, a key way of meeting design challenges with flexible aircraft structures was to design aircraft using ridged materials in areas where designers were worried about aeroservoelastic instabilities. Pak said he wants to change that assumption by seeking to control flexibility motion through an active control system he calls the Active/Adaptive Flexible Motion Controls with Aeroservoelastic System Uncertainties.

He would like to see his control methodology ultimately flown on an aircraft during a flight test. The predicted results of his control laws then would be compared to the actual aircraft measurements and used on a test flight in concert with standard control laws. The capability to turn off the adaptive portion of the system provides a mechanism for comparing the performance of each set of control laws and adding flight safety to early-stage development.

Curt Hanson

A day may come on which aircraft companies could cooperate to maximize fuel savings and fly aircraft in formation to destinations across the nation. It's a vision Dryden researcher Curt Hanson can see, and he isn't alone.

Curt Hanson

Gregory Hornby, who has a doctorate in computer science and is a senior scientist at Ames Research Center at Moffett Field, Calif., estimates that if formation flight were applied to just 5 to 10 percent of national airspace traffic, an annual fuel savings of as much as $750 million could be realized.

Dryden research into algorithms that can identify the peak of aerodynamic forces and autonomously reconfigure the airplane to improve efficiency will be key to achieving those levels of savings, Hanson said. Repositioning aircraft surfaces to reduce drag could cut fuel use in half and drastically reduce emissions.

"An aircraft flying in another aircraft's wingtip vortex creates a big rolling moment, and traditional trim schedules deflect the ailerons anti-symmetrically. It turns out that that type of trim scheme is exactly the wrong thing to do when flying in formation for drag reduction.

"CFD [computational fluid dynamics] analysis performed by the flow physics group here at Dryden will determine the optimal control trim configuration scheme, and then I will apply a peak-seeking control algorithm scheme to find that solution in real time," he explained.

The technology is called Wing Morphing for Optimal Drag Reduction in Formation Flight. Futuristic wings may have the capability to alter their own camber and twist to optimize lift distribution in the presence of another aircraft's vortex.

A peak-seeking controller will continually adjust the wing shape and control trim to account for changes in flight condition, aircraft weight and uncertainty in the strength and shape of the leading airplane's vortex.

Eventually, the peak-seeking controller could be tested on a Dryden research aircraft.

Hoh Aeronautics ... from page 25

I greatly enjoyed my time and I've had the chance to talk to others who have come along since I left. They are easy to work with [at Dryden] and very interested in the work. It's all positive," he said.

SBIR work has been good for Hoh beyond just the sale of a product.

"The SBIR did what it was intended to do – develop this product. We have had a few commercial sales of the product for flight test and for ground testing of new control laws. In both cases, it was not just a sale of a product, but also of our services with the analysis and interpretation of the results," he said.

Fasteners ... from page 21

Hyper-Therm made a presentation at the 35th Annual Conference on Composite Materials and Structures in Florida in January as a result of its SBIR work. Several large aerospace companies approached the company to learn more about the high-temperature fasteners, Steffier said. For example, The Boeing Company's Phantom Works division in Huntington Beach inquired about the Hyper-Therm ceramic fasteners for use in a potential reentry vehicle, he said.

As discussions continue for tapping the new high-tech fasteners, it is the combination of bright ideas generated in private industry and insight from NASA through SBIR work that will ensure the technology is ready when it is needed.

‘Everything and anything novel’

Holland helps protect ideas, commercialize tech

For Dryden researchers looking to protect their ideas, or seeking to commercialize their work, the center has added a key person to help them.

Julie Holland

Julie Holland, who has experience with Dryden and NASA, recently accepted a position at the center as the partnership development manager. In essence, she is looking for “everything and anything novel” that has licensing or infusion – also known as commercialization – potential.

Holland’s key goal is to “help the IPP office build an effective program that contributes to Dryden’s success,” she said. “Both by facilitating infusion partnerships and leveraging the taxpayer’s investment by making internally developed innovations available to the public and private sectors. I thoroughly enjoy putting the pieces together. There is some real potential here, and that makes me excited.”

Holland has been involved in all types of intellectual-property issues, including patenting and technology commercialization, from the ground up. One example is the establishment of the NASA Commercialization Center at the California State Polytechnic University in Pomona, Calif., where she was responsible for the feasibility study and raising the funds that created the center. She then was appointed to lead the new center’s development.

For six years beginning in 1998, she was the director of the center, a project developed under a cooperative agreement between NASA and the university. Her job was to develop the 40,000-square-foot facility, which is the anchor of the university’s 60-acre technology park. In addition to having the center becoming financially self-sufficient within two years of opening, she pioneered a novel technology-commercialization service model for early-stage companies preparing to launch new products.

Success of participating companies resulted in NASA’s request for Holland to build a national business services model targeting the particular needs of Small Business Innovative Research awardees. The National Academy of Sciences gave the model favorable reviews. Also during that time, she organized the team that has supported Dryden’s evaluation of the commercialization section of SBIR and Small Business Technology Transfer proposals and championed equity investment in early-stage technology companies.

She finished her tenure at Cal Poly Pomona as executive director of business services for the college of the extended university, where she was promoted to lead college-wide operations. She directed accounting and finance, registration, information technology, marketing, contracts and the NASA Commercialization Center. In that position, she also wrote a successful proposal and made a presentation resulting in a grant award of $2 million from the U.S. Economic Development Administration to add four wet labs to the NASA Commercialization Center that resulted in making highly specialized labs available to early-stage businesses at an affordable price.

Holland has also worked to take “game-changing technology,” a term NASA uses for an advancement that revolutionizes how something is done, or makes it possible to do something at all, to the marketplace. Game-changing technology is something Holland has been working with her entire career, including in her first job after college graduation, when she was responsible for helping launch an automated chemistry analyzer in the clinical laboratory marketplace. She had responsibility for overseeing the training, customer support

See Holland, page 32

CPP students aid in new-tech evaluation

When a researcher develops a technology or novel approach to completing a task, he or she writes and submits a new technology report, or NTR. If he or she needs help, it can be found at the Dryden Innovative Partnerships office.

The IPO office, known previously as the Innovative Partnerships Program office, offers help through its new NTR Plus program. NTR Plus is designed to collect the information most relevant to assessing the discovery’s patent and partnership potential, said Julie Holland, Dryden’s partnership development manager.

Once an NTR is approved, the IPO office completes the

See Students, page 31

ED11 0115-05 **NASA Photo by Tom Tschida**

Cal Poly-Pomona participants, from left, are Tyler Frisbie, Julio Perez, Ashley Knoblach, Ravin Kumar, Winny Dong and Olukemi Sawyerr.

Students ... from page 30

initial technology screen, which evaluates how unique the idea or invention is, what is available that is like it and the possibilities for commercialization. The evaluation can lead to a full assessment if the technology shows promise.

That’s where students from California State Polytechnic University, Pomona, come in. In the three-month Tech Screen pilot project – and, soon, in a six-month trial run – a technical student/business student pairing chose a Dryden technology to evaluate. Supervised by a professor, the student teams complete a preliminary assessment that includes market research, research that might be competitive with it, a search of the U.S. Patent Office database for similar ideas, commercial possibilities and recommendations for pursuing a patent or non-patent track with the new discovery.

In April, two of the student teams and two faculty advisors came to Dryden to present information on the technology each team had chosen for the pilot project. At this meeting, students and center representatives compared notes on what worked and what could be refined for the larger, six-month project that will soon begin.

A preliminary meeting to ensure that the students understand what the technology is was one of the suggested improvements. Overall, the Dryden representatives were encouraged by the students’ work, which included areas of thought no one at the center had considered, a key reason for seeking student collaboration.

“It points us in a direction,” Holland said. “We wanted to give students the framework, but we didn’t want to taint how they would see the possibilities. Put creative minds together and you experience the power of novel insights.”

The Dryden IPO, previously known as the Innovative Partnerships Program office, funded the grant. The Aerospace, Education, Research and Operations, or AERO Institute in Palmdale administered the grant.

In addition to inspiring students with resume-building work, the project aims to contribute to science, technology, engineering and mathematics, or STEM, education, providing a qualified external capability for Dryden technology screening. In addition, Cal Poly-Pomona’s three-quarter entrepreneurship program, which is part of the university’s Innovation and Commercialization Laboratory, adds a technology component.

The laboratory is co-taught by Olukemi Sawyerr of the university’s college of business, and Winny Dong of the college of engineering, principal investigator on the project. The idea is for students to learn about business development, entrepreneurship involving technology and product development in a hands-on manner while working on an interdisciplinary team.

Students had another incentive: the assignment could be a door to starting their own business, or a pathway to selling a new product to an established business.

“This program is novel in that non-patent-track technologies allow opportunities for students to put a business plan together. If they come up with a plan in the Cal Poly-Pomona curriculum,

“Working directly with NASA on the newest, coolest stuff and getting insight into how I can fit into NASA was the best. It was also like being thrown into ice water, trying to figure out if it was marketable and, if it is, who would want to buy it.”

Ravin Kumar
Cal Poly-Pomona mechanical engineering student

they are expected to go out and raise the money, make a prototype, then launch and sell it if they can. An example is an algorithm that might not be patent-track, but still might be very useful for games or an application of some kind. There are all kinds of possibilities,” Holland said.

The professors managing the program see the opportunities for their students.

“Students tested their capabilities in an unknown context. Bringing a business student and an engineering student together to do a tech screen for NASA is not something that many students have the opportunity to do,” Sawyerr said. “They were nervous about whether they would be able to do it. We didn’t give them much structure, and we let them struggle with the idea because the real world is unstructured. Then they were doing the research, collecting the data and coming out here, delivering and having such a positive reception.

“That’s priceless.”

“I like the fact that the students were able to see the intellectual property side of technology,” Dong said. “Engineering courses do not cover the importance of protecting intellectual property. How you protect ideas, when do you patent – exposure to that world was valuable for them.”

The students included Tyler Frisbie, Ashley Knoblach, Ravin Kumar and Julio Perez.

Perez, a business and supply chain management student, said he learned from a project that, at first, was as complicated to understand as hieroglyphics.

“The collaborative aspect was valuable – I never had experience with mechanical engineering,” he said. “Understanding how it works was a challenge in itself. Speaking to engineering professors, I started figuring it out. I was so used to everything having to do with business; I had to go outside my comfort zone to figure out what all these engineering terms mean. [The experience] was very valuable.”

His partner, Kumar, who is studying mechanical engineering, had another point.

“Working directly with NASA on the newest, coolest stuff and getting insight into how I can fit into NASA was the best. It was also like being thrown into ice water, trying to figure out if it was marketable and, if it is, who would want to buy it,” he said.

The project reinforces that Dryden and academia make good partners; Dryden’s new technologies are getting a much-needed boost from the partnership with Cal Poly-Pomona.

Holland ... from page 30

and troubleshooting of the first three beta (initial) products installed at prestigious institutions.

Her first experience had a number of career lessons related to new-technology commercialization best practices. Although the product eventually revolutionized the industry and remains a workhorse today, at launch it didn't work.

"The premature launch saw a $700 million company brought to its knees," she said.

Four binders full of engineering changes later, the first automated and computerized chemistry analyzer in the industry performed as promoted. Lesson learned: "The decision to move on something too soon and not adhere to cross-functional [teams comprised of members from engineering, manufacturing, finance, distribution and customer support] development best practices can make your company into a Harvard case study," she said. "No one wants to be a Harvard case study."

More recently, as vice president of marketing and sales for Select Universities Technologies Inc. of Newport Beach, Calif., she was a member of the executive team that assessed and selected technologies to be licensed from universities, raised equity investment funding, formed new companies around each licensed technology and oversaw the development and launch of the first commercial products. She had direct responsibility for creating and executing marketing and sales plans, including building marketing and sales teams, for each new company.

One of the new companies, IntelliStick, licensed technology capable of sensing oil oxidation as it was happening in harsh environments. The technology originated during the F-35 Joint Strike Fighter development. The first application was as an "intelligent" dipstick with a sensor at its tip that would indicate when to change oil to allow for optimum performance and maximizing an engine's lifespan.

Popular Mechanics editors judged the IntelliStick to be the best new product of the year in the automotive aftermarket sector, but the company couldn't deliver on the product's full promise initially, Holland said.

"The decision to move on something too soon and not adhere to cross-functional development best practices can make your company into a Harvard case study. No one wants to be a Harvard case study."

Julie Holland
Dryden partnership development manager

The company had targeted the technology for dipsticks for cars. However, the "generic" design was no match for the more than 1,300 types of dipsticks unique to each make and model of car. Fortunately, the product fit a sufficient number of cars that the demand was strong enough to keep the company financially viable and attractive to investors. It took another six months to fast track the second product to be used on remote oil and gas pipelines and negotiate marketing and distribution agreements with industry partners, she said.

A key lesson, she said, that emerges in every product development effort, and one often overlooked to great dismay later, is to listen to the voice of the customer. The interesting challenge is that the profile and buying behaviors for a customer for a new product based on new technology are not the same as for products with incremental improvements.

Another valuable asset that Holland brings is knowledge of the ins and outs of the patenting process, including protecting intellectual property – initial disclosure, technology assessments and patent filing – and the need to keep the patent history "clean" for licensing purposes.

Most prospective licensing partners, particularly those seeking exclusive licenses, will perform patent prosecution due diligence to ensure that the researcher originated the work. Other verifications made during the process are that relevant documents were controlled, that non-disclosure agreements were honored and that the risk of others contesting the patent is low. Most important, leakage of material information must be avoided that might have occurred in informal conversation among peers or external colleagues, leading to the invention being reduced to a practice by another entity, Holland explained.

Working with researchers and potential users of intellectual property for commercialization also requires something very important.

"It's not enough to have a company interested in commercializing a technology," she said. "Each potential licensing partner must prove they have the capacity and capability to develop and launch a new product. This is why companies interested in licensing technology from Dryden must, as a final step in the qualification process, submit a full development and marketing plan with basic financial information, in order to be considered as a viable licensing candidate."

Holland was recently director of business development at Tao of Systems Integration in Hampton, Va., a post in which she gained insight into some of the companies that work with Dryden. Companies like Tao use Small Business Innovative Research agreements to probe ideas. If those ideas blossom, there are other agreements that can be sought for a phase II agreement to raise the ideas' technology readiness level, a key NASA initiative.

Holland described the company as a "gazelle," a term describing the type of new technology-based companies that collectively contribute about 95 percent of the growth in new products and services year after year. These are early-stage companies that grow rapidly – by definition they grow at least 20 percent per year over five years – and have been working at developing their game-changing technology for a number of years. Prior to becoming gazelles, the companies on average have fewer than 10 employees.

Holland's experience goes from the discovery of intellectual property to commercialization with a bunch of stops in between for both commercial and private entities. Holland brings the best practices from her experiences to Dryden, where she plans to help accelerate licensing-and-infusion partnerships.

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

Editor: Jay Levine, TYBRIN, ext. 3459

Assistant Editor: Sarah Merlin, TYBRIN, ext. 2128

Managing Editor: Steve Lighthill, NASA

Acting Chief, Strategic Communications: Kevin Rohrer