The National Aeronautics and Space Administration

AEROVATIONS

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Through the Innovative Partnerships Program, NASA fosters partnerships among researchers, academia and industry to validate ideas and improve technology readiness so it is available when needed.

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Welcome to Aerovations

Valuable, interesting and potentially groundbreaking technology, enabled through the many facets of the Innovative Partnerships Program, is profiled on these pages.

The IPP seeks to add value to NASA's mission directorates and their programs and projects through technology development and infusion. To better facilitate technology breakthroughs, the IPP fosters partnerships that leverage funding to address technology barriers via cost-shared, jointly developed partnerships. Serving as a facilitator for partners inside and outside the agency, the IPP is bringing new sources of innovation together 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.

Some of these technologies may increase safety while reducing operational costs for military, commercial and civilian use. One technology may have diverse applications ranging from determining the structural health of buildings and bridges to assisting surgeons in medical procedures. Another may lead to new, proven technologies and combinations of concepts that will power future space vehicles more efficiently and economically.

The IPP acts as a pathfinder and an agent of change that will lead to new approaches and methods through creating partnerships such as those that will give small businesses the ability to compete for inclusion in technology-development efforts expected to lead to commercial products and become widely available to those who fund these projects, the taxpayers.

In partnerships with small businesses and research institutions, the IPP is pulling into the marketplace from colleges and universities the innovations that will help inspire a new generation of researchers. Some of the research is focused on perceived future challenges that may be a decade away. Thanks to the IPP, the technology will be ready when it is needed.

The cover story for this issue of Aerovations details opportunities for meeting technology challenges as well as the projects supported through the IPP. The article also profiles the avenue for reporting new technologies and maturing them for commercial products that benefit everyone.

Enjoy the variety of projects described on these pages, which are as diverse and innovative as the IPP itself.

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Innovative Partnerships Program

The Innovative Partnerships Program offers a variety of resources for collaborations that will advance technology and result in commercialization and technology transfer

By Jay Levine
X-Press Editor

A technology question emerges, but an individual NASA center does not have the resources to examine it in greater detail.

A researcher has an idea to solve a fundamental challenge, but not the expertise to take the concept to the next level.

University, small business or industry partners have a concept that could lead to a new technology, but not the technical knowhow, or the expensive and extensive diagnostic tools available at a NASA center.

What these three scenarios have in common is that NASA has a way of connecting the resources with the technical challenges. The Innovative Partnerships Program offers a number of initiatives to bridge the gaps between problem and resources to resolve it, or mature a technology so that it will be available when it is needed.

The IPP, which supports all four of NASA's mission directorates and includes an office at each of the agency's 10 field centers, uses a combination of investments and partnerships with industry, academia, government agencies and national labs to mature or investigate technologies. The three program elements are Technology Infusion, Innovation Incubator and Partnership Development.

Technology Infusion Element

Technology Infusion is the IPP element familiar to small businesses that seek to participate in government-funded research and development in key technology areas.

The Small Business Innovative Research – SBIR – program and the Small Business Technology Transfer, or STTR, program invite companies of fewer than 500 employees to submit proposals describing how the company's unique capabilities and novel approaches offer research and development that can help NASA reach its goals. The IPP Seed Fund offers a similar opportunity for NASA research staff to submit proposals that leverage external partners to assist in government research.

The three programs are engines for starting up new technologies and industries, while providing NASA, university and college and small business researchers tools for exploring the unknown and defining research paths.

Researchers and companies can respond to the annual SBIR and STTR solicitation for proposals, which are reviewed and ranked with the top concepts selected for contract awards.

The idea is to investigate new ideas and, in later phases, commercialize the technology into products and services for other NASA programs, government agencies and for wider public use. Often times, NASA seeks to "spin in" technology, where it finds someone doing the work that will lead to the readiness level that could meet NASA's needs and might also lead to a commercially available product or process. NASA mission directorates help to define the areas of technology that are needed, which vary from year to year.

Congress created the SBIR program in 1982 to provide ways for small businesses to participate in government research and development as a means of increasing national employment and improving U.S. competitiveness. The program has the additional goals of stimulating technological innovation and increasing its commercial application, and encouraging a wider infusion of ideas.

SBIR contracts are negotiated by representatives of a NASA center and the winning proposal teams. A NASA center repreentative oversees the work during the contract.

In addition, the STTR initiative was started in 1994 and follows many of the same guidelines as the SBIR program. However, STTR agreements include a university or college partner. The idea was to create cooperative research and development opportunities with a college or university nonprofit research institute and develop intellectual property, including patents and copyrights. The small business then works to move the technology from the laboratory to the marketplace through new commercial products.

Approving the work in phases

SBIR and STTR each have as many as three phases. The first phase begins after the award is announced and the funding is provided to demonstrate the feasibility of the technology. Funding up to $100,000 is awarded for an SBIR contract for a six-month period and up to $100,000 and one year for a STTR.

Phase I work usually results in a working model of the concept, or a software or hardware package that makes the benefits of the concept obvious.

A Phase II award, which is granted to less than half of the Phase I proposals, can include funding up to $600,000 for two years to further develop the innovation. These efforts usually culminate in a prototype that demonstrates benefits beyond those shown in the Phase I work. In addition to the technical advances, a business is expected to provide the case for the proposed product, including market analysis, financial planning and business expertise.

A Phase III agreement is when the technology is mature and is used and paid for by someone who needs the technology or wants to further refine it. When an SBIR/STTR project reaches that point, it is considered a success story. A Phase II contract is not a requirement for a company to receive a Phase III contract.

An additional benefit of a company participating in an SBIR/STTR project is that government agencies and their prime contractors may select to do Phase III contract work without having further competition to use that company, eliminating the need for competition in selecting the company for a contracted service associated with the original Phase I work.

IPP Seed Fund

Partnerships to eliminate technology barriers and assist in meeting mission and technology readiness goals sometimes involve a different approach.

For these needs, the Innovative Partnerships Program Seed Fund was developed as part of the NASA IPP. It is used to meet technology goals by providing resources for initiating cost-shared joint technology development. The idea is to encourage the leveraging of staff, resources and equipment from NASA, its field centers and non-NASA partners.

Douglas A. Comstock, NASA Innovative Partnerships Program director, said during the past two years that IPP investments of

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$15.9 million in the Seed Fund facilitated the generation of 67 partnerships and was leveraged by the various partners for goods, services and funding of $62.2 million for the advancement of critical technologies and capabilities for the agency.

The IPP Office at NASA Headquarters asks NASA field centers for proposals. NASA's mission directorates then determine critical technology areas identified in the proposals.

Proposed projects should have a one-year duration and must include one or more non-NASA partners who are willing to provide cost sharing equal to or greater than the IPP funding provided to the project. Seed Fund projects are structured to provide up to $250,000 of research funding. Acceptable cost sharing from the partner includes funds and project and in-kind considerations such as workforce labor and the use of facilities and test beds.

Innovation Incubator Element

This IPP element includes the Centennial Challenge, Facilitated Access to the Space Environment for Technology Development and Training, or FAST, and the Innovation Transfusion.

The Centennial Challenges presents prizes to winning challenge contests with novel technological solutions in areas chosen by NASA. NASA provides the purse for the winners of the challenges and the competitions are coordinated and funded by external allied organizations and corporate sponsors. Innovations are sought from non-traditional sources in academia, industry and the public.

"..NASA has a way of connecting the resources with the technical challenges. The Innovative Partnerships Program offers a number of initiatives to bridge the gaps between problem and resources to resolve it, or mature a technology so that it will be available when it is needed."

A Power Beaming Challenge at Dryden is intended to demonstrate wireless transmission of power to a robot designed to climb up a cable. In this case, NASA provided the prize money and the Spaceward Foundation coordinated the games.

Previous competitions used cranes to suspend the cable, but this event used a helicopter for the suspension of the one-kilometer long cable. The events for a particular challenge become increasingly larger, as does the prize money for the winning team. If there is no winner for a particular event, the prize money is rolled into the next competition – up to an award of $2 million for the power beaming competition.

The Power Beaming Challenge matures one of the two technologies sought through the space elevator games. A Tether Challenge scheduled for late this year in Seattle seeks advances in carbon nanotube material development. Other challenge competitions inspire advancement in the technologies such as those needed for a lunar lander, lunar regolith excavation and improvements to astronaut gloves.

Why fund challenges?

The reason why NASA funds Centennial Challenges is simple – it makes sense.

That was one of the conclusions in a broader study of government-funded research initiatives in the Federally Funded Innovation Inducement Prizes report (CRS R40677) issued June 29. The report was authored by Deborah D. Stine, a Congressional Research Service science and technology policy specialist.

Centennial Challenges are intended to drive progress in aerospace technology of value to NASA's missions; encourage the participation of independent teams, individual inventors, student groups and private companies of all sizes in aerospace research and development; and find the most innovative solutions to technical challenges through competition and cooperation.

To those ends, NASA officials' expectations have been exceeded in the Centennial Challenge competitions. The competitions have spurred the creation of new businesses and products, including innovations in pressure suit gloves and reusable rocket engines, according to the report.

Individual challenges are either "first-to-demonstrate" competitions, or "repeatable contests" with prizes that range from $300,000 to $2 million. Each challenge is a public and private partnership with co-sponsor organizations that contribute cash toward the prize purse and allied organizations that provide in-kind services to enhance the competition.

As the amount of the prize increases, the degree of participation and level of technical maturity and ingenuity also increase, the report detailed. In past competitions where the prizes were $300,000 each, it is estimated that the 10 to 15 participating teams represented an investment of $50,000 to

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FAST

The FAST initiative is an initiative to foster development of commercial services for NASA's need for microgravity environments. NASA's Glenn Research Center, Cleveland, and Vienna, Va.-based Zero Gravity Corp. provided commercial parabolic aircraft flight services to simulate multiple gravity environments.

The effort has the dual objectives of demonstrating the purchase of commercial services from the emerging commercial space sector, and advancing technology maturity through use of those services.

As commercial suborbital flights become available, the FAST project will seek to use those services as well – initially for technology development and eventually to support potential training needs. The

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options of 'shared rides' on sounding rockets or orbital vehicles, and space-environment training facilities may also be pursued. The goal is to eventually extend the commercial space service procurement model to a standard business practice within NASA.

The IPP works closely with mission directorates to identify technology development and users for micro-gravity flight services.

Innovation Transfusion

Through the Innovation Transfusion activity, the IPP hopes to create connections between innovative organizations outside NASA for increased agency benefit from external creativity.

Innovation Transfusion is intended to identify areas of innovation with potential benefit to NASA, recognize and learn from current innovations occurring outside the agency, broadly disseminate outside innovations to NASA, foster future partnerships and provide innovation focus to career development.

Innovation Transfusion contains two major components. The first is the Innovation Ambassadors program, which places NASA technical employees at external organizations for approximately three to 12 months to work on achieving the goals and objectives in their individual development plans.

The second component is the Innovation Scouts program, in which IPP staff and technology experts will visit innovative organizations for focused one- or two-day workshops to exchange information on specific innovations and to gather information on the host organization's latest technology developments.

Intellectual Property Management

Accordingly, partnership development efforts facilitate and provide for leveraging of partner expertise and funds to develop technologies critical to NASA's mission research and development goals. Sources of technology in the IPP portfolio include SBIR/STTR, Centennial Challenges, the IPP Seed Fund and dual-use technology development partnerships in addition to those technologies recorded in the NTTS database.

By surveying the available technology solutions and technology-needs landscapes inside and outside NASA, the IPP identifies potential matches.

To identify NASA's technology needs, the IPP works closely with NASA's mission directorates. The primary partnership agreement mechanism is the Space Act Agreement, although other agreement types are possible. NASA determines the appropriate agreement instrument.

Partnership Development Element

The final program element includes traditional technology commercialization activities that lead to patenting, licensing and protection of intellectual property.

New Technology Reports – required by contractors and government employees developing new government-funded technology – form the basis for communicating the new ideas to a broad audience thorugh a NASA technology tracking system. The IPP administers the processing of NTRs and provides commercial assessments, which are critical to patenting decisions for inventions reported in NTRs.

Management of intellectual property includes gathering those NTR reports and recording that information in a searchable database to track inventions and inventors. The NASA Technology Tracking System database tools aid in connecting specific technology needs with subject matter experts who have reported their research results.

With limited resources for technology development within NASA, it also has become increasingly important for the agency to bring in, or infuse, technology developed jointly in partnerships with industry, academia, other federal agencies and other external entities.

Technology Transfer

Another facet of intellectual property management is the licensing of NASA inventions. The IPP is responsible for originating and negotiating licenses and related partnerships with the private sector to facilitate the transfer of NASA-developed technologies for commercial application and other public benefits. Successful efforts in technology commercialization are referred to as "Spinoffs" and are showcased in an annual publication of the same name.

Licensing terms are negotiated on a case-by-case basis, although technology fields of use are defined as narrowly as is practical in every case, and exclusive licenses are rare. The IPP facilitates the protection of NASA's rights in its inventions identified in NTRs and enables NASA to license its technologies.

IPP benefits have permeated the U.S. and international economies, as the resulting commercial products – more than 1,600 of which are documented in NASA's Spinoff publication – contributed to development of services and technologies in health and medicine, transportation, public safety, consumer goods, agriculture, environmental resources, computer technology, manufacturing and other key industrial sectors.

Companies big and small bring different skills and ideas to the table and serve as a valuable asset to NASA. In turn, the agency has a number of tools through the IPP to help advance the most worthy ideas.

Special thanks to Technology Innovation magazine, a publication of the NASA IPP Office, and Douglas A. Comstock, director of NASA's IPP program, and Yvonne Kellogg and Greg Poteat of the Dryden IPP Office for contributions to this article.

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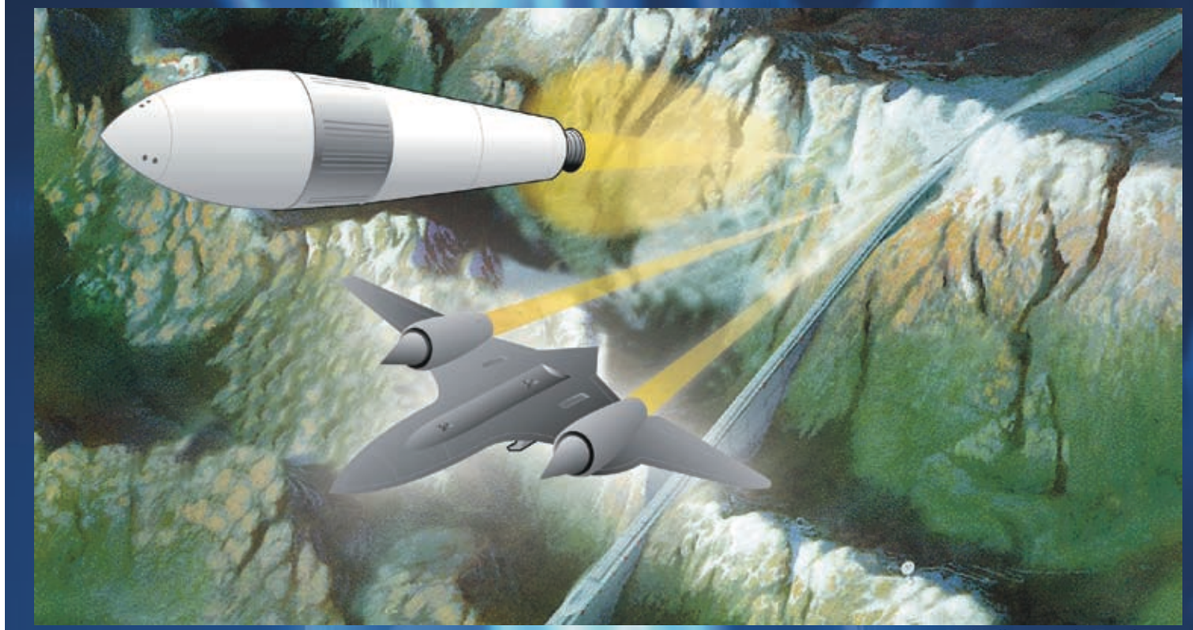
Launching future concepts



NASA Illustration by David Faust

Highly Reliable Reusable Launch System could offer alternative to brute force of solid rockets in first phase

By Jay Levine
X-Press Editor

Some of the same technology found in amusement park rides might one day help boost spacecraft during the first stage to radically reduce the costs of a launch.

If that happens, future spacecraft might use a version of a linear induction motor launch system, which essentially is an electromagnetic catapult that would move a spacecraft along a rail system with an air-breathing engine second stage and a rocket-powered third stage completing the job of propelling the vehicle into space, Dryden researcher Kurt Kloesel explained.

Kloesel is working to develop a system that is named the Highly Reliable Reusable Launch System. The goal is to validate and test elements of this launch system and research increasingly complex parts of the overall concept using Small Business Innovative Research and Innovative Partnerships Program funds.

Looking to overcome the challenges of nurturing a small, new technology program, Kloesel has partnered in the current effort with Michael Wright of Goddard Space Flight Center, Greenbelt, Md.; Darin Marriot, formerly of Embry-Riddle University; Leo Holland of General Atomics of San Diego; and Dryden operations engineer Jonathon Pickrel.

It is through SBIR contracts and leveraging IPP resources that these technologies can be matured from a concept to a capability that will take spacecraft on new missions, at lower costs and with greater reliability, Kloesel said. It might sound too good to be true, but it could be mature in a decade or two when ideas will be sought to make frequent resupply missions to the moon and beyond possible.

That's when the concept will really take off, he said. Until then, he is relying on a current IPP agreement with Embry-Riddle University and industry partner General Atomics to help move the fledgling idea along.

ED07 0243-18 NASA Photo by Tom Tschida

From left, Leo Holland, Rick Hutsell, Kurt Kloesel and Don Ketchen look at the linear induction motor that creates magnetic waves.

"This is real; this could happen. This is not just a paper study."

Kurt Kloesel
Dryden researcher

"There is money to leverage and interest from industry because of the IPP program. It has greatly helped to move the project along. IPP has taken it up a few levels," he said.

"This is real; this could happen. This is not just a paper study. When General Atomics throws $100,000 on the table that adds weight to it [the concept]. The IPP program says, 'here's half the money; if it's a good idea, you put up half' and that adds credibility."

The NASA IPP matched funds of $100,000 from General Atomics and $40,000 from Embry-Riddle. The project will look at the motors being developed in San Diego to go 300 mph.

The four motors are specialized for high speed and are not made of commercial off-the-shelf components. General Atomics took delivery of the components in summer 2008.

Kloesel is quick to add that he didn't originate all of the elements of the linear induction

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Technology may catch up to concept

By Jay Levine
X-Press Editor

Building a first stage of a future launch vehicle with an electromagnetic catapult is an idea that has merit and combines technologies that are already proven, said Leo Holland, director of the Special Projects office in the Advanced Technologies group for General Atomics of San Diego.

General Atomics is a key partner with Dryden in the development of a Highly Reliable Reusable Launch System, which is currently being studied as part of NASA's Innovative Partnerships Program.

The concept of an electromagnetic launcher is one that he has been interested in and working toward for more than 25 years, said Holland, who has a doctorate in electrical engineering. The development of magnetic levitation systems in the 1990s was used to power a train by essentially pulling it along with magnetic waves generated from a track that suspended the vehicle several inches in the air.

The technology is continuing to mature. In fact, General Atomics is under contract to the U.S. Navy to install electromagnetic aircraft launchers on the next new aircraft carrier, he added.

"We are building experience and a technology base to move forward. The Navy program is giving us, in the lower-speed range, a very advanced system and everything you would need to build a launch-assist system. Answering the remaining technical questions will lead to higher speeds," Holland explained.

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motor launch system and that he continually seeks help from people he thinks can help evolve these concepts. Kloesel's key contribution is combining the electromagnetic launch concept with a hybrid air-breathing system.

The origins of some of the concepts on which Kloesel based this project go back to research efforts made at Marshall Space Flight Center, Huntsville, Ala., in the late 1990s, he said. The Highly Reliable Reusable Launch System project capitalizes on lessons learned from the previous research and focuses solely on the linear acceleration of the vehicle, which commands the largest portion of system costs.

Technical hurdles include characterizing the system, validating coupling propulsion and superconducting magnet suspension, he said.

The Highly Reliable Reusable Launch System would use the linear induction motor launch system for its first stage and to a speed of about Mach 1.5. After that, a second-stage ramjet engine would propel the spacecraft to Mach 4, where a rocket would complete the trip to orbit, Kloesel said. Aside from the weight reduction, the combination is anticipated to be reliable, he said. It also would be more environmentally friendly than current booster rocket engines, he said.

A small investment from Dryden was required in an earlier phase.

"We obtained an off-the-shelf high-power inverter that is used in the HVAC [heating, ventilating and air conditioning] industry," Kloesel said. "The induction machine is off the shelf from the roller coaster industry and goes 60 miles per hour. In the first phase of this project, we put together the induction machine with Dr. Darin Marriot at Embry Riddle Aeronautical University in Prescott, Ariz. Marriot and his students put together an educational partnership that resulted in the machine going 150 miles per hour in February 2008."

Kloesel is always on the lookout for ways to advance his concepts. By arranging for student help in summer 2008, he was able to take another step.

Emily Sayles, who was a student in a minority undergraduate science and technology program researched ramjets that could work for a launch-assist vehicle (see related story).

Learning on the job

Student contributes to design of launch system

ED07 0243-18 NASA Photo by Tom Tschida

By Jay Levine
X-Press Editor

As a girl, Emily Sayles pretended to be an astronaut in a refrigerator box she made into a space shuttle. As a summer intern at Dryden in the NASA's Motivating Undergraduates in Science and Technology, or MUST program, the Bakersfield, Calif., woman assisted with work that might one day lead to a new launch-assist system that takes astronauts to space.

Sayles was a senior at the University of California, Irvine, and has since graduated with an aerospace engineering degree and begun her studies in aeronautics and astronautics at Stanford University graduate school. The MUST program is open to U.S. citizens pursuing undergraduate degrees in science, technology, engineering or mathematics. The summer research job also came with a paycheck.

"Spending last summer at Dryden was one of the most influential academic experience I've had so far," Sayles said. "Before that internship, my plans after college were not well defined and I didn't have a very good idea of what I would want to study in graduate school, if that opportunity presented itself to me. I finally had a chance to see what engineers do on a day-to-day basis and how NASA contributes to cutting-edge aeronautics and space research. A career at NASA is still definitely something I want to pursue."

She assisted Dryden engineer Kurt Kloesel with validation of software that will be used for preliminary design of a second-stage ramjet for use in a NASA ground-based launch-assist system. This work is associated with one of the agency's Innovative Partnerships Program Seed Fund initiatives.

"The ramjet will provide a lot of savings in fuel because it is air-breathing," Sayles explained. "I used engine

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The unique design problem required Sayles to examine data and model a ramjet to calibrate it with what goes on in the catapult, he explained.

While it will take time to mature the ideas Kloesel is advancing through the partnerships and technology and small business grants, he sees the value of the possibilities created through those funding mechanisms.

"IPP, SBIR contracts and other seed funding boosts morale and make [NASA and Dryden] even better places to work," he concluded.

The technology used to build electromagnetic launchers also is transferable to more everyday uses in items such as inverters for trucks and wind turbines. Each experience moves the technology a step closer, he added.

In its partnership with Dryden, General Atomics staff provides instrumentation for engine hardware provided by the center and runs tests prior to hooking it up to the company's inverter. The next step will be to run one motor with the inverter to test its power and then look for funding to add more of the four motors available for experimentation, Holland said.

"When we hook this up to an inverter, which basically creates three-phase voltage and current that is variable, I can change the frequency and the voltage level and therefore the current that's going into it. By driving a fairly high current through these windings [wiring], I can create a magnetic field that goes through that aluminum plate and moves it," he said.

The principles of this concept can be demonstrated by moving a common rare-earth magnet near a quarter-inch conducting aluminum or copper metal plate. The movement of the magnet will create opposing currents in the metal plate and those opposing currents will cause the plate to be pulled along. In a similar manner, the inverter produces a magnetic field that is moving and the opposing currents will pull the aluminum plate along. In a launch system, the plate is connected to a vehicle, much as the technology is currently used in roller coasters.

"IPP is a good way to highlight technologies and get them in front of people to see if you can get a program going," he said.

Time – and development dollars – will determine how the idea fits in with launch vehicles of the future.

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simulation software and data gathered from past ramjets like the D-21, a French ramjet and some missiles that have ramjets on them, and took that data and input it into the engine performance software."

The D-21 was a drone launched from a Blackbird aircraft variant in a 1960s-era joint project by the U.S. Air Force and the CIA.

Once the data obtained from actual engines and from software simulation are compared, that software can be used in the preliminary design of a ramjet for the launch-assist system. The software can provide engine dimensions, an idea of what the ramjet engine might look like, its size and its thrust capabilities, she said.

An air-breathing engine uses oxygen from the atmosphere as an oxidizer and as a result, oxidizer does not have to be carried on board the way it must be to fuel a rocket engine.

Sayles applied for the MUST program through an e-mail she received from the UCI school of engineering. The e-mail listed an opportunity to work at NASA – her dream job. Sayles decided to write the required essays and profile, ask for a letter of recommendation from a research professor and send her transcripts and resume.

She learned she was chosen in another e-mail.

"I had to read it over several times to make sure that I was reading it correctly. I wanted to make sure I did indeed get [the MUST position] before I called my parents," she said.

The excitement only intensified once she began her work at Dryden.

"I've really enjoyed working with Kurt. He's a great mentor," she said. "He allowed for a lot of freedom in my work, but he also gave me very clear direction as to where he's going and where the project is going. I've also enjoyed watching how he spreads his excitement about his work and his project to other people, getting them involved and fired up about what he's doing.

"It's exciting to see how much he enjoys his work. Someday I want to have that same experience where I'm motivated to go to work everyday to contribute."

Sayles' work at Dryden also presented frequent reminders about the importance of her college coursework.

"I had the most motivation and encouragement from seeing the correlation between [the job and] what I'm learning, and applying it to engineering work," she said. "Lecture halls and theory have real work applications. I used all my textbooks and course notes, and that is a huge motivation to do well in my classes."

A U.S. Space Camp based at Ames Research Center, Moffett Field Calif., first ignited Sayles' interest in aerospace. As her entry in a competition for a scholarship to the camp she wrote an essay, which was influenced by Neil Armstrong's moonwalk, about getting to go space camp. Her essay was chosen and she won the scholarship. At the camp, Sayles tried her hand at several activities, including a moon gravity simulator and playing the role of a mission specialist on a space shuttle mission that involved "lots on buttons to push."

She also participated in a simulated space journey to a Mars-like planet.

"It was very influential in my decision to pursue aerospace engineering. I came back wanting to be an astronaut."

Since then, she has worked toward her goal of becoming an astronaut by launching model rockets, solidifying her grasp of math and science, earning the MUST internship and, of course, there were those early rides in the cardboard space shuttle.

Sayles was valedictorian of the 2005 Bakersfield High School Class of 2005. That year, she was a member of the school's award-winning academic decathlon team. She was selected for California All-State Honor band each year during high school and received the John Philip Sousa Band Award in 2005.

While she knows it's a long shot to becoming an astronaut, she said her summer experience at Dryden helps keeps her goals on track and keeps her dream alive.

Beth Hagenauer contributed to this article.

ED08 0168-04
NASA Photo by Jim Ross

The DASP Toolbox

Technology has proven itself in the laboratory, and now it's time for the crucible of flight research – to separate the real from the imagined

Progress is being made in the Distributed Aerodynamic Sensing and Processing, or DASP, toolbox project. The Aeroelastic Test Wing 2 test fixture that will take the project into the flight environment on an F-15B is seen early in the process in this photo that includes some of the team members. From left are David Voracek, Siva M. Mangalam, Claudia Herrera, Marty Brenner and Arun Mangalam.

ED08 0168-04
NASA Photo
by Tony Landis

By Jay Levine
X-Press Editor

Safer airplanes capable of avoiding conditions that lead to accidents and the ability to monitor the structure of buildings and bridges before trouble arises are possibilities if flight experiments on an emerging technology are successful.

Once the integration of hardware is complete on the Aeroelastic Test Wing 2, flight experiments on the F-15B flight test fixture are scheduled to be flown later this year. The flights will mark the culmination of work on a system that includes new sensors, a system that will be the first of its kind to measure unsteady aerodynamic loads, or forcing function, in real time and correlate that data with how the structure responds to those loads. The system, called the distributed aerodynamic sensing and processing, or DASP, toolbox project, was accelerated in a 2007 Innovative Partnerships Program seed fund project.

The merits of this new system may be validated when the aircraft flies a five-flight series to characterize structural dynamic and aerodynamic behavior across a range of flight conditions, from low to high angles of attack, low to high Mach numbers, and in steady and unsteady maneuvers.

Strain gages and accelerometers will be used to measure the structural response, while hot-film gages will be used to characterize the aerodynamic-flow features and to determine the aerodynamic forcing function. The flight experiment is expected to pave the way for development of advanced computational modeling, flutter prediction techniques, and adaptive closed-loop control technology required for the design and development of flight vehicles with active aeroelastic wings. NASA's Aeronautics Research Mission Directorate is cost sharing in the effort.

Marty Brenner, a Dryden principal investigator for the project, encapsulated the DASP toolbox this way: "It is a combination of hardware-sensing devices with software to analyze the critical aerodynamic parameters and, hopefully, to eventually be used for different applications – eventually, distributed sensing and processing for distributed controls."

The multi-faceted system is capable of obtaining structural and aerodynamic data concurrently. The system is comprised of circuit boards that are fed with information by the sensors and accelerometers that can process information that can be used to determine skin friction/sheer stress, which ultimately gives variations in the instantaneous (unsteady) lift generated by a wing section in the presence of gusts as well as structural oscillations. Absolute values of the lift coefficient in unsteady flow are obtained as a function of the instantaneous locations of the leading-edge stagnation point and the flow-separation point, Brenner explained.

In the experiment, flying directly on the ATW2 is one element of the DASP toolbox called a hot-film sensor. These sensors are mounted on flexible or bending areas of the ATW2 lifting surfaces.

"There are also piezoceramic patches that, when you put power through them, vibrate the wing at pre-programmed frequencies. These are also strain gages that measure strain in the structure. The hot-film sensors will measure flow angularity through the stagnation point as measured by angle of attack or sideslip. A stagnation point is a point in the flow field where the local velocity

See DASP Toolbox, page 16

DASP Toolbox ... from page 15

of the fluid is zero. Static pressure is at its maximum value at stagnation points (stagnation pressure), and the streamline at the stagnation point is perpendicular to the surface of the body," Brenner explained.

The measurement tool would benefit research into topics such as alleviating the aerodynamic pressures on an aircraft by gusts, flutter suppression, improvement of aerodynamic efficiency and supersonic wave reduction, he said. The information from the sensors also could be used for distributed control of lifting surfaces, or controlling a wing that could change its shape in flight to take advantage of aerodynamic efficiencies, Brenner added.

In addition, the DASP toolbox offers a less obtrusive way of gaining the data without having to add tubing or other structures to the aircraft. It conforms to the aircraft's structure and has tolerances that can be adapted to within a millimeter, he said.

ED09 0135-05 NASA Photo by Tony Landis

Gary Williams, center, works on the ATW2 test structure that will take elements of the DASP toolbox into the flight research environment. Also pictured are Christine Jutte and Marty Brenner.

"It is a real-time aerodynamic measurement tool to identify flow-verification points on an elliptic surface. It enables us to determine the forces on that surface based on a few critical points. That can be used by NASA to determine what the wing is doing in real time and do what is necessary to control it to get the best performance," said Siva M. Mangalam, president of Tao Systems, Dryden's partner on the project.

David Voracek, who is serving as the project manager, said the concept evolved through collaboration with the Air Force Research Laboratories. The AFRL sponsored the sensors that are the focus of this flight experiment in the Langley Research Center, Hampton, Va., transonic wind tunnel. The excellent results in the wind tunnel provided the foundation for the IPP agreement, Voracek said.

"Part of my role is to look at what we are going to be doing in the future with that technology in terms of integrating that with several with other, different technologies. We are building a partnership with the Air Force Research Labs in hopes of getting it [the technology] off a test article and onto an airplane. Developing the technology through the IPP was a great opportunity for us to get funding we could not get anywhere else and get it to a technology readiness level that allows us to integrate it into a larger flight vehicle," Voracek said.

The IPP created an opportunity for Brenner, Voracek and partners Tao Systems to further develop the program.

"We have been working on this with Dryden for a long time. Some of the basic ideas were already there and this was a culmination of the ideas," Mangalam said.

A series of increasingly complex Small Business Innovative Research projects are at the heart of the DASP toolbox and qualified it as an IPP project. It evolved from sensing and instrumentation to diagnostics and ultimately it is intended to lead to controls that offer better performance and safety, Mangalam explained.

DASP toolbox components also are expected to be incorporated onto the F-18 Intelligent Flight Control System aircraft when it is ready to fly, Brenner said. The aircraft is a good choice for the DASP toolbox because F-18 no. 853 was used for Active Aeroelastic Wing research, through which a wing was controlled with twisting.

"Using this technology, we are able to look at the structure of the airplane wing and use the sensors and integration with the adaptive control to re-distribute the control surfaces to obtain a more aero-efficient shape for the flight condition. Using stagnation point control will be one technology we will look at after the sensors are proven through the IPP," Voracek said.

Dryden project co-chief engineers Claudia Herrera, Christine Jutte and Brenner said Voracek has worked with Robert Medina, Dryden small business procurement officer, and Greg Poteat of the Dryden IPP office to streamline the IPP processes that resulted in

See DASP Toolbox, page 34

DWT may remove the guesswork

By Jay Levine
X-Press Editor

Rather than calculate a best guess about where flutter of an aircraft will occur in flight, a new tool called the Dry Wind Tunnel developed through a recently awarded Small Business Technology Transfer, or STTR, Program Phase II agreement might pinpoint the exact location flutter will occur.

Knowing where flutter – uncontrolled vibration of an aircraft's structure – is occurring could result in a tool that saves time and money, increases safety and makes aerospace vehicle design work easier to validate, said Starr Ginn. Ginn is a Dryden contracting officer technical representative and Dryden aerostructures deputy branch chief.

"Today's flutter prediction methods have come a long way," Ginn explained. "But our main focus of flight-test validation is to determine there are no aeroelastic instabilities due to structural non-linear effects, which are not modeled. This new tool will demonstrate the flight condition in which an aeroelastic instability will

See DWT, page 21

Design tool may support hypersonic vehicles

By Jay Levine
X-Press Editor

A recently awarded Small Business Technology Transfer Program contract will be used to continue work on a design tool for aero-thermo-elastic-propulsion simulation of air-breathing hypersonic flight vehicles.

In addition, the award will permit the team that includes Dryden, Advanced Engineering Solutions, Inc. of Ormond Beach, Fla., and Oklahoma State University, Stillwater, to further extend modeling from a previous Phase I STTR to include acoustics, said Kajal Gupta, Dryden's contracting officer and technical representative on the project.

"The resulting code can be used for simulation of novel Dryden flight vehicles. We can use this simulation to ensure flight safety for any new project that comes to Dryden," he explained.

Using an STTR agreement to complete the work has a number of advantages, Gupta said.

"The agreement is unique in the sense it partners Dryden with industry and academia. We are

See Design Tool, page 35

Nuts & Bolts

New IPP awards aim to validate the basics in ideas that could mean a lot to the readiness level of technology

Tool could mean revolution in radio communications

By Jay Levine
X-Press Editor

Radio communications could be revolutionized if a new Innovative Partnerships Program Innovation Fund project succeeds.

The new concept, called Direct Spatial Antenna Modulation, may offer an approach for reducing the size, weight, power and complexity of radio subsystems that enable data communications, said project lead Larry Freudinger.

These advances could benefit all aircraft and spacecraft seeking to improve communication system performance or implement solutions that are constrained by volume and available power, he said.

The conventional approach for sending data is to modulate, or encode the data onto the signal to be transmitted prior to sending it to the signal amplifier. If the antenna is a phased array, a separate set of phase shifter electronics is used to steer the modulated signal in the desired direction, Freudinger explained.

The Direct Spatial Antenna Modulation, or

See DSAM, page 35

Composite Structures

Research focuses on monitoring the health of composite airframes, which could improve safety and maintenace for commercial, military and business aircraft

By Jay Levine
X-Press Editor

In an era of rapidly changing technologies to build and operate aircraft, it is becoming more and more important to understand the limits of those technologies to ensure safety and reduce maintenance costs and aircraft downtime.

Dryden researcher Sunil Kukreja, who holds a doctorate in nonlinear system identification, is leading an Innovative Partnerships Program Seed Fund project to do exactly that with aircraft made of composite materials: create a way to monitor the aircraft's health.

"If we can develop the criteria for health monitoring of composite aircraft in flight, we can help the aerospace industry improve safety. Also, airlines want their airplanes flying as much as possible because when they are on the ground for maintenance, airlines are losing money. This could greatly reduce downtime and refine maintenance schedules," he explained.

Metallic structures that have defined most of modern aviation are well understood in what they require in maintenance and when they will need attention. However, not as much is known about composite material that was first used in the construction of military aircraft to reduce weight and radar signature while increasing the structure's strength, Kukreja said.

As an increasing number of commercial airliners are moving in the same direction to reduce weight and add durability, the need is becoming greater to understand composite materials, he said. To those ends Kukreja formed a partnership with long-time colleague Dennis Bernstein of the University of Michigan in Ann Arbor. Bernstein has a doctorate in control engineering.

Additional Dryden partners include co-principal investigator Marty Brenner and aerospace engineer Shaun McWherter. Kukreja's team developed a plan that included facilities, people and in-kind services of about $975,000 and a strong proposal that earned $250,000 in IPP funds through an agreement, he said.

"It is not well understood how composite materials age, or how those materials behave," he said. "What we are trying to determine is if we can use system identification – mathematical modeling techniques – for determining the health of composite aircraft."

Researchers are approaching the challenge by developing a sensor-only, fault-detection approach using pseudo-transfer function identification, Kukreja said. His team's goal is to identify a pseudo-transfer function – a type of mathematical representation – between two sensors in the presence of variations from the baseline operation and external factors.

If the fault-detection architecture is validated, it could eliminate the need for ground testing or building onboard equipment to monitor aircraft health, he said.

"Using this fault detection architecture, we hypothesize that the pseudo-transfer function for the nominal system or aircraft, which can be determined at time of manufacture, should be significantly different when compared to a potentially faulty system," Kukreja said.

If his hypothesis is proven, then the next step is to determine what parameters to monitor for estimating its health, he

See Monitoring, page 20

Academic provides another viewpoint

Academia and NASA benefit from cooperative work in research efforts such as those fostered by the Innovative Partnerships Program.

Dennis Bernstein of the University of Michigan aerospace engineering department and editor-in-chief of the Institute of Electrical and Electronics Engineers, or IEEE, Control Systems magazine provided insight into some of the benefits of these research agreements to X-Press editor Jay Levine.

Bernstein, who has a doctorate degree in control engineering, is partnering with Dryden researcher Sunil Kukreja on the 2008 IPP Seed Fund proposal to develop a way to monitor the health of composite-material airframes. It is an effort that could lead to safer flight and, perhaps in the future, slightly cheaper fares.

Levine: What are the mutual benefits of the cooperative work on this project between NASA and the university?

Bernstein: For this IPP Seed Fund project, my research group benefits from the guidance of NASA personnel on which technology issues are the most important. My NASA partners have direct knowledge from a scientific and engineering perspective about which research challenges are the most critical and will likely have the highest relevance and payoff.

From the NASA perspective, universities can investigate basic research issues that may have a long lead time and low probability of success but, if successful, will have huge payoff. For example, my group is working with NASA Dryden researcher Sunil Kukreja to develop a new technique for passive health monitoring, where the word "passive" refers to the fact that we don't attempt to excite the structure but rather just use sensors to monitor its behavior.

The idea is to extract information about the health of a structure (such as a composite aircraft wing) by observing its response to ambient disturbances. By collecting and processing information, our goal is to analyze the health of the structure by detecting how it changes over time. If this approach is successful, then it will facilitate practical, low-cost, online health monitoring for a wide range of applications.

To do this, we follow a development process involving mathematical analysis, algorithm development, numerical simulation and, finally, demonstration and validation on data sets. It takes time and patience to carry out this process, but the payoff in the end is hopefully of real value to NASA and industry in general. It's virtually impossible to follow through on this process without a NASA collaborator.

Levine: What do these agreements mean for students interested in these kinds of investigations?

Bernstein: Students have a chance to work on technology that has the potential to be used on real applications. In addition,

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Monitoring ... from page 19

said. That information could be used to develop criteria for monitoring composite structures, Kukreja explained.

Once the mathematical analysis and algorithmic developments are complete, the algorithm will be validated through simulation of aircraft models such as the F/A-18 or F-15B and eventually compared with flight-test data from different flight conditions to judge how well it monitors the health of the composite elements of the aircraft, he said.

An analysis of flight-test data offers verification of the algorithm or points the way to a revision of the theory and assumption behind them. With further developments, Kukreja said the theoretical work could lead to breakthroughs in safety – and possibly economy – for future air travelers.

One key benefit to developing a method for monitoring a composite structure's health could lead to a technician on the ground downloading computer data that will signal if something requires attention, as opposed to requiring a scheduled maintenance regime, Kukreja said.

A possibility as the project progresses is to demonstrate and verify the theoretical and simulation studies, as well as analysis of flight-test data, by applying this algorithm on the Aeroelastic Test Wing 2, a scale version of a composite aircraft wing, he said.

The ATW2 is attached to a test fixture under the Dryden F-15B flight research test bed and can be flown to conditions that induce stress and fatigue for the ATW2, yet retain operational conditions for the F-15B, allowing for in-flight demonstration of this advanced health-monitoring approach, he explained.

"While one flight test demonstration does not make the experiment globally valid, it would be a solid step toward establishing the applicability of this approach for in-flight health-monitoring systems," he added.

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students are motivated by the opportunity to interact with NASA researchers. We always want to do our best to deliver high-quality work, and having an ongoing, two-way interaction with NASA personnel such as [Kukreja] provides tremendous motivation. Through ongoing communication, we also have the chance to discuss technical issues, seek advice and benefit from readily available guidance.

Levine: What benefit do you see for the University of Michigan?

Bernstein: The College of Engineering at the University of Michigan encourages the faculty to link new research ideas to real-world applications. Basic research remains essential, but our "charge" is to develop new ideas and techniques that can make a real impact on real-world problems, such as economic, societal, environmental, etc. Having this collaboration with NASA gives us the motivation and means to develop and transition the research that we work on.

Levine: What other insights do you have on this project?

Bernstein: There are three essential ingredients for doing good research; namely, one, having a good problem for motivating the research, two, having innovative and promising ideas for solving the problem, and, three, having the means to carry out the ideas. This collaboration with [Kukreja] has already impacted all of these ingredients. As the project progresses, guidance from NASA personnel will be increasingly valuable.

NASA and the University of Michigan aerospace engineering department are partners in an Innovative Partnerships Program Seed Fund project to create a way of monitoring composite aircraft health. Project participants include, seated left to right, Bojana Drincic, Matthew Holzel, Marty Brenner and Dennis Bernstein. Standing are Sunil Kukreja, left, and Anthony D'Amato.

Photo courtesy Dennis Bernstein

DWT ... from page 17

or will not occur, on the ground and, as a result, increase safety and reduce the time it takes to validate the flight envelope. For example, only a few flights might be necessary to prove the absence of flutter, rather than having to build up the flight series over a number of tests."

The work completed on Phase I of the Dry Wind Tunnel STTR developed a ground-flutter testing system that verified it is possible to physically simulate flutter of very simple structures on the ground. This DWT could one day augment wind tunnels as a means for flutter and aeroservoelastic instability testing, she said.

Developed through an agreement among Dryden, Zona Technology Inc. of Scottsdale, Ariz., and Arizona State University, Tempe, the DWT system consists of a ground-vibration test hardware system and a real-time unsteady-aerodynamic-force-generation software system, Ginn said.

The DWT tests simulate in real time the unsteady aerodynamic forces through ground-vibration test hardware, namely shakers and sensors.

"What will make the DWT even more successful is to conduct the test on Dryden's soft support system, which makes the analyst's life easier and allows and apples-to-apples comparison," Ginn said.

Ginn previously developed the Starr Soft Support system, which is an aircraft jacking system that integrated an existing isolation system.

Dryden aerospace engineer Leonard Voelker resurrected the idea of a ground flutter test and brainstormed the idea with Dryden Structural Dynamics group lead Chan-gi Pak. The concept came up again during a meeting between Dryden and Zona representatives. Dryden uses Zona's Zaero code for flutter analysis.

Zona representatives decided to pursue the idea, but needed ASU to join them. ASU had testing hardware required to incorporate vital information to tell the shakers how to interpret and react to information fed into them, which was validated in Phase I work.

Phase I proved that the feedback controller was fast enough to communicate between the shakers and accelerometers to induce flutter, Ginn said.

The flutter predictions were close, but Phase II will raise the stakes with more complex test structures. A small wing used extensively at Langley Research Center, Hampton, Va., for wind-tunnel tests will be compared to tests with the Dry Wind Tunnel to see how the numbers match up.

If the research works as expected on a couple of small-scale test articles, within two years it will be applied to an F-15 or F-18 research aircraft, Ginn added.

Merits of a DWT could be many, Ginn said. It can accommodate full-size aircraft or wing structures, including inherent structural nonlinearity and flight-controller-in-the loop, or in essence tell the computer to configure itself a certain way then tell researchers how it would react to those changes, she said.

Potential NASA applications for the Dry Wind Tunnel include use as a pre-flight testing effort to identify any aeroelastic or aeroservoelastic instability that is not predicted by analysis. For example, inherent structural nonlinearities such as friction and freeplay, or areas where stiffness characteristics vary, are difficult to model in linearized analyses but would be present in the DWT testing on the actual structure.

DWT testing also could be used for a post-flight testing procedure to resolve discrepancies between the analysis and flight-test results. The DWT test concept is applicable to a broad range of test structures, from components to wing to full aircraft.

Commercial applications for the Dry Wind Tunnel system include flutter-envelope expansion and flying-quality programs for military, civil transport and general aviation aircraft.

Potential customers include the Air Force, Navy, Defense Advanced Research Projects Agency, and the aerospace industry.

ED06 0054-128 **NASA Photo by Tony Landis**

A Dryden F-15 is configured with the Starr Soft Support system that will be used in the Dry Wind Tunnel for ground-flutter testing anticipated as part of a Small Business Technology Transfer, or STTR, Program Phase II agreement. The Phase II study might pinpoint the exact location at which flutter will occur, which could streamline expansion of the flight test envelope at earlier stages of a flight project.

ED08 0109-08 NASA Photo by Tom Tschida

A fiber optic cable is the thickness of a human hair and can't be seen in the center of this wing, but the tiny fiber could have ramifications for every future aircraft and spacecraft. Team members include, from left, Anthony "Nino" Piazza, Allen Parker, William Ko and Lance Richards.

NTR

New Technology Reporting begins practically with a researcher's first thought. Data gathered can be vital, and the rewards great.

By Jay Levine
X-Press Editor

Reporting the results of research is almost as important as the work itself.

For that reason, NASA requires investigators to file new technology reports to explain the results of their research and make the findings available to others seeking to do related work. Reporting new technology developments also protects NASA's intellectual property, or technology advanced from its research, said Lance Richards, a Dryden research engineer.

In a modern era where the demands are many, it can be a challenge for investigators to complete their reporting requirements, but it must be part of the NASA culture, he said.

"It comes down to stewardship. We are entrusted with the responsibility to taxpayers to conduct flight research. We work to accomplish the mission, but we still have to answer the mail on our reporting of our findings. A second benefit is the personal satisfaction of flying a one-of-a-kind aircraft to advance technology and the tangible result of providing something to the technical community that solves a need or makes life better," said Richards, who has a doctorate in mechanical engineering.

New technology reports are incorporated into the searchable NASA Technology Tracking System database that includes new or improved techniques, products, devices, materials, processes, compositions, systems, machines, apparatuses, articles, fixtures, tools, methods, basic scientific data and software. The database includes inventors' contact information and provides opportunities for connecting a technology need with the innovator.

Although it is not a primary reason for the reporting, there also is the potential for some research projects to result in patents, he added. NASA is tasked with transferring its technology to the private sector for people to reap the benefits of NASA's research, but the patents also allow NASA to use the technology it has developed without having to pay a private company to use it, Richards said.

New Technology Reporting

Good research culminates with a publication that explains what was accomplished, provides analysis of the data and synthesizes the results so others can read and benefit from the work, he said. However, reporting of the new technology begins even sooner.

"Reporting should begin when the experiment is being designed and the researchers should think about types of data they want to see in published format. They should be thinking about where are the gaps in knowledge and use the research to hit the right target by filling that gap," Richards explained.

The reporting also can have unintended benefits.

"In the midst of a flight experiment you might see something you didn't see before. I thought of an idea for real-time loads measurement when I was looking at data. I thought, 'that's interesting,'" he said.

"In the midst of day-to-day flight research is when you can have an 'ah-ha' moment. This could be very beneficial, this is patentable, it is something the scientific community can benefit from."

Sometimes it takes longer to determine the real value of the research, something that can be cleared up by writing about it.

"Sometimes you don't realize what you have until you put it in a presentation or put the rough draft together for a paper. In the case of the Fiber Optic Wing Shape Sensing Technology we had already released it publicly, but there is a window you have to operate in for the patent process," he said.

Patent work

Richards and a team of researchers proved the merits of their technology developments of the FOWSS, which was demonstrated in flight on the wings of the remotely piloted Ikhana unmanned aircraft system in 2008.

William Ko, who has a doctorate in aeronautics, and Richards collaborated to obtain a patent on the Method for Real-Time Structure Shape Sensing. The system uses fiber optic strain sensors to measure surface strains and the Ko Displacement Theory to determine the wing shape using those strains as inputs.

See NTR, page 36

NTR has benefits

New Technology Reporting is required from the start of any new development effort. Just because it is required, however, does not mean there are not rewards. Here's what's in it for researchers:

- Publication in NASA Tech Briefs magazine for selected new technology reports is worth $350 per author
- Release of new software nets $500 for each contributor in a team effort, or $1,000 for a single contributor
- Patent applications are valued at $500 each for members of a team, or $1,000 for a single contributor
- Based on the value of the contribution to NASA and the public, Space Act Awards of up to $100,000 are available

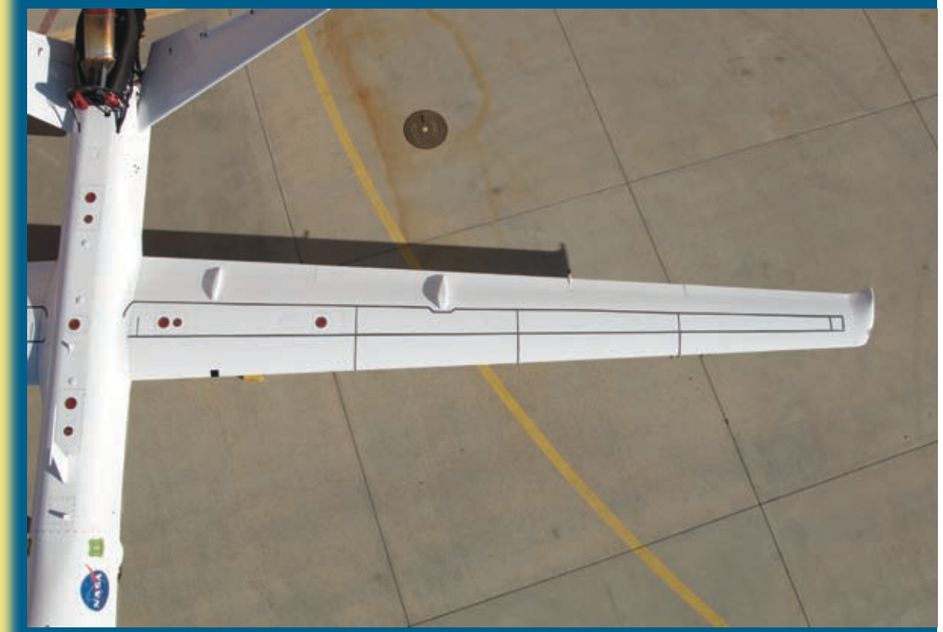
Questions? Call Yvonne Kellogg, Dryden's award liaison officer, at 661-276-3720 for more information.

First steps to filing an NTR

If a researcher is stumped on how to get started with new technology reporting, here are a few steps to build momentum:

- Get an eNTRe account set up at http://entre.nasa.gov
- Go to the eNTRe login at http://invention.nasa.gov/
- Complete online NASA Form 1679 "Disclosure of Invention and New Technology, including Software"
- Submit the form

Questions? Call Greg Poteat, Dryden's New Technology Reporting officer, at 661-276-3872 for more information.



ED07 0287-08 NASA Photo by Tony Landis

Although the fiber optic wing shape sensors, which are located on fibers that are the diameter of a human hair, aren't visible, the sealant used to apply them can be seen in this view from above the Ikhana wing containing them.

Knowing if it's safe

Lightweight NASA technology can monitor a wing's shape in flight. It could be used for building and bridge health to determine if it's safe to travel, even after an earthquake

Gray Creech
Dryden Public Affairs

Imagine wind turbine blades whose shape can automatically adjust, in real time, to produce more energy. Or imagine aircraft wings that can stiffen when an aircraft experiences turbulence to save fuel and improve the ride for passengers. At present, the shape of these structures can't be measured in real time and therefore can't adapt to these types of changes in their environment.

Or, imagine civil engineers being able to immediately see and record precise bridge movements along a bridge's braces and spans. Future incidents like the 2007 eight-lane bridge collapse in Minneapolis, Minn., might be avoided.

These and other such advances are now possible because of a new technology patented by Dryden engineers.

Recently patented fiber optic-based sensor technology provides a way to easily determine the shape of real world structures in real time.

"It's gratifying to see this patent awarded, which means we can take the next step toward licensing and commercialization so that the technology can be used in the marketplace," says Dryden research engineer Lance Richards, who co-authored the patent application with Dryden's William Ko. "We just want to see this technology used and people benefiting from it."

"This is an exciting opportunity for us to have a patent with such a broad range of potential benefits for the public," said Greg Poteat, Dryden's new technology officer.

"This technology is unique for us in that it can be used commercially, such as in structural safety applications, in a way that Dryden's flight research-specific technology traditionally hasn't been," Poteat said. "Our Technology Transfer office will also be initiating a marketing activity to look for commercial companies that may be interested in licensing the technology."

The shape-sensing technology moved from years of laboratory development and testing to large-scale, dynamic field testing in 2008 when it was flown on Dryden's Ikhana remotely piloted aircraft to measure the change in the aircraft's wing shape in real time, in flight. The effort represented one of the first comprehensive flight validations of fiber optic sensor technology.

In application, a long, hair-thin fiber optic strand is attached to a structure, such as the Ikhana's wings. Every quarter-inch along the fiber, a sensor instantaneously feeds data on the strain and shape of the structure back to a computer. The result is a complete, as-it-happens look at every twist and turn of the structure from literally hundreds of sensors along a single strand of optical fiber attached to it.

"In addition to aerospace applications like some we've tested, the sensors can also be used to look at the stress of other structures, like bridges and dams, and possibilities extend to biomedical uses as well. The applications of this technology are mind-boggling," Richards said.

It's an incredible amount of data, and it doesn't get lost in electronic noise; it all gets displayed in colorful computer graphics fed back to a control system. NASA engineers can measure strain, temperature and displacement changes with it.

The patented technology can be used on wings as well as other complex structures such as re-entry vehicles. For example, NASA is looking at using this technology behind the Constellation program's Orion capsule heat shield in order to see exactly where strain, temperature and structural deformations are occurring even as the capsules re-enter Earth's atmosphere.

"Generations of aircraft and spacecraft could benefit from work with the new sensors since the sensors have performed well, both in the laboratory and now in flight," said Richards.

The weight reduction that fiber optic sensors would make possible could reduce operating costs and improve aircraft fuel efficiency.

The development also opens up new opportunities and applications that would not be achievable with conventional technology. The new sensors, for example, could enable adaptive wing-shape control.

"The sensors on Ikhana are imperceptibly small because they're located on fibers approximately the diameter of a human hair," Richards explained. "You can get the information you need from the thousands of sensors on a few fibers without the weight and complexity of conventional sensors. Strain gages, for example, require three copper lead wires for every sensor and are significantly heavier than optical fiber."

When using the fiber optic sensors, researchers do not require analytical models for determining strain and other measurements because data derived with the sensors include the actual measurements being sought.

Intelligent flight control software technology now being developed can incorporate structural monitoring data from the fiber optic sensors to compensate for stresses on the airframe, helping prevent situations that might otherwise result in a loss of flight control.

By extension, the application of the technology to wind turbines could improve their performance by making their blades more efficient. "An improvement of only a few percent equals a huge economic benefit," Richards said.

NASA's Aeronautics Research Mission Directorate funded algorithm and systems development, instrument and ground test validation of the new sensor system.

Help from above

Ikhana partnership recognized for effort that resulted in an 'eye in the sky' that delivered critical information to fire commanders

ED09 0166-6 **NASA Photo by Tom Tschida**

Dryden Ikhana team members recently met to celebrate their roles in an joint effort with Ames Research Center, Moffett Field, Calif., and the U.S. Department of Agriculture Forest Service, the National Interagency Fire Center and the Federal Aviation Administration. Front row, from left, are Randy Button, Joseph Kinn, Beth Hagenauer, Mark Pestana, Teresa Kline, Tom Rigney, Ryan Lefkofsky, Mary Odom, Randal Albertson and David McBride. Back row, from left, are James Smith, Michael Young, John Del Frate, Kelly Snapp, Russ James, Jeremy Knittel, Gregory Buoni, Jesus Vazquez, Joseph Innis, Kathleen Howell, Gregory Poteat, Terry Bishop and Shawn Albertson. At left, the Ikhana flies a fire mission. ***(NASA Photo ED 07 0243-35 by Jim Ross)***

By Jay Levine
X-Press Editor

The Ikhana team recently received the prestigious Federal Laboratory Consortium for Technology Transfer Interagency Partnership Award for its efforts in developing and using technologies that assisted in the successful 2008 California wildfire missions.

The Dryden-based, remotely piloted Ikhana flew with a cutting-edge-technology sensor, developed at Ames Research Center, Moffett Field, Calif., in a pod under a wing of the aircraft during the fire missions. Images were sent from the aircraft to fire commanders on the ground, said Thomas Rigney, Dryden's Ikhana project manager.

The U.S. Department of Agriculture Forest Service, the National Interagency Fire Center and the Federal Aviation Administration also were key partners. The team shared the distinction of the technology and partnership award at a ceremony in North Carolina May 7.

"The award is an affirmation that we are working well with other agencies within the federal government," Rigney said. "We are working together for a common goal, which is to help the firefighter identify fire boundaries and hot spots."

Dryden Acting Center Director David McBride said the team's work and the honor shows the value NASA and Dryden bring to customers and stakeholders.

"It's validation of what we're doing here," McBride said. "What this is all about is the ability to look at technology developed in the government sector that actually makes a difference in peoples' lives. What we have done in demonstrating the fire sensors for the Forest Service is show that you can fly over the fires and feed that data to fire captains in the field. That really makes the difference in protecting somebody's house, or livestock, or just public property.

"It also shows that things we do don't just stay in the lab. At Dryden, we try to make sure that everything, technology-wise, eventually makes it to the market and helps taxpayers."

At the core of this effort is the sophisticated Autonomous Modular Sensor, which can detect temperature up to 1,000 degrees Celsius. The sensor is a scanning spectrometer that acquires high spatial-resolution imagery of Earth's features from its vantage point on board low- and medium-altitude research aircraft.

Previous technologies were unable to penetrate dense smoke to seek the underlying fires, but lives were saved during the fire missions because the scanner can see through the smoke and to the hot spots, Rigney said. Because the Ikhana identified an unknown fire, lives of firefighters potentially were saved, he added. Also as a result of the Ikhana imagery, 10,000 people in Paradise, Calif., were evacuated after fire commanders reviewed the data showing the fire's progress.

In 2007, Ikhana missions were focused on validating sensor capability and the ability to be deployed in areas across the western United States, while the 2008 fire missions were within the borders of California, where more than 500 fires burned in June 2008, he said. Most of those fires were started by lightning striking dry brush and trees and flames moving

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Photo courtesy 10 Tanker Air Carrier

Getting the drop on a challenge

Small business has a role in determining whether very large aerial tankers are the answer to U.S. Forest Service needs

By Jay Levine
X-Press Editor

When the U.S. Department of Agriculture Forest Service asked Dryden to evaluate the operational uses of two aircraft as very large aerial tankers, a Small Business Innovative Research agreement helped answer the question.

Mark Dickerson, Very Large Aerial Tanker – or VLAT – project manager, and Dryden researcher Tim Cox began to consider options to answer the key questions in determining if two large aircraft could be used as tankers for the Forest Service and the U.S. Department of the Interior.

Cox, a Dryden aerospace engineer, had recently overseen System Technology's work as the contracting officer on the company's recently completed SBIR phase II on flying qualities and topics relevant and applicable to the tanker questions. The company agreed to take on the work as a phase III SBIR. Phase I SBIRs flesh out a concept, which is validated by a phase II agreement if it is judged worthy. A phase III agreement shows the concept is ready for use, Cox explained.

"The Forest Service does not assess handling qualities – that's not what they do, so they approached Dryden. Under a cooperative agreement they had in place, they could ask Dryden to look into it and Dryden asked for our help," Klyde said.

Cox explained what Systems Technology was asked to do.

"They were brought in to help plan and analyze data from simulation sessions using a [Boeing] 747 simulator at Ames and a DC-10 simulator in Florida. A future project might compare flight data to the simulations," Cox said.

"Systems Technology assisted in the analysis of the simulations that we did, using their expertise in handling quality issues such as pilot-induced oscillation. Their significant experience benefited our investigation on whether these big airplanes have sufficient handling qualities to maneuver in close proximity to terrain, set up approaches to a targeted drop line, and successfully perform the drop," Cox added.

Using small businesses can make a difference in NASA research, said Dickerson.

"The value of small business is that they do a good job of complementing our indigenous capabilities. Dryden is only so big, so having access to small and big business brings great expertise. Small business also tends to be an excellent value," he said.

For more than 20 years, Systems Technology has worked with Dryden, especially with the controls and dynamics branch. This [Systems Technology and Dryden] agreement contracted the company to work on aircraft simulations at Ames Research Center, Moffett Field, Calif., and a separate simulation in Florida to determine if the handling qualities of the two aircraft under study would fit the firefighting missions for which the Forest Service was considering them.

The company took data from the piloted simulation and did analysis and reported those results back to Dryden, said David Klyde, Systems Technology technical director and principal research engineer. Klyde also went to the DC-10 facility in Victorville for an assessment, then helped with the final report writing and assisted with the briefing to the Forest Service.

Photo courtesy Systems Technology

David Klyde, Systems Technology technical director and principal research engineer, is seen here as an evaluation pilot for the Calpsan Learjet II In-Flight Simulator. The purpose of the flight was to generate a flying-qualities database that has since been used to develop and assess new system of identification techniques. The work was sponsored by the Air Force Flight Test Center under a Phase II SBIR.

The aircraft were determined to be airworthy because they would be operating well under their maximum weight limitations, could carry a full load of water or retardant, have excess engine capability to get them out of difficult situations and their handling qualities are good depending on terrain, Klyde said. Steep turns in the simulation were harder for the larger aircraft than for the smaller aircraft currently used by the Forest Service, he said.

The final report did not recommend using the aircraft in very steep or rugged terrain unless deliveries of water or slurry can be made with minimal maneuvering, with a lead plane available and with adequate terrain clearance at the wingtips as well as on centerline, he added.

The initial chapter is complete for this research, but the forest service has expressed interested in this work. Not just the airplanes in this study, but also others. This study did not include flight test evaluation, another recommendation Systems Technology suggested to validate the simulations for a follow-on research effort, Klyde said.

Concerning working with NASA, he said the company experienced unexpected but welcome results from their work.

"There was a lot more visibility [for the company] than we expected. Usually we do research and present results and researchers on the other end are interested in the technical data. However, this received a lot more play in the media than we expected. The reaction to our work is good and the work is getting so much notice," Klyde said.

This work is characteristic of the kinds of things that can happen for a company once it has proven that its ideas work, he said. Once people work with the company on one idea, other ideas are easier because often times "there are people at the centers to bounce ideas

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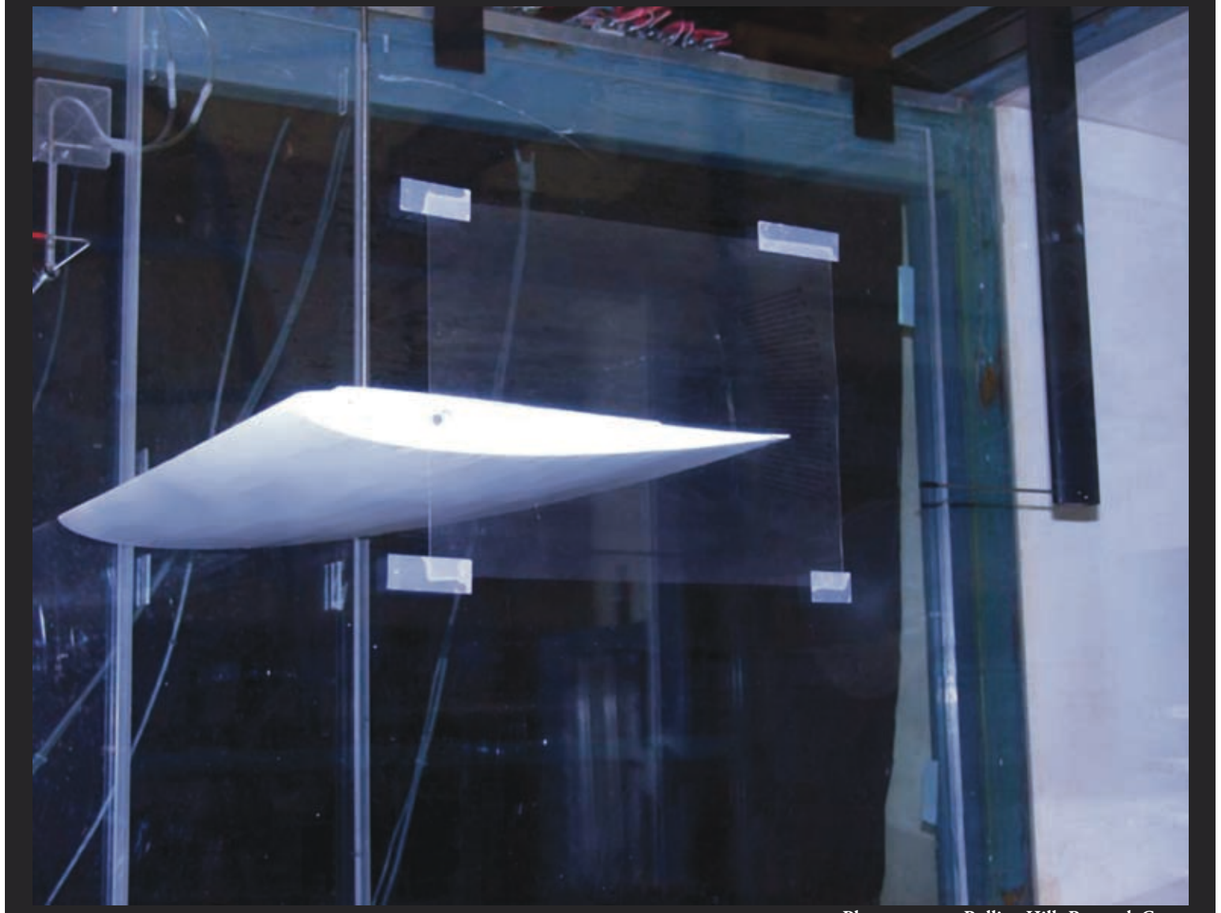

Photo courtesy Rolling Hills Research Corp.

Rolling Hills researchers measure airfoil surface pressures on this model at very low Reynolds numbers in the water tunnel.

Rolling Hills

Small businesses can maximize IPP funds to develop technology NASA needs and that leads to commercial products

By Jay Levine
X-Press Editor

Rolling Hills Research Corp. is a small business that has earned success through its work and its use of Innovative Partnerships Program funding, such as the Small Business Innovative Research and Small Business Technology Transfer programs, to more closely examine its ideas.

Rolling Hills President and CEO Brian Kramer said at the core of the company's success is, "we are very interested in the ideas we propose and we have a lean operation."

In addition, the company has become focused on using aerodynamics to improve vehicles and their safety and promoting creativity and freedom in applying innovative ideas to problems.

Two categories summarize many of Rolling Hill's successes: its water tunnel and application of evolutionary flow-visualization and measurement techniques, and using the water tunnel to do "pretty much anything you can do in a wind tunnel," Kramer said. In addition, the company also is known for its research into flow control and drag reduction techniques.

The water tunnel and SBIR

The water tunnel and the expansion of its capabilities are SBIR success stories showcasing what technology development agreements are intended to lead to – a commercially viable product that can resolve technology challenges, Kramer said.

A wide range of challenges can be met through the use of the water tunnel and at an economical cost. Small models used in the water tunnel are less expensive and can be developed early in the program, when changes can prevent errors leading to big-dollar investments, he added.

The water tunnel was first designed and built for flow visualization, or how flow moves over aerodynamic surfaces. Over the years Rolling Hills researchers took the tool to the next level by using SBIR agreements to develop instruments for use in the water tunnel, such as the five-component submersible balance to measure forces and moments in the water tunnel.

During the past year Rolling Hills researchers were studying surface pressures on a fully instrumented airfoil model in the water tunnel for an SBIR-funded investigation. It simulated a wing in flight, which is common in a wind tunnel but not in a water tunnel.

Very low Reynolds number airfoil development with pressure measurements did not exist before, and the new tool allowed the company to take a qualitative tool and make it more quantitative, said Mike Kerho, Rolling Hills chief aerodynamicist and a principal investigator on many of the company's projects.

"Through an SBIR with Dryden, we were able to develop the technology to accurately measure model surface pressures at very low Reynolds numbers. If you're going to do airfoil models and you want to learn something about what the flow field is doing, pressures are a good diagnostic tool to obtain a quantitative understanding of the state of the flow field," Kerho said.

In addition to using the water tunnel for two-dimensional airfoil studies, three-dimensional aircraft models can be studied using a unique computer-controlled dynamic model support system, which provides the ability to rotate the model in the water tunnel about the three axes – pitch, yaw and roll – to permit researchers to take data as the test article is rotated in the water tunnel and for which the stability derivatives can be calculated, Kerho said.

Photo courtesy Rolling Hills Research Corp.

Rolling Hills Research Corp. President Brian Kramer, left, and Michael Kerho, the company's chief aerodynamicist, are pictured at an American Institute of Aeronautics and Astronautics event promoting the company's water tunnels and research capabilities.

The new capabilities for the water tunnel have made it even more attractive to universities that continue to purchase them in the United States and in a number of countries around the world, including Mexico, France and England.

Stereo lithography

A rapid-prototyping technology, which Rolling Hills contracts out for its customers to gain even greater use of the water tunnel, is stereo lithography, Kerho explained.

While metal and fiber glass models are required for a wind-tunnel environment they are typically costly and time-consuming to manufacture. A system similar to three-dimensional computer-assisted drawing programs now can use lasers to sculpt plastic, resulting in an accurate prototype that is strong enough to endure water-tunnel testing, he said.

Because the water tunnel applies less pressure to a test object compared to a wind tunnel, the stereo lithography models hold up, Kerho said. Model accuracy is essential in wind and water tunnel testing and this process for model manufacturing coupled with the water tunnel can provide both a time- and cost-effective alternative to traditional wind-tunnel testing. Rolling Hills worked with several rapid prototyping shops to develop a methodology that provides high-quality models quickly and economically.

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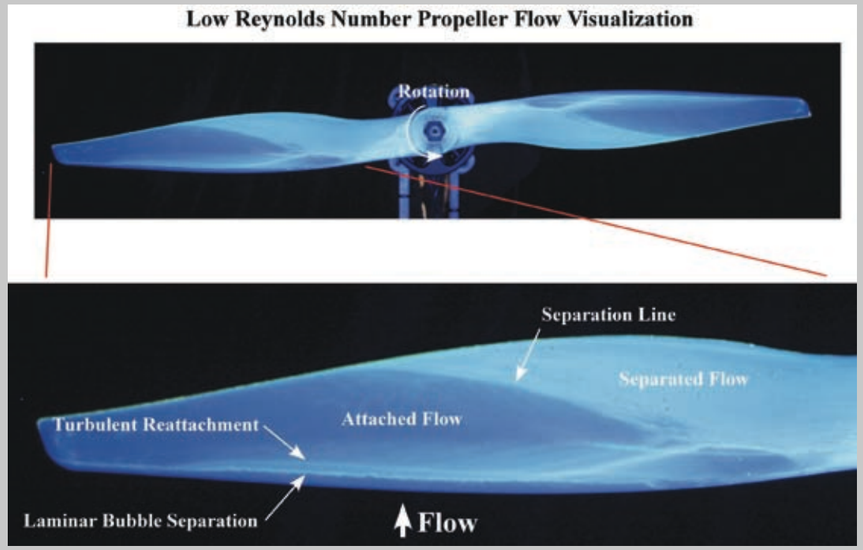

These images show a new Rolling Hills Research flow-visualization technique developed for studying the effect of the company's patented method of controlling boundary-layer transition from laminar to turbulent on a low-Reynolds-number propeller. The flow-visualization technique shows the separation pattern on the low-Reynolds-number propeller as a function of full revolutions per minute.

Graphic courtesy Rolling Hills Research Corp.

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Using SBIR for innovative research

The SBIR grants have been invaluable to Rolling Hills for examining its new concepts, Kramer said.

"It's like peeling back the skin of an onion. When you peel away a layer, you can learn about a limiting factor somewhere else," he said. "Once we identify a problem, sometimes we have to solve five others before we get there."

The funding provided by the SBIR awards is key for the company.

"SBIRs help us to pursue new ideas that we want to research and is our primary source for funding them," Kerho said. "We couldn't do it without SBIR. We do not have the extra capital to do research and development. We use the SBIR agreements to take our ideas and flesh them out to see if they can work. In addition, the technical reviews often give us other ideas on how to best make it work out."

Dryden is a frequent partner with Rolling Hills on SBIR proposals, but the company also has worked with Langley Research Center, Hampton Va., and Ames Research Center, Moffett Field, Calif.

Micro UAVs

The Rolling Hills water tunnel work does have a downside: the Reynolds number produced by the water tunnel cannot be scaled for larger vehicles because of the boundary layer differences, or airflow that moves directly above aerodynamic surfaces, he said.

However, smaller unmanned air vehicles, or micro UAVs, are one class of aircraft that does not have that challenge, he said. Those vehicles can be tested at full-size and full-flight Reynolds numbers, so the water tunnel can produce accurate results.

In addition, the company has applied for a patent for a method for controlling the boundary layer transition from laminar to turbulent on low-Reynolds-number aircraft as a result of some of its SBIR work. Micro UAVs and high-altitude, long-endurance aircraft have challenges caused by very low Reynolds numbers, such as laminar separation bubbles. This technology has proven to reduce drag by 35 to 40 percent, Kramer said.

Through the same SBIR used to develop the low-Reynolds-number airfoil drag-reduction technologies, Rolling Hills also developed a flow-visualization methodology to study the flow field of small, low-Reynolds-number propellers. Similar to the main airfoils on micro UAVs and high-altitude, long-endurance aircraft, the propellers on these aircraft that generate propulsion also suffer from the same low-Reynolds-number-based degradation. Rolling Hills developed a flow-visualization technique to apply its SBIR-developed technology to provide a detailed picture of the propeller surface flow field that can be used to help improve propeller performance.

IPP concept

A current Innovative Partnership Program seed fund proposal that Rolling Hills has on the table is for a separation detector. The IPP is the big umbrella that includes a number of funding mechanisms, such as SBIR, STTR, and the IPP seed fund, to assist companies with their fledgling technology projects.

Called "electronic yarn," the detector is essentially an array consisting of 100 or more self-powered and self-contained sensors. The idea is to replace tufts and cameras for detecting separated airflow in flight with a simple and robust system that does not require calibration or cameras and gives a simple yes-or-no answer to the question of whether there is an aerodynamic separation.

This could be useful in programs like that of the Stratospheric

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Rolling Hills ... from page 32

Observatory for Infrared Astronomy, in which there is a large opening in the side of the aircraft where the telescope "peers" out from its host NASA 747SP. NASA may need to investigate and modify configurations like the SOFIA to ensure flow-separation problems do not exist, Kramer said.

The commercialization prospects are high if the detector performs as predicted, Kramer said. The sensors can record information on a flash drive and require no external power source. The application of the idea goes beyond flight research. It could be used in automobiles, ducting and other scenarios in which sensors are required and where there is no visual access available.

STTR projects

Rolling Hills researchers are looking forward with an ongoing STTR agreement with partner California Polytechnic State University in San Luis Obispo, Calif. That work is focused on a thrust-vectoring aerospike nozzle and evolved into a current project with an oxidizer-cooled aerospike.

Aerospike nozzles are considered to be efficient because they adjust to changes in atmospheric pressure due to altitude (compared to a bell-shaped nozzle that does not) as the rocket propels a vehicle. The problem with aerospike nozzles is they often become too hot and need to be cooled, Kramer said. The oxidizer-cooled aerospike concept does what its name implies – it turns fuel into vapor and uses that phase change to cool the engine.

Another new development for Rolling Hills researchers is an STTR agreement with the University of Illinois for a real-time flight-envelope monitoring capability that would give pilot alerts in situations such as icing, heavy rain, battle damage, bird strikes, and other safety-related dangers. If the systems prove robust, they would be good candidates for commercialization, he said.

Indications are that IPP funding mechanisms will continue to be a primary way for small businesses to find ways to work on innovative research ideas. Kramer offered this advice for companies looking to succeed in obtaining grants for their research: "It is best not to chase the 'hot technology' and jump on the bandwagon. Stick to what you have knowledge and interest in. Stick with your strengths. That's not to say don't look to branch out or be creative, but be smart about it."

Award ... from page 27

fast through areas suffering after years of drought conditions.

NASA is anticipated to again participate in California fire missions this fire season, Rigney said. The Ikhana's ability to fly for long durations and send imagery overlaid with maps to fire commanders on the ground has been a valuable tool that possibly can save lives and property this fire season by identifying where the best uses of resources are, he said.

ED07 0139-19 NASA Photo by Lori Losey

The Ikhana makes a research flight over the high desert. A government team that collaborated on getting the technology available was recently recognized.

In addition to fire missions, the U.S. Army is using the Ikhana and Dryden's unmanned aircraft systems expertise to demonstrate some of the Army's sensors aboard the aircraft, he added.

Regardless of how the Ikhana is used in fire missions or research, the aim is to benefit the public and partner when it makes sense to maximize the investment in developing the aircraft. The current award supports the view that using the aircraft for the maximum use of partners and the public is paying dividends.

Why ... from page 27

$100,000 each. In the competition with a $2 million prize, teams invested on the order of $250,000 to $500,000 each.

The return on investment with prizes is high, as NASA expends no funds unless the accomplishment is demonstrated. NASA provides only the prize money and the administration of the competitions is done at no cost to NASA by allied nonprofit organizations. Prizes also focus public attention on NASA programs and generate interest in science and engineering.

NASA is considering future challenges focused on revolutionary energy storage systems, solar and other renewable energy technologies, laser communications, demonstration of near-Earth object survey and deflection strategies, innovative approaches to improving the safety and efficiency of aviation systems, closed-loop life support and other resource recycling techniques, and low-cost access to space.

Tanker ... from page 29

off of," he said.

SBIR is the primary way small businesses can tap government dollars to fund new ideas and concepts, Klyde said. Prior to the introduction of those funds in the 1980s, it was more of a competitive process among all companies regardless of size, said Klyde, a 22-year veteran of the SBIR process with Systems Technology.

SBIR agreements also present opportunities to build relationships among companies, he said.

"It is easier to work with people than against them," he said. "We know what to do and we have learned to germinate partnerships with universities and other businesses. We had The Boeing Company as a sub contractor on one project and we also work with other small businesses like us."

His advice to companies just starting off in SBIR projects: "Start early. If you wait until the last minute you can get overwhelmed if you have never done it before," he said.

The Boy Scouts of America would appreciate his other recommendation, "Do your homework, and be prepared."

Micro UAV validates new ability

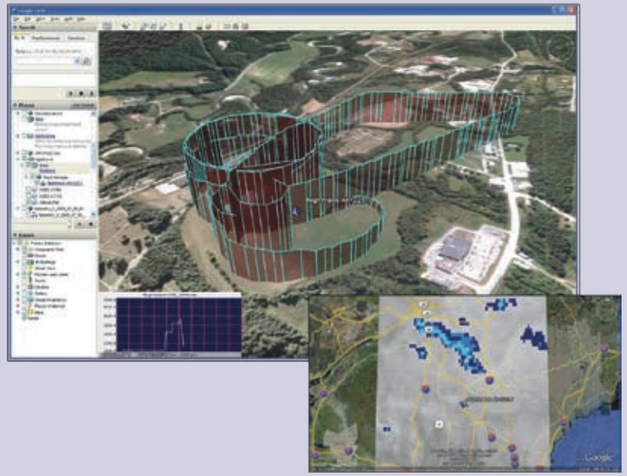
The challenges of meeting size, weight and power constraints for data systems supporting airborne science payloads become greater as the aircraft get smaller. But a July 9 flight experiment with a micro unmanned air vehicle demonstrated that those challenges could be met.

Researchers sponsored by Dryden's Small Business Innovation Research program introduced airborne science networking capabilities, such as telepresence and over-the-horizon, on an aircraft bearing a payload of instrumentation with a combined gross weight of less than three pounds.

The battery-powered NightHawk micro air vehicle, built by Applied Research Associates Inc. of Randolph, Vt., communicated with ground systems via the Iridium Satellite constellation. Simultaneously, a mission monitor delivered situational-awareness information from the satellites as computer displays that ground personnel could then access.

In recent years, NASA researchers have successfully prototyped and deployed infrastructure that enables communication between researchers and instruments on airborne platforms. The vision within airborne science is to continue expanding such sensor-

See KnightHawk, page 35



Above, situational-awareness displays show flight track and local storm data for the micro unmanned air vehicle containing the Miniature Suborbital Telepresence system on its inaugural test fight in Vermont. ***(Weather imagery provided by NASA Marshall Space Flight Center)***

DASP Toolbox ... from page 16

an agreement that meant IPP funding of $238,000, with in-kind services, work force and use of facilities totaling about $250,000.

Fiber optic wing shape sensors, adaptive controls and distributed sensing controls could benefit from the DASP toolbox technology and potential partnerships are forming for a larger program, Voracek said.

The DASP toolbox also offers the potential to prevent accidents.

"With this technology we should be able to identify the load in real time so it does not exceed its [design] limits. The other type of accident that could be avoided is the computer mistakenly acting as if the aircraft were in a dive because pitot tube measurements were wrong and the flight controls reacted to that information instead of the actual flight conditions of the aircraft climbing following a takeoff," Voracek explained.

Mangalam's son, Arun, said the DASP toolbox could maximize wind turbine efficiency and productivity, minimize structural oscillations and fatigue and maximize energy transfer. Formula One and yacht racing could be made more efficient using the technology as well, he added. In addition, health monitoring of building or bridges could be possible.

The IPP creates a partnership with NASA, where NASA's platforms and ideas can be tapped, Arun Mangalam said. This partnership permits a small business to move technology readiness up a level so that the innovation can be ready for when it is needed.

For small business, IPP partnership projects like this one offer vast opportunities.

"This helps us in many ways. When we do SBIR we generally work on our own. Because of this partnership, we get to work with people who know the problem and who are looking for a solution and we can more effectively support that type activity. This IPP program, from that point of view, is extremely useful for getting the players together. We are able to work with all the people at NASA – that's a big plus for us. Because of that opportunity, we know what needs to be done to this instrumentation if you want to put it into an aircraft," Arun Mangalam said.

And the equipment to do the "baking-and-shaking" tests to validate it for flight is not usually found at a small business. That's another benefit of the partnership: the resources of a NASA center can be used for the flight validation process, he added.

Brenner agrees that IPP partnerships help move technology along.

"It's a good outlet for bringing in outside ideas and more efficient ones," Brenner said. "It's also a way for engineers to get small, invaluable ideas out, put together a plan and use that in the technology development. It is a way to develop big plans by showing the potential of critical applications. It is a block approach to technology that would not be advanced any other way."

Design Tool ... from page 17

exposed to what is going on in this field and this is a good research program that will train students for the types of work NASA will need when they graduate," he said.

The team will complete development of the Multidisciplinary Design and Analysis, or MDA, tool, primarily using its respective numerical, finite element codes integrating disciplines such as structures, aerodynamics, thermal, acoustics, controls and propulsion.

The resulting MDA code, designed in modular form, could be effortlessly used with existing commercial or user-provided codes. Once completed, the code is expected to have extensive applications in the design and analysis of flight vehicles. In its request for proposals, the Aeronautics Research Mission Directorate Fundamental Aeronautics program highlighted MDA as a need, Gupta explained.

An earlier STTR Phase I permitted the team to evaluate simulation capabilities, develop an aero-thermo-elastic-propulsion simulation of air-breathing hypersonic flight vehicles and other flight vehicles, and generate recommendations for multidisciplinary simulation capability.

NASA could potentially use the MDA for research aimed at enabling advanced future flight vehicle design and analysis capabilities. One thrust of this research is hypersonics, including air-breathing vehicles that will enable safe, affordable and routine travel to low-Earth orbit in support of space science, exploration and commerce and planetary entry vehicles to enable manned and unmanned explorations, he said.

Proposed Highly Reliable Reusable Launch Systems of the future will be conceived, designed and developed to fulfill the nation's space exploration aspirations and NASA's mission, and maintain the country's aerospace edge, Gupta said. Airbreathing hypersonic flight vehicles present a promising alternative for affordable and reliable access to space.

For that reason, development of predictive capabilities and simulation tools for design of a future advanced class of flight vehicles is necessary. Also, additional capabilities in the area of aero-acoustics will have imminent applications in a number of ongoing NASA projects.

Commercially, the technology could enable industrial companies and academia to use the MDA code for analysis in individual disciplines and, more important, in the design of complete aerospace vehicles as well as other classes of vehicles in a coupled mode.

Aeroelastic, aero-thermo-elastic, aero-propulsion, and aero-acoustic analyses can be performed routinely for accurate and reliable design of complex, advanced flight vehicles, using standard personal computers, Gupta said. The optimization capability will help in achieving an economical configuration.

Potential use of MDA code for aerospace is vast. As NASA looks for in its technology development efforts, the MDA code could also have applications to fields such as mechanical, marine and civil engineering.

KnightHawk ... from page 34

web capabilities for use in all science platforms.

Existing REVEAL – Research Environment for Vehicle-Embedded Analysis on Linux – systems are too big for unmanned vehicles being considered as candidates for certain types of missions such as volcanic plume studies or situational awareness for rapidly deployed disaster relief. A REVEAL system is an "aircraft in a box" for sensor-web research, and a programmable gateway between onboard instruments and wireless communication paths to and from aircraft.

"The Miniature Suborbital Telepresence System uses NASA's REVEAL software and the same DataTurbine software used on the dominant airborne science platforms," said Matt Miller, project lead at Erigo Technologies LLC of Enfield, N.H. "We were able to demonstrate feasibility and a path toward introducing whole new families of small, reconfigurable data systems for communities that include but are not limited to environmental science."

DSAM ... from page 17

DSAM, approach implements the modulation as a function of the antenna in a manner that simplifies directional control of the antenna's sensitivity, he added.

"DSAM might offer a path to closing capability gaps we see in the evolution of network-enhanced telemetry," Freudinger said. "For multiple vehicles and ground systems to communicate with each other as they move around, we need an affordable approach for focusing antennas in multiple directions at the same time. We will have to do this on vehicles that can't support the size, weight and power of existing approaches."

The project is a collaborative effort between Dryden and the Invertix Corporation of McClean, Va. Invertix is a communications company focused on the needs of federal agencies. Dryden team members include the Research Instrumentation, Range Operations and Range Engineering branches.

"Power efficiency, spectral efficiency, resistance to jamming, and joint modulation-beam steering are the key advantages for test applications. The ability to use less-expensive nonlinear power amplifiers in a manner that improves power efficiency by orders of magnitude is just the tip of the iceberg," said Brecken Uhl, technical lead for the project at Invertix and developer of the DSAM concept.

The recent IPP award made to the company will fund development of a prototype array element suitable for laboratory demonstration within a few months, Freudinger said. The demonstration is expected to confirm whether the technical approach will work as promoted. The Dryden team will evaluate the results of the test and recommend a technology-maturation strategy if one is warranted.

If successful, this research may enable for the first time small, low-complexity, low-cost steerable antennas that can reduce system cost. In addition, the technology could replace omni-directional antennas used not only in aircraft but also in products such as cell phones and Wi-Fi access points.

NTR ... from page 23

Yvonne Kellogg, Dryden's awards liaison officer, nominated the team's fiber optic work for a NASA Space Act Award. NASA's Inventions and Contributions Board, which is chaired by NASA's chief engineer, is composed of representatives from across 40 fields of science and technology across the agency. Based on the value of the work's contribution to NASA and to the public, as determined by the board, Space Act awards of up to $100,000 are available.

In addition, Allen Parker's work on algorithms for high-speed acquisition processing of data was also put in for a patent. Other potential patents, which include the work of partner Anthony "Nino" Piazza, are for operational flight loads on complex structures using fiber optic strain sensors, real-time loads measurement using the fiber optic strain sensors, and several others, Richards said (see related story).

A researcher has a year to file for a patent after releasing information about it, such as a research paper. The idea to patent the concept is not always immediately obvious.

"I have given presentations and then figured out that it is something we should protect. We think about publishing results, not about applying for patents," Richards said.

Applying for a patent can be a daunting process, but there are resources to help.

"It is a formidable task that can be hard to get your arms around. Mark Homer, a JPL patent attorney who also assists Dryden, made it as painless as possible," Richards said.

Reporting begins with a one- to two-page summary of the invention or description of the intellectual process in an email to Homer. A second step is going to the eNTRe [Electronic New Technology Reporting System] Web site and talking to Kellogg, who also serves as Dryden's Intellectual Property manager. To begin the patent process, Homer works with researchers to convert the summary language from technical to legal wording then completes a search to ensure that similar patents do not already exist.

"NASA is not in the business to make money; we are not here to build systems and provide those to our customers. We want to spin this technology off and let those who develop systems for profit do what they do best. Our goal is, once we have our intellectual property protected we want to license those patents and allow companies to build those systems and provide them to customers."

Lance Richards
Aerospace research engineer

Additional NTR results

New technology reporting – NTR – helps move technology along and gives future researchers a starting point for their research.

"NASA is not in the business to make money; we are not here to build systems and provide those to our customers," Richards emphasized. "We want to spin this technology off and let those who develop systems for profit do what they do best. Our goal is, once we have our intellectual property protected we want to license those patents and allow companies to build those systems and provide them to customers.

"We want to solve problems so they can do their business. We don't want to compete with private industry, we want to complement private industry."

Reporting has a lot of value, Richards said.

"Take the process to publish seriously. A lot of times we just want to get our publications out. But there's a form and you have to disclose what technology is potentially worth protecting," he said.

Form 1676, Scientific and Technical Information Document Availability Authorization process, and Dryden Form 156, Technology Transfer Assessment, allow release of the findings. The forms are available on the forms link on the Dryden Xnet page. New STI manager Greg Poteat is available to assist in developing STI documentation.

"It's helpful to talk to people who have done it before. Having gone through it now I would be willing to talk to anyone who has questions about how to work through it," Richards said.

"I know there are quite a few steps and it takes a lot to overcome your own daily work load to complete New Technology Reporting – the pressures to deal with the day-to-day of flight experiments or projects. However, the biggest hurdle and bottleneck is usually the researcher. We need to get out of the trenches and, with due diligence, get that paperwork filed," he concluded.

SBIR, STTR awards made

Sixteen small business projects have been selected by NASA to receive agency support for important research and technology needs. The awards are part of NASA's Small Business Innovation Research, or SBIR, and Small Business Technology Transfer – STTR – programs.

Twelve proposals were selected in the SBIR program for negotiation of phase II contracts, with a total value of approximately $7.2 million. The awards went to small high-technology firms in nine states.

Four proposals were selected in the STTR program for negotiation of phase II contract awards, with a total value of approximately $2.4 million. The awards went to four small high-technology firms in four states partnered with three research institutions in three states.

These selections are supplementary to the 142 phase II SBIR awards announced Oct. 28, 2008, and the 16 STTR phase II awards announced April 15.

The SBIR and STTR programs are part of the Innovative Partnerships Program Office at NASA Headquarters. The office partners with U.S. industry to infuse innovative technologies into NASA missions and help them to be transitioned into commercially available products and services for use by the agency and in other markets.

For a list of selected proposals, visit http://www.nasa.gov/offices/ipp/technology_infusion/sbir/index.html.

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