NASA Office of Aeronautics and Space Transportation Technology
Volume 6, Number 3 May/June 1998

Aerospace Technology

INNOVATION

Forty Years: NASA's Aviation Safety Efforts Soar

One-of-a-Kind Testing Facility

The 40th Anniversary Commemorates Explorer 1

Safer Travel Possible With Sensor

NASA 40

Fortieth Anniversary

Aerospace Technology
INNOVATION

Volume 6, Number 3 May/June 1998

Contents

About the Cover:
Over the past 40 years, NASA has made significant accomplishments in its efforts to make flying the safest of all major modes of transportation.

On-Line Edition: Go to **http://nctn.hq.nasa.gov** on the World Wide Web for current and past issues.

Aerospace Technology Innovation *is published bimonthly by the NASA Office of Aeronautics and Space Transportation Technology. Your feedback provides an important contribution to this publication.* ***To provide comments or input, or be added to our regular distribution, please write to the Editor's Internet address listed above or the following postal address: Aerospace Technology Innovation, NASA, Code RW, 300 E Street, SW, Washington, DC 20546.*** *Please provide your address, phone number, and your industry classification.*

COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
8/98	STS-93 AXAF	AEROGEL Commercial Generic Bioprocessing Apparatus-04**	Marshall Space Flight Center BioServe Space Technologies
10/98	STS-95 BioTechHab (SPACEHAB short module)	*Includes eight commercial development payloads:* Advanced Organic Separation Unit (ADSEP) AEROGEL ASTROCULTURE™ BioDyn-A Commercial Generic Bioprocessing Apparatus Commercial ITA Biomedical Experiments Commercial Protein Crystal Growth-15 Microencapsulation Electrostatic Processing System	*Commercial Space Centers and NASA Centers* Consortium for Materials Development In Space Marshall Space Flight Center (MSFC) Wisconsin Center for Space Automation & Robotics Consortium for Materials Development In Space BioServe Space Technologies Instrumentation Technology Associates, Inc. Center for Macromolecular Crystallography Johnson Space Center/MSFC

Note: Sortie flights beyond STS-95, and Space Station operations, under review at this time

* As of June 1998
** In combination with National Institutes of Health payload NIH-B1 in support of Life Sciences Division requirements
Key: STS—Space Transportation System
AXAF—Advanced X-ray Astrophysics Facility
ITA—Instrumentation Technology Associates, Inc.

NASA Aviation Safety Program Working to Improve on Excellence

By Michael S. Lewis
Director, Aviation Safety Program Office
NASA Langley Research Center

HUMANS AND FLYING MACHINES ARE CAPABLE of extremely complementary attributes. Humans, especially well-trained and motivated ones, are able to mentally and physically adapt to a nearly infinite variety of circumstances with a high level of performance. Machines, especially those that are as well developed as the ones in the aviation world, operate with extraordinary performance within a finite set of circumstances. This fortunate marriage, operating within well-developed and regulated procedures, has resulted in an aviation system that safely completes a given flight over 99.9999 percent of the time.

Yet this success rate must dramatically improve over the coming decades if the aviation system (both commercial and general aviation) is to continue to grow and prosper. The disheartening specter of a major accident nearly every week has been well publicized as the direct result of the forecast upward trend in airline departures and a constant accident rate. Today's environment of instant worldwide media communications, coupled with the public's intense interest in air travel, means that a major accident anywhere affects the perception of safety everywhere. More and more frequent accidents will assuredly dampen the public's enthusiasm for air travel. Thus, the accident rate must go down for the aviation system to continue to grow to its full potential.

Indeed, the current period presents us with a unique and fortunate confluence of political focus, coordinated government and industry activity, incredible new technologies and significant resources available to get the job done. How? There are five steps that are fundamental for timely success.

First, work together. NASA, the FAA, manufacturers, operators and other parties (both in this country and internationally) all have unique and valuable contributions to make for enhanced safety. Teamed together, new ideas can be developed, tested and implemented faster and better than any individual organization working alone could produce.

Second, identify safety issues based upon the data. A data-driven approach is a common theme of joint NASA-FAA safety research activity, as well as industry's coordinated efforts. Multiple accident cases are now undergoing detailed examination to identify common critical causes, factors and precursor events. These studies are forming the basis of an emerging systematic—as opposed to judgmental and reactive—approach to focusing safety improvement efforts.

Third, take maximum advantage of emerging technologies. Although the list of new technology advancements is too long to detail, four can be considered especially critical in providing the foundation for an operational revolution: the global positioning system (GPS) and all of its incredible uses; worldwide high-bandwidth digital data links; ever cheaper and more capable digital data storage and general-purpose onboard processing; and affordably retrofittable liquid crystal and head-up displays. With these basic capabilities in every cockpit, the opportunities to improve both air and ground decision making are nearly boundless.

...A MAJOR ACCIDENT ANYWHERE AFFECTS THE PERCEPTION OF SAFETY EVERYWHERE.

Fourth, aggressively implement improvements. There is no question that safety improvements that are also economic improvements are clear winners. Beyond that, it is up to industry and government to work together to incorporate enhancements into the fleet as early as possible. Industry needs to keep in mind that the long-term effect of improved safety is a barrier removed to a huge total market; government needs to streamline the process needed to turn good new ideas into certified applications. Recent actions with the enhanced ground proximity warning system are a good example.

Fifth, measure the results. Monitoring the aviation system through the intelligent combination of flight operations quality assurance programs and new information technology tools is the feedback process required to assess the impact of changes from established baselines.

None of these steps is a grand new idea. What is new is how they can be taken together and aimed at a unifying and challenging goal. NASA is committing $500 million over the next five years. The FAA is committing the full force of its agency. Industry is joining together.

Let the race begin.

Forty Years: NASA's Aviation Safety Efforts Soar

MAJOR STRIDES HAVE BEEN MADE DURING the last 40 years to make flying the safest of all major modes of transportation. The story of military aviation and the American aircraft industry during World War II is well known. Lesser known, but no less meaningful, is NASA's important contributions to aviation through its research, development and production of military aircraft for use during World War II. This beneficence serves as the foundation of NASA's present aeronautical research, accomplishments, goals and partnerships.

More technological advances are needed, however, to prevent a rise in accidents if air traffic triples as predicted in the next 20 years. NASA is leading the nation's efforts with its aviation safety partnerships and its own ongoing endeavors to reduce general aviation accidents by 80 percent in 10 years—and by 90 percent in two decades.

NASA's Efforts Today

The most recent development toward this goal is NASA's Aviation Safety Program, an ambitious $500 million program in partnership with the Federal Aviation Administration (FAA), the aviation industry and the Department of Defense. The Aviation Safety Program emphasizes not only accident reduction, but also a decrease in injuries when accidents do occur. The program will include research to reduce human-error-caused accidents and incidents, predict and prevent mechanical and software malfunction and eliminate accidents involving hazardous weather and controlled flight into terrain.

Information technology will be used to build a safer aviation system to support pilots and air traffic controllers. The FAA will help define requirements and actions to enact many of the safety standards.

NASA's ongoing air safety efforts include the Advanced General Aviation Transport Experiments (AGATE), the General Aviation Propulsion (GAP) Program and the Advanced Aircraft Transportation Technologies (ATT) Program. Significant accomplishments by NASA and its partnerships with the FAA and private industry to make aviation safer include:

- Providing technology for advanced warning of wind shear
- Designing advanced air traffic management equipment and procedures
- Developing ways to ensure older aircraft are as structurally sound as new ones
- Improving engine reliability systems and displays
- Developing advanced ice protection concepts to improve aircraft operations
- Improving the control of general aviation aircraft stall and spin

The historical wind tunnel at Langley Research Center, famous for pioneering drag research, was still used in the 1970s.

NASA's Role in General Aviation History: The Untold Story

Much of what we take for granted in aviation today, and the recent past, was pioneered by the National Advisory Committee for Aeronautics (NACA), the group we know today as NASA under the National Aeronautics and Space Act of 1958. As the United States entered World War II on December 8, 1941, the NACA increased in size from one research facility—the Langley Memorial Aeronautical Laboratory in Hampton, Virginia—to three. Ames Aeronautical Laboratory in Mountain View, California, and the Aircraft Engine Research Laboratory in Cleveland, Ohio (Lewis Research Center today), were brand new. Those three facilities and Dryden Flight Research Center in Edwards, California, continue to be among the leaders in NASA's aviation research today.

The NACA's fundamental research agenda (basic research, mainly aerodynamics and flight research) proved a solid foundation for its new wartime responsibilities. The NACA mandate to find "practical solutions" assumed paramount importance in guiding the organization during the war. The NACA

had a new role in conducting applied development work for industry and the military. Among the many important accomplishments during the war, a few of the NACA's major research projects included drag cleanup, de-icing, engine development, low-drag wing, stability and control, compressibility, ditching and seaplane studies.

"Drag cleanup" (minimizing airflow resistance) was the most important work for the NACA during the war, using what was the largest facility in the world at the time—a full-scale, 40- by 80-foot wind tunnel. The "drag cleanup" process helped the military solve technical problems, and it was quick and inexpensive. Time-consuming and expensive aircraft redesign became unnecessary.

Right from the start, the entire aviation community was unanimous in its desire to develop a system that would make flying safer. When ice covers wings and propellers, reducing lift and increasing drag, the result can often be fatal crashes. Icing studies were started at Langley. Work was transferred to Ames and consisted of both research and extensive design of actual hardware used on airplanes. Significant research on icing today is done at Lewis Research Center. The NACA developed a heat de-icing system, which piped air heated by hot engine exhaust along the leading edge of the wing. The system saved the lives of countless pilots flying in dangerous weather conditions. The NACA was awarded the Collier Trophy, aviation's highest award, for its de-icing work.

The NACA pioneered new methods of "troubleshooting" defects in new, higher powered piston engines at the new Aircraft Engine Research Laboratory in Cleveland, beginning in 1942. Engineers closely examined engines slated for rapid production and use in military aircraft. They developed new ways to solve complex combustion, heat exchange and supercharger problems. They swiftly introduced a single standard test procedure and followed by developing the centrifugal supercharger—work that was extremely useful to manufacturers.

Engine research did not receive very much public attention then. Work performed at the laboratory on an army aircraft, however, went on to become one of the military's most successful—the Army's Boeing B-17 Flying Fortress, a true high-altitude, high-speed bomber.

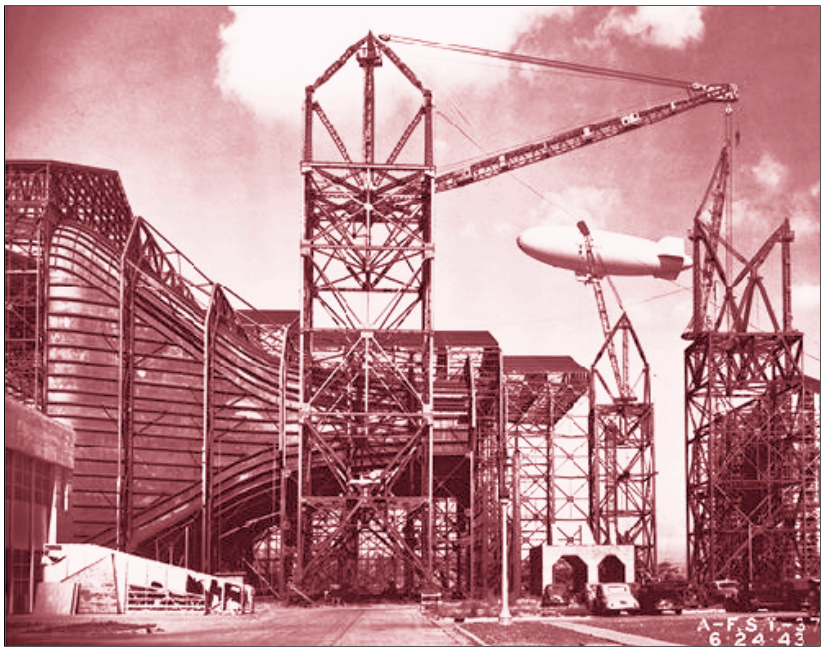
The NACA researchers had been virtually excluded from some aspects of wartime jet propulsion research and were behind Great Britain and Germany in jet aircraft development. Nonetheless, the NACA engine research facility tested the General Electric I-16 turbojet engine, and a dedicated group at the engine laboratory seized every opportunity to work on the General Electric project, thus building the foundation for the NACA's postwar work on jet engine technology.

Ground was broken in the early 1940s for an aircraft engine research lab at Lewis Research Center.

A new series of airfoils (a wing's cross-sectional shape), developed by the NACA, was the basis of the NACA's low-drag wing research, which had a profound effect on the outcome of World War II. Most enemy fighters were outclassed in aerial combat from the NACA's low-drag laminar flow airfoils that created high speed at cruise conditions.

Representing a decade of work, the NACA introduced to industry a new set of quantitative measures to characterize the stability, control and handling qualities of an airplane. The military readily adopted the NACA findings and spin tunnel tests. This work led to the military's first-ever issuance of specific design standards to its aircraft manufacturers and to changes in airplane tail design to help pilots recover from high-speed dives.

NACA research also produced vital information on airflow over wing surfaces and dive flaps that helped pilots retain control over a diving airplane. The NACA also was asked to assist in finding information to help air crews and aircraft better withstand water impacts. The NACA's test results were forwarded to aircraft manufacturers and helped save the lives of countless air crews.



The 40- by 80-foot wind tunnel under construction at Ames Research Center in 1943—at the time the world's largest.

NASA began full-scale research when it was the NACA. In its 40 years, four basic tools have been used: computational fluid dynamics, wind tunnels, ground-based flight simulators and flights of the vehicles themselves.

Until the 1970s, experimental planes (designated "X"-planes for "experimental") were the chief research tools. This was simply because research at Dryden probed flight regimes that wind tunnels, simulators and production aircraft could not approach, until the breaking of the "sound barrier" by the XS-1 brought proof that the best available supersonic wind tunnel data were reliable. Vast amounts of data that the X-1s and other early research airplanes obtained were important for validating the new wind tunnels (particularly the ventilated-throat transonic tunnels) under development at the time. One of the greatest benefits was intangible—the confidence gained at the time by the achievement of safe, controllable supersonic flight.

The X-15s of the 1950s and 1960s helped verify theories and wind tunnel predictions concerning hypersonic flight (at speeds greater than Mach 5). The X-15 program data in more than 750 research papers and reports had real-life applications as well, such as the practical, full-pressure flight suit for pilot protection in space, the first large, restartable, throttleable rocket engine and the first reusable aircraft structure capable of withstanding the temperatures of hypersonic reentry into the atmosphere. The program also illuminated discoveries about hypersonic aerodynamic heating that were not predicted by other methods. Similar to the 1940s supersonic research, the X-15 program gathered unique data, and it expanded the human experience—this time successfully taking piloted flight to the edge of space.

The NASA F-8 Digital-Fly-by-Wire is an example of a conventional aircraft that became an important research vehicle. It was a former Navy fighter, modified in the early 1970s so it could be flown with computer-driven, electronic flight controls instead of the mechanical types that were common on all aircraft at the time. It was the forerunner of the fly-by-wire flight control systems that are now the norm on space vehicles, the latest airliners and virtually all new fighter aircraft. Its use on the X-29 proved that even an extremely unstable aircraft could be flown with superior reliability.

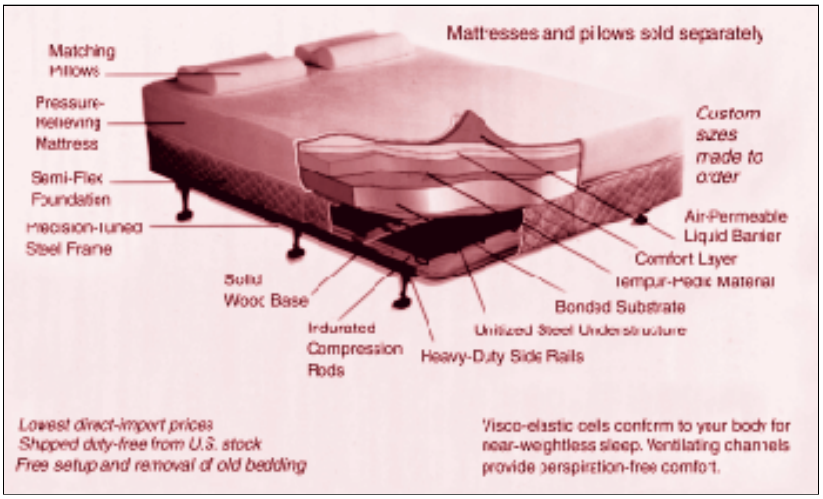
In its efforts to ensure safer skies for commercial, military and private aircraft, NASA is seeing promising results.

For more information, contact Karen Kafton at the National Technology Transfer Center. 800/678-6882, 304/243-2457, *kkafton@nttc.edu* Please mention you read about it in *Innovation.*

Famous Foam Has a Future

A NASA FOAM MATERIAL IS SAVING LIVES, reducing health care costs and providing cushioning aboard the Space Shuttle and in air flight tests. Temper Foam, a material first developed by NASA in the 1970s to improve seat cushioning and crash protection for airplane pilots and passengers, was recently inducted into the U.S. Space Foundation's Space Technology Hall of Fame.

Developed at NASA's Ames Research Center at Moffett Field, California, the material eventually found its way into commercial products, such as orthopedic support cushions, operating table pads, ear plugs, football helmets and furniture cushions. The foam is also used in Space Shuttle seats. The nonflammable, nontoxic and inexpensive Temper Foam takes the shape of impressed objects, but it returns to its original form even after 90-percent compression.



Temper Foam is used in pillows and mattress to treat such disorders as sleeplessness and bedsores.

Co-inventor Charles Kubokawa of Palo Alto, California, now retired from Ames, says continued product development looks promising. "If you think about the potential uses for this material for passenger protection and comfort, infant protection and use by handicapped persons, the future for this product is almost unlimited," Kubokawa said.

Tempur-Pedic, a Lexington, Kentucky, company, is using the material in pillows and mattresses to treat disorders ranging from sleeplessness to the more severe illness of bedsores (pressure ulcers). Bedsores can be fatal if left untreated and cost the Medicare and Medicaid programs almost $2 billion annually for the treatment of wheelchair-bound, nursing home and hospital patients.

Tempur-Pedic's products have been cited by the U.S. Department of Veterans Affairs as "very effective for the treatment and prevention" of bedsores and "very comfortable" to patients. The company recently produced its one-millionth pillow using Temper Foam and billions of self-ventilating memory molecules that slowly react to body heat and weight.

In presenting the foam to NASA Administrator Daniel S. Goldin, Tempur-Pedic CEO Robert Trussell said, "We have taken NASA's space-age material and developed it into 'body-friendly' bedding, which distributes pressure more evenly throughout the spine, joints and other parts of the body."

"I was trying to develop seating for aerospace vehicles so people could better survive any crashes or impacts," said Kubokawa. "We crash-tested several seats at the Civil Aeromedical Institute in Oklahoma City to validate them for impact survival, and we found it was good for 36 g's. The seat can outsurvive the aircraft in a crash."

Commercial application was initially developed by one of the co-inventors, Charles A. Yost of Dynamic Systems in Leicester, North Carolina. This private company produces Temper Foam for industrial applications and for toy companies.

The Space Technology Hall of Fame was established in 1988 in cooperation with NASA, and 27 technologies have been inducted to date. The U.S. Space Foundation administers the program, which honors technologies that were originally designed for aerospace programs and were later adapted for commercial use. The program also recognizes innovators who have transferred aerospace technology to industry.

Cushy Space Shuttle seat foam saves lives and provides patient comfort.

For more information, contact Betsy Robinson at Ames Research Center. 650/604-3360, 650/604-1592, *brobinson@mail.arc.nasa.gov*
Please mention you read about it in *Innovation.*

Tests Show Fewer Air Pockets

NASA IS CONDUCTING EARLY TESTS OF A NEW sensor that could make air travel safer. The sensor detects previously undetectable clear air turbulence, often referred to as "rough air" or "air pockets" that can be felt, but not seen.

Although seldom damaging to modern aircraft designed to withstand its stresses, clear air turbulence is an invisible public air safety hazard and is the leading cause of in-flight injuries among the flying public. Currently, there are no effective warning systems to give pilots time to take passenger safety precautions for clear air turbulence, which occurs at high altitudes near jet streams, in the vicinity of mountain ranges and as far as 50 miles or more from developing storm systems.

The sensor device, called Airborne Coherent LiDAR (Light Detection and Ranging) for Advanced In-flight Measurement, uses a laser beam, which can be envisioned as a type of infrared radar, that relies on infrared light waves. A light pulse is transmitted from a laser. Some of the light is reflected off the particles back to a sensor at the source. It analyzes a Doppler shift in frequency, which changes the wind velocity, to determine the laser beam's path.

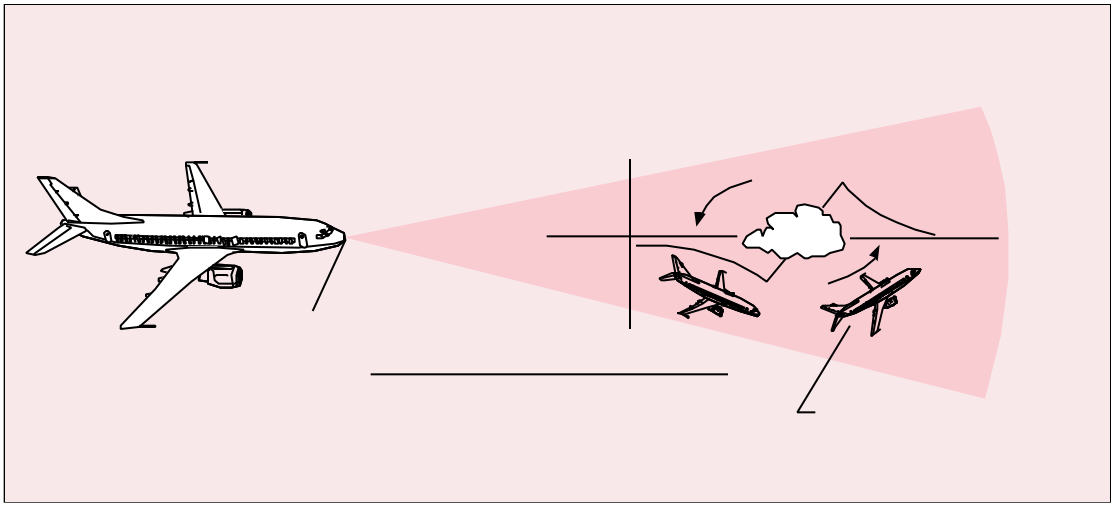
As long as the wind velocity remains uniform, no turbulence exists. If, however, the laser beam detects changes in the velocity in regions of air ahead of the aircraft as it moves forward, an alarm is sounded as a clear indication that air turbulence is ahead.

Experiments were flown on three separate flights for a total of more than seven hours at altitudes as high as 25,000 feet. Additional flights are slated to add to the turbulence data base and to fine-tune the sensor for better measurements.

Before flying through disturbed air, the test flight crew located turbulent conditions and used the infrared laser radar to measure the changes in wind speed—a measure of turbulence. Then, the crew compared the pre-encounter measurements with the effects of the turbulence they experienced. In this way, the team is exploring the relationship between the laser radar-measured turbulence characteristics and the actual turbulence experienced by the aircraft. These tests are designed to provide an efficient checkout of the flight hardware and to help characterize turbulence measurements.

Langley Research Center in Hampton, Virginia, is NASA's lead center for the Aviation Safety Program. Other participating NASA centers include Dryden Flight Research Center in Edwards, California, Ames Research Center at Moffett Field, California, and Lewis Research Center in Cleveland, Ohio.

For more information, contact Rod Bogue at Dryden Flight Research Center. 805/258-3193, *Rod.Bogue@mail.dfrc.nasa.gov* Please mention you read about it in *Innovation.*



A new sensor could detect invisible clear air turbulence, reducing in-flight injuries.

Software Supports Pilot Safety

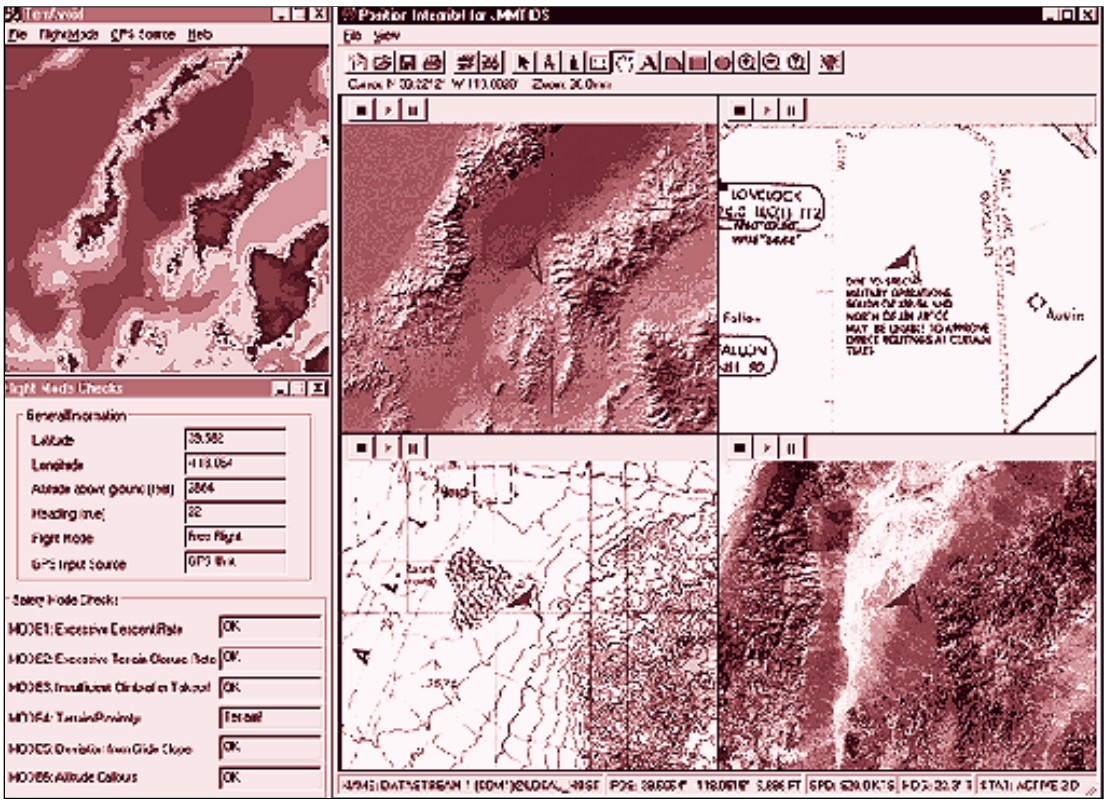
TWO NEW SOFTWARE PACKAGES THAT enable pilots to use laptops to avoid hazardous terrain and find their place on maps are the latest success stories of a NASA program bringing together entrepreneurs and space engineers. Pilots of small planes, for whom such tools have been largely unavailable until now because of cost and the sheer size of bulky hardware, may soon be able to carry aboard the personal computer equivalent of collision-avoidance systems now used by the military and commercial airlines.

"TerrAvoid" and "Position Integrity" combine global positioning system (GPS) data with high-resolution maps of Earth's topography. Dubbs and Severino, Inc., based in Irvine, California, has developed software that allows the system to be run on a battery-powered laptop in the cockpit.

"TerrAvoid" is a terrain avoidance system that graphically shows pilots whether they are flying dangerously close to mountains. Safe sections can be seen in green, while hazardous sections show up in red, with those proportions changing in real time as the pilot moves through hilly terrain. "Position Integrity," which also co-registers real-time GPS data with local maps on CD–ROM, is a moving map detailing the exact position of the pilot.

The packages, designed primarily for military sponsors and now positioned to hit the consumer market in the coming months, came about as the result of the Technology Affiliates Program at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. Intended to give American industry assistance from NASA experts and to facilitate business use of intellectual property developed for the space program, the Technology Affiliates Program introduced the start-up company of Dubbs and Severino to JPL's Dr. Nevin Bryant four years ago.

Dubbs and Severino had an idea for mapping software to help private airplane pilots, inspired in part by the fatal crash of a pilot friend of company president Bob Severino. The twist? The package was to be completely software driven, instead



Collision-avoidance systems, such as those used commercially and in the military, are becoming affordable for small plane pilots.

AIRLINE TRAVEL CHEAPER AND IMPROVING

Air travelers industry-wide could see cheaper air fares, less missed flights, less waiting time and improved overall customer service from an airline information gathering system currently being tested at Atlanta Hartsfield International Airport by NASA and the Federal Aviation Administration (FAA). Since the system testing has been in use, ground operations bottlenecks have been reduced, allowing planes to be serviced and dispatched more quickly and reducing airline taxi departure times by more than a minute per flight.

"There are well over 1,000 daily departures from Atlanta Hartsfield. That's at least 1,000 minutes a day saved, or at least $40,000 to $50,000 a day saved in airline direct operating costs," NASA Project Manager Brian Glass said. "That's an annual savings at Hartsfield of $16 to $20 million in direct operating costs, and could potentially translate into cheaper air fares for travelers."

The Surface Movement Advisor is primarily a set of computers and software that electronically connects operating information from three airport entities—the local airport authority managing the airport's ramp areas, the airlines managing the gates and the FAA's air traffic controllers. Before the Surface Movement Advisor system, all three operating units constantly, but separately, gathered information that was not easily accessible.

This is the first automated system that distributes each group's information to the others. It was designed by engineers at NASA's Ames Research Center at Moffett Field, California, in collaboration with FAA engineers, air traffic controllers and airline and airport management staffs. Atlanta Hartsfield, the nation's second largest airport in total passengers, was selected as the field test site in 1995, and several airlines began using the system daily in 1996.

For more information, contact Dr. Brian Glass at Ames Research Center. 650/604-3512, 650/604-3594, *bglass@mail.arc.nasa.gov* Please mention you read about it in *Innovation.*

of requiring expensive hardware, as was the norm up to that time.

Bryant's Cartographic Applications Group at JPL had developed GeoTIFF, an architecture standard providing geo-location tools for mapping applications. GeoTIFF proved to be the crucial key that the start-up company needed to bring the idea to fruition, allowing the firm to develop low-cost software packages.

GeoTIFF is now in the public domain, and its use for commercial product development has evolved into an industry standard over the last year. Through the Technology Affiliates Program, Dubbs and Severino obtained JPL's assistance early on and thus gained a jump-start in adapting the architecture for their products' specific needs. "JPL gave us a demonstration and opened up the red carpet," Severino said. "It was a match made in heaven."

For more information, contact John Watson at Jet Propulsion Laboratory. 818/354-5011, 818/354-5357, *john.g.watson@jpl.nasa.gov* Please mention you read about it in *Innovation.*

Safer, More Effective, More Efficient De-icer

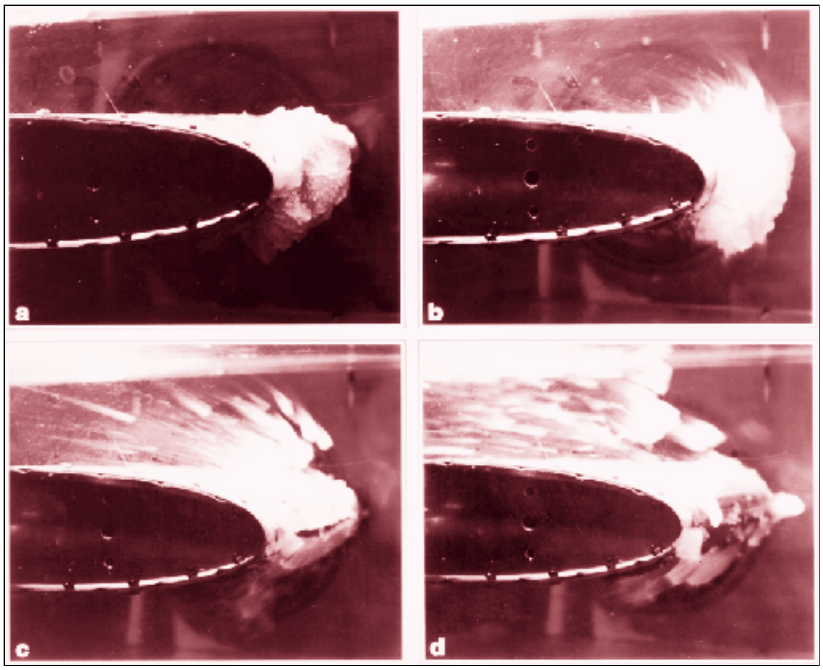
AN INNOVATIVE NASA ICE REMOVAL SYSTEM will be included with the first new general aviation aircraft to be introduced in the United States in 15 years. The lightweight, patented ice zapper device could help NASA meet its goal of greatly improving commercial aircraft safety by keeping wings and other aircraft parts free of dangerous ice during an aircraft's entire flight.

An electric current runs through parallel layers of flat, copper ribbon. A repelling magnetic field is created, causing a high acceleration to break the ice into tiny particles that fall from the airplane's surface. Even in warm climates, aircraft icing can be a problem at higher altitudes where temperatures are cold.

"The ice zapper uses one-thousandth the power and is one-tenth the weight of electro-thermal ice removal systems used today," said inventor Leonard Haslim of NASA's Ames Research Center, Moffett Field, California. "The

system pulverizes ice into small particles and removes layers of ice as thin as frost or as thick as an inch of glaze."

There are other, less effective methods to combat airframe icing, including thermal deicing and pneumatic boots. "Thermal deicers that melt ice use a lot of energy," Haslim said. "Also, melted ice can refreeze elsewhere on the aircraft, or larger loose ice shards can fly into the aircraft to cause damage."



This high-speed photography sequence demonstrates how the Electro-Expulsive Separation System shatters and ejects ice from a wing model in a wind tunnel test.

Pneumatic boots inflate slowly and need as much as a quarter inch of ice to accumulate before they start to work. They also dislodge bigger ice pieces that can damage aircraft engines, according to Haslim. "In one winter alone, 26 F/A-18 engines were damaged by ice chunks hitting engine fan blades," he said.

"The system uses a powerful electronic photoflash-like power supply combined with a thin copper ribbon that looks like a belt flattened on itself and embedded in a rubbery plastic," said Haslim. "The looped, flattened copper ribbons are bonded to wings, engine inlets and other airplane parts where ice can form."

In less than a millisecond, the system sends bursts of high-current electricity through the two parallel layers of copper ribbon, resulting in magnetic fields that repel each other. The upper ribbon jumps less than twenty-thousandth of an inch, causing a high acceleration. The motion breaks the ice bond, shatters the ice into table-salt-size particles and expels them from the airplane's surface. The system can run continually during flight, pulsing once or twice a minute, to keep airplane surfaces ice free. The system's overlapping copper ribbon prevents electrical interference.

Lancair Inc. in Bend, Oregon, will test the ice removal system with its Lancair IV aircraft. The company will make the system available later in 1998 with the new Columbia 300, a four-seat, general aviation airplane.

The ice zapper device keeps airplane surfaces ice-free without refreezing.

In 1995, NASA licensed the ice zapper, officially known as the Electro-Expulsive Separation System, to Ice Management Systems, Inc., Temecula, California, for development and marketing. Ice Management recently agreed to develop the system for Lancair aircraft. Haslim won NASA's inventor of the year award in 1988 for the ice zapper system.

For more information, contact Dr. Leonard Haslim at Ames Research Center. 650/604-6575, 650/604-6996. Or contact Bob Fair at Lancair Inc. 541/923-2233. Please mention you read about it in *Innovation.*

One-of-a-Kind Testing Facility

NASA HAS BEGUN CONSTRUCTION OF A FULL-scale air traffic control tower simulator that will provide information essential for addressing and improving elements of present-day commercial airflight. It will also provide cost-saving analysis about technology for transfer, commercialization and dual use in airport conditions and configurations.

This ideal, realistic airport environment will test ways to combat potential air and runway traffic problems at commercial airports and provide information that may assist in the development of proposed changes to airport ground procedures and in the construction of new airport facilities. Researchers will look primarily at the feasibility, safety, reliability and cost benefits of technologies prior to incorporating them into airports.

"This will be the only one of its kind in the world," said Stan Harke, project manager at NASA's Ames Research Center, where the facility is being built. "It will allow the commercial aviation industry to study and correct potential problems in a safe setting before they become actual problems. This will be as real as it can get," he added.

The $9.3 million, two-story building, known as the Surface Development and Test Facility, is jointly funded by NASA's Advanced Air Transportation Technologies Office and the Federal Aviation Administration (FAA). It will begin testing operations in 1999.

"We will be able to simulate any airport in the world," said Nancy Dorighi, deputy project manager at Ames. "The three-dimensional visual data base of the airport will be viewed through the 360-degree window of the simulator. The visual scene, along with specific airport traffic patterns and operating procedures, will give us a very credible simulation capability."

This system is being tested to more efficiently process aircraft data.

"The principal value of this facility is risk mitigation. We have no business introducing new functions into delicate environments like Chicago O'Hare, Dallas/Fort Worth, Los Angeles, New York or Atlanta, without first shaking them down with the actual users in an environment which very closely replicates the real world," said Dennis Lawson, FAA lead surface management advisor on the project.

The facility's second floor is designed to replicate a typical air traffic control tower. Computer software, provided by Raytheon Systems Company of Arlington, Texas, will be integrated with the tower simulation hardware technologies at Ames to support both radar and out-the-window visual simulation.

The tower cab will have reconfigurable site-specific displays, such as terminal area radar, surface radar and weather, installed to FAA specifications. Twelve rear-projection video screens will provide a seamless, 360-degree high-resolution view of the airport or other scenes being depicted. These image generators will provide a realistic view of weather conditions, environmental and seasonal effects and the movement of 200 or more active aircraft in the air or on the ground.

The imaging system will be powered by supercomputers, with the remainder of the simulation by approximately 100 Pentium processors. Video cameras will record air traffic controllers' activities for human factors research and also provide visitors and researchers unobtrusive remote viewing of simulations in progress.

On the first floor, ramp controllers, airport operators, simulation engineers, software developers and researchers will be located in separate work areas. A briefing room will accommodate simulation participants and allow visitors to observe a simulation in progress through remote video and sound monitoring.

Project engineering for the facility is provided by the firm of Daniel, Mann, Johnson & Mendenhall of Moffett Field, California. Project partners also include Oracle Corporation of Redwood Shores, California, and Silicon Graphics Inc. of Mountain View, California. Representatives from the FAA's air traffic control supervisors committee, the National Air Traffic Controller's Association and the Air Transport Association participated in all phases of the facility's design.

For more information, contact Stan Harke at Ames Research Center. 650/604-5012, 650/604-3594, *sharke@mail.arc.nasa.gov* Or contact Nancy Dorighi at Ames. 650/604-3258, 650/604-3594, *ndorighi@mail.arc.nasa.gov* Please mention you read about it in *Innovation.*

A Broad-Based Accident Prevention Program

NASA, IN COOPERATION WITH THE FEDERAL Aviation Administration (FAA), is developing an automated system that could better prevent commercial aviation accidents. It could also provide technology transfer of prototype products to commercial vendors using present safety programs and technology.

The Aviation Performance Measuring System, being developed at NASA's Ames Research Center, reduces the human labor needed to process large quantities of troubleshooting performance data used in today's aircraft systems. This makes the processing of the data more efficient and enhances the data collection and cost-effectiveness of present safety programs of U.S. carriers.

The system monitors more than 1,200 aircraft operational functions, providing valuable early warnings of potential problems involving performance, cockpit instrument inputs, electrical equipment, fuel and hydraulics. Funded by the FAA, the $3 million research program began in 1993 as a collaborative effort between NASA and the FAA to develop a set of tools that would allow large quantities of flight data to be processed in a highly automated fashion.

Operational testing of the system is being done by personnel of Alaska Airlines, who are analyzing data from their first six MD-80 aircraft equipped with Quick Access Recorders. A process of developing future system upgrades will be ongoing as the employees of Alaska Airlines become familiar with the system's capabilities and have time to identify new requirements.

The system provides a prototype of a flight data analysis ground station with customized, broad-based reporting capabilities for the U.S. airline industry. Technology transfer and commercialization opportunities are built in using present safety programs and technology.

Under NASA's new Aviation Safety Program, the system eventually will service airline engineering, maintenance and training functions, as well as commuter, cargo and corporate air carrier needs. The entire aviation system could benefit from the program in monitoring regulations or operating practices needing improvement. The FAA's funding of this research and development is an effort to expand industry capability by making the best use of digital flight data on a routine basis.

This initiative supports a National Civil Aviation Review Commission preliminary report, presented recently to U.S. Secretary of Transportation Rodney Slater. The report contained recommendations on how best to finance, manage and improve the performance of the nation's civil aviation programs.

Flight operations safety programs using flight-recorded data have been providing critical safety information to non-U.S. airlines for more than two decades. In cooperation with an FAA-sponsored study, four U.S. airlines initiated trial programs in 1995 that resulted in the need to improve existing off-the-shelf software to enhance the effectiveness of current safety programs of large U.S. airlines.

For more information, contact Dr. Kevin Corker at Ames Research Center. 650/604-0055, 650/604-2698, *corker@mail.arc.nasa.gov* Or contact Dr. Irv Statler at Ames. 650/604-6655, 650/604-2698, *statler@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

CLOSE-UP ON SOLAR CONDITIONS

NASA's Transition Region and Coronal Explorer (TRACE) mission launched at the end of March will affect power and communications systems on Earth by greatly improving our understanding of events in the Sun's atmosphere. It is the first space science mission with an open data policy that will be available to other scientists, students and the general public shortly after the information becomes available to the primary science team.

The TRACE mission joins a fleet of spacecraft studying the Sun during a critical period when solar activity is beginning its rise to a peak early in the new millennium. The Sun goes through an 11-year cycle from a period of numerous intense storms and sunspots to a period of relative calm. The coming months in the Sun's cycle will provide solar scientists with periods of strong solar activity interspersed with periods when the Sun is relatively passive and quiet. This will give TRACE the chance to study the full range of solar conditions, even in its relatively short planned lifetime.

The TRACE telescope is really four telescopes in one. It allows light reflection and analysis, collecting images over nearly 25 percent of the Sun's disk with a powerful, flexible data handling computer that allows adaptive target selection, data compression and image stabilization. The power of the TRACE telescope to perform detailed studies of the solar atmosphere makes this observatory unique among the current group of spacecraft studying the Sun.

"The spacecraft has roughly ten times the temporal resolution and five times the spatial resolution of previously launched solar spacecraft. We can expect to resolve some present mysteries of the Sun's atmospheric dynamics as well as discover new and exciting phenomena," said Dr. Alan Title, TRACE principal investigator from the Stanford Lockheed Institute for Scientific Research in Palo Alto, California. The TRACE telescope was designed and developed in cooperation between Lockheed Martin Corporation and Stanford University, with additional design and testing at NASA's Goddard Space Flight Center.

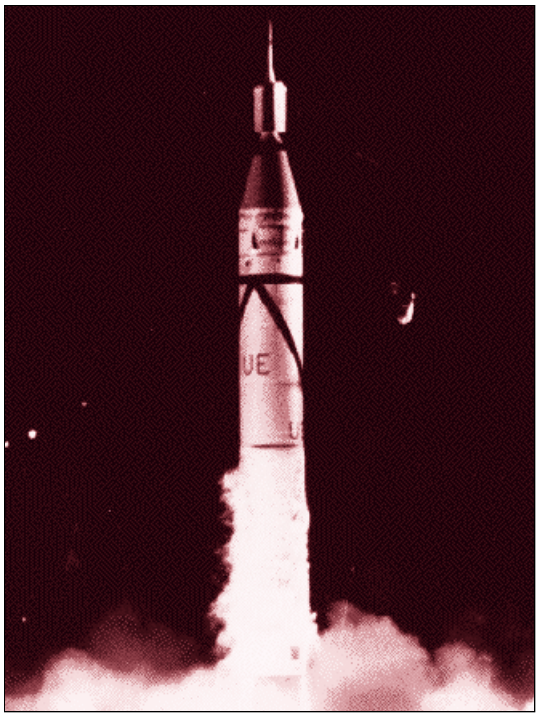
For more information, contact Gerry Daelemans at Goddard Space Flight Center. 301/286-2193, 301/286-1694, *gdaelema@pop700.gsfc.nasa.gov* Please mention you read about it in *Innovation*.

The 40th Anniversary Commemorates Explorer 1

IT WAS 40 YEARS AGO WHEN A TEAM OF scientists and engineers successfully launched Explorer 1, the first U.S. satellite to orbit Earth. This historic accomplishment marked the nation's debut in the Cold War–era space race and set the stage for the establishment of the civilian space agency that would become NASA.

The scientific experiment on board, a cosmic ray detector built by Dr. James Van Allen of the University of Iowa, soon returned one of the most important findings of the space program: the discovery of radiation belts that are now known as the Van Allen Belts around Earth. Explorer 1 went on to operate for three months.

NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, was still operated as a research laboratory for the U.S. Army in November 1957 when it developed the first U.S. satellite, including its science package, its communications system and the high-speed upper stages for the Army's Redstone rocket that would guide the tiny, 20-pound Explorer 1 into the great unknown. JPL and the Army completed the assignment and successfully launched the satellite in less than three months. JPL and the Army Ballistic Missile Agency, based in Huntsville, Alabama, joined in firing the satellite toward space from the missile test center at Cape Canaveral, Florida, on January 31, 1958.



The January 1958 satellite launch of Explorer 1 marked the beginning of the space race and the U.S. civilian space agency, NASA.

Following the Soviet Union's launch of Sputnik on October 4, 1957, "there was a lot of pressure to get a satellite in orbit as quickly as possible," said Dr. William Pickering, then JPL's director and the orchestrator of the Explorer 1 effort at JPL. The intensive effort was accomplished by a team of experts from U.S. academia and the military, along with top World War II German rocket scientists.

A globally linked telecommunications system developed by JPL tracked Explorer 1 and received its scientific data as it circled Earth. Amateur radio operators around the world were invited to listen in on Explorer 1's radio communications, including one key amateur radio shack operated largely by JPL ham radio operators at the Los Angeles County Sheriff's substation in Temple City, near JPL.

The most difficult technical challenge, said Pickering, "was getting the three rocket stages to work consistently, to get it all to go in the right direction, with no guidance system." Considering the telecommunications and computing capability of the Explorer 1 era versus that available for last summer's Mars Pathfinder mission, Pickering said, "it's astonishing to think what has happened over 40 years."

Donna Shirley, Mars Exploration program manager at JPL, was in high school when the news hit that Explorer 1 had been launched. "It was a terrific emotional moment," she recalled. "It seemed like a scary thing that the Soviet Union was so powerful that they could launch Sputnik. When Explorer went up, it was, 'Rah, rah, our team!,'" she said. "It seemed to be framed in 'us versus them' rather than focused on the real technical and scientific achievement. But the dawn of the Space Age affected my life a lot. I don't think the 'right stuff' to work in the space program has really changed all that much" since the days of Explorer 1, said Shirley. "You don't have cigar-smoking guys with slide rules anymore, but I think the 'right stuff' is still the same: dedication and competence."

In late 1958, JPL was reassigned from the U.S. Army to NASA when the civilian space agency was created. The laboratory has gone on to help lead the world's exploration of space with robotic spacecraft since then.

As the size of NASA's space missions takes advantage of miniaturized electronics to shrink in order to fit the new "faster, better, cheaper" mold, some complete space science instrument packages are about the size of that on tiny Explorer 1, Shirley said. "Miniaturization is allowing us to shrink down the brains of our spacecraft but still allows us to do more with them than we used to. The challenge now is to shrink the rest of the spacecraft down."

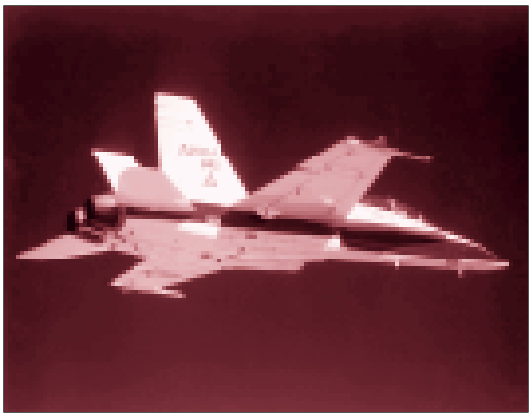
Considering the future of space science, Van Allen observed that "there is no shortage of great ideas on what we'd like to do. 'Faster, better, cheaper' is NASA's mantra, and the recent successful launch of the Lunar Prospector spacecraft is the best example of that. But the Hubble Space Telescope is a good example of big projects that will continue to be conducted. I think we have a very bright future in space science in all areas. There is good public support," he said. "There is virtually no limit to what can be investigated in interplanetary science and astronomy."

For more information, contact Winston Gin at Jet Propulsion Laboratory.
818/354-0300, 818/354-3122, *Winston.Gin@jpl.nasa.gov*
Please mention you read about it in *Innovation.*

All-Electric Airplanes Prove Efficient

ENGINEERS AT NASA'S DRYDEN FLIGHT Research Center in Edwards, California, have completed tests on a device that paves the way for developing future all-electric airplanes. These planes could be safer and more fuel efficient than today's aircraft.

Called the Electro-Hydrostatic Actuator (EHA), the device eliminates or minimizes airborne dependence on pneumatic, hydraulic and mechanical systems. Along with related electrical systems, it also could lead to a 5- to 9-percent fuel savings on an all-electric passenger plane, a 30- to 50-percent reduction in ground equipment, and a reduction in the vulnerability of military aircraft in combat situations.



NASA's F/A-18 is a former Navy fighter aircraft modified to test new and advanced aviation technologies.

The EHA uses an electric motor to drive a hydraulic pump and relies on local hydraulics for force transmission without using or interfering with the aircraft's central hydraulics. The EHA contains its own hydraulic fluid reservoir/accumulator. Its two back-to-back check valves allows the reservoir to replenish fluid in the balanced actuator cylinder. The EHA performed as well as a standard actuator and completed 36 hours of flight, said Robert Navarro, Dryden's principal investigator.

The actuator does not require active cooling and has a solenoid-operated bypass shutoff valve that reverts to cycling the fluid through one orifice. It also has components that provide measurements and position feedback.

The device, designed as part of a joint Air Force-Navy-NASA effort, was tested on the left aileron of NASA's F/A-18 Systems Research Aircraft.

Taking its signals from the aircraft's flight-control computers, the EHA uses its electronics to "fool" aircraft computers into thinking a standard actuator is on board. The device contains a small amount of hydraulic fluid and uses an electric motor to drive its pump, creating a force that moves the aileron.

For many years, NASA, the U.S. Air Force and the U.S. Navy have sought to eliminate sophisticated but heavy hydraulic systems in aircraft in favor of electrical "power-by-wire" systems for operating flight controls. Besides savings in costs and support, electrical systems promise diminished vulnerability in combat by eliminating hydraulic lines in the fuselage and wing box. The power-by-wire arrangement also will reduce complexity and improve reliability.

The EHA is part of the Electrically Powered Actuation Design Program. The U.S. Air Force Research Laboratory, located at Wright-Patterson Air Force Base in Ohio, manages the overall program. Dryden is responsible for flight safety and provided ground testing for the actuator and the necessary data acquisition systems. Dryden also installed and integrated it in the F/A-18.

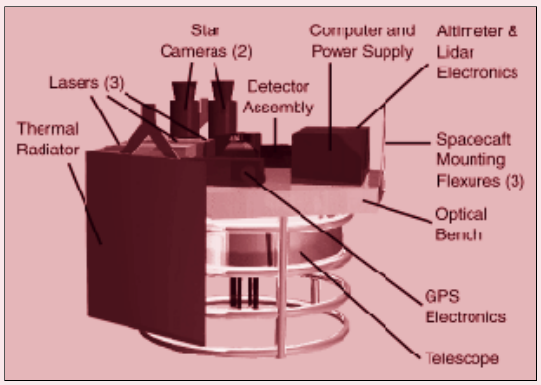
The device is the second of three actuators being tested. It will continue to fly aboard the F/A-18 until it is replaced by the Electro-Mechanical Actuator. The Air Force is sponsoring this mechanical actuator, which is powered by electronics.

For more information, contact Robert Navarro at Dryden Flight Research Center. 805/258-3193, *Robert.Navarro@mail.dfrc.nasa.gov* Please mention you read about it in *Innovation.*

ICE SPACECRAFT ELEVATES COMMERCIAL APPLICATIONS

A laser study about the growth or shrinking of the Earth's polar ice sheets and the future rise and fall of global sea level will also measure land topography for a variety of scientific and potential commercial applications. The Laser Altimetry Mission, recently known as ICESAT—for Ice, Cloud and land Elevation Satellite—will accurately measure the elevations of Earth's ice sheets, clouds and land, as well as the heights of clouds for studies of Earth's temperature balance.

The Laser Altimetry Mission is scheduled to be launched in a near-polar orbit in July 2001. The Greenland and Antarctic ice sheets cover 10 percent of Earth's land area, and they contain 77 percent of Earth's fresh water and 99 percent of its glacier ice. Measurements of the ice sheets are essential for assessing whether future changes in ice volume will add to the sea-level rise, which is already occurring, or whether the ice sheets might grow and absorb a significant part of the predicted sea-level rise.



Results from the Laser Altimetry Mission could result in commercial applications.

The laser altimeter, being developed at Goddard Space Flight Center, will provide precise elevation of the land, ice and clouds that are overflown. The laser transmits short pulses of infrared light and visible-green light to measure ice sheet elevation and land topography (infrared light) to measure clouds and aerosols (green light). The distance from the spacecraft to clouds and to Earth's surface will be determined from measurements of the time taken for the laser pulses to travel to these targets and return.

For more information, contact Joe Dezio at Goddard Space Flight Center. 301/286-5102, 301/286-1736, *jdezio@pop400.gsfc.nasa.gov* Please mention you read about it in *Innovation.*

Getting a Grip on Runaway Runways

NASA IS LEADING AN INTERNATIONAL EFFORT to create a system that allows airport operators to get a better handle on winter weather conditions to reduce the amount of accidents attributed to ice and snow on runways. A research team spent time in Canada proving technology concepts for a better understanding of runway friction, improved tire designs, better chemical treatments for snow and ice, and new types of runway surfaces that minimize bad weather effects.

In spite of advances in technology and operational procedures, safe winter operations remain a challenge for airport operators, air traffic controllers, airline personnel and pilots who must coordinate their efforts under rapidly changing weather conditions. In response, the research team developed an international runway friction indexing method tested on wintry runways at the Jack Garland Airport in North Bay, Ontario, Canada, about 200 miles north of Toronto.

Researchers are comparing friction measurements from ground-friction-measuring vehicles and research aircraft in different winter runway conditions. The team is midway through a five-year study called the Joint Winter Runway Friction Measurement Program, which is also expected to help relieve airport congestion during bad weather.

Inaccurate, incomplete or confusing runway surface information has been a contributing factor in a number of cases in which airliners have slid off the end of the runway upon takeoff or landing or have been dangerously slow in reaching liftoff speed because of the slowing effect of snow, ice or rain. An aircraft's loss of traction has been a factor in approximately 30 airplane accidents between 1983 and 1995, according to reports from the National Transportation Safety Board.

Once confident in the new indexing method, the research team will focus on relating it to different aircraft types and sizes. "The index will be a single, accurate and easy-to-use tool to help both pilots and airport operators worldwide quickly assess winter runway conditions," said Thomas Yager, lead NASA engineer, who is based at the Langley Research Center in Hampton, Virginia.

The index—probably in the form of a simple chart—will help pilots with "go/no-go" runway decisions based on readings taken by a ground-friction-measuring vehicle on the same runway. The index will help airport operators determine whether their runways are suitable for aircraft operations and when maintenance is required.

Getting a grip on runaway runways is a joint effort led by NASA and Transport Canada, with support from the Federal Aviation Administration (FAA), the Canadian National Research Council and several airframe manufacturers. European and Scandinavian countries are also participating.

The study contributes to NASA's recently established effort to reduce the U.S. aircraft accident rate by a factor of five within 10 years, while maintaining safety. NASA also has the goal of tripling airline system capacity in all weather conditions within 10 years.

For more information, contact Tom Yager at Langley Research Center.
757/864-1304, 757/864-8090, T.J.Yager@larc.nasa.gov
Please mention you read about it in *Innovation.*

"Go/no-go" icy runway decisions could be helped with results from current international runway friction index testing.

QwikBoost™ Raises Engine Performance

SMALL BUSINESS INNOVATION RESEARCH (SBIR) Phase I and II contracts from NASA's Goddard Space Flight Center aided Mainstream Engineering Corporation of Rockledge, Florida, in its development of a unique, low-cost additive that increases the performance of air conditioners, heat pumps, refrigerators and freezers. QwikBoost™ works by increasing the cooling capacity of refrigerant. It travels through a refrigeration system much as a lubricant circulating through a system.

QwikBoost™ is effective because of its high affinity for liquid hydrofluorocarbon (HFC) and hydrochlorofluorocarbon refrigerants. When combined, these elements create a significant heat solution (heat gained or lost when two or more chemicals are mixed to form a solution). This solution heat increases the available cooling capacity of the refrigerant during evaporation, providing an increase in the performance of the system. Once the additive is introduced into the system, it remains active for the life of the system and does not need to be replaced.

ONCE THE ADDITIVE IS INTRODUCED INTO THE SYSTEM, IT REMAINS ACTIVE FOR THE LIFE OF THE SYSTEM AND DOES NOT NEED TO BE REPLACED.

QwikBoost™ debuted at the 1998 International Air Conditioning, Heating, and Refrigeration Exposition. The compound is now commercially available in a packaged, handy three-ounce can (pressurized with R-134a) for automotive air conditioning applications.

Performance and capacity improvements were demonstrated in HFC-134a refrigerator/freezer systems and in HFC-134a automotive air conditioning systems using this blend. Increases in cooling capacity ranging from 5 to 10 percent were demonstrated in an automotive air conditioning system operating with a 10-percent concentration of this additive in the lubricant. Increased automotive air conditioning cooling capacity means faster automobile cool-downs and greater cooling capability—a feature that meets the reduced capacity requirements of new automobile air conditioning systems operating with R-134a refrigerant.

This inexpensive additive developed from spacecraft heat rejection systems increases engine performance.

Lubrication and compressor life tests were also performed and confirm that the QwikBoost™ solution does not adversely affect system lubrication or compressor life. Lubrication tests (Falex Pin and Vee Block Test) performed by an independent laboratory showed that adding this solvent to a lubricant resulted in reduced wear properties compared to using lubricant alone. Also, more than 100,000 hours of compressor life tests were performed on reciprocating, scroll and rotary compressors. These tests indicated that QwikBoost™ reduced the accumulation of wear metals in the lubricant.

Energy efficiency and environmentally friendly benefits of this new compound earned its commercial developer and manufacturer, Mainstream, a Tibbetts Award—a prestigious national award given by the Small Business Administration for significant technological accomplishments and associated business successes—during a White House ceremony last year in October.

This technology was originally developed for advanced heat pumps for spacecraft heat rejection

systems. One of the evaluation systems, based on a chemical/mechanical heat pump, led to the development of this performance-enhancing additive.

For more information, contact E. James Chern at Goddard Space Flight Center. 301/286-5836, *engmin.j.chern.1@gsfc.nasa.gov* Or contact Nancy A. MacLennan, Small Business Innovation Research (SBIR) program, at Goddard. 301/286-6705, *nancy.a.maclennan.1@gsfc.nasa.gov* Or contact Larry Grzyll at Mainstream Engineering Corporation. 407/631-3550, *lrg@mainstream-engr.com* Please mention you read about it in *Innovation.*

Safer Travel Possible With Sensor

JET AIR TRAVEL COULD BE SAFER, MORE FUEL efficient and subsequently less costly by using an optical sensor developed by an Andover, Massachusetts, company under a Small Business Innovation Research (SBIR) program contract with Dryden Flight Research Center. The Air Mass Flux Sensor, developed by Physical Sciences, Inc. (PSI), detects the density and velocity of air passing through an aircraft engine and provides airflow data without interrupting airflow through the engine.

"No aircraft engine currently in production carries any instrument to precisely measure how much air is flowing through it," said Dr. Mark Allen, PSI manager of aeropropulsion technologies. The current mechanical premise used to build aircraft engines—more fuel pumped equals faster travel, less fuel is slower—is logically effective, but not entirely efficient, according to Allen. A jet engine is similar to a pump pushing through the atmosphere, explains Allen. To efficiently control how hard an engine needs to pump, the quantity of air flowing through the pump needs to be known.

The sensor uses a diode laser, similar to the laser in a compact disc player, that shines upstream of the main part of an engine to measure the amount of airflow. The small, lightweight package does not interfere with engine operation.

PSI's Air Mass Flux Sensor makes it possible to determine the optimal amount of fuel necessary to fly an aircraft in given atmospheric conditions. The application of the optical sensor to commercial airline carriers will support enhanced fuel efficiency and lower flight costs. The Air Mass Flux Sensor also has the potential to increase air safety because of its ability to rapidly detect changes in engine operating conditions preceding hazardous events, such as compressor stall. "The Air Mass Flux Sensor broadens the envelope of the engine, permitting optimum engine performance," Allen said.

SBIR Phase I and Phase II contracts moved the air sensor idea from a concept on paper to a demonstrated prototype that was tested on a test stand with a full-scale engine from Pratt & Whitney, a producer of engines, components, modules

NASA LEWIS AWARDS $33 MILLION CONTRACT TO SMALL BUSINESS

NASA's Lewis Research Center in Cleveland, Ohio, has selected a small business in Cocoa, Florida, for a contract to provide maintenance, repair, operation and modification services for several systems and facilities at Lewis. Call Henry, Inc., a small business, has been awarded this performance-based, firm-fixed-price contract, valued at $6.6 million, for a period of one year, which started on March 1, 1998. There are also four planned option periods of one year each, with each year also valued at about $6.6 million. This contract has an "indefinite delivery/indefinite quantity" portion, which provides for firm-fixed-price delivery orders needed for major repairs or modifications to the systems maintained under the contract.

Services under this contract include fire alarms and extinguishing systems, high- and low-voltage electrical distribution, communications, elevators, heating, ventilating and air conditioning, chilled water, energy management control and utility distribution. The contractor will also operate the central and outlying heating plants. Call Henry's goal of subcontracting at least 15 percent to small disadvantaged businesses is in line with the government's goal requirements.

For more information, contact Mark Manthey at Lewis Research Center. 216/433-2750, 216/433-8000, *Mark.W.Manthey@lerc.nasa.gov* Please mention you read about it in *Innovation.*

and spare parts for the aerospace industry. Continued high-level development of the sensor was accomplished largely because of critical tests run at NASA's Lewis Research Center in Cleveland, Ohio, and on test stands at Dryden.

PSI began another Phase II SBIR program with Dryden to build the flight version of this product, scheduled to fly aboard the NASA-owned F-18 aircraft in early 1999. It will be the pioneering flight of an air mass flux sensor.

Components of the Air Mass Flux Sensor are cost-compatible with other engine sensor and control components. Assuming that operational and safety improvements are realized through ongoing engine and flight testing, incorporating the sensor into commercial and military aircraft technology would seem to be feasible within the next five years.

For more information, contact the Public Affairs Office at Dryden Flight Research Center. 805/258-3449, 805/258-3566, *pao@news.dfrc.nasa.gov* Please mention you read about it in *Innovation.*

Exhibit Provides Favorable Conditions

THE SMALL BUSINESS INNOVATION RESEARCH (SBIR) Technology Exhibit, the first of its kind, was held recently at Goddard Space Flight Center in Greenbelt, Maryland, to showcase SBIR contractors doing business with Goddard, while providing a favorable atmosphere for building business contacts. The day-long exhibit was held in conjunction with Goddard's Twenty-Fifth Annual Small and Small Disadvantaged Business Conference to give small businesses a forum for pursuing additional opportunities with Goddard, other government agencies and private industry to commercially market their technologies.

Research and development achievements were displayed by a variety of small businesses from all over the country, including Maryland, Virginia, Delaware, Pennsylvania, Florida and California. Companies' technical representatives shared information on technologies and innovations developed with funding from the NASA SBIR program. Eighteen SBIR companies exhibited 20 NASA/Goddard-developed SBIR technologies, and approximately 200 participants attended the informative, cutting-edge displays and demonstrations and picked up company literature.

Several of these SBIR companies have converted NASA-developed technologies into commercial products. This includes a Florida company that developed a unique, low-cost additive that increases the performance of air conditioners, heat pumps, refrigerators and freezers (see page 18).

The entire NASA SBIR and Small Business Technology Transfer Research (STTR) proposal solicitation and evaluation processes are supported by the work of an SBIR contractor. REI Systems, Inc., McLean, Virginia, has developed a web-based electronic handbook system to manage complex, distributed, information-intensive processes in an integrated and intuitive environment.

Two NASA/Goddard SBIR companies (Composite Optics, Inc., of San Diego, California, and Illgen Simulation Technologies, Inc.) were selected as presenters at the 1998 Semi-Annual Science Forum. Each high-tech small company presented its technical capabilities to key NASA personnel, including management, scientists, engineers, procurement specialists and major prime contractors. This forum provided these small firms with a significant marketing opportunity.

Paul Mexcur, the NASA SBIR and STTR Program Manager, presented an overview of the NASA SBIR program. Dr. E. James Chern, SBIR/STTR Program Manager at Goddard, presented information on NASA/Goddard programs. The event, sponsored by Goddard's Technology Commercialization Office, brought forth positive interaction about the technologies on display and their potential relevance to planned and current projects.

The NASA SBIR/STTR program is now available on the World Wide Web at *http://sbir.nasa.gov*. The site provides comprehensive information on program solicitations, participation guidelines and the NASA Small Business Innovation Center, a growing resource for locating technologies and partners.

For more information, contact E. James Chern at Goddard Space Flight Center. 301/286-5836, *engmin.j.chern.1@gsfc.nasa.gov* Or contact Nancy A. MacLennan, SBIR program, at Goddard. 301/286-6705, *nancy.a.maclennan.1@gsfc.nasa.gov* Please mention you read about it in *Innovation.*

Weather Channel in Every Cockpit

NASA IS MOVING A STEP CLOSER TO PROVIDING up-to-the-minute, graphical "weather channel"–style displays in the cockpits of commercial airliners and general aviation aircraft. A new NASA aviation safety initiative has just selected research proposals from eight industry teams to develop the Aviation Weather Information (AWIN) systems.

"Pilots tell us their number-one priority is graphical weather information. We want to make it as easy to get a weather channel in the cockpit as it is in your living room. Technologies already exist that could help make that happen," said NASA Aviation Safety Program (AvSP) Director Michael Lewis, based at the Langley Research Center in Hampton, Virginia.

NASA envisions a futuristic system that would allow aircraft to be both a source and user of weather information. Airborne sensors would provide data for weather systems on board the plane, on the ground and in other aircraft. The cockpit would be equipped with easy-to-read, real-time displays that show weather conditions across the country, allowing pilots to more easily monitor possible trouble spots and make better, more cost-efficient routing decisions.

AWIN weather information would get to and from aircraft by satellite and ground transceivers using broadcast datalink and two-way communications systems. Many industry teams also propose to incorporate decision aids into their AWIN designs. Those could include, among other tools, alarm systems or displays of suggested routes to help pilots better avoid potentially hazardous weather situations.

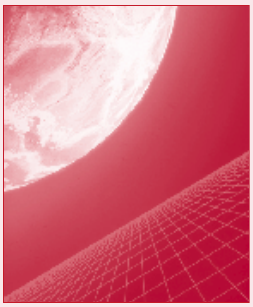
The weather information selections are one of NASA's new investments in the ambitious challenge from President Clinton last year—to reduce the fatal aircraft accident rate by 80 percent in 10 years and by 90 percent over two decades. AvSP is a partnership with the Federal Aviation Administration (FAA), the aviation industry (manufacturers and operators) and the Department of Defense. This partnership supports President Clinton's national goal.

U.S. companies submitted more than 40 proposals for research, development, prototyping and implementation of AWIN systems and components in three weather information categories: a national and worldwide system, a general aviation system and topical areas or specific components. The proposals were evaluated on technical merit, cost and feasibility.

NASA has set aside more than $8 million, which will be matched by industry, to fund AWIN projects over the next 18 months. More money is expected to be designated later to accelerate commercialization and make some systems available within five years. The AWIN industry teams list may be accessed at: *http://oea.larc.nasa.gov/news_rels/1998/May98/98_23.html*

For more information, contact Charles Scanlon at Langley Research Center.
757/864-2034, 757-864-8858, c.h.scanlon@larc.nasa.gov
Please mention you read about it in *Innovation*.

The Transport Systems Research Vehicle, used as a project research tool, includes cockpit weather information.



Technology Opportunity Showcase *highlights some unique technologies that NASA has developed and which we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in* Innovation.

New Opportunities at Ames and Lewis

Toughened Uni-Piece Fibrous Insulation

Ames Research Center is offering licensing options to manufacture and distribute, as well as seeking industry partnerships to further develop, a low-density rigid ceramic composite called Toughened Uni-Piece Fibrous Insulation (TUFI) with multiple applications. Its resistance in extreme heat environments is between 20 to 100 times more than coating currently used on Space Shuttle reusable surface insulation tiles. TUFI performs well in a convectively heated environment at temperatures in excess of 1,260 degrees Celsius (2,300 degrees Fahrenheit), and it is very lightweight. It can be machined and molded and has manipulative properties, such as density, thickness, and surface porosity. TUFI can be used in construction for improved, lightweight drywall, ceiling material and roofing shingles. It can also be used to insulate boxes for electrical units and wiring, to make lightweight tools designed to work with heated objects or to make bricks for use in furnaces and fireplaces in which temperatures do not consistently exceed 2,200 degrees Fahrenheit. TUFI is easy to waterproof, possesses superb insulating qualities to enhance existing thermal and acoustic insulation in any structure and can be custom-tailored. TUFI is a new process resulting from an effort to improve reusable surface insulation coatings, in which the system's surface density was intentionally reduced from that of the fully dense reaction cured glass coatings on the Space Shuttle.

Liquid Crystal Coating Method

Licensing opportunities are available for U.S. companies interested in developing commercial applications of Ames Research Center's liquid crystal coating method. This technique, which measures surface stress patterns, is inexpensive, requires no surface penetration and produces immediate full-surface cause-and-effect results. It uses rapid, continuous and nonintrusive measurements of surface shear stress magnitude to identify frictional forces generated by gases or liquids. The coating is applied to the test surface and illuminated by a white light source, and the reflected color patterns are recorded using a color video camera. Time responses are in milliseconds, and the accuracy is equivalent to existing point-measurement sensors. Commercial uses for this diagnostic method include road testing of high-performance racing equipment and various types of wind tunnel testing for fixed-wing aircraft and components, automotive designs and components, and missile configurations. It can also be used in laboratory testing of dynamic air flowing around buildings or structures, as well as scientific, medical or engineering fields in which the measurement of high-speed internal flows through channels, pumps or compressors is needed.

For more information regarding the above two Ames technologies, contact Technology Access at the National Technology Transfer Center. 800 678-6882, *technology@nttc.edu* Please mention you read about it in *Innovation.*

Affordable Silicon Carbide–Based Ceramics and Fiber-Reinforced Composites

NASA is seeking to transfer a fabrication approach for silicon carbide–based ceramics and fiber-reinforced composites. NASA is looking for companies interested in developing and commercializing these materials for a variety of low- and high-temperature applications developed at the Lewis Research Center in collaboration with NYMA, Inc. The precursor materials used in this approach, which has near-net and complex shape capabilities, are low cost and can be used in hot sections of jet engines, such as the combustor liner of the high-speed civil transport, nose cones and leading edges of reentry vehicles and hypersonic aircraft. Applications in the energy industries include radiant heat tubes, heat exchangers, heat recuperators, ceramic burner inserts and components of land-based turbines for power generation. All of the constituents are on-the-shelf, low-cost chemicals. The process requires no special handling and low or no-cost tooling, and it can be carried out below 1,500 degrees Celsius for relatively short durations. The key properties of these materials, such as strength and toughness, creep, and environmental and thermal shock resistance, can be modified to accept virtually any type of fiber and fiber architecture. The fabrication parameters have been optimized, and properties of the resulting materials have been tested at Lewis. Additional development might be needed, however, to optimize and further refine the priorities for specific applications.

For more information, contact Don Costello at Lewis Research Center. 216/433-6635, *Donald.E.Costello@lerc.nasa.gov* Please mention you read about it in *Innovation.*

NCTN DIRECTORY

Moving Forward

NASA Field Centers

Ames Research Center
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

Caroline Blake
Ames Research Center
Moffett Field, California 94035-1000
650/604-0893
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Eugene (Lee) Duke
Dryden Flight Research Center
Edwards, California 93523-0273
805/258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

George Alcorn
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
george.e.alcorn.1@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics, and Autonomous Systems.

Merle McKenzie
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-2577
merle.mckenzie@jpl.nasa.gov

Johnson Space Center
Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations

Henry (Hank) Davis
Johnson Space Center
Houston, Texas 77058
281/483-0474
henry.l.davis@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

Gale Allen
Kennedy Space Center
Kennedy Space Center,
Florida 32899
407/867-6226
gale.allen-1@kmail.ksc.nasa.gov

Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

Joe Heyman
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

Larry Viterna
Lewis Research Center
Cleveland, Ohio 44135
216/433-3484
Larry.A.Viterna@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, Nondestructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

Sally Little
Marshall Space Flight Center
Huntsville, Alabama 35812
256/544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
601/688-1914
kirk.sharp@ssc.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker
Ames Technology Commercialization Center
San Jose, CA
408/557-6789

Lyn Stabler (Acting)
Mississippi Enterprise for Technology
Stennis Space Center, MS
601/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
216/586-3888

Thomas G. Rainey
Florida/NASA Business Incubation Center
Titusville, FL
407/383-5200

Small Business Programs

Carl Ray
NASA Headquarters
Small Business Innovation Research Program (SBIR/STTR)
202/358-4652
cray@hq. nasa.gov

Paul Mexcur
Goddard Space Flight Center
Small Business Technology Transfer (SBIR/STTR)
301/286-8888
paul.mexcur@pop700.gsfc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
213/743-2353

Dr. William Gasko
Center for Technology Commercialization
508/870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
352/294-7822

Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
409/845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
412/383-2500

Christopher Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
440/734-0094

Joseph P. Allen
National Technology Transfer Center
Wheeling Jesuit University
800/678-6882

Doris Rouse
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC
919/541-6980

NASA ON-LINE

Go to **NASA's Commercial Technology Network (CTN)** on the World Wide Web at ***http://nctn.hq.nasa.gov*** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

Events

The second ***Ultra Long Duration Ballooning Technology Workshop*** will be held November 12–13, 1998, at NASA's Goddard Space Flight Center in Greenbelt, Maryland. The two primary objectives of the workshop are to identify the types of technology needed to support very long-duration balloon science missions and to identify, for the commercial technology providers, what sources of funding are available to build these technologies and how to access these funds successfully. For more information, contact Dr. Jack Tueller at 301/286-4678 or *tueller@gsfc.nasa.gov,* or visit our web site at *http:///lheawww.gsfc.nasa.gov/docs/balloon/ULDBWorkshopGenInfo.html*

Tech East '98' will debut on November 3–5, 1998, at the Hynes Convention Center in Boston. Tech East '98' will consist of six shows: Photonics East, Technology 2008, Small Business Tech Expo, Electronic Imaging, New England Design & Manufacturing Expo and National SBIR Conference. For more information, call 212/490-3999. For more information on the Small Business Tech Expo and SBIR conferences, call 360/683-1828.

Inspection98 will be held October 14–16, 1998, at NASA's Johnson Space Center to expand the opportunities for using NASA-developed technologies to solve problems on Earth and to identify areas in which collaborative work would provide better approaches for all partners. More than 200 technology presentations and exhibits in up to 20 different facilities will be showcased by experts in engineering, science and technology transfer. For more information, call 281/244-1316, e-mail *inspection@jsc.nasa.gov* or visit *http://inspection.jsc.nasa.gov*

"Turning Goals Into Reality," a one-day seminar about the goals and highlights of economic and social benefits of sustained U.S. leadership in aviation and space with conference sessions, will be held October 9, 1998, at NASA's Lewis Research Center in Cleveland, Ohio. Progress on the Aeronautics and Space Transportation Technology Enterprise program will be reported. Programs and topics will be organized for three main audiences—education/K–12, industry/university, and the public. For more information, visit *http://www.hq.nasa.gov/office/aero/conf98*

PRINTED WITH SOY INK

Printed on Recycled Paper
Please Recycle

National Aeronautics and
Space Administration

Office of Aeronautics and Space
Transportation Technology, Code R
Washington DC 20546-0001

OFFICIAL BUSINESS
Penalty for Private Use $300

PRE-SORT
FIRST CLASS MAIL
POSTAGE & FEES PAID
NASA
PERMIT NO. G27