AEROSPACE TECHNOLOGY

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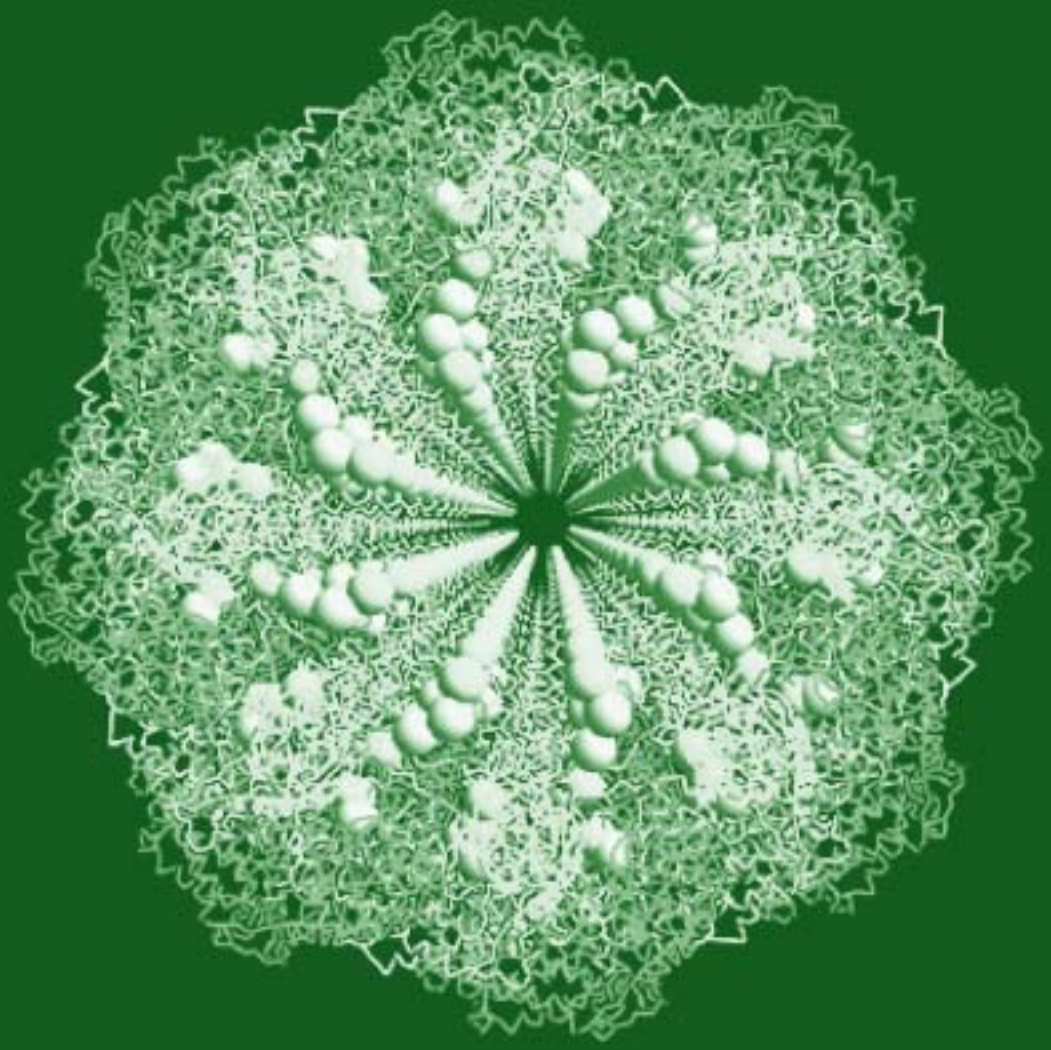

Convergence of Biotechnology, Information Technology and Nanotechnology: A NASA Perspective

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New Alloy Could Reduce Emissions
Interactive Training Tool Makes General Aviation Safer

NASA

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About the Cover:
Protein-based nanotubes are potentially capable of self-organization and replication.

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

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Commercial Development Mission Update

Date	Flight	Payload	Sponsor/Coordinator
10/2/02	9A, STS-112	Plant Generic Bioprocessing Apparatus (PGBA)	Bioserve Space Technologies
		Commercial Generic Bioprocessing Apparatus (CGBA)	Bioserve Space Technologies
		Zeolite Crystal Growth (ZCG) Samples	Center for Advanced Microgravity Materials Processing
11/10/02	11A, STS-113	Zeolite Crystal Growth (ZCG) Samples	Center for Advanced Microgravity Materials Processing
03/01/03	ULF-1, STS-114	Advanced Astroculture (ADVASC)	Wisconsin Center for Space Automation and Robotics
		Commercial Protein Crystal Growth (CPCG)	Center for Biophysical Sciences and Engineering
		Space Dynamically Responding Ultrasonic Matrix System (Space-DRUMS™)	Center for Commercial Applications of Combustion in Space

NASA's Nanotechnology Initiative

By Minoo N. Dastoor, PhD
Senior Advisor to the Associate Administrator
NASA Office of Aerospace Technology

A critical element of science missions and human exploration and development of space is safe and affordable access to space and dramatically reduced transit times for in-space transportation systems. Concurrently, NASA's aeronautics goals are focused on two areas. The first goal is developing technology to support new generations of aircraft that are safer, quieter, more fuel efficient, environmentally cleaner and more economical to operate than today's aircraft. The second goal is developing technology to enable new approaches to air systems management that can greatly expand the capacity of our air space and make it even safer than it is today. In pursuance of these goals, NASA needs tools and technologies that must push beyond the present state of the art. NASA spacecraft must function safely and reliably in the extremely harsh space environment. This places demands on NASA technologies—demands that are highly unique to the agency.

Virtually all of NASA's vision for the future of space exploration—and new generations of aircraft—is dependent upon mass, power requirements and the size and intelligence of components that make up air and space vehicles, spacecraft and rovers. Dramatic increases in the strength-to-weight ratio of structural materials offer the potential to reduce launch and flight costs to acceptable levels. Such structural materials can also lead to increases in payload and range for aircraft, which can translate into longer, more expansive missions. Packing densities and power consumption are absolutely critical to realizing the sophisticated on-board computing capability required for such stressful applications as autonomous exploration of planetary bodies for evidence of simple life forms or their precursors.

The integration of sensing, computing and wireless transmission will enable true health management of reusable launch vehicles and aircraft of the future. To do this, NASA aircraft and space systems will have to be much more capable than they are today. They will need biological characteristics that include autonomy to be able to think for themselves; self-reliance to identify, diagnose and correct internal problems and failures; self-repair to overcome damage; adaptability to function and explore in new and unknown environments; and efficiency to operate with very limited resources. These are typically characteristics of robust biological systems, and they will also be the characteristics of future aerospace systems. Acquisition of such intelligence, adaptability and computer power go beyond the present capabilities of microelectronic devices.

Current state-of-the-art microelectronics is rapidly approaching its limit in terms of feature size, and future enhancements will need novel alternatives to microelectronics fabrication and design as they are known today. The use of nanotechnology will afford a new class of electronics. Nanotechnology will, in addition to its inherent smaller feature size, harness the full power of quantum effects, which are operable only at nanoscale distances. Not only should performance enhancement at the quantitative level occur due to the higher packing density of nanoscale components, but also the emergence of qualitatively new functionalities associated with harnessing the full power of quantum effects. The hybridization of nanolithography and self-assembly could serve as the basis of an engineering revolution in the fabrication of complex systems.

We are already seeing the potential of nanotechnology through extensive research into the production and use of carbon nanotubes, nano-phase materials and molecular electronics. For example, on the basis of computer simulations and available experimental data, some specific forms of carbon nanotubes appear to possess extraordinary strength. The full potential of nanotechnology for the systems NASA needs is in its association with biology. Nanotechnology will enable us to take the notion of "small but powerful" to its extreme limits, but biology will provide many of the paradigms and processes for doing so. Biology has inherent characteristics that enable the building of the systems needed—selectivity and sensitivity at a scale of a few atoms; the ability of single units to massively reproduce with near-zero error rates; organizational capability to self-assemble into highly complex systems; the ability to adapt form and function to changing conditions; the ability to detect damage and perform self-repair; and the ability to communicate among themselves. Biologically inspired sensors will be sensitive to a single photon. Data storage based on DNA will be a trillion times more dense than current media, and supercomputers modeled after the brain will use as little as one billionth the power of existing designs.

Biological concepts and nanotechnology will enable the creation of both the "brains and the body" of future systems with the characteristics needed. Together, nanotechnology, biology and information technologies form a powerful and intimate scientific and technological triad. ❑

Cover Story

Convergence of Biotechnology, Information Technology and Nanotechnology: A NASA Perspective

The driving considerations for developing advanced technologies in the pursuit of NASA's goals and missions are cost, safety and the advancement of science that operate within the constraints of mass, power and radiation exposure. In this regard, the agency has embarked on a technology strategy that relies on the convergence of nanotechnology, biotechnology and information technology. It is expected that this triad of technologies will provide unprecedented benefits and solutions to the future grand challenges of space science and exploration. Currently, NASA's Bio/Nanotechnology program is apportioned primarily between the Office of Aerospace Technology (OAT), with a focus on nanotechnology research and applications, and the Office of Biological and Physical Research (OBPR), with a focus on basic research in nanoscience related to biomedical applications. Furthermore, the OAT program integrates nanotechnology development into three areas—materials and structures, nanoelectronics and computing, and sensors and spacecraft components.

NTTC's marketing team works closely with the NASA marketing team to develop and utilize a marketing strategy for NASA's commercial technology.

Materials and Structures

A major emphasis for the materials and structures area over the next five years will be the production and scale-up of homogeneous carbon nanotubes; the development of carbon nanotube-reinforced polymer matrix composites for structural applications; and the development of analysis and design tools to incorporate these materials into new vehicle concepts and validate their performance and lifecycles.

Furthermore, NASA will also explore the use of other nanotubes such as boron nitride for high-temperature applications and research the use of crystalline nanotubes to ultimately exploit the full potential of these materials. NASA studies indicate that nanotube composites can reduce the weight of a reusable launch vehicle by a factor of two over the best composite systems today and by 80 percent over current aluminum structures. Early studies also indicate that the dry weight of a large commercial transport could similarly be reduced by about half, resulting in a fuel saving of about 25 percent. In the long term, the ability to create materials and structures that are biologically inspired provides a unique opportunity to produce new classes of self-assembling material systems. Some unique characteristics anticipated from biomimetics ("mimicking" biology) include: multifunctional material systems, hierarchical organization, adaptability, self-healing/self-repair and evolvability. This will allow for the tailoring of the material properties to meet the design requirements and revolutionize aerospace and spacecraft systems.

Nanoelectronics and Computing

NASA has requirements for computers that provide extraordinary computational speed and memory, as well as powerful new electronic tools that can function as human cognitive prostheses. These machines will need to be manufactured from nanoelectronic devices that feature both low-power consumption and resistance to harsh radiation environments, revolutionizing the way NASA accomplishes its missions. Future space systems could have all of their electronic systems on a single chip, where the computing and memory necessary for guidance, navigation, communications and integrated vehicle health management (IVHM) reside. Such a capability will enable inexpensive and powerful microspacecrafts. Much of the technology to accomplish this is envisioned to come from the knowledge of biological systems, which can be up to a million times more power and mass efficient than conventional electronics, and are able to self-assemble and self-adapt to changing conditions, and self-repair when damaged.

Today, biologically inspired neural nets have been developed in simulated demonstrations that allow computers to rapidly account for loss of aircraft-control elements, understand the resulting aerodynamics and then teach the pilot or autopilot how to avoid the loss of

the vehicle and crew by an innovative use of the remaining aerodynamic control. Such approaches, coupled with the advances in computer power anticipated from nanoelectronics, will revolutionize the way "aerospacecraft" deal with condition-based maintenance, aborts and recovery from serious in-flight anomalies.

While global aeronautics do not require electronic devices that can tolerate ultra-high radiation, space exploration (both deep space as well as near-Earth orbits) will require such tolerance. NASA mission planners view such capabilities as enabling spacecraft to conduct in-situ science (without real-time Earth operators) where huge amounts of data must be processed, converted to useful information and then sent as knowledge to Earth with minimum bandwidth requirements. A longer-term vision incorporates the added complexity of morphing devices, circuits and systems whose characteristics and functionalities may be modified in flight. NASA will support work at the underlying device level, in which new device configurations with new functionalities may be created through intra-device switching. Combined research in the "zone of convergence" of nanotechnology, biotechnology and information technology will lead to the development of new nanoelectronics and computing devices to meet NASA's unique requirements.

Sensors and Spacecraft Components

NASA's challenge to detect ultra-weak signals from sources at astronomical distances makes every photon or particle a precious commodity which must be fully analyzed to retrieve all the available information it carries. Nanostructured sensing and spacecraft elements, in which each absorbed quantum is fully characterized so as to extract the full range of information, provide an approach to achieve this goal. NASA will also develop field and inertial sensors with many orders of magnitude enhancement in the sensitivity by harnessing quantum effects of photons, electrons and atoms. A gravity gradiometer based on interference of atom beams is currently under development by NASA with the potential to conduct space-based mapping of the interior of Earth or other astronomical bodies.

Miniaturization of entire spacecraft will entail reduction in the size and power required for all system functionalities, not just for sensors. Low-power, integrable nanodevices are needed for inertial sensing, power generation and management, telemetry and

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Using microgravity technology to look into the eye. Artwork courtesy of Glenn Research Center.

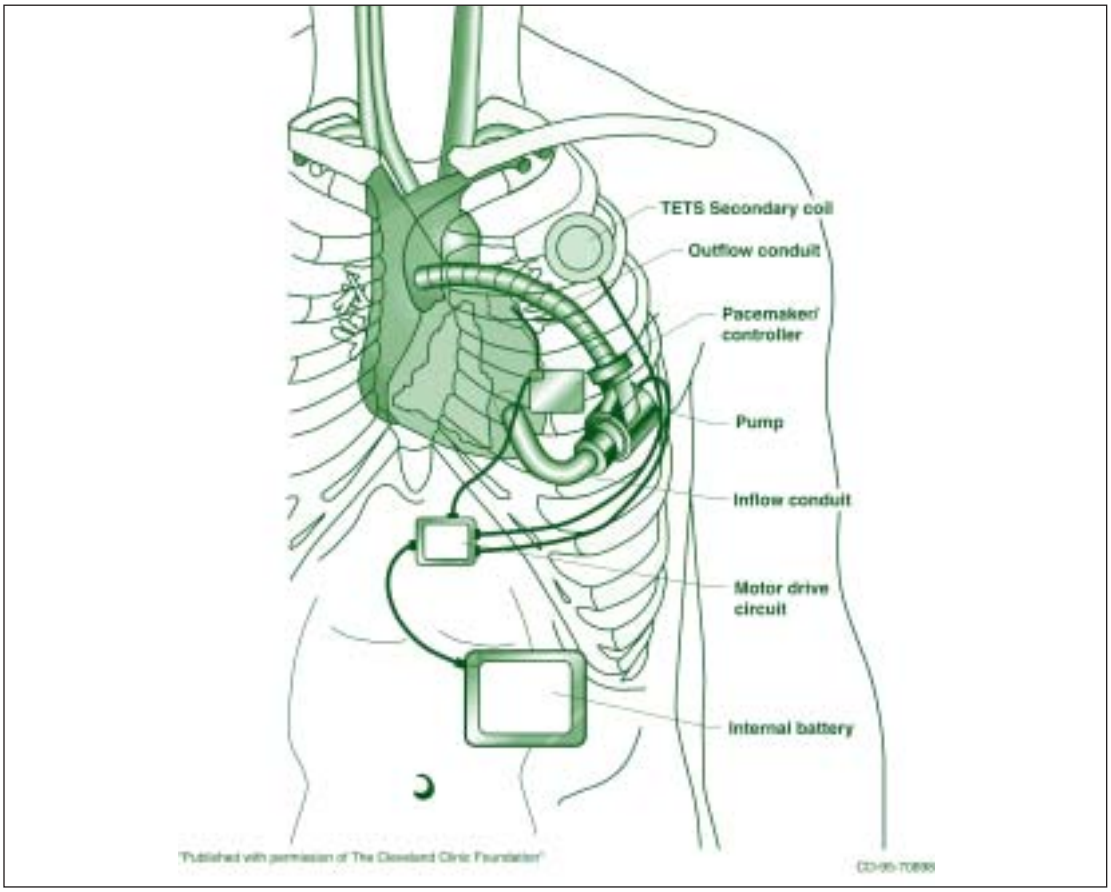
Continued from page 5

communication, navigation and control, propulsion and in-situ mobility, etc. Integrated nano-electro-mechanical systems (or NEMS) will be the basis for future avionics control systems incorporating transducers, electromagnetic sources, active and passive electronic devices, electromagnetic radiators, electron emitters and actuators.

Basic Nanoscience

Foremost among the technological challenges of long-duration human space flight are the dangers to human health and physiology presented by the space environment. Acute clinical care is essential to the survival of astronauts who must face potentially life-threatening injuries and illnesses in the isolation of space. Currently, NASA can provide clinical care and life support for a limited time, but the only existing option in the treatment of serious illness or injury is expeditious stabilization and evacuation to Earth. Effective tertiary clinical care in space will require advanced, accurate diagnostics coupled with autonomous intervention. This must be accomplished within a complex man-machine interface, in a weightless environment of highly limited available space and resources, and in the context of physiology altered by microgravity and chronic radiation exposure. Biomolecular approaches promise to enable lightweight, convenient, highly focused therapies, guided with the assistance of artificial intelligence. Nanoscopic, minimally invasive technologies for the early diagnosis and monitoring of disease and targeted intervention will ensure good health in space. Prompt implementation of specifically targeted treatment will ensure optimum use and conservation of therapeutic resources, making the necessity for invasive interventions less likely and minimizing possible therapeutic complications.

Together, nanotechnology, biology and information technologies form a powerful and intimate scientific and technological triad that will help shape the direction and success of NASA. ❑



This heart pump is an example of NASA's work in biotechnology. Artwork courtesy of Glenn Research Center.

Glenn Founds Biomedical Engineering Consortium

The Cleveland, Ohio biomedical community is coming together to make use of a $7.5-million NASA Office of Biological and Physical Research (OBPR) grant devoted to reaching NASA's goal of protecting astronauts' health while in long-term space flight.

A signing event that took place on June 7 in the Space Experiments Laboratory at NASA Glenn Research Center marked the starting point for interdisciplinary research and development in 10 biomedical areas. The signing ceremony cemented the establishment of a Biomedical Engineering Consortium (BEC), which consisted of the following members: NASA Glenn National Center for Microgravity Research, Case Western Reserve University, Cleveland Clinic Foundation and University Hospitals of Cleveland.

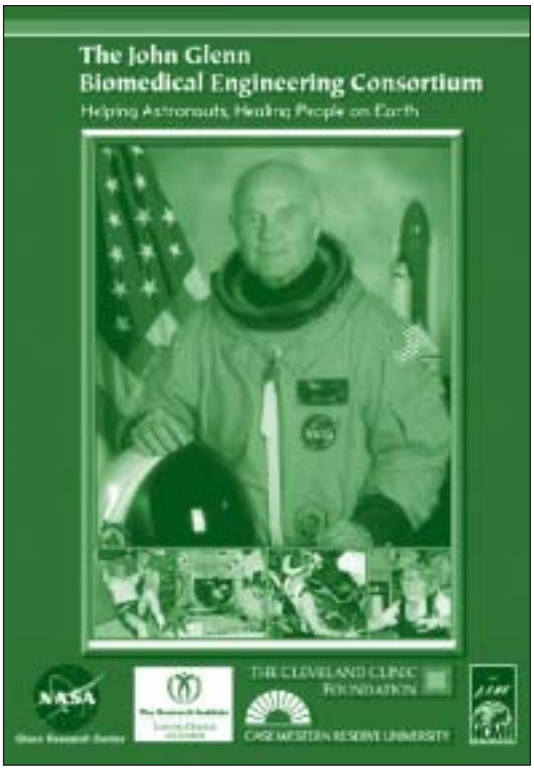
Bill Sanford, interim president of BioEnterprise Corporation, as part of the BEC concluded, "This is a terrific project for Northeast Ohio that will showcase the value of the space program, demonstrate the extraordinary biomedical engineering capabilities of our institutions, enhance the economic vitality of our region and contribute to a healthier population everywhere."

Over the next three years of funds dispersal, member organizations will pool their unique skills in the disciplines of physics, chemistry, biology and engineering to research human health, safety and performance in space. According to NASA's OBPR Associate Administrator, Mary Kicza, "Long-term space flight exposes human beings to physiological and psychological health risks from radiation, reduced gravity and isolation, and requires the ability to provide crew medical care remotely." Through medical research and projects concerning fluid physics and sensor development, new technologies could emerge that would be applicable to medical needs in space as well as on Earth.

While there are no known immediate threats to an astronaut's health while in space, it is thought that microgravity conditions can contribute to kidney stones, loss of protein or loss of calcium over the long term. Atmospheric conditions or altered body chemistry can cause an insufficiency in the body, preventing it from using nutrients to effectively conduct the amount of energy needed for upkeep or activity. Research on stress on the body over a long-term flight has not yet been thoroughly recorded or analyzed. ❑

The Cleveland, Ohio biomedical community is coming together to make use of a $7.5-million NASA Office of Biological and Physical Research (OBPR) grant devoted to reaching NASA's goal of protecting astronauts' health while in long-term space flight.

For more information, contact Marsha Nall at Glenn Research Center, ✆ 216/433-5374, ✉ *Marsha.M.Nall@grc.nasa.gov*. Please mention you read about it in Innovation.



The Biomedical Engineering Consortium (BEC) consists of the following members: NASA Glenn National Center for Microgravity Research, Case Western Reserve University, University Hospitals of Cleveland and Cleveland Clinic Foundation. Artwork courtesy of Glenn Research Center.

NorTech Recognizes Best New Products

Technologies developed at NASA Glenn Research Center will result in safer and less costly airplane engines, as well as more environmentally friendly materials used in those engines. These technology advances, Numerical Propulsion System Simulation (NPSS) and Environment Conscious Ceramics (Ecoceramics), were among the award recipients at the 2002 NorTech Innovation Award ceremony.

NPSS is considered a world-class propulsion system simulation tool that provides the US aerospace industry with unprecedented capability and ease of use. An emerging US standard for aerospace simulations, it was designed and is maintained with the full interaction of every major aircraft engine manufacturer in the world. This software tool will reduce the cost and risk associated with advanced propulsion system development. The reduced risk translates into increased safety for aeronautics and the human exploration of space.

Gregory J. Follen, Thomas M. Lavelle and Cynthia Gutierrez Naiman, employees of Glenn, and Bret A. Naylor, of Integral Systems Inc., worked with a team of 39 other engineers from Glenn and 14 other organizations in the development of this simulation tool.

Ecoceramics technology uses processes and materials that minimize harmful effects on the environment. The starting materials are renewable resources and environmental wastes, such as natural wood, sawdust or cellulosic fibers. The shaped preforms from these cellulosic materials are pyrolyzed and infiltrated with various non-oxide- and oxide-based materials to form ceramics with different compositions and densities. The process, resulting in lighter, less costly ceramics that can operate at high temperatures, is important in the development of more efficient airplane engines. The manufacturing process was developed by Dr. Mrityunjay Singh, an employee of QSS Group Inc., Cleveland, working in Glenn's Materials Division.

NorTech Innovation Awards, formerly known as the EDI Innovation Awards, are named for the Northeast Ohio Technology Coalition (NorTech), the technology affiliate of Cleveland Tomorrow. The awards honor innovators and companies for creating some of the best new products in Northeast Ohio. ❑

NPSS is considered a world-class propulsion system simulation tool that provides the U.S. aerospace industry with unprecedented capability and ease of use. Artwork courtesy of Glenn Research Center.

For more information, contact Dr. M. Singh at Glenn Research Center, ✆ 216/433-8883, ✉ *Mrityunjay.Singh@grc.nasa.gov*. Please mention you read about it in Innovation.

NASA to Partner in Sustainable Computing Consortium

NASA and a coalition of leading global businesses, world-class software developers and federal agencies, led by Carnegie Mellon University, recently announced the formation of the Sustainable Computing Consortium (SCC). The groundbreaking collaboration is designed to protect the nation's computing infrastructure and improve the reliability of its information technology systems.

This marks the first time that such a broad-based group of stakeholders has been formed to address issues relating to software dependability, quality and security. Software defects cost global business an estimated $175 billion in 2001. With the participation of top businesses, information technology developers and public policy experts, the SCC aims to be an essential forum and resource for matters relating to software development.

"Having worked with Carnegie Mellon on a number of initiatives relating to software dependability, we are pleased to see the university take on an initiative of this scope and scale," said Dr. Henry McDonald, director of NASA Ames Research Center located in California's Silicon Valley. "It is clear that our nation's computing infrastructure demands this kind of collaborative initiative, bringing together major players in business, industry and government to address these issues."

The purpose of the SCC is to foster the development of standards and methodologies to reduce software defects while quantifying and reducing the risks software flaws pose to the nation's computing infrastructure. At the same time, the SCC will bring together global businesses, software industry leaders and public policy experts to address policy, technical, legal and economical issues surrounding sustainable computing. Finally, the SCC will conduct independent research, provide measurement and design tools, and document best practices to quantify and improve software quality, dependability and security.

"The issue of ensuring software quality and security is one of the most important technical and public policy issues facing the nation and the world," said Jeffrey Hunker, dean of Carnegie Mellon's H. John Heinz III School of Public Policy and Management. "The mission of the SCC and its members will be to drive new developments in information technology and to produce groundbreaking research on software economics, risk management, auditing and liability."

The SCC will leverage nearly $30 million in research grants and membership commitments. Founding SCC members include: AIG, Alcoa, Caterpillar, Cisco, CMP Media LLC, Confluence, General Atlantic Partners, Mellon Financial Corp., Merck, Microsoft, NASA, Oracle, Pfizer, Raytheon, RedSiren Technologies, Reed Smith, Tata Consultancy Services, and the UPMC Health System. In addition, Carnegie Mellon's two-year-old High Dependability Computing Consortium, which includes 15 software industry companies and NASA, will form a High Dependability Working Group within the SCC.

An *InformationWeek* survey of IT professionals indicated that 89 percent of organizations that use IT have experienced software defects resulting in higher costs or lost revenue. Some 62 percent of respondents said the software industry was doing an unsatisfactory job of ensuring that commercial software is bug-free.

"We live in a digital world," said SCC director William Guttman, distinguished service professor of economics and technology at Carnegie Mellon's Heinz School. "It is a world of staggering complexity and scale, in which software plays an increasingly vital role in our daily lives. It is critical that business, industry,

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The groundbreaking Sustainable Computing Consortium is designed to protect the nation's computing infrastructure and improve the reliability of its information technology systems. Artwork courtesy of the Sustainable Computing Consortium.

Expanding Biotech Cooperation in Space

NASA Administrator Sean O'Keefe and Biotechnology Industry Organization (BIO) president Carl B. Feldbaum signed a memorandum of understanding to expand cooperation between NASA and the biotechnology industry.

"NASA currently supports cutting-edge basic and commercial biotechnology research and development," said O'Keefe. "We recognize the importance of biotechnology as an expanding industry with increasing significance for healthcare, agriculture, our economy and space exploration. This partnership helps NASA further the commercial use of space."

Citing NASA's participation at BIO conferences and meetings, Feldbaum said, "This agreement underscores the existing convergence of space technology and biotechnology. We've already seen biotech research underway in space. This agreement will promote investment by the biotechnology industry in commercial space development for the benefit of patients, consumers and our economy."

The memorandum builds on an already strong partnership by establishing three goals of collaboration —enhanced communication between NASA and industry; expanded commercial biotechnology space research and development; and formal and informal education of industry and the public regarding biotechnology and space research.

Biotechnology research already plays an important role in space. On Space Shuttle Endeavour's last trip to the International Space Station (ISS), a biotechnology company's experiment that will compare human liver cell function in space with that on Earth was transported. This research could aid in the development of treatments for those in need of liver transplants.

NASA will utilize space as a laboratory to test the fundamental principles of chemistry and biology, and BIO will provide the industry support needed to maximize both the research and potential commercial opportunities.

> "NASA currently supports cutting-edge basic and commercial biotechnology research and development," said O'Keefe.

BIO represents more than 1,000 biotechnology companies, academic institutions, state biotechnology centers and related organizations in all 50 US states and 33 other nations. BIO members are involved in the research and development of healthcare, agricultural, industrial and environmental biotechnology products. ❑

For more information, contact Barry Epstein at NASA Headquarters, ✆ 202/358-4434, ✉ *bepstein@hq.nasa.gov*. Please mention you read about it in Innovation.

NASA to Partner

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technology and public policy experts come together now to ensure that software meets the standards of quality, dependability and security that our modern world requires."

Co-directors of the SCC include William L. Scherlis, principal research scientist at the Institute for Software Research International (ISRI), a division of Carnegie Mellon's School of Computer Science, and Ashish Arora, associate professor of economics and public policy at the Heinz School. The SCC will leverage resources at several existing Carnegie Mellon research entities, including the Software Industry Center at the Heinz School, funded by the Alfred P. Sloan Foundation; the High Dependability Computing Program (HDCP) in the School of Computer Science, funded by NASA; the Software Engineering Institute, home to the federally funded Computer Emergency Response Team (CERT) Coordination Center; and the ISRI, which houses the Information Technology Services Qualification Center (ITSQC), a source of standards for rating outsourcing firms. ❑

For more information, contact Dr. Michael Evangelist at ✆ 650/603-7004, ✉ *wme@cs.cmu.edu*. Please mention you read about it in Innovation.

Infrared Camera's View Widens

Researchers at NASA Jet Propulsion Laboratory, in Pasadena, CA, have created the world's first four-band infrared focal camera that will allow them to "see" details in infrared that were unachievable with previous technology.

The detail provided by the new technology will give researchers a wider view in the field of remote sensing for pollution detection, weather prediction and a host of other vital atmospheric and geological applications on Earth. It will assist with monitoring crop health, tropical rainforest deforestation and industrial pollutants.

Although a part of the electromagnetic spectrum, human eyes cannot detect infrared light. It is, essentially, heat that is emitted from every object whose temperature is above absolute zero (about -273 degrees Celsius or -460 degrees Fahrenheit).

"This technology will revolutionize the way we develop new remote-sensing instruments," said team leader Dr. Sarath Gunapala, senior research scientist at JPL. "One such example is the detection of smog. Smog contains a range of chemicals, which only appear in certain infrared ranges. The multi-band capacity of the camera array will allow researchers a full spectral view to identify them."

The new four-band Quantum Well Infrared Photodetector camera can see up to 15.5 microns, or 15 one-millionths of a meter in the infrared. Its focal plane can be compared to the retina of an eye. More nerve endings on a retina provide more detailed sight. Thus, adding more pixels to the bands increases the detail and information the camera can capture. Each band, or focal plane, measures 128 by 640 pixels.

The existing one-band technology Quantum Well Infrared Photodetector technology developed at JPL has been licensed for various commercial applications, including noninvasive detection of breast and skin cancers. The camera also has proven useful to firefighters and television news helicopter crews by allowing them to see forest fire hot spots through heavy smoke.

The camera has already flown over and imaged parts of Africa as part of an international project to study the environmental impact of vegetation burning

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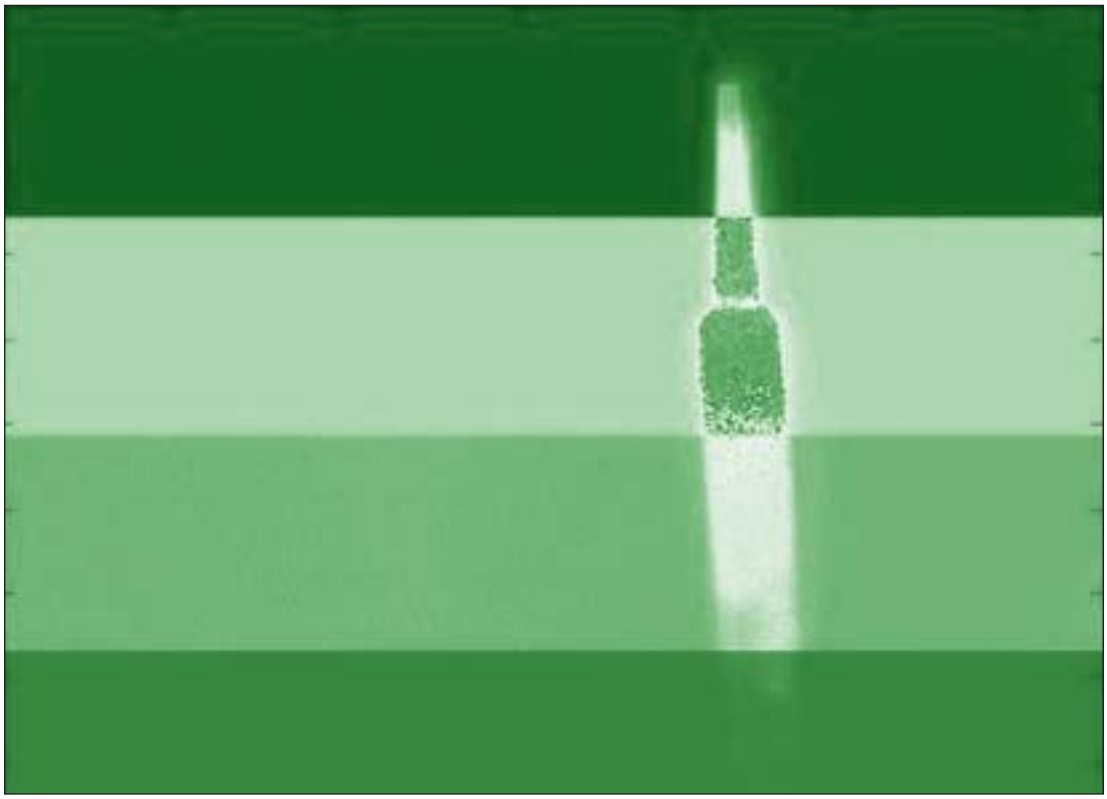

Each band in this false color image represents different wavelengths in the infrared. Artwork courtesy of Jet Propulsion Laboratory.

NASA to Aid Utility's Environmental Operations

Consolidated Edison of New York, Inc. (Con Edison) has turned to NASA to develop sensor technology to detect and quickly analyze hazardous materials in the field. Using the best available commercial methods can take several hours of laboratory analysis to determine how to protect the environment and public when there is an environmental incident. Con Edison hopes to reduce that time to less than one hour.

"At Con Edison, we are constantly searching for the best technology available to improve our operations," said Jerry Mele, Con Edison's director of the Corporate Environmental Department. "We are optimistic that NASA's sensor technology will help make our underground work more efficient and environmentally safer."

Con Edison recently signed a technology affiliate agreement with NASA Jet Propulsion Laboratory (JPL), in Pasadena, CA, to gain access to JPL researchers with experience in developing sensors. By becoming a technology affiliate member, Con Edison will work directly with JPL researchers to develop the sensors. It will search for two specific chemical families—polychlorinated biphenyl compounds, or PCBs, and perfluorocarbon tracers, or PFTs.

PCB is a toxic chemical that was used to insulate high-voltage transformers. It also prevents pipes from rusting, adheres to any surface, tolerates extreme heat and does not degrade. Prior to 1970, all major utility companies used PCB oil in their transformers. The United States banned the use of PCBs in the early 1970s.

The current method of identifying PCB concentrations at an environmental incident takes up to eight hours. The crew must drive to the location, take a sample of the suspect liquid or sludge, transport it to the analytical laboratory and then analyze the samples using a gas chromatograph system.

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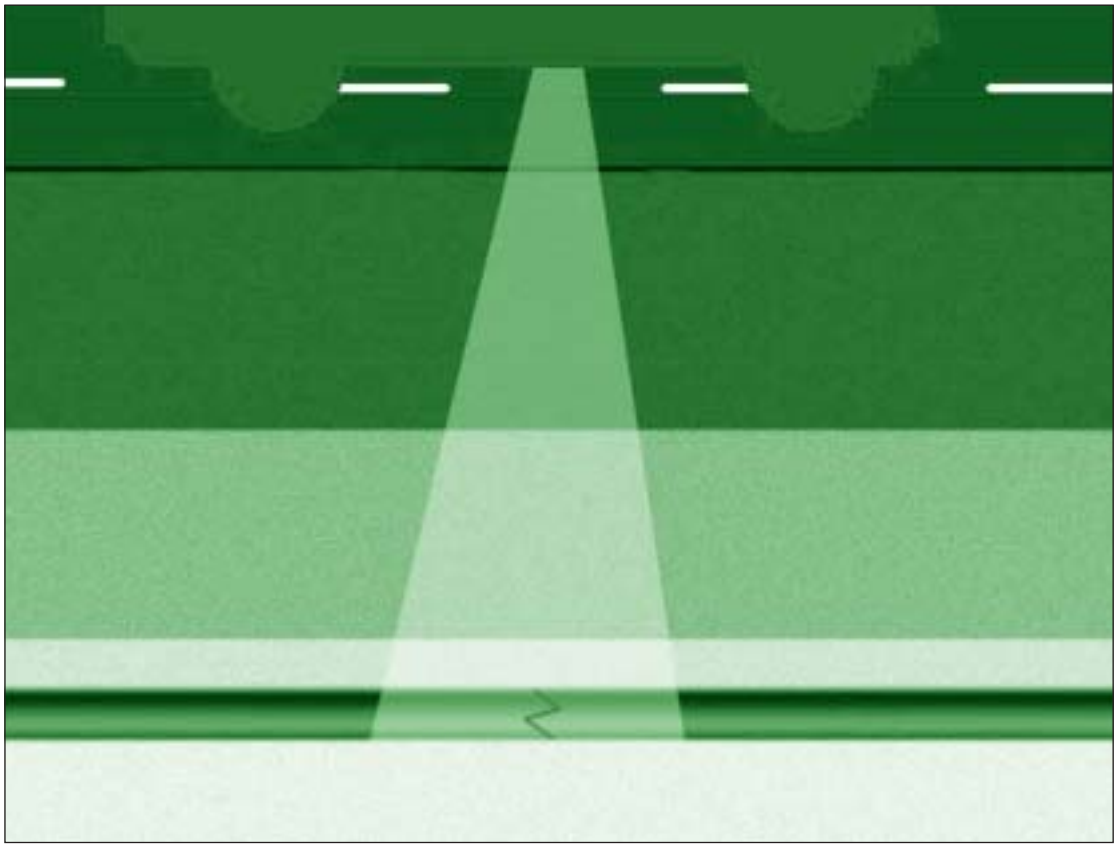


An artist's rendering of the subsystem detection system. Artwork courtesy of Jet Propulsion Laboratory.

New Alloy Could Reduce Emissions

A new high-strength aluminum-silicon alloy developed at NASA Marshall Space Flight Center, in Huntsville, AL, promises to lower engine emissions and could improve gas mileage in cars, boats and recreational vehicles. The new alloy, co-invented by Jonathan Lee, a NASA structural materials engineer, was originally developed for the automotive industry.

Although most Americans associate NASA with space flight, one of the space agency's missions is to share its cutting-edge technologies with US industry. "Partnerships with US industries are the main way NASA transfers these technologies to the public," explains Vernotto McMillan, deputy manager of Marshall's Technology Transfer Department.

Lee and co-inventor PoShou Chen, a scientist with Morgan Research Corp., began work on the new alloy seven years ago when a major automobile manufacturer approached NASA about developing a strong and low-cost aluminum alloy for use in a piston redesign that would lower engine emissions.

Lee and Chen came up with MSFC-398, a wear-resistant alloy that exhibits dramatic strength at temperatures as high as 500 to 700 degrees Fahrenheit. In fact, when tested at 600 degrees Fahrenheit, it is three to four times stronger than conventional cast-aluminum alloys. The new metal also can be produced at a projected cost of less than a dollar per pound.

NASA's High-Strength Alloy can be poured as a molten metal into conventional steel molds or die-casting molds to create specially shaped parts—a cost-saving advantage over the machining of parts.

"The new alloy is ideal for high-temperature cast components used in engines such as pistons, connecting rods, actuators, brake calipers and rotors," said Lee. This makes NASA's High-Strength Alloy a good choice for high-temperature applications in the automotive, aerospace, marine and recreational vehicle industries.

"Increasingly stringent exhaust-emission regulations for internal combustion engines have forced piston designers into a redesign to lower emissions," said Lee. "The current modification is to reduce the piston's crevice volume—the air gap between the piston wall and the cylinder bore—by moving the top piston ring closer to the top of the piston crown."

Such a modification promises to be a key to reaching the goal of making today's high-performance gasoline and diesel engines meet tougher exhaust standards.

To accomplish this, engine makers needed a strong, low-cost alloy that would allow them to make the piston-crown depth thinner yet still curb piston failure caused by high work and heat loads.

"NASA's High-Strength Alloy offers greater wear resistance and surface hardness which enables manufacturers to use less material, thus reducing the part's weight and cost and improving gas mileage, engine performance and engine durability," said Lee.

Two US patents have been awarded, with other domestic patents pending. An international patent is pending for the technology as well, said Sammy Nabors, the commercialization lead in the Marshall Technology Transfer Department. Through NASA's Technology Transfer program, nonexclusive licenses to develop new products from the improved alloy have been awarded to Advanced Materials Technology Inc., Manitowoc, WI; Swan Metal Composites Inc., Woodinville, WA; and Eck Industries, Manitowoc, WI.

NASA is continuing to seek US industries as partners to further transfer this technology to the public and private sector. ❑

For more information, contact Jonathan Lee, NASA Marshall Space Flight Center, ✉ *jonathan.lee@msfc.nasa.gov*, ✆ 256/544-9290, 🖷 256/544-5877. Please mention you read about it in Innovation.

Infrared

Continued from page 11

and related ecological effects. Ultimately, this detector will form the basis for a hyperspectral infrared-imaging instrument (perhaps upwards of 64 bands) as part of a collaboration among JPL, NASA Goddard Space Flight Center, Greenbelt, MD, and US Army Research Laboratory, Adelphi, MD.

NASA's Earth Science Enterprises Advanced Technology Initiative Program and NASA's Cross Enterprise Technology Development Program funded work on the four-band technology development. ❑

For more information, contact Dr. Sarath Gunapala at the Jet Propulsion Laboratory, ✆ 818/354-1880, ✉ *Sarath.D.Gunapala@jpl.nasa.gov*. Please mention you read about it in Innovation.

NASA to Aid

Continued from page 12

Mounted on a truck, JPL's Reversal Electron Attachment Detection System would allow workers to take the sample and analyze it on the spot in about 30 minutes. This would give Con Edison the ability to quickly determine what worker protection is necessary and if any personnel or equipment exposed to the PCBs must be decontaminated. It will also characterize the waste for disposal. The increased speed of analysis will allow for faster clean-up response and further protection of the environment.

"This is one example where the increased sensitivity of the JPL detection system translates directly into speed of detection and quantification," said Dr. Ara Chutjian, senior research scientist and leader of the Atomic and Molecular Collisions Team at JPL. "This will be true in New York City. It will also be true for detecting other chemical vapors, such as explosives, and for nerve-agent detection at airports, harbors and in public buildings where speed is key in attaining security without impeding the commercial flow."

Another application of the JPL system is the detection of PFTs. Con Edison injects trace amounts of PFTs into the insulating oil used in its high-voltage transmission lines routed under the streets of New York City. These trace amounts of PFTs are used to pinpoint insulating oil leaks from underground power lines.

The current system uses a slower PFT detector on a truck. The truck moves continuously along city streets until it detects a leak. The driver must drive over the area several times and gradually "home in" on the leak. The slower the detector, the farther the distance the truck moves from the leak site before a "hit" is registered and the longer it takes to backtrack and find the leak. The JPL system would be faster with no lag time. A "hit" would be made in close proximity to the actual leak, requiring minimal backtracking, saving worker time.

In this first phase, which began on May 1 and lasted through August, JPL researchers tested pure PCB samples from New York manholes. They successfully demonstrated the system cannot only detect PCBs, but also quantify their concentrations. In the second phase, JPL and Con Edison will make the sensors compact and portable.

The sensor technology being applied to help Con Edison was first developed through two separate partnerships with the Federal Aviation Administration to detect explosive vapors at airports and with the US Navy to detect unexploded ordnance on the ocean floor. ❑

For more information, contact Dr. Ara Chutjian at Jet Propulsion Laboratory, ✆ 818/354-7012, ✉ *Ara.Chutjian@jpl.nasa.gov*. Please mention you read about it in Innovation.

Clamp Measures Applied Force

Mark Nunnelee, group lead of the Facility Operations Branch at NASA Dryden Flight Research Center, has developed a clamp that can measure the clamping force being applied to a sensitive substrate or between two parts being bonded together. Flight Loads Laboratory data has proven the functionality of the force-measuring clamp.

The process for measuring the amount of clamping force applied to any object has a history of being tedious. Older versions were bulky and required external power sources, load sensors and equipment that could make the system unstable. The new force-measuring clamp has many advantages, one of them being its compact size. It can be adapted to almost any size clamp to accurately measure and display almost any magnitude of force being applied. It needs no external equipment and is easy to operate, moving the process from tedious to effortless.

Not only does the force-measuring clamp act as a sensor that detects and measures the amount of force being applied by a clamping tool, but also it serves as a loading mechanism, contains the signal conditioning, contains its own power source and displays the amount of force.

"The strain gauge signal is fed into the data-acquisition circuitry and calibrated to read the desired units. The calibrated signal is then fed into a digital display that the user can read," says Nunnelee. All of these features are included in one innovative device.

The force-measuring clamp could be applied to numerous practical purposes, from measuring the appropriate force for adhesive curing, to measuring clamping forces while curing composites, or determining the exact pressure exerted by delicate medical equipment.

In the future, Nunnelee would like to see this device become even more compact, with more options for the digital display, special packaging of components and the use of the same technique on other force devices. More extensive testing will take place in the future. ❑

For more information, contact Mark Nunnelee at Dryden Flight Research Center, ✆ 661/276-2882, ✉ *mark.nunnelee@dfrc.nasa.gov*. Please mention you read about it in Innovation.

Interactive Training Tool Makes General Aviation Safer

A unique and revolutionary aviation-training tool, available to everyone on the Internet, is making general aviation safer than ever by helping pilots manage fatigue.

The interactive online General Aviation Education and Training Module provides information for general aviation pilots about how to manage alertness issues during flight operations. The Fatigue Countermeasures Group at NASA Ames Research Center, in California's Silicon Valley, created the module to mitigate incidents and accidents due to fatigue. Dr. Melissa Mallis of NASA Ames is the project's principal investigator.

"This easy-to-use, hands-on module is designed for people in complex environments, facing challenging schedules, yet seeking to enhance safety," said Ray Oyung, a senior research associate in Ames' Information Sciences and Technology Directorate.

The primary audiences for this online training are commercial and general aviation pilots, but the training also can be beneficial to aviation managers, mechanics, medical flight crews and law-enforcement personnel. Topics discussed during the training include causes of fatigue and strategies to help manage it, the importance of sleep, factors associated with sleep loss, sleepiness, circadian rhythms and signs of fatigue.

The training module can be completed in 40 minutes, but it also is broken down into segments for shorter, more tailored and recurrent viewing sessions. The system requirements to complete training on the Internet are a Macromedia Flash 5 Player and Netscape Navigator, version 3.0 or higher.

The Web-based version of the training was created to reach more people, with a focus on general aviation pilots who may not have easy access to this type of information. Fatigue countermeasures training previously was available only at two-day workshops conducted at NASA Ames and attended heavily by the commercial airline community.

"This valuable training is meant to be spread and shared with others to increase safety everywhere, for everybody, at all times," said Oyung.

The NASA Ames Fatigue Countermeasures Group was created in 1980 in response to a congressional concern about safety in aviation related to flying long or rapidly recurring flight segments and the resultant crew fatigue. Since that time, NASA Ames researchers have conducted studies in a variety of full-mission flight simulations, aviation field studies and space-related research.

Since 1993, NASA Ames researchers have conducted 34 two-day workshops with nearly 700 attendees and 240 organizations from 21 countries. Development of the General Aviation Education and Training Module started in 1999.

To access the online training, visit: *http://humanfactors.arc.nasa.gov/zteam/fcp/WebGA-ETM.intro.html*

More information about the NASA Ames Fatigue Countermeasures Group is available at: *http://humanfactors.arc.nasa.gov/zteam/* ❑

For more information, contact Jonas Diño at NASA Ames Research Center, ✆ 650/604-5612, ✉ *jdino@mail.arc.nasa.gov*. Please mention you read about it in Innovation.

The interactive, online General Aviation Education and Training Module provides information for general aviation pilots about how to manage alertness issues during flight operations. Artwork courtesy of Ames Research Center.

Diagnostic Software to Keep Launch Vehicles Healthy

As launch vehicles become more and more complex, ensuring crew safety and mission success becomes increasingly difficult, but, according to a recent technologies demonstration, help is on the way.

Identifying minor system errors before they become critical is one key to developing safer, more reliable and less expensive space vehicles. As part of NASA's Space Launch Initiative (SLI), Honeywell, Phoenix and NASA Ames Research Center, located in California's Silicon Valley, recently demonstrated a suite of advanced diagnostic tools for NASA's Integrated Vehicle Health Management (IVHM) program. The milestone demonstration showed that separate technologies could be integrated into a cohesive package that can handle realistic problem scenarios that might be encountered in space.

For the demonstration, realism was a must, so engineers investigated various types of failures. Along with key subsystem failures, cross-subsystem "sympathetic" failures were tested.

"The Space Launch Initiative develops critical technologies, but it also demonstrates the value of those technologies in a relevant environment. Early demonstrations such as this are part of making sure we are on the right track," said William Kahle, IVHM project manager at NASA Ames.

For the demonstration, realism was a must, so engineers investigated various types of failures. Along with key subsystem failures, cross-subsystem "sympathetic" failures were tested. "Sympathetic" failures occur when problems in one system affect the performance in an unrelated system. To handle these types of failures and to build system flexibility, the engineers used a variety of techniques.

"We recognized early on that the health management requirements of RLVs [reusable launch vehicles] demand a range of diagnostic approaches from model-based to expert system technologies," said Ronald Quinn, principal investigator for Honeywell.

To ensure this realism, NASA Ames and Honeywell collaborated to develop scenarios and select component technologies that would provide relevant and significant results for the next generation of RLVs. In one scenario, the IVHM systems were able to determine that an indicated pressure system failure in a propulsion subsystem actually was caused by a failure in a power system control module.

"This is a realistic scenario that occurs often in complex systems such as RLVs," said Dr. Ann Patterson-Hine of NASA Ames. "It demonstrates the need for a vehicle-wide health management system."

NASA Ames, which leads the IVHM effort for the agency's Space Launch Initiative, also has developed other diagnostic and simulation tools. Livingstone, a model-based reasoner, was selected to emulate the propulsion health management system while TEAMS (Testability Engineering and Maintenance System), a product of Ames' Small Business Innovative Research program, provided model-based reasoning for the power system and vehicle level diagnoses. Spacecraft Control Language was used to develop expert systems and the architectural infrastructure that integrated these technologies. They cover a wide range of capabilities necessary to satisfy the health-management needs for RLVs.

The Space Launch Initiative is NASA's technology research and development program aimed at dramatically increasing safety and reliability, and reducing the cost of a second-generation reusable launch vehicle. All NASA field centers and the Air Force Research Laboratory are actively participating in the Space Launch Initiative and are vital to its success. NASA Marshall Space Flight Center, in Huntsville, AL, leads the Space Launch Initiative for NASA's Office of Aerospace Technology. ❑

For more information, contact Jonas Diño at NASA Ames Research Center, ✆ 650/604-5612, ✉ *jdino@mail.arc.nasa.gov*. Please mention you read about it in Innovation.

UAV Center Trains Students for Aerial Missions

NASA and Clark University are developing a system to train students to plan and conduct missions by remotely controlled aircraft capable of taking aerial images of natural disasters, crops and even of Mars and other planets.

NASA anticipates that as the use of remotely piloted, unmanned aerial vehicles (UAVs) expands, specialists must be trained to support aerial missions expected to generate large numbers of pictures taken with on-board, high-resolution digital-imaging systems. Future missions may include imaging flights that would help firefighters, disaster relief workers and farmers.

"The primary thrusts of this new educational program are to train people who can develop UAV technology, plan missions, conduct them and accurately and quickly interpret the real-time digital images acquired," said Dr. Stanley Herwitz, professor of Earth science at Clark University, Worcester, MA. Herwitz serves as a UAV principal investigator and leads a team of more than 20 researchers at NASA Ames Research Center. "New technology is now being developed that will produce an astonishing number of aerial images taken from UAVs capable of long-duration flight."

Specific activities will include planning future UAV image-acquisition campaigns; developing procedures for operating UAVs in Federal Aviation Administration controlled airspace; testing and evaluating high-resolution imaging systems; testing real-time telemetry systems for payload control and data transfer; evaluating data acquisition and control systems for real-time applications; developing and packaging automated image-processing streams; integrating imaging payloads onto UAVs; and implementing educational research opportunities for university students.

"More trained people are needed to evaluate aerial images so they will be available on a timely basis," he said. "These pictures will have to be studied by specialists in order to be useful during disasters, at harvest time and in other time-critical situations."

An Ames-based research team led by Herwitz is conducting the $3.76-million project for NASA's UAV Science Demonstration Program. The effort will provide the first-ever commercial demonstration test of a solar-powered UAV operating in national airspace this fall over the largest coffee plantation in the United States, located in Kauai, HI. In addition, Herwitz spearheaded the formation of a center at NASA Research Park, adjacent to NASA Ames, to conduct collaborative UAV research and development, as well as educate students.

Officials from Ames, NASA Dryden Flight Research Center (Edwards, CA), Clark University and the Girvan Institute, a non-profit organization located in NASA Research Park, signed an agreement to establish the UAV Applications Center in NASA Research Park. The charter of the new center is to conduct collaborative research and development, leading to enhanced scientific and commercial utilization of UAVs as high-resolution imaging platforms in national airspace.

"Formation of the UAV Applications Center has led to the development of an innovative educational program that will provide a trained workforce with skills in UAV mission planning, geographic information systems (GIS) and digital image analysis," Herwitz said. "The nature of our current UAV coffee project, using an environmentally friendly solar-powered aircraft, has an inspiring effect on students because it is so futuristic."

"Long-duration solar-powered aircraft, able to fly for many days without landing, will develop in the future, and these students will have an opportunity to be actively involved in the early stages," said Herwitz.

"The program will produce a significant return on investment," Herwitz said. "Its benefits may include such things as protecting the environment and natural disaster response and mitigation. We are also inspiring the next generation by involving them in the future of UAVs." ❑

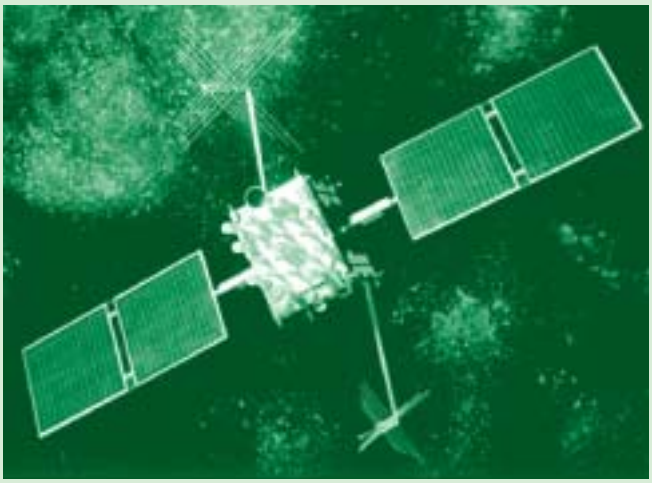
For more information, contact Dr. Stanley Herwitz at ✉ *sherwitz@mail.arc.nasa.gov.* Please mention you read about it in Innovation.

Solar-powered airplane in flight. Artwork courtesy of Ames Research Center.

New Earth-Monitoring Technology Comes to Light

A new, cost-effective technology based on the venerable global positioning system (GPS) may soon revolutionize the way Earth's atmosphere is monitored.

Scientists at NASA Jet Propulsion Laboratory, in Pasadena, CA, are excited by early analysis of data from their prototype instruments aboard two international scientific spacecraft in low-Earth orbit. Blackjack GPS receivers aboard the German Challenging Minisatellite Payload, or "Champ," and the Argentine Satelite de Aplicaciones Cientificas-C (Scientific Applications Satellite), fitted with special antennas that focus on Earth's horizon, are tracking the radio signals broadcast by each of the 28 high-orbiting global positioning system satellites as they rise and set on Earth's horizon. The process is called GPS limb sounding (also known as GPS occultation).



An artist's rendering of a GPS satellite. Artwork courtesy of Jet Propulsion Laboratory.

By measuring—to within a few trillionths of a second—the subtle changes in the time it takes for the global positioning system signals to arrive at the spacecraft as they travel through Earth's atmosphere, scientists can derive a surprising amount of data. These data include extremely precise profiles of atmospheric density, pressure, temperature and moisture content. Additional analysis can yield global pressure contour maps, critical climate variables and even the stratospheric wind fields that affect airline routes.

Preliminary evaluations indicate this technology will be applicable to fields as diverse as weather prediction and climate research, Sun-Earth interaction research, solid Earth dynamics and oceanography. It may also be used to create the first 3-D images of Earth's ionosphere, a turbulent and mysterious shroud of charged particles that, when stimulated by solar flares, can disrupt communications around the world.

"GPS occultation is a novel, cost-effective technology that augments current methods of Earth remote sensing from space," said Dr. Thomas Yunck, manager of JPL's GPS Observatories Office. "It offers accuracies and resolutions that rival those of instruments aboard weather balloons, while filling in large global coverage gaps. Such precise measurements of the lower atmosphere have never before been accomplished from space. Our prototype instruments are serving as vital developmental test beds for GPS remote sensing. NASA looks forward to a blossoming of this remote-sensing research as we continue to refine our knowledge of this new data source."

Global positioning system limb sounding offers numerous attractions. It can probe Earth's atmosphere from the top of the stratosphere (50 kilometers, or 31 miles up) directly to the Earth's surface. It can operate in all weather conditions. It can calibrate itself, resulting in stable measurements that can be compared between all occultation sensors over time. Its fully independent measurements of pressure and height permit atmospheric wind fields to be derived without external calibration or reference.

The technology's biggest advantage may well be its low cost. GPS receivers, comparable in size and complexity to a notebook computer, can be built for a fraction of the cost of traditional spaceborne sensors and placed unobtrusively on many low-orbiting spacecraft. Since most Earth satellites already carry such devices for timing and navigation, upgrading those instruments for science purposes might possibly ignite a revolution in Earth remote sensing.

Yunck says the potential from even a small array of such instruments is impressive. A single GPS receiver in low orbit could acquire more than 500 soundings a day, spread uniformly across the globe—comparable to the number of weather balloons launched worldwide every 12 hours. When combined with Russia's 24-satellite GPS-like Global Navigation Satellite System and Europe's planned 32-satellite GPS-like Galileo system, a single GPS sensor could conceivably collect more than 2,000 soundings a day.

GPS limb-sounding data from the Argentine Scientific Applications Satellite and Champ are available through JPL's GPS Environmental and Earth Science Information System at *http://genesis.jpl.nasa.gov*. The database is one of a new generation of data systems created under NASA's Earth Science Information Partners program, which seeks to create government-industry partnerships to advance Earth science. Additional information on this program is available at *http://www.esipfed.org*

This GPS limb-sounding research was carried out as a part of NASA's Earth Science Enterprise, a long-term research effort dedicated to understanding and protecting our home planet. ❑

For more information, contact Dr. Tom Yunck at Jet Propulsion Laboratory, ✆ 818/354-3369, ✉ *Tom.Yunck@jpl.nasa.gov*. Please mention you read about it in Innovation.

NICMOS Cryocooler—Reactivating a Hubble Instrument

The Near-Infrared Camera and Multi-Object Spectrometer (NICMOS), dormant since January of 1999, has been reactivated by a high-tech cooling system, the NICMOS Cryocooler.

Installed on Hubble in February of 1997, NICMOS used infrared vision to probe dark, dusty, never-before-seen regions of space with the optical clarity that only Hubble can provide. Its infrared detectors operated at a very cold temperature (minus 352 degrees Fahrenheit, which is minus 272 degrees Celsius, or 60 degrees Kelvin). To keep the detectors cold, NICMOS was encased in a thermos-like container filled with solid nitrogen ice. Unfortunately, the nitrogen ice was consumed more quickly than planned, due to a very small heat leak. In anticipation of this shortened lifespan, NICMOS's subscribed observations were tripled in order to get the most usage of this instrument before it ran out of coolant. In 1999, with its supply of ice exhausted, NICMOS became dormant.

Scientists and engineers coordinated by NASA Goddard Space Flight Center, in Greenbelt, MD, devised a way of adding a new high-tech refrigeration device to NICMOS to re-cool its detectors and other components. The Hubble team developed the NICMOS Cryocooler—a state-of-the-art, mechanical, cryogenic cooler that has returned NICMOS to active duty.

Using nonexpendable neon gas as a coolant, this closed system delivers high cooling capacity, extremely low vibration and high reliability. It employs a miniature cryogenic circulator to remove heat from NICMOS and transport it to the Cryocooler. The system uses a tiny turbine turning at up to 400,000 rpm (over 100 times the maximum speed of a typical car engine). The NICMOS Cryocooler is virtually vibration-free—which is very important for Hubble. Vibrations could affect image quality in much the same way that a shaky camera produces blurred pictures.

The new cryogenic system cools the NICMOS infrared detectors to about minus 334 degrees Fahrenheit (minus 203 degrees Celsius or 70 degrees Kelvin). This is an ideal temperature for the detectors and will make NICMOS more sensitive than ever to incoming light, enabling discoveries not previously possible. Engineers expect it to increase the life span of NICMOS to more than five years, with hopes that it will last as long as Hubble itself.

The unique technologies required for the NICMOS Cryocooler were only made possible by a series of SBIR contracts beginning in the 1980s, developing the miniature rotor fabrication techniques, high-speed motors, heat exchangers and cold bearings. Creare, Inc., a small R&D lab in New Hampshire, had applied its talented staff to needs identified by NASA and had slowly assembled the required building blocks for a very sophisticated cooling system. When Hubble called, these components were already able to provide the low-vibration, high-efficiency, and instrument-cooling characteristics that NICMOS needed.

In 1998, the Hubble team successfully demonstrated this new technology as a complete system aboard the space shuttle Discovery on STS-95. The test took place less than 18 months after system development began—

Continued on page 21

This image was possible because of the installation of the NICMOS Cryocooler, a high-tech cooling system, on the Hubble Telescope.

SBIR Plays Role in Biological Cell Selection

In an SBIR effort with Marshall Space Flight Center, Science Research Laboratory (SRL) and teammate Massachusetts General Hospital have developed a breadboard technology—pulsed electric field (PEF) cell selection—that could play a key role in treating certain cancers. Using the PEF treatment, the SBIR team has successfully demonstrated the selective purging of tumor cells in tumor-contaminated blood and bone marrow, while isolating and preserving healthy stem cells—cells that are critical for regenerating human immune systems.

The PEF technology could be pivotal in preparing bone marrow transplants that follow high-dose chemotherapies (HDC). These therapies are often essential in treating such hematologic cancers as myeloma, leukemia and lymphoma. Bone marrow is withdrawn from a patient before HDC and then re-infused after HDC. In the interim, the PEF treatment is used to purge the contaminating tumor cells, which could contribute to a cancer relapse, from the marrow. Healthy, regenerating stem cells are preserved. Initial efforts have demonstrated the efficacy of the technology in purging multiple myeloma cells from bone marrow.

Another key benefit of the PEF technology is the ability to prepare purified stem cell transplants for emergency situations. NASA missions are a prime example for this application.

One of the perils faced by humans in space—whether on space shuttle missions, missions on the International Space Station or a mission to Mars—is potential exposure to ionizing radiation. Radiation exposure can lead to immune system compromise and predispose mission personnel to life-threatening infections. One solution would be having shielded populations of stem cells on board that could be used to reconstitute the immune systems of the crew. Transplants in space would involve simple intravenous injections of cryo-preserved stem cells after hazardous conditions have subsided.

Other potential emergency applications of the SRL technology include the use of stem cell populations to combat the effects of radiation accidents in civilian and military situations, and to offer protection against certain biological warfare agents, including Sarin.

Purified stem cells are also essential in the development of new cancer drugs; as highly efficient, nonviral vectors for certain gene therapy applications in support of the human genome discoveries; and for organ and tissue generation, perhaps providing an alternative to the controversial use of embryonic stem cells.

The PEF technology could be pivotal in preparing bone marrow transplants that follow high-dose chemotherapies (HDC). These therapies are often essential in treating such hematologic cancers as myeloma, leukemia and lymphoma. Bone marrow is withdrawn from a patient before HDC and then re-infused after HDC. In the interim, the PEF treatment is used to purge the contaminating tumor cells, which could contribute to a cancer relapse, from the marrow. Healthy, regenerating stem cells are preserved.

The commercialization potential of the SRL technology is staggering. The estimated commercial market for individual cancer pharmaceuticals could be one billion dollars. The market for effective strategies for purging autologous stem cell transplants for high-dose therapy regimens is estimated at $100–$200 million. ❑

For more information, contact Joseph Mangano at the Science Research Laboratory, ✆ 703/522-6391. Please mention you read about it in Innovation.

NICMOS

Continued from page 19

an extremely short time for successfully developing a new space technology. The demonstration system was then refurbished and installed on Hubble during Servicing Mission 3B in March 2002. With a command to turn on the Cryocooler, the NICMOS was finally brought back to life! Starting with a new idea for a tiny turbine, this revolutionary technology now paves the way for exciting advances in infrared astronomy on Hubble and beyond.

"It is fantastic that we have restored Hubble's infrared eyesight. NICMOS has taken us to the very fringes of the universe and to a time when the first galaxies were formed. We can't wait to get back out there," said Dr. Rodger Thompson, NICMOS principle investigator, University of Arizona, Tucson.

In the case of NICMOS, the Cryocooler is replacing the solid nitrogen cooler that originally encased the instrument. But this advanced type of Cryocooler can replace both liquid and solid nitrogen-based cooling systems on Earth, as well as in space.

The Cyrocooler offers earthly benefits in electronics manufacturing, medical imaging and magnetic field detection. One particularly important application is in brain imaging. Magnetic encephalograms, which measure brain waves, allow doctors to determine if the various parts of the brain are functioning properly. This new cooler technology may someday make such brain-imaging equipment more user-friendly, compact and affordable. ❑

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For more information, contact Rob Boyle at NASA Goddard Space Flight Center, AETD Code 552, Greenbelt, MD 20771, ✆ 301/286-7185, 🖷 301/286-0389. Please mention you read about it in Innovation.

Small Business Projects Selected

NASA has selected 142 research proposals for negotiation of Phase II contract awards for its Small Business Innovation Research (SBIR) Program. The selected projects will be conducted by 124 small high-technology firms located in 27 states. The awards have a total value of approximately $85 million.

The goals of this NASA program are to stimulate technological innovation, increase the use of small business—including women-owned and disadvantaged firms—in meeting federal research and development needs, and increase private-sector commercialization of innovations derived from federally funded research.

A total of 291 proposals were submitted by SBIR contractors completing Phase I projects. These proposals were evaluated to determine that they met SBIR Phase I objectives and are feasible research innovations for meeting NASA needs.

Phase II continues development of the most promising Phase I projects. Selection criteria include technical merit and innovation, Phase I results, value to NASA, commercial potential and company capabilities. Funding for Phase II contracts could be up to $600,000 for a two-year performance period. ❑

For more information, contact Bob Nelson at Goddard Space Flight Center, ✆ 301/286-0077, ✉ *robert.w.nelson@gsfc.nasa.gov*. Please mention you read about it in Innovation.

Moving Forward

Technology Opportunity Showcase

Technology Opportunity Showcase highlights some unique technologies that NASA has developed and that 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**.

Langley Scanning Thermography

NASA Langley is seeking licensing partners for their Scanning Thermography technology. The subject technology is a transportable scanning thermographic system for nondestructive evaluation or testing (NDE/NDT) of materials for cracks, flaws, disbonds, corrosion and wear.

A carriage conveys a heat source and a thermal imager at a constant speed over a test surface structure. The imager follows the heat source and produces a video image of the thermal characteristics of the test surface as the induced heat is diffused. Temperature differences indicate regions of differing heat diffusivity. Because damaged, corroded or disbonded areas are thinner, and dissipate heat differently from unaffected sections, they show a corresponding difference in temperature. The system's infrared imager converts this thermal response into a video signal, which is analyzed by an attached microcomputer and image processor.

Material defects produce deviations from the induced surface temperature that move at a speed proportional to the constant speed. Thermal noise produces deviations that move at random speeds. Computer averaging of the digitized thermal data with respect to the constant speed minimizes noise and improves the signal of valid defects. The motility and high scan rates of the thermographic equipment coupled with the high signal-to-noise ratio render the system suitable for portable, on-site analysis. Technicians can then examine the system's digital output in real time for a precise diagnosis of structural degradation.

The advantages of NASA's thermographic imaging method include noninvasive and noncontacting; suitability to a wide range of materials including composites and metals employing aluminum, plastic and resin matrices; real-time imaging; transportable/in-service use; rapid coverage of large areas of varying shapes (six times that of point-and-shoot methods); good defect resolution (dependent on depth of material), especially for disbonds, delaminations and corroded areas; scanning speed of over six feet per second; and relatively inexpensive equipment. ❑

For more information, contact the Robert C. Byrd National Technology Transfer Center, ✆ 800/678-6882, ✉ *hottechnologies@nttc.edu*. Please mention you read about it in Innovation.

3-D Roller Locking Sprags

NASA invites commercial companies to license the 3-D roller locking sprag technology for use in commercial applications.

Originally developed at NASA Goddard Space Flight Center, this technology provides a solution to torque-coupling locking brake and clutch applications that are too demanding for conventional sprag brakes/clutches. NASA's 3-D roller locking sprag brake/clutch provides superior holding torque at a reduced size and weight.

Many machines with rotating parts use brakes and clutches to stop or control the degree and direction of motion of the driven parts. Brakes and clutches often are incorporated between concentric races (i.e., rotating shafts). One class of locking brake/clutch uses spherical balls or cylindrical rollers located between an inner and outer race. At least one of the races contains cam surfaces against which the balls or rollers wedge and lock to produce instantaneous torque coupling. A variation on this approach incorporates the cam shape into the roller (i.e., sprag), which rotates through a small angle to engage the sprag's cam surfaces against the concentric cylindrical surfaces of the inner and outer races. Springs often are used to preload the sprags against the race surfaces so that the sprags engage and disengage instantly with no backlash.

NASA's innovative 3-D roller locking sprag has a tapered periphery and replaces the concentric, cylindrical surfaces of the inner and outer races of the brake/clutch with grooves into which the 3-D sprag fits. This geometry creates four points of locking contact—two between the outer taper of the 3-D sprag and the outer grooved race, and two between the inner taper of the 3-D sprag and the inner grooved race—twice as many as with conventional, simple ball-based roller locking brakes/clutches. The two additional contact points increase the locking efficiency of the device while reducing the level of sprag-to-race contact stresses. In conventional cylindrical roller sprags, the roller contacts the races along the full length of the roller sprags. However, NASA's 3-D roller locking sprag contacts only the diametrically opposing sides of the grooved races at the four points noted above, reducing contact stress and increasing holding power. ❑

For more information, contact Darryl Mitchell at Goddard Space Flight Center, ✆ 301/286-5169, ✉ *Darryl.R.Mitchell.1@gsfc.nasa.gov*. Please mention you read about it in Innovation.

NASA Commercial Technology Network Directory

NASA ONLINE

Go to the NASA Commercial Technology Network (NCTN) 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.

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.

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650/604-1754
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Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Jenny Baer-Riedhart
Dryden Flight Research Center
Edwards, California 93523-0273
661/276-3689
jenny.baer-riedhart@mail.dfrc.nasa.gov

Glenn 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
Glenn Research Center
Cleveland, Ohio 44135
216/433-3484
Larry.A.Viterna@grc.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.

Nona Cheeks
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
ncheeks@pop700.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.

Charlene Gilbert
Johnson Space Center
Houston, Texas 77058
281/483-0474
charlene.e.gilbert@jsc.nasa.gov

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

Jim Aliberti
Kennedy Space Center
Kennedy Space Center,
Florida 32899
321/867-6224
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Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

Wilson Lundy
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
w.t.lundy@larc.nasa.gov

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

Vernotto McMillan
Marshall Space Flight Center
Huntsville, Alabama 35812
256/544-2615
vernotto.mcmillan@msfc.nasa.gov

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

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
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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.

Bill Musgrave
Ames Technology Commercialization Center
San Jose, CA
408/557-6820

Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
440/260-3300

David Kershaw
Florida/NASA Business Incubation Center
Titusville, FL
321/267-5601

Bridget Smalley
University of Houston/NASA Technology Center
Houston, TX
713/743-9155

Joanne Randolph
Business Technology Development Center
Huntsville, AL
256/704-6000, ext. 202

Julie A. Holland
NASA Commercialization Center/California State Polytechnic University
Pomona, CA
909/869-4477

Martin Kaszubowski
Hampton Roads Technology Incubator
Hampton, VA
757/865-2140

Ann Lansinger
Emerging Technology Center NASA Business Incubator
Baltimore, MD
410/327-9150

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 agencies and to 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
Los Angeles, CA 90007
213/743-2353

William Gasko
Center for Technology Commercialization
Westborough, MA 01581
508/870-0042

David Bridges
Economic Development Institute
Georgia Institute of Technology
Atlanta, GA 30332
404/894-6786

Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
College Station, TX 77840
979/845-8762

Charlie Blankenship
Technology Commercialization Center, Inc.
Newport News, VA 23606
757/269-0025

Pierrette Woodford
Great Lakes Industrial Technology Center
Battelle Memorial Institute
Cleveland, OH 44070
216/898-6400

Joseph P. Allen
National Technology Transfer Center
Wheeling Jesuit University
Wheeling, WV 26003
800/678-6882

Dan Winfield
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC 27709
919/541-6431

Events/ Awards/ Heads-Up

Events

Space Technology Hall of Fame Nominations Sought

The Space Foundation is currently accepting nominations for 2003's 15th anniversary of the Space Technology Hall of Fame.

Nominations for the Space Hall of Fame are solicited from NASA Centers, the Departments of Defense, Commerce and Transportation, and commercial aerospace and technology companies. Each organization may nominate up to three aerospace spin-off technologies, and re-nomination is permitted.

Applications are submitted to a panel of judges for review and then undergo comprehensive due diligence. The deadline for nominations is October 31, 2002. Nomination forms can be downloaded from the Space Technology Hall of Fame Web site, which can be accessed through the Space Foundation's site at *www.spacefoundation.org*. Honorees will be announced in February and honored during the 19th National Space Symposium on April 10, 2003 in Colorado Springs.

Remediation Technology Tour and Demo

NASA and the US Environmental Protection Agency (EPA) are sponsoring a Remediation Technology Tour and Demo on November 7, 2002. This event, which will be held at the Kennedy Space Center in Florida, will showcase two technologies being demonstrated as part of the EPA's Superfund Innovative Technology Evaluation (SITE) program.

The featured technologies include:
NASA's Emulsified Zero-Valent Iron (EZVI)
Bioaugmentation Using KB1

The Remediation Technology Tour and Demo is a free event. The registration deadline is October 24. Non-US citizens MUST register by October 7. Attendance for this event will be limited, and NASA will allow individuals to participate on a first-come-first-serve basis. For more information about this event and/or to register, please visit *http://nasa.rti.org/ksc/remediation/TechTour.cfm*

SBIR/STTR Conference

Coming soon, the National SBIR/STTR Conference October 28 - November 1 in Burlington, VT.

Vist our registration site at: *http://www.sbirworld.com/vermont*

Heads-Up

NASA's annual publication ***Spinoff*** documents NASA technologies initially developed for space missions and commercialized by industry for the development of products and services. Look for the next issue, ***Spinoff 2002,*** in October and visit the Spinoff Web site at *http://netsrv.casi.sti.nasa.gov/tto/spinoff.html* or *http://nctn.hq.nasa.gov*

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