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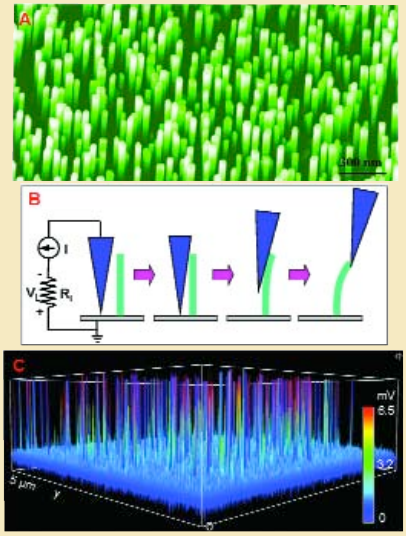
Nanogenerators

Researchers convert mechanical energy for self-powered nanoscale devices.

IMAGES COURTESY OF Z.L. WANG



ABOVE: *At top, a scanning electron microscope image shows an array of zinc oxide nanowires. The middle image shows a schematic of how an AFM tip was used to bend nanowires to produce current. And the bottom image depicts output voltages produced by the array as it is scanned by the probe.*

Researchers have developed a new technique for powering nanometer-scale devices without the need for bulky energy sources such as batteries.

By converting mechanical energy from body movement, muscle stretching or water flow into electricity, these "nanogenerators" could make possible a new class of self-powered implantable medical devices, sensors and portable electronics.

Described in the April 14 issue of the journal *Science*, the nanogenerators produce current by bending and then releasing zinc oxide nanowires — which are both piezoelectric and semiconducting. The research was sponsored by the National Science Foundation (NSF), the NASA Vehicle Systems Program and the Defense Advanced Research Projects Agency (DARPA).

"There is a lot of mechanical energy available in our environment," says Zhong Lin Wang, a Regents Professor in the School of Materials Science and Engineering at the Georgia Institute of Technology. "Our nanogenerators can convert this mechanical energy to electrical energy. This could potentially open up a lot of possibilities for the future of nanotechnology."

Nanotechnology researchers have proposed and developed a broad range of nanoscale devices, but their use has been limited by the sources of energy available to power them. Conventional batteries make the nanoscale systems too large, and the toxic contents of batteries limit their use in the body. Other potential power sources also suffer from significant drawbacks.

"We can build nanodevices that are very small, but if the complete integrated system must include a large power source, that defeats the purpose," adds Wang, who also holds affiliated faculty positions at Peking University and the National Center for Nanoscience and Technology of China.

The nanogenerators developed by Wang and graduate student Jinhui Song use the very small piezoelectric discharges created when zinc-oxide nanowires are bent and then released. By building interconnected arrays containing millions of such wires, Wang believes he can produce enough current to power nanoscale devices.

To study the effect, the researchers grew arrays of zinc-oxide nanowires, then used an atomic-force microscope tip to deflect individual wires. As a wire was contacted and deflected by the tip, stretching on one side of the

PHOTO BY GARY MEEK

RIGHT: *Georgia Tech Professor Zhong Lin Wang conducts nanotechnology research in his laboratory.*

structure and compression on the other side created a charge separation — positive on the stretched side and negative on the compressed side — because of the piezoelectric effect.

The charges were preserved in the nanowire because a Schottky barrier was formed between the AFM tip and the nanowire. The coupling between semiconducting and piezoelectric properties resulted in the charging and discharging process when the tip scanned across the nanowire, Wang explains.

When the tip lost contact with the wire, the strain was released — and the researchers measured an electrical current. After the strain release, the nanowire vibrated through many cycles, but the electrical discharge was measured only at the instant when the strain was released.

To rule out other potential sources of the current, the researchers conducted similar tests using structures that were not piezoelectric or semiconducting. "After a variety of tests, we are confident that what we are seeing is a piezoelectric-induced discharge process," Wang says.

— John Toon

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Optical-Wireless Convergence

Telecommunications researchers have demonstrated a novel communications network design that would provide both ultra-high-speed wireless and wired access services from the same signals carried on a single optical fiber.

The new hybrid system could allow dual wired/wireless transmission of the same content such as high-definition television, data and voice up to 100 times faster than current networks. The new architecture would reduce the cost of providing dramatically improved service to conference centers, airports, hotels, shopping malls — and ultimately to homes and small offices.

"The same services would be provided to customers who would either plug into the wired connection in the wall or access the same information through a wireless system," explains Gee-Kung Chang, a professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology. "In an airport, for instance, a traveler could watch a movie, talk to a friend and work interactively through a wireless system or by plugging into the wall."

Chang described the network architecture and experimental demonstrations of it at the OFC/NFOEC optical conference in March. Chang, who holds the Byers Endowed Chair in Optical Networks at Georgia Tech, is a Georgia Research Alliance Eminent Scholar and a researcher at the Georgia Tech Broadband Institute in the Georgia Centers for Advanced Telecommunications Technology (GCATT).

Today, telecommunications providers generally supply services that are either all-wireless, through cellular telephones or similar devices, or all-wired — through DSL, cable or optical access network. As wireless providers seek to provide new bandwidth-intensive services such as video, music and high-speed Internet access, however, the bandwidth needs of wired and wireless services are converging.

The optical-wireless access network envisioned by Chang and his colleagues would connect to existing optical fiber networks that already serve much of the nation. But before entering a building, signals on the optical fiber would be optically up-converted in the central office from their normal infrared wavelengths to the millimeter-wave spectrum. Using a technique developed at Georgia Tech, wireless and baseband signals carried by multiple wavelengths would be converted onto the millimeter-wave carrier simultaneously.

"You could have one network shared by many providers because bandwidth is not a limitation once you combine the advantages of optical and wireless access systems," Chang says. "If you look into the future, the broadest bandwidth possible would come through combining and integrating optical and wireless services in a single network."

— John Toon

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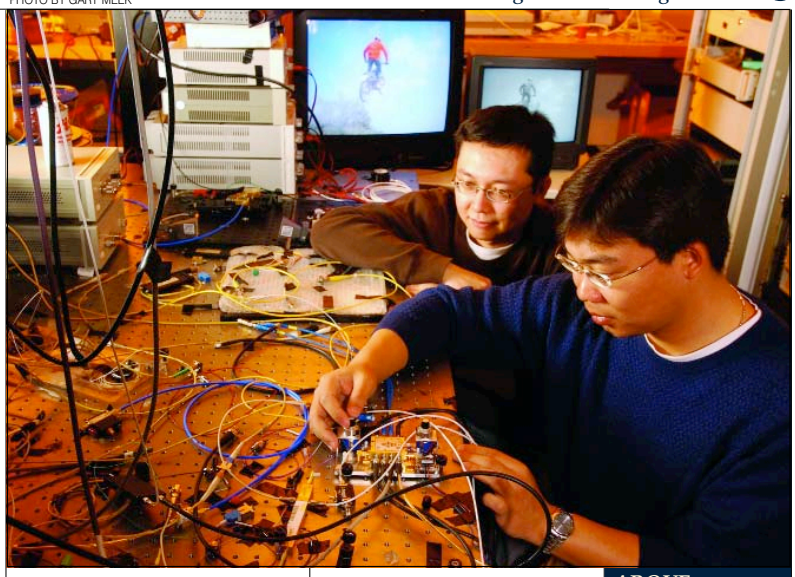
PHOTO BY GARY MEEK



ABOVE: Graduate students Yong-Kee Yeo and Zhensheng Jia operate optical equipment in a hybrid wired/wireless network.

> "The same services would be provided to customers who would either plug into the wired connection in the wall or access the same information through a wireless system."
>
> **G.K. Chang,** professor in the School of Electrical and Computer Engineering

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Green Chemistry

Using the unique properties of new nanometer-scale magnetic particles, researchers have for the first time separated for reuse two different catalysts from a multi-step chemical reaction done in a single vessel.

By combining the new magnetic separation process with traditional gravity-driven separation, the technique could lead to more efficient production of specialty chemicals — and a reduction in waste normally produced by separation processes. The research was reported March 27 in the journal *Angewandte Chemie International Edition*.

"We have developed a way to do multiple reactions in a single vessel while being able to recover the catalysts in pure form for reuse," explains Christopher W. Jones, an associate professor in the School of Chemical & Biomolecular Engineering at the Georgia Institute of Technology. "By doing the reactions in a single vessel, we can cut out two or three separation steps to provide both an economic advantage and an environmentally benign process."

Separations using magnetic catalysts have been limited by a tendency of the nanoparticles to clump together because of their magnetic attraction for one another. The clumping dramatically reduces their catalytic activity.

To overcome this problem, the Georgia Tech researchers used nanometer-scale magnetic particles that are so small (5 to 20 nanometers in diameter) that they no longer exhibit a net magnetic attraction. But these superparamagnetic nanoparticles, developed by the research group of Z. John Zhang in Georgia Tech's School of Chemistry and Biochemistry, are attracted to an external magnetic source, providing a mechanism for separating them in pure form from the reaction vessel.

"These magnetic nanoparticles work well as catalyst supports because they are very small and so have a high surface area that allows creation of many catalytic sites for high activity levels," Jones says. "Because they are superparamagnetic, they remain suspended in the reaction vessel and do not clump together until a magnetic source is brought near them."

The new technique would allow more than one catalyst to be recovered and reused at the end of the one-pot reactions. Jones envisions the new process being used in the specialty chemical and pharmaceutical industries that produce relatively small volumes of high-value chemicals.

— John Toon

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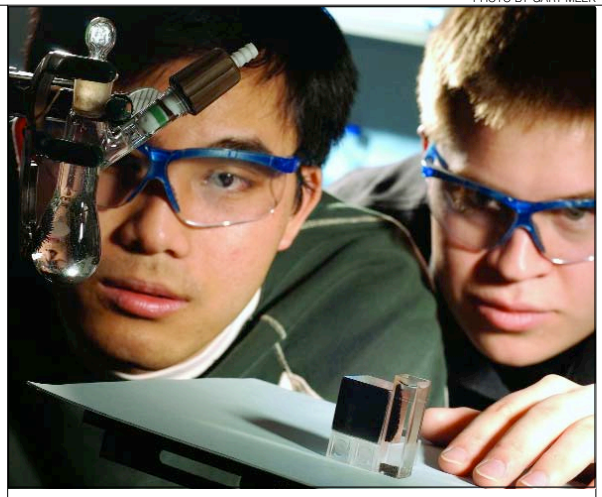
PHOTO BY GARY MEEK



ABOVE: *Post-doctoral researcher Nam Phan, left, and graduate student Christopher Gill study the separation of magnetic nanoparticle catalysts from polymeric resin catalysts. The magnetic nanoparticles are easily manipulated with magnets as small as simple kitchen magnets.*

BELOW: *A small magnet is used to separate magnetic nanoparticle catalysts containing base sites from polymeric resin beads containing acid sites. The normally incompatible catalysts can be used simultaneously in the same vessel by sequestering each catalyst in a separate solid.*

PHOTO BY GARY MEEK

First Responders

Officials from the Georgia Institute of Technology and Carbon Motors Corporation — a new U.S. automaker that has announced plans to locate in Georgia — have taken the first step toward a collaboration that would develop the world's first vehicle built expressly for law enforcement agencies.

The company, which will market its innovative "purpose-built" vehicle directly to customers, also plans to revolutionize U.S. automobile manufacturing as a lean and integrated organization. In March, the firm announced plans to locate its headquarters, research and development center, direct sales center, customer service, and mid-volume production and logistics operations in the metropolitan Atlanta area. On April 19, officials from Georgia Tech and Carbon Motors signed a memorandum of understanding setting out their intent to establish research, education and financial arrangements.

"In this era of enhanced homeland security concerns, law enforcement first responders require the most appropriate specialized equipment delivered to them in the most efficient way possible so our women and men in uniform can patrol our communities in a more effective and safe manner," says William

IMAGE COURTESY OF CARBON MOTORS

Santana Li, chairman and CEO of Carbon Motors. "With more than 200 law enforcement agencies nationwide, we have developed a list of 74 critical criteria that law enforcement vehicles need to meet. This vehicle will be different in almost every way to truly meet the needs and desires of law enforcement."

To make that vision a reality, Carbon Motors plans to take advantage of Georgia Tech's expertise in a broad range of areas. Initially, the company's designers and engineers plan to tap Georgia Tech's expertise in the ergonomic design of aircraft cockpits and the integration of highly complex electronic and electrical systems.

"Police vehicles today have a complex set of systems that need to be ergonomically configured to ensure proper flow of information to officers, especially when they are in pursuit or in stressful situations," Li says. "What we essentially need is comparable to the cockpit of a helicopter — which Georgia Tech has experience in designing. That is expertise not normally found in the automotive industry."

Beyond the human factors interface expertise, the company also intends to take advantage of Georgia Tech experience with integrating complex electronic systems — expertise also developed in decades of work done for military agencies.

The Georgia Tech Research Institute (GTRI), which recently developed a new concept vehicle for the U.S. military, plans to work with Carbon Motors on key tasks.

— John Toon

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Manufacturing Road Map

Using a combination of experimental data and simulations, researchers have identified key parameters that predict the outcome of nanoimprint lithography, a fabrication technique that offers an alternative to traditional lithography in patterning integrated circuits and other small-scale structures into polymers.

Results of the three-year study, conducted by researchers at the Georgia Institute of Technology and Sandia National Laboratories, provide a "road map" to guide development of next-generation micron- and nanometer-scale, high-resolution imprint manufacturing. By reducing cost and time, the design rules could help make high-volume production of nanotechnology-based products more economically feasible.

"This work provides a rational link between what engineers want to make using nanoimprint lithography and the path for creating them," says William King, an assistant professor in Georgia Tech's School of Mechanical Engineering. "We have developed manufacturing design rules that will give future users of this technology a predictive tool kit so they'll know what to expect over a broad range of parameters."

The research results have been published in the *Journal of Vacuum Science Technology B* and the *Journal of Micromechanics and Microengineering*. The research was supported by awards to King through the National Science Foundation's CAREER program and the PECASE award program of the U.S. Department of Energy.

Nanoimprint lithography is the ultra-miniaturized version of the decades-old embossing process in which a master tool — or a mold — is pressed into a soft material to create detailed patterns. Using a broad range of polymer materials, nanoimprint lithography produces structures on the micron- or nanometer-size scales, offering the potential for lowering production costs.

But quality issues caused by unpredictable polymer flow into the non-uniform features of embossing tools pose a major stumbling block. Earlier research into this complex process has produced often-conflicting recommendations, forcing manufacturers to pursue costly trial and error.

Using the results of experimental work and a simulation program adapted in collaboration with researchers at Sandia, King's research team examined every variable involved in the nanoimprinting process, recording the outcome of each incremental change through the design space. They studied such variables as shear deformation of the polymer, elastic stress release, capillary flow and viscous flow during the filling of imprinting tool cavities that had varying sizes and shapes.

"This helped us to resolve the phenomenological events that occur during the manufacturing process and to link them to the observed experimental outcomes," King explains. "Because we have blanketed the entire design space, we have a firm understanding on the linkage between process parameters and outcomes."

— John Toon

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FAR LEFT: *This computer-aided industrial design model represents the law enforcement vehicle Carbon Motors plans to produce.*

PHOTO BY GARY MEEK

ABOVE: *Graduate student Andrew Cannon holds a plastic sheet containing micro-mechanical features.*

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Extraterrestrial Life

Research to improve instruments for analysis of samples from outer space.

Researchers have identified a new test case that could be used for evaluating extraterrestrial samples for evidence of life. The new test could ultimately allow the use of simpler analytical instrumentation on future space missions.

In the search for life on other planets, astrobiologists regard liquid water and chiral biomolecules to be critical components. "Yet because chiral molecules can be made synthetically as well as biologically, it's not enough to just find them on other planets. We need to show a change of chirality over time," says Tracey Thaler, a graduate student at Georgia Tech's School of Chemistry and Biochemistry. She works with Professor Andreas Bommarius in the School of Chemical and Biomolecular Engineering.

Thaler has investigated racemization — the conversion of an optically active compound to a racemic form, which has no optical rotation — as a new approach for analyzing samples in outer space. "Because this type of reaction is found only in biological systems, it could serve as a marker for extraterrestrial life," Thaler explains. She presented results from the study in March at the 231st American Chemical Society National Meeting.

The study is part of a collaborative effort with Professor Rick Trebino's research group in Georgia Tech's School of Physics. The two research groups are trying to improve analytical instruments used on space missions, research that is sponsored by NASA.

Chromatography, the current method used to evaluate extraterrestrial samples on space missions, is a tedious process, Bommarius explains. Another drawback, researchers must know in advance the specific compounds they're looking for, which isn't always possible. In contrast, polarimetry, a method for measuring optical activity, does not require knowledge of the structure being analyzed. But because existing polarimeters have performance limitations, Georgia Tech researchers are developing a more sensitive polarimeter that can detect smaller concentrations of optically active compounds. Thaler's work serves as a test bed for such an instrument.

"Tracey's study is significant because it marks the first time that racemization has been looked on as a sign of life on other planets," Bommarius says. "What's more, she has identified two new media in which the enzyme mandelate racemase is active."

Mandelate racemase (MR) is an enzyme that catalyzes the racemization reaction for the substrate mandelic acid. Mandelate is one the simplest chiral molecules and has a large specific optical rotation, making it well-suited for polarization analysis, Thaler explains.

An important part of the study was to determine if MR reactivity could occur at subzero temperatures found on planets like Mars or moons like Titan, Europa or Enceladus, where recent data shows water is likely to exist.

After a number of unsuccessful attempts with organic cryosolvents — the most common medium to probe enzyme activity at low temperatures — Thaler achieved MR reactivity in two unconventional media. They were concentrated ammonium salt solutions and water-in-oil microemulsions (anionic surfactant Aerosol OT and non-ionic surfactant Triton X-100). Racemization occurred in temperatures as low as -30 degrees Celsius. This was promising because both the microemulsions and the concentrated salt solutions are expected to form on other planets and moons.

Another auspicious finding: Measurements for the activation parameters (thermodynamics) in the ammonium salt solutions and water-in-oil microemulsions were very similar. "This tells us that racemization is not only possible in other media, but thermodynamic parameters found in these media are similar to those found in media that's normally used," Thaler says.

— T.J. Becker

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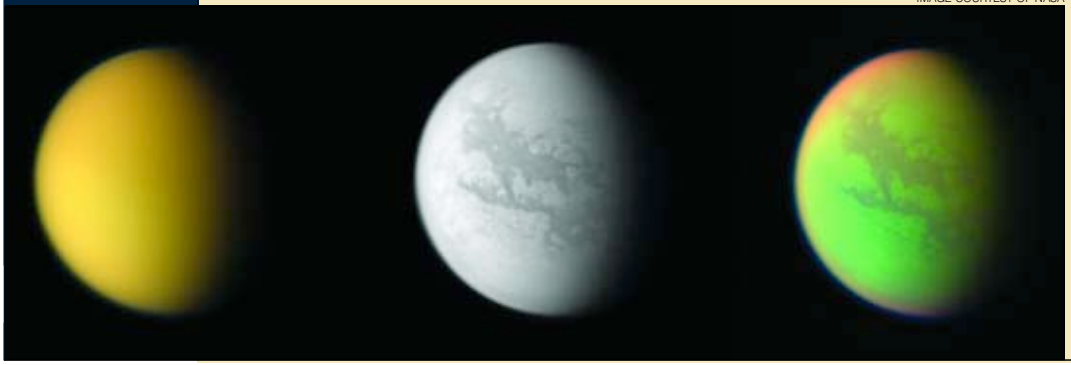
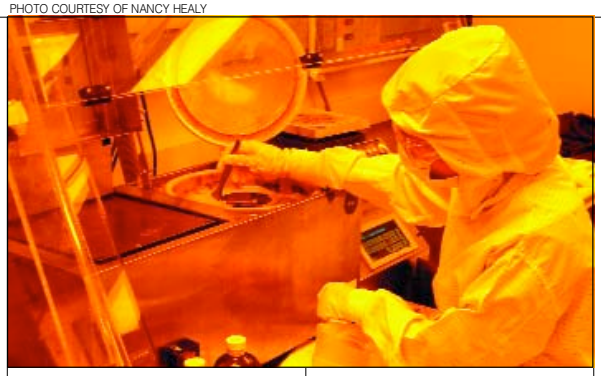
IMAGE COURTESY OF NASA



BELOW: *These three views of Titan from the Cassini spacecraft illustrate how different the same place can look in different wavelengths of light. Data shows water is likely to exist — and therefore life may have existed — on Titan.*

PHOTO COURTESY OF NANCY HEALY



Explaining Nanotech

Who will operate the nanotechnology factories of the future? Will the public be able to make informed decisions about new nanometer-scale products and services? Will tomorrow's nanotechnology industry face the same kind of backlash as today's genetically modified food industry?

These are some of the questions that concern Nancy Healy. As education coordinator for the National Nanotechnology Infrastructure Network (NNIN), she's helping develop educational outreach programs designed to ensure that tomorrow's workers have the right skills for nanotechnology industries — and that the public will be able to separate nanotechnology fact from fiction.

Her biggest challenge: helping people relate to structures whose size is measured in billionths of meters. And that's without explaining the quantum mechanical effects that make ordinary processes, such as friction, dramatically different at the nanoscale.

"There's a misperception that nanotechnology is really still science fiction," says Healy, who described NNIN education efforts at the 2006 meeting of the American Association for the Advancement of Science. "People generally don't know what nanotechnology really is. There's a risk that their perceptions will be based on popular culture portrayals of it rather than fact."

The U.S. government is investing a billion dollars a year in the technology of the very small. The National Science Foundation (NSF) estimates that by 2015, nanotechnology will directly employ more than two million workers worldwide. Yet 80 percent of the people recently surveyed by the Project on Emerging Nanotechnologies admitted to knowing little or nothing about it.

"We still have a long road ahead in educating people," says Healy, whose efforts are headquartered at the Georgia Institute of Technology. "But we don't have much time because the technology is moving forward quickly. Nanotechnology is already here, though some of the most important aspects of it are still 10 or 15 years away."

Today, nanotechnology is mostly seen as the province of Ph.D. scientists and engineers. But as the industry grows, it will need people at all education and skill levels to meet needs that range from cutting-edge research to maintenance of manufacturing equipment.

"The field is wide open," Healy adds. "There are many opportunities, not just for technical people, but also for specialists such as patent attorneys, pharmacists, entrepreneurs and marketers. The most important skill will be the ability to work with people in other disciplines — to be an interdisciplinary person."

— John Toon

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Military IT Capability

Georgia Tech Research Institute engineers are leading the system integration and production design effort that will create a broad-based information technology capability for the command and control needs of future U.S. task forces.

Their work is part of an approach that includes not only full information technology (IT) capabilities (networks, voice, video, telephone, etc), but also shelters environmental control units and power for a stand alone, fully deployable system.

The Deployable Joint Command and Control (DJC2) program is envisioned as a "system of systems." It will integrate new and existing applications into a shared-information environment that connects a joint task force (JTF) with the national military command structure, combat support, regional combatant commands, intelligence, and service and multinational components.

The DJC2 program is headed by the DJC2 Joint Program Office and is run through the Naval Surface Warfare Center in Panama City, Fla. Georgia Tech Research Institute (GTRI) support is funded under the C4I Munitions Test and Improvement Contract (CIMTIC II) contract, for which GTRI is a prime contractor.

"DJC2 is the hardware and software solution to bring everything together that needs to be packaged and sent out for joint task force deployments," says Carlee Bishop, a GTRI researcher and DJC2 project director. "With this equipment, they can set up a command center in the middle of nowhere and run a full JTF."

GTRI engineers are designing the information technology portion of DJC2, with the aim of integrating custom military technology and off-the-shelf civilian technology into a seamless unit. This effort includes network, software, communications and telephony/video subsystems. GTRI is also researching state-of-the-art concepts to enhance the

LEFT: *A student learns clean room processes necessary for nanotechnology as part of the NNIN's Research Experience for Undergraduates program.*

PHOTO COURTESY U.S. DEPARTMENT OF DEFENSE

ABOVE: *Georgia Tech Research Institute engineers are leading the system integration and production design of the Deployable Joint Command and Control (DJC2) program, which was tested during the Hurricane Katrina rescue efforts in 2005. It integrates new and existing applications into a shared-information environment.*

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DJC2 capabilities, plus designing and integrating the engineering solution.

The prototype DJC2 system was tested during the Hurricane Katrina relief effort last year. While the task force was being formed to support the victims of the hurricane, the DJC2 system was being packed up and shipped to Louisiana to support command and control of these efforts. Although still under development, the system provided essential communications capabilities needed to conduct the complex task of coordinating civilian, state, federal and military personnel.

— Rick Robinson

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Read more at:
gtresearchnews.gatech.edu/reshor/rh-ss06/DJC2.html

Georgia Tech in Ireland

The Georgia Tech Research Institute (GTRI), the applied research arm of the Georgia Institute of Technology, is establishing a research enterprise in Athlone, Ireland, to focus on industry research and development needs. GTRI Ireland will be GTRI's first applied research facility outside the United States.

Over the next five years, the Irish operation plans to build up a portfolio of research programs and collaborations with industry valued in excess of $24 million, and at full operation, it will employ 50 highly qualified researchers.

GTRI, which conducts nearly $140 million in research and development each year for industry, government and academic institutions across the world, will receive support from IDA Ireland, the agency responsible for industrial development and overseas investment in Ireland. The new institute will focus on four technology areas that mirror Ireland's research strengths — digital media, radio frequency identification (RFID), biotechnology and energy.

"Ireland is increasingly known as a world leader in innovation and for embracing technology. As Georgia Tech expands its global horizons, we seek partners who share our values and goals," says Georgia Tech President Wayne Clough. "Thus, we are especially pleased to celebrate the formation of this forward-looking collaboration with Ireland and our Georgia Tech Research Institute. We are grateful to the government and civic leaders of Ireland who worked on this exciting initiative with us."

The institute will work closely with Irish corporations and universities, the Georgia Tech research community and U.S. companies to provide companies on both sides of the Atlantic with industry-focused research and development that bridge the gap between academic discovery and commercial success.

Stephen E. Cross, Georgia Tech vice president and GTRI director notes: "GTRI Ireland is an integral part of GTRI's plan to develop international operations and build long-term relationships with industrial partners by providing innovative solutions through customer-focused R&D. This initiative directly supports Georgia Tech's vision to define the technological university of the 21st century."

— Megan McRainey

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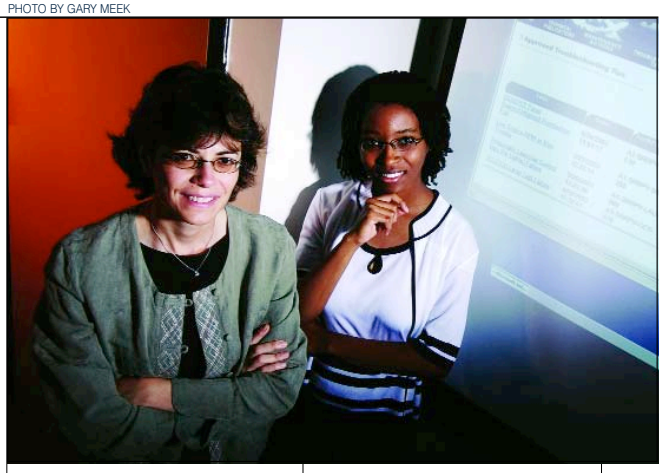
Read more at:
www.gatech.edu/news-room/release.php?id=897

BELOW: The Georgia Tech Research Institute will provide companies in Ireland and the United States with industry-focused research and development that bridge the gap between academic discovery and commercial success.

PHOTO COURTESY GTRI

PHOTO BY GARY MEEK



***ABOVE:** Researchers Gisele Bennett, left, and Keesah Hall developed the Maintainer's Electronic Performance Support System. The system is used to help maintain two key U.S. Navy aircraft.*

Maintainer's Support

Aircraft technicians these days are as likely to use a laptop as a printed manual and logbook, and to turn to the Internet for the latest job-status reports and technical information.

Engineers from the Georgia Tech Research Institute (GTRI) are assisting them, using current computer and database technology to help military aircraft maintainers get their work done more efficiently. A team from GTRI's Electro-Optical Systems Laboratory (EOSL) has been developing and improving maintenance software for the U.S. Navy since 2000.

Called the Maintainer's Electronic Performance Support System (MEPSS™), this software was initially developed for the Navy's P-3C Orion patrol aircraft. A more recent version is now helping maintain the RQ-2 Pioneer Unmanned Aerial Vehicle, and portions of the GTRI software are being used in other aircraft maintenance programs.

"The idea is to give maintainers all the information tools and decision-making capabilities that they need," says Gisele Bennett, director of EOSL and principal investigator for the project. "From a simplified standpoint, you can almost look at it as an information portal, where you're collecting and disseminating information to the maintainers."

MEPSS is typically installed on a laptop computer. Technicians can check parts lists, consult manuals and add information about their work as they go.

The system can be updated in a variety of ways — through a squadron LAN, a standalone server, CD-ROMs, USB devices, or the World Wide Web. A Web-enabled system gives maintainers access to up-to-the-minute technical and parts information, and helps them both access and share work-related information.

Whatever the connectivity approaches used, the software performs a needed centralizing function, Bennett says. For example, by reviewing software reports maintainers can detect trends involving, say, troublesome parts that need multiple replacements. Or they can pinpoint repair techniques that need improvement.

And maintainers can conveniently brief themselves on an aircraft's maintenance history, right down to work done recently by a previous shift that is not on site to answer questions.

MEPSS uses MS Internet Explorer as the delivery mechanism for the information that is extracted from a database. The system also has the ability to post announcements, allowing effective dissemination of critical issues and information among an entire maintenance community.

— Rick Robinson

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Read more at: **gtresearchnews.gatech.edu/newsrelease/maintainer.htm**

U.S. NAVY PHOTO BY PHOTOGRAPHERS MATE 2ND CLASS DANIEL J. MCLAIN

ABOVE: *U.S. Navy personnel prepare an RQ-2 Pioneer Unmanned Aerial Vehicle for flight. Engineers from the Georgia Tech Research Institute developed a software system that is used to help maintain the aircraft.*

Enterprise Innovation Institute

The Georgia Institute of Technology has launched a sweeping restructuring of its business and community assistance programs as part of a new initiative known as the Enterprise Innovation Institute.

The restructuring brings new and established Georgia Tech programs together into a broadly integrated initiative designed to help industry, entrepreneurs, economic developers and communities become more competitive through the application of science, technology and innovation.

Creation of the Enterprise Innovation Institute represents the first major reorganization of Georgia Tech's economic development and business assistance programs since the Economic Development Institute (EDI) was formed in 1993. The changes affect all activities of Georgia Tech's former Office of Economic Development and Technology Ventures, including the Advanced Technology Development Center (ATDC) business incubator, VentureLab research commercialization effort, Commercialization Services initiative and former Economic Development Institute.

Supporting Georgia Tech's goal of defining the technological university of the 21st century, the new organization is expanding efforts to identify and transfer key innovations likely to have significant impacts on local, state and national economies. Plans for the restructuring grew out of consultations with key Georgia Tech stakeholders, findings of the 2005 Georgia Manufacturing Survey and recommendations from the National Innovation Initiative co-chaired by Georgia Tech President Wayne Clough.

"The future viability of local, state and national economies will depend largely on their ability to successful apply science, technology and innovation," says Georgia Tech Provost Jean-Lou Chameau. "Through the Enterprise Innovation Institute, Georgia Tech will bring its considerable resources to bear on helping enterprises of all types become more competitive in today's global marketplace."

A leader in science and engineering education and with a research program totaling more than $400 million a year, Georgia Tech is a major developer of science and technology innovations. Building on these new technologies and collaborating with like-minded organizations, the Enterprise Innovation Institute will work with the private sector to apply innovations to real marketplace needs, Chameau adds.

PHOTO BY GARY MEEK

ABOVE: *Georgia Tech Vice Provost Wayne Hodges leads the new Enterprise Innovation Institute.*

> "Business is now global, and companies must compete on the basis of innovation."
>
> **Wayne Hodges,** Georgia Tech Vice Provost

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PHOTO BY GARY MEEK

ABOVE: Vivonetics Research Scientist Omar Alexander works in the company's laboratory in the Advanced Technology Development Center Biosciences Center on the Georgia Tech campus.

RIGHT: Emergency signage is important in preventing pollution from fueling stations. Pollution prevention experts Jim Walsh, center, and Ed Hardison, right, discuss information on a sign with Michael Jordan of Georgia Tech's Facilities Division.

"The rapid and dramatic changes taking place throughout the world mean U.S. companies can no longer compete just by reducing costs and boosting efficiency," says Georgia Tech Vice Provost Wayne Hodges, who heads the new organization. "Business is now global, and companies must compete on the basis of innovation. To succeed in the future, companies must be able to develop and commercialize innovative products, processes and services ahead of their competition."

— John Toon

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Preventing Pollution

Although stormwater runoff may not seem particularly threatening, it ranks among the most common sources of water pollution in the United States. Especially at industrial sites, rain and melting snow can pick up a variety of pollutants — ranging from processing chemicals to cleaning solvents — and sweep them into nearby creeks, lakes and rivers.

Federal regulation calls for companies engaged in certain industrial activities to obtain a stormwater permit and implement a pollution prevention program. Although an important endeavor, this can also be an onerous task, especially for small and mid-sized companies with fewer resources.

To ease compliance headaches, the Georgia Institute of Technology's Energy and Environmental Management Center (EEMC) has developed stormwater pollution prevention plan (SWPPP) software that streamlines the planning process — reducing time and effort by as much as 80 percent.

Funded by the U.S. Environmental Protection Agency's Office of Water, this Web-based tool helps companies determine whether they even need a stormwater permit. "If you don't have any pollutants exposed to storm water, you are exempt, but most manufacturers fall into one of the 11 categories that require a permit," says Ginny Key, an instructional designer at EEMC.

Available at either **www.gatechstormwater.com** or **www.gatechenvironment.com**, the SWPPP software walks companies through a series of questions about their facilities, such as whether they have outdoor fueling stations or loading docks. Then the tool guides companies through:

- assembling a pollution prevention team;
- identifying potential pollutants;
- selecting appropriate best management practices to control pollutants;
- record keeping and reporting;
- employee training; and
- implementing and updating the plan.

Some pollution-prevention remedies may require structural modifications, such as installing mechanisms to equipment to prevent fuel spills. Yet many best practices are a simple matter of good housekeeping, say Ed Hardison and Jim Walsh, EEMC project engineers who helped develop the SWPPP tool.

When the SWPPP tool presents a best practice, it includes various business factors, such as implementation and maintenance costs, level of difficulty and expertise required.

At the end of the program, the SWPPP tool produces a customized plan in a rich-text-format document that can be easily converted to any word-processing system.

— T.J. Becker

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