Research Notes

Protecting Big Birds

GTRI engineers test new flare decoys on military aircraft.

With the increasing threat of enemy attack on military aircraft by heat-seeking missiles, engineers at the Georgia Tech Research Institute (GTRI) are testing new defensive countermeasures called decoy flares, which confuse the weapons' tracking systems.

Because these missiles vary in their schemes for rejecting decoys, researchers are trying to develop a one-size-fits-all flare pattern. They are running thousands of computer simulations to examine as many flare pattern combinations as possible. Then they test the best ones in the field.

In summer 2003, the researchers tested decoy flare patterns on military aircraft at Eglin Air Force Base in Florida as part of their project for the U.S. Air Mobility Command and the Air National Guard. Field tests are key to tailoring the flare pattern to individual aircraft and determining the relative success rate between different patterns, researchers explain.

In these tests, researchers use real flares and real planes, but captive missiles in seeker test vans, which behave as though the missiles were in flight. If the missile seeker transfers its track from the aircraft to the decoy, then the flare pattern is considered a success.

At Eglin, GTRI researchers evaluated flares on four large transport aircraft: the C-5, C-17, C-130 and MH-53. This followed a field test in May 2003 in Yuma, Ariz., which evaluated new flares for the A-10, F-15 and F-16 fighter planes.

Although GTRI has been developing countermeasures for many years, the war on terrorism has accelerated efforts.

"We're working at a heavy, steady pace – building on the progress we make from each test," says project director Charles Carstensen, a senior research scientist in GTRI's Electro-Optics, Environment and Materials Laboratory. "Flares are part of our country's overall requirement to be prepared to fight. If we're ready to fight, then there's less likelihood we'll need to."

Made of magnesium, decoy flares confuse a missile's tracking system by burning white-hot when dispensed. They can defend military aircraft against man-portable air defense missile systems (MANPADS), which use infrared sensors to detect jet engine exhaust. An estimated 500,000 MANPADS exist, posing particular danger to the large aircraft that refuel fighter planes and transport troops, such as the C-5 and the C-17. These aircraft are attractive targets for MANPADS because of their large size and slower speeds.

"MANPADS have been around for three decades, but they've become a bigger threat in recent years because of their increasing sophistication and relative ease of use," Carstensen says. He estimates that MANPADS represent 65 to 70 percent of the United States' air defense problems.

In addition to flares, GTRI also has expertise in directional infrared countermeasure systems (DIRCM), which are jamming systems that use laser beams to inject a signal into the tracking system of an incoming missile, causing it to fly away from the aircraft.

"The beauty of being a research institute is providing independent assessments on different types of countermeasures. We don't have an agenda at GTRI," Carstensen adds. "We evaluate what is the best that can be done with each system. Our bottom line is to protect the air crew."

— T.J. Becker

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U.S. AIR FORCE PHOTO BY MASTER SGT. ROGERT HARGREAVES JR.

A British C-130J launches flare countermeasures prior to landing at the reopened military runway at Baghdad International Airport on July 1, 2003.

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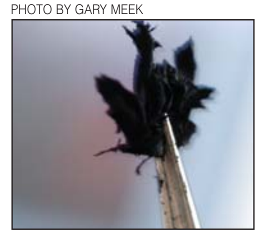
Carbon Copy

GTRI researchers are developing manufacturing technologies to produce electrical devices from carbon nanotubes.

First discovered in 1991, carbon nanotubes have remained largely a laboratory curiosity. Yet researchers at the Georgia Tech Research Institute are out to change that by producing carbon nanotube-based devices for commercial applications.

Carbon nanotubes (CNTs) are a hexagonal network of carbon atoms rolled to form a seamless cylinder – a sort of "chicken wire" lattice of graphite. "This material has tremendous electrical, thermal and structural properties, however, few products utilizing CNTs have hit the commercial market," says Jud Ready, a

PHOTO BY GARY MEEK



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research engineer in Georgia Tech Research Institute's (GTRI) Electro-Optics, Environment and Materials Lab.

Ready is developing a CNT-based electrochemical double-layer capacitor, a project sponsored by the U.S. Army Space and Missile Command.

Such supercapacitors would provide more power, increased energy density (more charge per gram of weight) and longer life than traditional batteries and capacitors that store electrical energy. Ready's supercapacitors are made of two CNT-based active electrodes immersed in an electrolyte and separated by an ion-permeable membrane that prevents electron transfer.

Carbon nanotube-based supercapacitors would provide more power, increased energy density and longer life than traditional batteries and capacitors.

"CNTs are ideal to use as the active electrode material because their nanoscale dimensions provide more surface area for storing charge," Ready says. That extra surface area exponentially increases capacitance – the amount of power that can be stored.

Ready began work on the project last year, aided by Stephan Turano, a materials science graduate student at Georgia Tech, and Charlie Higgins, a computer engineering major from Georgia State University. The team has already produced dozens of CNT supercapacitors, which have been used for electrical tests.

Feedback from those tests helps improve the manufacturing process. For example, the researchers have learned that when pressure is applied to electrodes during testing, the supercapacitor performs better. With that in mind, Ready is trying to incorporate a clamping or bolting between the two electrode plates during production to increase pressure.

The next step is reliability testing to see how the CNT supercapacitors hold up under different environments, which is especially important for space-based applications. The devices are placed in a chamber that exposes them to extreme temperature and humidity, accelerating the aging process. Initially, Ready obtained CNTs from NASA's Johnson Space Center. But with a new piece of equipment, a chemical vapor deposition furnace, the researchers can now produce CNTs on site.

"This will enable us to try a different manufacturing technique – chemical vapor deposition versus the HiPCO (high pressure carbon monoxide) process – and compare and contrast the two methods," Ready says.

Besides providing an alternative manufacturing technique, the new furnace enables researchers to produce CNTs in a controlled manner: They can alter the temperature and flowrates of gases (hydrogen, methane and ethylene) used to form the CNTs. Varying these factors will affect both the quantity and quality of CNTs produced.

One of the biggest challenges is controlling the physical dimensions of CNTs, as their electrical properties vary depending on length, diameter and chirality (how the graphite rolls up). Controlling chirality is by far the most daunting task, which Ready calls "the Holy Grail" of CNT production.

Although Ready focuses on electronic and power applications, CNTs hold potential for a wide variety of uses, including flat-panel displays, electric field generators, solar cells and loss-less motor windings.

Yet a consistent manufacturing method is the key to introducing CNT-materials into real-world devices. With that in mind, Ready is trying to establish partnerships with large manufacturers that could aid in testing and production, and recently signed an agreement with Maxwell Technologies Inc, a San Diego-based manufacturer of supercapacitors.

— *T.J. Becker*

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Bolstering Biotech

ATDC's new Biosciences Center assists life-science startups, accelerates technology transfer.

With bioscience research on the increase in Georgia, Georgia Tech's Advanced Technology Development Center (ATDC) has launched a new incubator devoted exclusively to the commercialization of life-science innovations.

The 22,000-square-foot ATDC Biosciences Center is the first ATDC unit on the Georgia Tech campus to offer wet labs. Equipped with fume hoods and sinks, this kind of laboratory space is important for bioscience companies that typically need special ventilation and purified water systems to advance their research.

Another hallmark of the new incubator is its location within the new Ford Environmental Science & Technology (ES & T) Building, a 287,000-square-foot research center that houses life-science programs ranging from biomedical engineering to clean energy. ES & T is part of Georgia Tech's Life Sciences and Technology Complex.

The ATDC Biosciences Center's location in this complex enables entrepreneurs and university faculty – individuals who are typically isolated from each other – to collaborate more easily. The arrangement also fosters an interesting exchange of perspectives, says Wayne Hodges, ATDC director and Georgia Tech's vice provost for Economic Development and Technology Ventures.

Bolstering Biotech: Dr. Karim Godamunné poses with research scientist Omar Alexander in the Vivonetics laboratory at the ATDC Biosciences Center.

PHOTO BY GARY MEEK

"It helps investors and entrepreneurs better understand the interests of faculty and vice versa," he adds.

ATDC first experimented with this sort of holistic approach in 1996 when it opened an incubator in the Georgia Centers for Advanced Telecommunication Technology (GCATT) building, home for some 20 research centers funded by government and industry. Numerous success stories have emerged from ATDC at GCATT.

The ATDC Biosciences Center is an important "first step" in advancing Georgia's bioscience prowess, says Susan Shows, vice president of the Georgia Research Alliance.

"Although bioscience is growing rapidly, it's still a relatively new industry in Georgia," she explains. "We're trying to identify our core competencies and build industry around those strengths. By putting startups next to outstanding scientists and sophisticated equipment, we hope to generate more successful commercialization and tech transfer."

Although the road to success is bumpy for most entrepreneurs, bioscience startups encounter even more potholes. They have greater capital needs, take longer to get to market and face significant technical risks. They typically operate within a regulated environment, which also complicates commercialization.

"Most products must undergo extensive pre-marketing testing," says Lee Herron, ATDC's general manager of biosciences. "The ultimate commercial product depends on the outcome of clinical trials, and it's not uncommon to spend large sums in pre-clinical and clinical development only to have products fail in clinical studies."

But ATDC helps transform fledgling firms into high-growth companies by providing strategic business advice and resources. And ATDC's sister entity, VentureLab, assists Georgia Tech faculty in the tech-transfer process.

The ATDC Biosciences Center houses both ATDC member companies and VentureLab participants, including:

- Aderans Research Institute, a tissue-engineering company doing research on hair transplantation.
- CardioMEMS, a medical device company using microelectromechanical systems (MEMS) technology to create tiny wireless sensors that will enable doctors to monitor heart patients more easily.
- Focal Point Microsystems, which is creating 3D microstructures with broad applications that range from medicine to advanced communications.
- Orthonics, a tissue-engineering company developing advanced biomaterials to promote bone growth and adhesion.
- Stheno Corp., which is advancing consumer safety through the development of chemical detection systems.
- Vivonetics, which is developing a living-cell gene detection system for drug discovery and research.

Many companies in the new incubator have strong faculty connections. Faculty members may be inventors of technology that's being commercialized, or they may be providing expertise to assist an ATDC member company. Either way, the incubator's campus location allows university faculty to engage in entrepreneurial activity without sacrificing their teaching or research responsibilities.

Also of note, the new incubator provides space for companies that cannot be accommodated in the limited space at EmTech Bio, an incubator on Emory University's campus that is jointly operated by Georgia Tech and Emory. Not only a benefit for companies, the arrangement also strengthens ties between the two universities, Herron says.

— T.J. Becker

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PHOTO BY GARY MEEK

CardioMEMS engineer Florent Cros examines electroplating on samples. The electroplating process is a key manufacturing step in the company's MEMS-based sensors.

Learning by Experience

Undergraduate research program yields multiple benefits for two institutions.

Researchers and students at the Georgia Institute of Technology and Agnes Scott College in Atlanta recently collaborated in an innovative program to provide hands-on undergraduate research experience and build a laboratory instrument for environmental studies, including air quality research.

Led by Georgia Tech Research Institute Principal Research Scientist Gary Gimmestad and Agnes Scott Associate Professor of Physics Arthur Bowling, undergraduate students at both institutions designed and built a laser-based instrument patterned after a type of light detection and ranging (LIDAR) technology. It is eye-safe and operates in the visible light spectrum.

"This instrument development and atmospheric research project has provided an unrivaled undergraduate research experience for the students," Gimmestad says. "…. We believe this program will serve as a national model."

Students spent two semesters designing and building the instrument – called an eye-safe atmospheric research LIDAR, or EARL. It now operates in a new laboratory at the Bradley Observatory at Agnes Scott, a private women's college that has expanded its curriculum because of the instrument.

Like other LIDARs, the students' instrument works like this: 1) A laser emits pulses of light into

Georgia Tech Research Institute Principal Research Scientist Gary Gimmestad, shown, and Agnes Scott Associate Professor of Physics Arthur Bowling led a joint undergraduate research project.

PHOTO BY T. MICHAEL KEZA

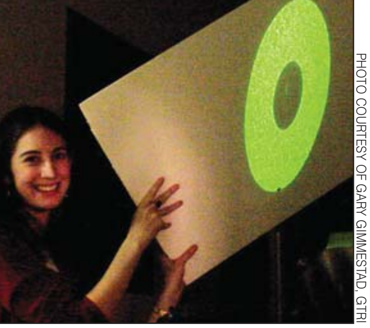

PHOTO COURTESY OF GARY GIMMESTAD, GTRI

Agnes Scott College student Lauren Davis participated in an undergraduate research project jointly led by GTRI and the women's college. The students built a laser-based, air-quality measurement instrument patterned after a type of light detection and ranging (LIDAR) technology.

the atmosphere, where some of the light is scattered. 2) Then a telescope receives some of that scattered light. 3) A detector converts the light to electronic signals. 4) A data system digitizes and stores those signals. 5) Finally, researchers determine the distance the light traveled by multiplying the speed of light by the flight time it took the pulse to travel up and back.

Though they patterned their design after traditional LIDAR instruments, students had to develop detailed designs of the transmitter, receiver and overall structure, Gimmestad notes. And they are evaluating the instrument based on a comparison of its actual measurements to results predicted by a simulation, he adds.

Then students can use EARL to gather environmental data, such as measurements of atmospheric particulate matter, a key indicator of air quality. Gimmestad is hopeful researchers elsewhere also will use data gathered by EARL.

The National Science Foundation funded the three-year program, which began in September 2001. The Georgia Tech College of Engineering also provided funds for the project.

"The collaboration between Agnes Scott and Georgia Tech has benefited both institutions," Gimmestad says. "Agnes Scott has obtained a state-of-the-art research instrument…. For Georgia Tech, the collaboration is providing a natural way to attract qualified female students into its graduate programs."

— Jane M. Sanders

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Faculty Awards and Honors

Georgia Tech faculty and staff receive recognition.

In September, four Georgia Tech faculty members were among 348 scientists and engineers worldwide elected as fellows of the American Association for the Advancement of Science (AAAS). They are:

- **Russell D. Dupuis**, professor in the School of Electrical and Computer Engineering, a Georgia Research Alliance Eminent Scholar and holder of the Steve W. Chaddick Chair in Electro-Optics;
- **Yogendra Kumar Joshi**, a professor in the School of Mechanical Engineering and associate chair for graduate studies in that school;
- **William J. Koros**, a professor in the School of Chemical and Biomolecular Engineering, a Georgia Research Alliance Eminent Scholar and holder of the Roberto C. Goizueta Chair, and
- **Thomas M. Orlando**, professor in the School of Chemistry and Biochemistry and chair of that school.

Headquartered in Washington, D.C., the AAAS is the world's largest general scientific society and publisher of the journal *Science*.

Several professors in the School of Electrical and Computer Engineering and the School of Mechanical Engineering were recently elected to the position of IEEE Fellow, one of the highest honors in the field of electrical engineering. They are

- Associate Professor **Miroslav Begovic** was cited for leadership in developing analysis tools and protection techniques for electric power transmission systems and renewable generation.
- The late Professor **Kevin Brennan** was elected posthumously and cited for contributions to the modeling of impact ionization in heterostructures and multiquantum well structures.
- Professor **Krishna Palem** was noted for contributions to embedded computing. Palem is founder of the Georgia Tech Center for Research in Embedded Systems and Technology.
- Professor **Paul Steffes** was cited for contributions to the understanding of planetary atmospheres. He has been involved with numerous NASA missions, including Pioneer-Venus, Magellan, the Advanced Communications Technology Satellite and the High Resolution Microwave Survey.
- Professor **Charles Ume** was noted for contributions to the thermomechanical reliability of microelectronic packaging. He conducts research in mechatronics.

Professor **Mindy Millard-Stafford** in the School of Applied Physiology was elected a member of the American Academy of Kinesiology and Physical Education. Membership is considered a "who's who list" of the top individuals in the field. Millard-Stafford studies exercise physiology.

The U.S. Department of Energy's National Renewable Energy Laboratory presented the 2003 Paul Rappaport Renewable Energy and Energy Efficiency Award to Regents' Professor of Electrical and Computer Engineering **Ajeet Rohatgi**, founding director of the University Center of Excellence for Photovoltaics Research and Education at Georgia Tech. Rohatgi was cited for development of low-cost and high-efficiency solar cells.