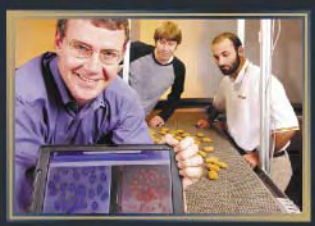
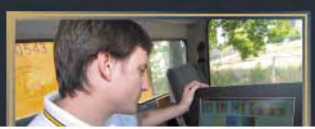
# 2006 ANNUAL REPORT

## RESEARCH FOR THE REAL WORLD

Georgia Tech Research Institute



www.gtri.gatech.edu



RESEARCH FOR A

SAFER WORLD

MORE EFFICIENT WORLD

HEALTHIER WORLD

FAST-PACED WORLD

CLEANER WORLD

BETTER WORLD

# GTRI DOES

## RESEARCH FOR THE REAL WORLD

## TABLE OF CONTENTS



www.gtri.gatech.edu

# 72 SEVENTY-TWO YEARS OF RESEARCH for the Real World

The Georgia Tech Research Institute (GTRI) is a nonprofit applied research organization that operates as part of the Georgia Institute of Technology, a top-ranked academic and research institution located in Atlanta, Ga. For more than 72 years, GTRI has transformed innovative basic research into leading-edge real-world solutions, prototype systems and training for a broad range of customers – including industry and government organizations in Georgia, across the nation and throughout the world.

GTRI traces its roots to 1919, when the State Engineering Experiment Station (EES) was formed by the Georgia Legislature. The Station, which began operation in 1934, was given the mission of helping develop the resources, industries and commerce of Georgia, while assisting with national programs of science, technology and preparedness. Seventy-two years later, the organization – which became the Georgia Tech Research Institute in 1984 – continues to meet all of those needs and many more.

Today, GTRI research involves a broad spectrum of activities combining engineering, science, economics, policy and technical exploration. Like its Georgia Tech parent organization, GTRI's research is interdisciplinary, bringing together key elements of multiple disciplines to address today's most challenging issues. Core research areas include full-spectrum sensing, information technology and integrated systems development.

At GTRI, nearly 600 of the nation's best and brightest scientists and engineers work on solutions to today's real-world problems – while anticipating the challenges of tomorrow. They apply the results of innovative basic research to provide solutions to challenging technical issues while maintaining a worldwide reputation for unsurpassed creativity and technical excellence.

GTRI research takes place within seven laboratories and a dozen field locations that have focused technical missions linked to one another by coordinated program thrusts. The interdisciplinary nature of GTRI research facilitates the formation of teams that bring together expertise to provide clients with the right mix of talent and experience to meet their needs – and consistently exceed their expectations.

## THE GTRI MISSION:

To serve the university, the state, the nation and the world by maturing selected technologies and developing innovative engineering solutions to important and challenging problems of society.





## THE THEME FOR THIS 2006 GTRI ANNUAL REPORT IS "RESEARCH FOR THE REAL WORLD."

The stories that follow illustrate the impact GTRI has by delivering innovative solutions to our diverse stakeholders. There are three key attributes that allow GTRI to consistently develop and deliver high-payoff solutions to our customers:

- **EXPERIENCED AND HIGHLY CAPABLE SUBJECT MATTER EXPERTS:** Throughout our seven laboratories, a dozen national field locations – and now our first international location in Ireland – GTRI's research staff of skilled and experienced engineers and scientists is recognized for technical expertise and commitment to doing what it takes to solve the most difficult problems of our stakeholders.
- **TRUSTED PARTNERSHIPS:** The research results we deliver to our stakeholders depend in large part on trusted relationships developed through all levels of the government and industry organizations with which we work. The relationships can be developed and maintained because we are committed to being an independent, "honest broker" choosing the best solutions regardless of where they originate. The unique partnerships that result allow GTRI to develop a deep understanding of the challenges facing our stakeholders. Because of the trust they place in us, we are able to anticipate future needs and recommend innovative solutions.
- **UNIQUE POSITIONING:** Through our connections to Georgia Tech, and with a national network of field locations, we are able to quickly bring the necessary expertise to bear on our stakeholders' most difficult problems. Because we are an integral part of Georgia Tech, we can contribute to and benefit from the advances made by this leading research university, which operates a $400 million-per-year research program with top-ranked activities in most major areas of science and technology.

> "GTRI's research staff of skilled and experienced engineers and scientists is recognized for technical expertise and commitment to doing what it takes to solve the most difficult problems of our stakeholders."

These three attributes – world-class subject matter experts, trusted partnerships and our place within a major research university with worldwide operating locations – enable us to deliver solutions through innovation. We innovate, by helping to improve how things are done now . We also change the game – by providing a unique venue and capability that help our stakeholders envision new solutions and be the first to use disruptive innovations.

In the pages that follow, I invite you to read about some of our innovations from the past year. Please feel free to contact me about any of our "research for the real world."

Stephen E. Cross
Vice President, Georgia Institute of Technology
Director, Georgia Tech Research Institute

www.gtri.gatech.edu

# GTRI OPENS FACILITY in Athlone, Ireland

GTRI has opened a new European facility, GT Ireland, to conduct applied research.

GT Ireland complements Georgia Tech's international strategy, observed Georgia Tech President Wayne Clough. "Georgia Tech is building its global presence by choosing strategic partners who share our values and our entrepreneurial spirit," he explained. "GT Ireland is a great fit for us given Ireland's innovative approach to developing its economy, the engagement of the research universities of Ireland and the plans to involve industry."

**Georgia Tech already has operations in Europe and Asia:**

- In 1990, Georgia Tech Lorraine was opened in Metz, France, offering graduate and undergraduate classes and conducting sponsored research.
- In late 1999, Georgia Tech partnered with the National University of Singapore to form The Logistics Institute-Asia Pacific in Singapore, which conducts research and offers educational programs in supply-chain management, optimization and technology.

In contrast to these operations, GT Ireland focuses on applied research in partnership with an entire country, noted David Parekh, GTRI's deputy director and GT Ireland's executive director. "Ireland is especially compelling because it has the complexity and resources of a nation but, because it's a small country, it has the agility of a startup. It's an ideal testbed for developing new technologies on a national scale," he added.

GT Ireland will begin with a core group of six researchers and grow to a staff of 50 in the next five years. Parekh expects the new initiative to build a research portfolio exceeding $24 million with work focused on four key areas: Internet protocol television (IPTV), radio frequency identification (RFID), biotechnology and sustainable energy. "This is market-driven research rather than R&D for its own sake," Parekh stressed.

When it comes to sustainable energy, GT Ireland provides a way to tap into the European perspective, said Tom Fuller, a GTRI Fellow and director of Georgia Tech's Center for Innovative Fuel Cell and Battery Technologies.

That's important, because sustainable-energy technologies will be implemented on a larger scale abroad, Fuller said, noting that Europe and the United Kingdom have fewer energy resources and a greater environmental awareness compared to the United States.

"As we move to renewable energy, we have to think about how we manage, distribute, legislate and regulate it," Fuller added. "Ireland is going to have to deal with these challenges much sooner than we are, so we're really interested in how that plays out."

*"Successful economies of the future will be those that embrace knowledge and learn to leverage knowledge to its fullest potential. The Irish government has therefore placed the encouragement of research, development and innovation at the heart of Ireland's economic development strategy. The government's recently announced allocation of $4.7 billion to the ongoing development of Ireland's knowledge economy is evidence of this commitment to innovation and creativity.*

*Further evidence can be seen in IDA's partnership with the Georgia Tech Research Institute, an acknowledged international leader in applied research with a sterling reputation for working alongside industry to solve difficult problems. I am delighted that in 2006, GTRI selected Athlone as the location for its first applied research institute outside the United States. Georgia Tech Ireland is a unique and innovative research institute which I am confident will become a critical component of Ireland's innovation infrastructure. I am proud of our partnership with GTRI and look forward to its continuing success in the future."*

Sean Dorgan, CEO
IDA Ireland
www.idaireland.com

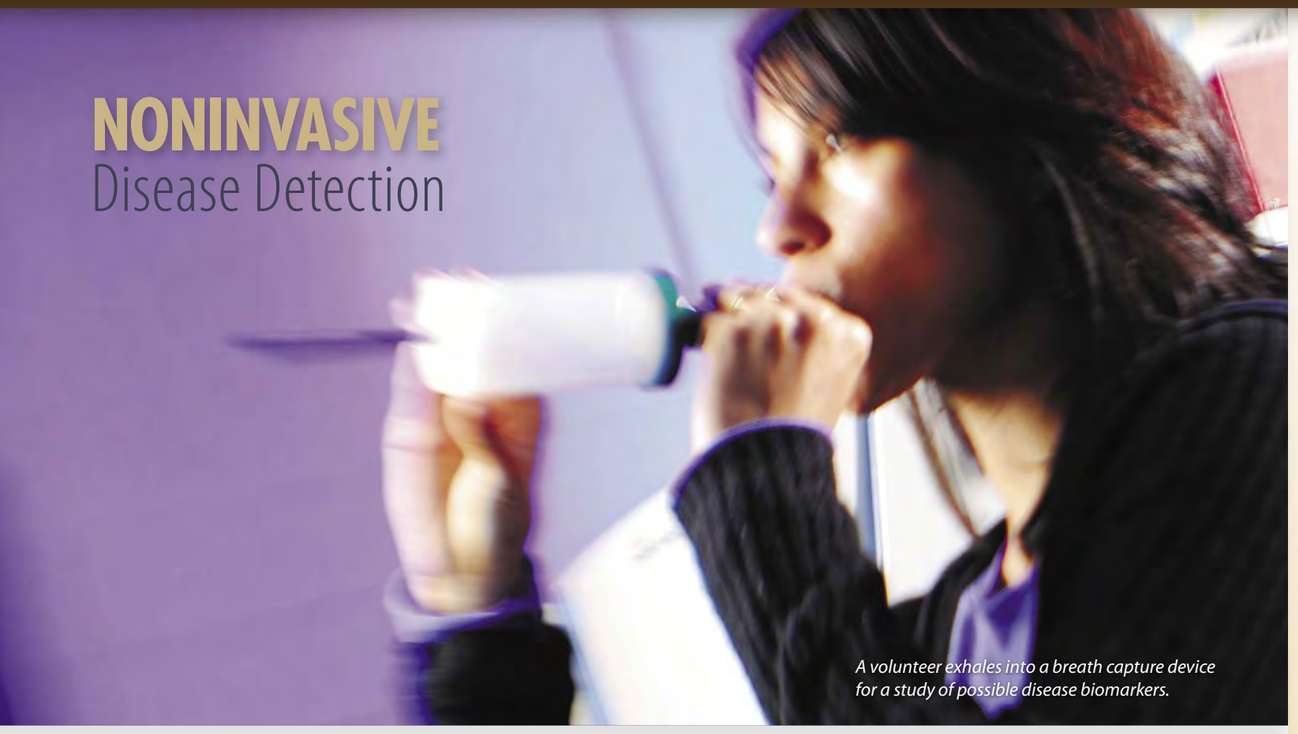




# Research for the Real World


The Georgia Tech Research Institute (GTRI) keeps an eye on innovation to help meet the needs of its customers. GTRI conducts research in full-spectrum sensing, information technology and integrated systems development, serving society with **research for the real world.**

# NONINVASIVE
## Disease Detection



*A volunteer exhales into a breath capture device for a study of possible disease biomarkers.*

Breath analysis has tremendous potential as a non-invasive method for detecting disease, but it hasn't been adapted for clinical use. Among major stumbling blocks are a lack of standard analytical methods and the wide variation in results obtained in existing studies. "Scientists know that it's possible to detect different chemical compounds from people's breath and relate them to illness," explained Charlene Bayer, a GTRI principal research scientist. "Yet they haven't been able to quantify results – such as determining a patient has a tumor because he or she has X amount of Y compounds in his or her breath."

Bayer hopes to change that. She is leading a multidisciplinary team of researchers to identify and measure breath biomarkers for disease detection, beginning with breast cancer. (Biomarkers are biochemical features used to measure the presence of disease, its progress and the effects of treatment.) The researchers' methodology will incorporate gas chromatography – a technique for separating complex compounds – with mass spectrometry, which identifies the chemical makeup of a substance and records data electronically.

In the first phase of the project, researchers will identify different breath biomarkers in women with and without breast cancer. For this pilot study, Bayer's team is collaborating with Dr. Sheryl G. Gabram-Mendola, a professor at Emory University's School of Medicine and director of the Avon Comprehensive Breast Cancer Center at Grady Memorial Hospital.

One of the biggest challenges in developing this measurement system is reproducibility, Bayer said. "We must reproduce results within acceptable parameters from the same patient repeatedly – and have similar results among a similar population to understand the results," she explained. "There are a lot of factors that go into breath analysis, such as what subjects have eaten, how recently they've eaten and if they smoke. We need to be able to minimize those factors."

GTRI researchers will begin looking for chemical compounds related to oxidative stress, which is the body's response to inflammation and often an indicator of disease. Based on the results, the researchers will target specific chemical compounds and then develop statistical techniques for data analysis and interpretation. The researchers are also working with Boris Mizaikoff, an associate professor in Georgia Tech's School of Chemistry and Biochemistry, to develop a sensor that gives real-time results.

If successful, the methodology could lead to a new breed of diagnostic instruments, such as a pre-screening tool for mammograms, which could reduce testing time and costs.

Potential applications are broad, Bayer said. "Take asthma. If we're able to identify biomarkers for inflammation in asthma patients, we could develop an instrument to help doctors know if medicine is actually working," she explained.



FULL-SPECTRUM SENSING

# IMPROVING
## Temperature Control in Industrial Cooking

Consumers can expect that meat products will be safer, tastier and less costly to produce within a year or so as the food processing industry begins to use infrared computer vision scanning systems under development at the Georgia Tech Research Institute.

Infrared (IR) camera technology promises to help prevent potentially harmful undercooking and minimize overcooking – which diminishes taste – of ready-to-serve meat products. It is also expected to reduce energy costs and lower yield loss in the food processing industry.

"IR camera technology is evolving," said Craig Wyvill, chief of GTRI's Food Processing Technology Division. "Today's solid-state camera systems are less expensive and more versatile than units produced in the past. Our research is seeking to exploit these advantages for a very challenging application."

An initial GTRI study funded by Georgia's Food Processing Advisory Council (FoodPAC) determined that IR computer vision technology, which measures product surface temperatures, could be used in conjunction with thermal models to reasonably estimate the core temperature of some meat products as they exit industrial ovens. This ability interests food processors, who want the product thoroughly cooked, but not overcooked. GTRI senior research engineer John Stewart led that project, which included a field study at a Gold Kist plant in Boaz, Ala.

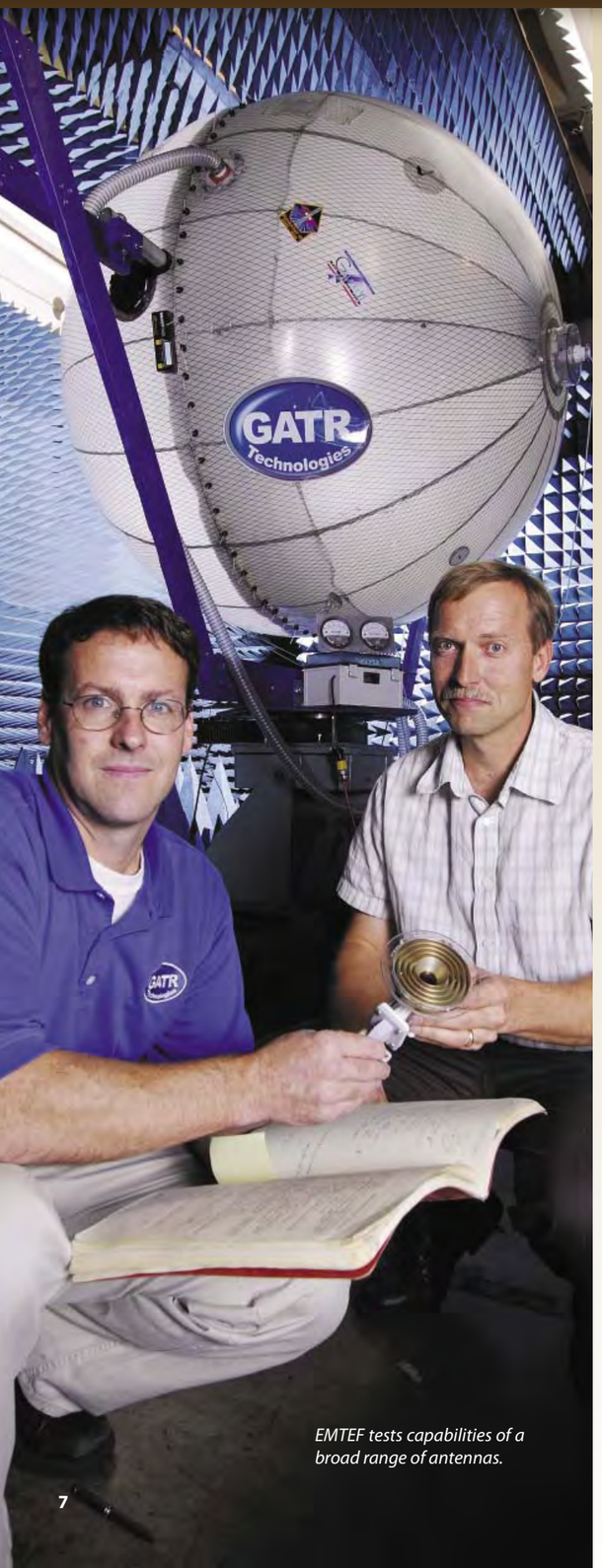
"We also confirmed that the real, near-term value of the IR camera system is its ability to continuously track surface temperature variability on all products coming out of an oven – information with strong potential to help control oven-cooking inconsistencies," Wyvill explained.

These findings led to a new FoodPAC-funded project that GTRI began in 2006. Now, Stewart and his colleagues are studying how information from IR cameras, in conjunction with visible light cameras, can be used to control product temperature within emerging microwave precooking technology, which will be used in conjunction with conventional ovens to shorten overall cooking time.

One of the challenges the team has addressed is synchronizing the images from two different camera systems to simultaneously deliver information on product temperature, color and size. But a bigger challenge being addressed is dealing with high product flow rates and complex product presentations.

The food processing industry is likely to begin using IR computer vision technology by late 2007, Wyvill said.


*Researchers evaluate infrared temperature sensing to control meat cooking.*




*EMTEF tests capabilities of a broad range of antennas.*

# TESTING CAPABILITIES
## Support New Antenna Development

GTRI supports development of a wide variety of cutting-edge antennas, using capabilities based on an extensive installed testing infrastructure.

The Electromagnetic Test & Evaluation Facility (EMTEF), based at GTRI's Cobb Country Research Facility near Atlanta, uses an array of wideband electromagnetic ranges that can provide a battery of tests for virtually any antenna, from the smallest handheld devices to large satellite communications reflectors.

EMTEF's research involves mainly work on prototype antennas for both industry and government, said Greg Hampton, a GTRI senior research scientist. Currently, he said, most testing is commercial, especially in the areas of cellular, personal communication systems and other wireless communications links.

"With the expanding commercial markets, we've had to adapt to different approaches to measuring antenna patterns," Hampton said. "The new customers are more demanding. They're looking for accuracy, but also need efficient testing."

EMTEF has also supported projects as diverse as meteorological drop-sondes, radio telescopes, orbiting antennas and RFID devices.

The test group provides services for many local and regional companies, as well as others throughout the country, Hampton said. The facility emphasizes providing services in a way that is both flexible and cost-effective.

Characteristic of today's emerging antenna concepts is an inflatable plastic antenna that GTRI tested recently for GATR Technologies, said Alyssa Daya, a GTRI research scientist. The large antenna weighs only 11 pounds and can be carried in a suitcase.

When GTRI engineers finished testing the device in the rooftop lab of one of EMTEF's two Far-Field Range towers, Daya said, they dropped the antenna from the 70-foot height to demonstrate its durability.

### EMTEF's current testing resources include:

- Far-Field Range, a complete, high-precision outdoor test facility that includes a 1,300-foot antenna range, including a source tower and a receive tower with a rooftop instrumented radar laboratory.
- Near-Field Range, an indoor range that uses a 10-by-20-foot scanner with a laser-based correction system to minimize out-of-plane probe position errors.
- Spherical Near-Field Range, an indoor, instrumented range that can accommodate antennas up to 8 feet in diameter, and can completely characterize devices in a single, uninterrupted scan.
- Anechoic Test Chamber, an instrumented chamber for indoor testing that is echo-free and is used to test small- to medium-sized antennas at frequencies from 200 MHz to 110 GHz.
- RCS Turntable Range, an outdoor range that supports a variety of instrumentation radars and antenna tests, generally for use on vehicles, at frequencies from 500 MHz to 110 GHz.





*A researcher adjusts a test mannequin in GTRI's environmental chamber.*

# ASSESSING & IMPROVING
## Indoor Air Quality

As scientists learn more about the potentially harmful effects of indoor air pollution, nations around the world are imposing increasingly strict regulations on chemical emissions from furnishings, paints and building materials.

Using a new, room-sized environmental test chamber, more than a dozen smaller chambers and a mass spectrometric center able to measure ultra-trace concentrations of airborne chemicals being emitted from products, GTRI scientists are helping manufacturers meet those international standards to minimize emissions.

"We can help manufacturers address regulatory issues," said Charlene Bayer, a GTRI principal research scientist. "Because U.S. manufacturers sell their products worldwide, they must meet emission regulations imposed by nations in Europe and Asia. We make the measurements companies need to improve their products."

For example, the testing helps manufacturers of indoor furnishings select components that have lower emissions. It also helps textile and apparel companies choose fabric finishes that both survive cleaning and minimize emissions. And it helps makers of paints and other wall coverings select biocides and other chemical constituents with the least impact on the indoor environment.

Large enough to accommodate humans or animals, the new 27.5-cubic-meter environmental chamber allows researchers to study broader concerns, including the impact of low-level indoor air pollutants on productivity and human health.

"There is an emphasis now on developing high-performance schools, and part of that will be to measure how changes in indoor air quality improve the performance of children," Bayer explained. "By studying how emissions from normal furnishings affect children performing classroom tasks, you can estimate what might happen if you reduce the emissions."

Tests involving humans are carefully designed to avoid exposing subjects to potentially harmful levels. The research also is done under close medical supervision, with cameras and a special windowed door to monitor subjects inside the chamber.

Beyond helping manufacturers improve their products, the new facility may lead to a better understanding of what compounds cause problems and how indoor pollutants form.

# PROVIDING Secure Monitoring of Shipping Containers

A new shipping container security device in development by the Georgia Tech Research Institute could make U.S. ports less vulnerable to terrorist activities. The contract is funded by the U.S. Department of Homeland Security (DHS).

Containers equipped with the new devices will be continuously monitored for unauthorized attempts to open the container doors, using a novel sensing technique that is sensitive to door angular position. The system will securely communicate container information remotely to port authorities, providing a log of door activity and an alarm if an event occurs that requires immediate attention.

"The system is intended to improve port security by monitoring improper access to the container," said lead researcher Gisele Bennett, director of GTRI's Electro-Optical Systems Laboratory. "We need the ability to automatically detect unauthorized openings of container doors to prevent the potential introduction of illicit materials."

*Research team with test shipping container.*

The function of the device is to automatically detect the opening, closing and/or removal of container doors. A key feature of the sensing technique is that the design prevents tampering with or removal of the device from the container without an alarm being generated. This will provide a significant upgrade over current door security methods that rely on seals, which can be easily defeated, and will fix a major vulnerability in existing port security protocols.

Engineers are designing the system to monitor 20- and 40-foot "dry box" (non-refrigerated) containers. They are drawing upon GTRI's expertise in integrated sensor systems development, including another DHS-sponsored project to develop concepts for an Advanced Container Security Device that was completed in October 2005.

Working with Bennett are lead GTRI optical engineers Terence Haran and Chris James. In addition, Tim Strike, David Fentem and Adam Tichelaar, with engineering expertise in packaging and electronics, were added to the original team. Work on the security device is expected to be finished by early spring 2007.

*A container ship unloads at the port of Savannah.*







*Command and Control, Battle Management and Communications Control Center for the Ballistic Missile Defense System.*

# SUPPORTING Development of the Missile Defense System

A modeling and simulation tool developed as part of a multi-organizational team, and now maintained by GTRI engineers, is helping U.S. government agencies and contractors improve the nation's ability to defend against ballistic missile attacks.

The Ballistic Missile Defense (BMD) Benchmark is a complex computer simulation used for developing and testing the algorithms that track missiles, associate and combine sensor data, control sensor resources, and provide management and communications support for the U.S. Command, Control, Battle Management and Communications (C2BMC) system. The C2BMC provides the digital foundation for the nation's Ballistic Missile Defense System.

With sponsorship from the Office of Naval Research and the Missile Defense Agency, the Benchmark has been made broadly available to the agencies and contractors working on the C2BMC and other related programs for the Department of Defense. Within this community, the modeling and simulation tool provides a consistent shared environment for the independent development and evaluation of the algorithms that make the Ballistic Missile Defense System work.

The C2BMC relies on information from multiple tracking and monitoring systems located on ships, satellites and land-based facilities. The merger of information from those systems – which were never designed to work together – has posed significant and complex challenges. By providing an accurate simulation of those systems that all agencies and contractors can use, the Benchmark creates a "level playing field" that facilitates the development and evaluation of solutions to those challenges.

"The BMD Benchmark software provides designers an independent and in some ways peer-reviewed model representation that they can use to solve their tracking and sensor-networking challenges," said Phillip D. West, a GTRI principal research engineer. "By providing a standardized development and testing environment, it allows different groups to work together to solve problems of national importance."

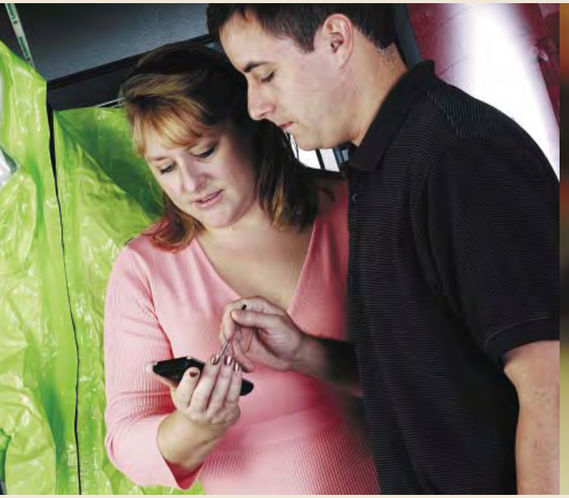
Tracking even a single missile can be extremely complicated. To provide decision-makers with high-level information, the C2BMC must separate tracks on the harmless boosters and debris from the track on the warhead, determine which tracks represent real threats, and associate information provided by different sensor systems – integrating all the information to help make evaluations that can be used for rapid decision-making.

"To develop the algorithms for forming an accurate track picture, you have to very carefully model the properties of the sensors and trackers involved, the networks that carry the information from the radars back to the central processor, and the phenomenology associated with the missile complex," noted William Dale Blair, also a GTRI principal research engineer.

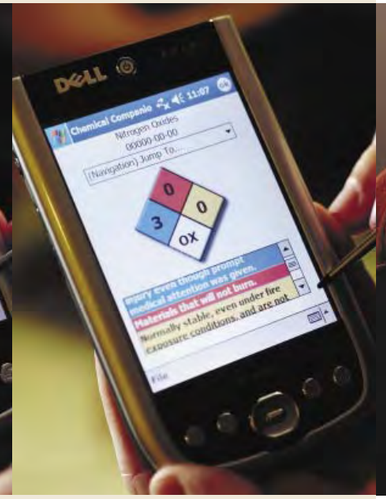
GTRI is responsible for maintaining and improving the BMD Benchmark for the approximately 40 agencies and contractors that use it. As lead for the development, GTRI integrates the contributions of other organizations and small businesses into the modeling simulation infrastructure. Part of that support involves conducting periodic courses that train new users and user meetings that communicate enhancements in the simulator.

Written in Matlab, the Benchmark is designed to run on desktop computers so it can be used by individuals or smaller organizations without large computer centers.

# NEW-AND-IMPROVED Chemical Companion



Researchers demonstrate use of the Chemical Companion.


Chemical Companion screens display vital information about chemical hazards.

GTRI's Chemical Companion provides first responders with critical information about hazardous materials. Launched in early 2006, the software tool is now being expanded from 120 to more than 1,000 chemical agents.

Sponsored by the federal government's Technical Support Working Group with funding from the Department of Homeland Security (DHS) and the Department of Defense (DoD), the Chemical Companion helps hazmat teams make decisions about:

- Chemical reactivity that could result in toxic fumes, fires and explosions.
- Which protective clothing and respirators to wear.
- How long responders can remain in a contaminated zone.
- Boundaries to establish for isolation and protective zones.
- Appropriate medical aid.

"Chemical Companion provides quick and easy access to knowledge about chemical reactions and containment," said Gisele Bennett, director of GTRI's Electro-Optical Systems Laboratory. Before first responders can aid victims and decontaminate the scene of an accident – be it a truck spill or terrorist attack – they must first determine what substances are present and understand risks, she explained.

Although other tools exist for hazmat teams, such software programs can cost as much as $2,000 per license. Not only does Chemical Companion offer a greater depth of information, but the software is also free to the military, law enforcement agencies and fire departments.

"We're also working out a plan to give commercial entities access to the software for a nominal fee," Bennett added. "For example, after a natural disaster like a hurricane, energy companies may encounter unknown liquids or gases while their workers are restoring power."

### Other new developments include:

- A Web site (www.chemicalcompanion.org) where users can register, download the software and access updates.
- A section on decontamination.
- A "help" section that clarifies acronyms and features.
- A desktop version.

Currently, the software runs on Windows CE-based personal digital assistants (PDAs). "During beta-testing, we got a lot of feedback from users who would like to use the program on their laptops," explained Benjamin Medlin, a GTRI research scientist. "The desktop software will contain the same information as the PDA version, but we'll make changes to the user interface since there's a lot more screen space to work with."

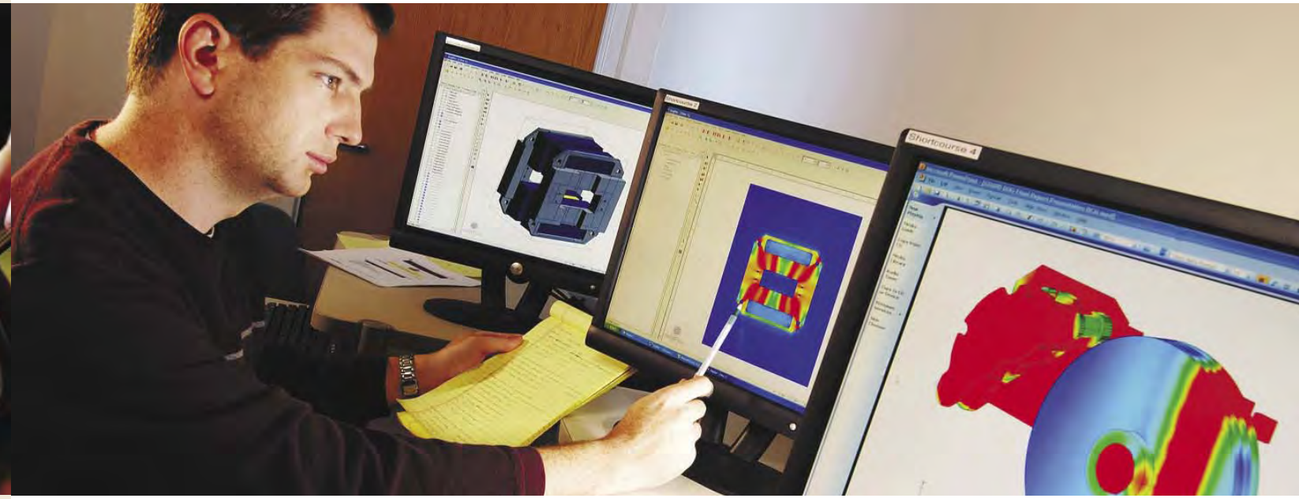
The PDA version, he explained, features many dropdown menus and automatic fill-ins to minimize the amount of typing required from first responders who typically wear bulky hazmat suits and gloves.

As Chemical Companion becomes more robust, Bennett envisions additional applications. "It could be an interesting screening tool at airports," she said, referring to new restrictions on liquids for air travelers. "Security officers could use the tool to see what sort of reactivity might result from a combination of products that, by themselves, are benign."





# FAIL-SAFE TECHNIQUES for Protecting Sensitive Data




A researcher models a data destruction circuit for erasing sensitive data.

After a U.S. intelligence-gathering aircraft was involved in a mid-air collision off the coast of China four years ago, the crew was unable to erase sensitive information from magnetic data storage systems before making an emergency landing in Chinese territory.

That event underscored the need for simple techniques to provide fail-safe destruction of sensitive data aboard such aircraft. Working with defense contractor L-3 Communications Corp., GTRI scientists have developed a series of prototype systems that use special high-strength permanent magnets to quickly erase a wide variety of storage media.

Developed so far for VHS tapes, floppy drives, data cassettes and small computer hard drives, the techniques could also have commercial applications for banking, human resource and other industries that must also protect sensitive information.

"This is a very challenging problem," said Michael Knotts, a GTRI senior research scientist. "We had to verify that the data would be beyond all possible recovery even with an unlimited budget and unlimited time. Commercial devices on the market for data erasure just couldn't fill the bill, because they were magnetically too weak, they were physically too large and heavy, or they didn't meet stringent air safety standards."

During the three-year project, Knotts and collaborators Don Creyts, Dave Maybury, Candy Ekangaki and Tedd Toler explored a broad range of possible destruction techniques, including burning diskettes with heat-generating thermite materials, crushing drives in presses and chemically destroying the media. Ultimately, they determined that magnetic destruction was the only feasible technique.

The researchers had to select techniques and equipment that would be light enough for aircraft use and operate independently of aircraft electrical systems, be mechanically simple to ensure reliable operation, produce no harmful gases or flame and provide mechanisms to prevent inadvertent erasure.

Producing a magnetic field sufficient to destroy data patterns required the use of neodymium iron-boron magnets custom-designed for the project and special pole pieces made of esoteric cobalt alloys. The magnets, which weigh as much as 125 pounds, had to produce fields sufficient to penetrate metallic housings that surround some drives.

Mechanically, the researchers faced challenges in reliably moving data storage devices through the magnetic fields. In some cases, aircraft crews would simply insert removable media into a motorized mechanism that pushes them past the magnets, while for other media, crews would have to twist a knob and pull drives out of their enclosures and through a magnetic field. To prevent accidental erasure, each technique requires several deliberate steps.

*Children using the Internet must be protected from a range of threats.*

# CYBER SAFETY for Kids

With the proliferation of Web communities aimed at young people, child molesters are no longer hanging out at playgrounds – the Internet has become their new venue for finding victims. To combat this threat, GTRI's Foundations for the Future (F3) is developing a cyber-safety program for children and teens.

Launched in 1996, F3 is a group of GTRI researchers that seeks to improve learning in K-12 classrooms through technology. Initially, F3 focused efforts on connecting schools to the Internet and bridging the digital divide, but in recent years, the group's work has broadened.

"Today there's a new emphasis on safety," said Claudia Huff, F3's director, referring to danger from both network hackers and online predators. "Students need to be protected while they're connected. Our initiative will help youngsters change their online behavior so they're not targets for predators."

F3 is modeling its cyber-safety program after NetSafe, a highly successful program in New Zealand that takes a community approach to online safety. Joining F3 as program partners are the Georgia Bureau of Investigation, the Georgia Department of Education, the Georgia Emergency Management Agency and Georgia Public Broadcasting.

In addition to new technology solutions, Georgia's cyber-safety program will help schools set policies on how to handle incidents, such as discovering child pornography on someone's computer. "There are certain procedures that must happen for evidence to be valid in court," explained Dara O'Neil, an F3 staffer and GTRI researcher.

Awareness training is large component of the program, O'Neil added. She referred to MySpace.com, an online community where participants can create custom Web pages, post pictures, write blogs and exchange e-mails. In an effort to get more hits on their Web pages, many young men and women have posted revealing photographs of themselves along with personal information that could be used to identify and locate them, such as what school they attend.

"They don't realize that by doing this, they're making themselves vulnerable to online predators," O'Neil said. "Educators, parents and children need to take responsibility."

> "Students need to be protected while they're connected. Our initiative will help youngsters change their online behavior so they're not targets for predators."





# CREATING an Integrated Development & Test Environment

*The Mission Systems Testbed combines several existing simulators.*

Engineers at the Georgia Tech Research Institute (GTRI) have developed a new Mission Systems Testbed that combines the capabilities of several different simulators into a single integrated system that provides a realistic model of the information flowing into the cockpit of a modern military aircraft.

The testbed provides a realistic environment for developing and testing new mission software for increasingly "network-centric" aircraft systems that can access information previously available only at central command facilities. The new testbed also helps software developers address the challenges of correlating data to help aircrews better understand the information coming in.

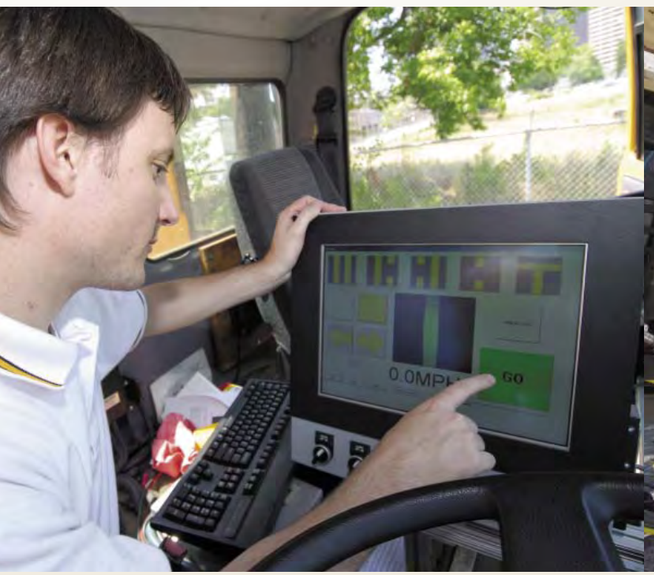
"We've had independent simulators for onboard electronic systems, radar warning receivers and data link simulations for tactical data links, fighter networks and ground control networks," noted Joe Brooks, a GTRI principal research engineer. "We've also had systems for simulating the intelligence provided by satellite systems. In the Mission Systems Testbed, we've put all these together with some additional capabilities to create a fully integrated environment for testing and developing new mission software."

Previously, different aircraft avionics systems were created and tested by independent developers, then brought together and integrated into the aircraft. Availability of the new testbed allows software development and testing to take place in a more realistic environment where these systems must work together.

Just as computer networks have given the business world access to crucial supply chain and similar information, military networks have also made aircraft crews better informed about the threats around them. As a result, crews on transports, helicopters and fighters now know what's happening on other aircraft, and can get information directly from satellites, ground stations and other sources. But all this information can increase the workload for crews that were already busy.

"One of the key challenges ahead is correlation of all the data that comes in from the different networks," Brooks explained. "The type of data provided by those sources may appear to be somewhat different, but it may be pointing to the same threat. So it will help aircrews if we can correlate information to let them know what refers to the same threat – not two different threats. We will be working in that area to write software and develop systems to solve that correlation challenge, and this testbed will support that work."

Initially, the Mission Systems Testbed will be used internally by GTRI researchers, but plans call for it to be made available to outside organizations also working in the area. Supported by GTRI independent research and development funds, the new testbed can be easily expanded as new mission system capabilities are added to U.S. aircraft.




*Pavement marker placement is controlled by an in-cab system.*

*Researchers examine pavement marker placement system.*


*Researchers prepare the fuel-cell aircraft for flight.*



INTEGRATED SYSTEMS DEVELOPMENT

# AUTOMATED SYSTEM Places Pavement Markings

On rainy nights in Georgia and across the nation, drivers greatly benefit from small, reflective markers that make roadway lanes more visible.

There are more than 3 million of these safety devices, called raised pavement markers (RPMs), in service on Georgia highways. They are installed and then need to be replaced about every two years by road crews who consider the task one of the riskiest they face. Workers typically ride on a seat cantilevered off the side of a trailer just inches from highway traffic.

Manual RPM placement is not only risky for personnel, but it is also expensive and time-consuming. A typical RPM placement operation includes four vehicles and a six-person crew. All the vehicles must stop at each marker location, so there is tremendous wear on the equipment and increased fuel use.

The Georgia Department of Transportation (GDOT) believed there was a better way to do it and funded the Georgia Tech Research Institute (GTRI) to develop a first-of-its-kind system capable of automatically placing RPMs along the lane stripes while in motion. After almost three years of research and development, a prototype system is completed.

"The advantages of our automated system are that it's less labor-intensive, it's faster and safer, uses less fuel, and it causes less wear and tear on GDOT equipment," explained project manager Wiley Holcombe, a GTRI senior research engineer.

Engineers conducted the work in two phases. First, they designed an RPM-placement mechanism using pressure-sensitive adhesive and a lane-stripe tracking system. Then, they developed a full-scale, truck-mounted RPM placement system.

After some field-testing, the project resulted in a prototype system capable of dispensing an RPM onto the pavement, along with the necessary hot-melt adhesive, all applied while traveling at 5 miles an hour. A pattern-change mechanism can position two placement mechanisms to accommodate any of GDOT's five specified RPM placement patterns, Holcombe explained. Operation of the system requires only two people.

"The GDOT's primary use for the automated RPM placement machine will be placing markers on the skip lines for interstate and multi-lane highways," said GDOT spokesperson Karlene Barron. "These types of routes pose the highest safety risks to our employees and equipment. The GDOT also plans to use the system on high-traffic-volume secondary or two-lane roads, when possible."

# FLYING on Hydrogen

Georgia Tech researchers have developed a hydrogen-powered aircraft believed to be the largest unmanned aircraft to fly on a fuel cell using compressed hydrogen.

The fuel-cell system that powers the 22-foot wingspan aircraft generates only 500 watts. "That raises a lot of eyebrows," said Adam Broughton, a research engineer in Georgia Tech's Aerospace Systems Design Laboratory (ASDL). "Five hundred watts is plenty of power for a light bulb, but not for the propulsion system of an aircraft this size."

A collaboration between ASDL and GTRI, the project was spearheaded by David Parekh, GTRI's deputy director and founder of Georgia Tech's Center for Innovative Fuel Cell and Battery Technologies. "A fuel cell aircraft is more compelling than just a lab demonstration or even a fuel cell system powering a house," Parekh observed. "With an airplane, you really push the limits for durability, robustness, power density and efficiency."

Fuel cells, which create an electrical current when they convert hydrogen and oxygen into water, are attractive energy sources because of their high energy density and low environmental impact.

"The range of potential applications is tremendous," said Dimitri Mavris, ASDL director and Boeing Professor in Advanced Aerospace Systems Analysis in Georgia Tech's School of Aerospace Engineering. "Improvements in power densities for fuel cell systems will enable new aircraft and aircraft subsystem concepts, particularly in UAVs (unmanned aerial vehicles)."

For example, hydrogen-powered UAVs could be used for weather monitoring, storm tracking, border patrol and surveillance, disaster relief imaging and communication capabilities.

Although other research groups have also flown UAVs on compressed hydrogen, these planes were designed at a much smaller scale and had to be hand launched. In contrast, Georgia Tech's demonstrator vehicle operates like a full-sized aircraft, requiring no auxiliary batteries or boosters for takeoff.

To build the power plant, researchers used a commercial proton exchange membrane (PEM) fuel cell that they modified extensively, adding systems for hydrogen delivery and refueling, thermal management and air management.

Because of the power plant's heavy weight and low output, the research team – which also included doctoral students Tom Bradley and Blake Moffitt – faced slim performance margins. By developing innovative computer tools to analyze and model performance, they were able to optimize the propulsion system and aircraft design.

In June 2006, researchers conducted four test flights that validated their design tools and methodologies. The research team will continue to test and refine the aircraft, making it more reliable and robust. Ultimately, they plan to design and build a UAV capable of a trans-Atlantic flight, which Parekh believes will be possible within the next five years.

The project is supported with internal funding from GTRI, along with grants from the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF).

# MODERNIZING Sweden's HAWK Air Defense System

*GTRI helped Sweden modernize its HAWK Air Defense System.*

GTRI engineers have worked with the government of Sweden to modernize that country's HAWK Air Defense System with a new fire control post that works closely with Swedish-built radar and communications systems. The modernized fire control system relies on rugged, commercial-off-the-shelf computers, and includes an embedded training system to help maintain operator readiness.

The HAWK Air Defense System provides the ability to combat medium-range aircraft and missile threats. At the heart of each HAWK battery is a fire control system that tracks targets, communicates with commanders, processes commands and controls missile firing. The Swedish government wanted to upgrade the system to use modern software and digital components compatible with other equipment used by its military.

First fielded in 1960, the HAWK system has undergone many improvements over the years and remains a formidable air defense system. But because it includes some older analog components, the GTRI task included development of interfaces that allow legacy equipment to work with modern digital hardware.

GTRI engineers were familiar with the HAWK system through their earlier assistance to the U.S. government during development of the Phase III HAWK system. GTRI engineers traveled to Sweden to learn about the radar and communications systems used by the Swedish government, as well as the shelters built to house the fire control system and its operators. GTRI researchers were an integral part of the first live missile-firing exercise with the new system, and this past fall, provided technical support for a second test firing.

"The new system allows them to interface with their modern hardware, including their new radars and their command-and-communications systems," explained David Pyne, a GTRI research scientist who headed up the project's final phase. "This allows the system to be more scalable, and provides more information so operators can make better decisions. This will improve their overall combat effectiveness."

Beyond the fire control tasks, the new system also includes an embedded program that allows training to take place apart from major components of the missile system. Simulating radar inputs and the missiles, the program reduces the cost of training.

"They don't have to set up the whole system every time they want to train," Pyne added. "There are scenario situations that can be created that give them flexibility in training their soldiers."

Though the project is now winding down, GTRI is looking ahead to future cooperation with the Swedish government. Other GTRI researchers who worked on the HAWK modernization project include Patrick Dowdy, Robert Kearney, Brandon McMahan, James Smith, Glenn Parker and Ken Hudson.



INTEGRATED SYSTEMS DEVELOPMENT

# UNIFYING Military Communications Software

GTRI is integrating several versions of its military communications network testing software into a single centralized approach, while also adding new capabilities for tactical training.

Called the Network Centric Test/Training System (NeTTS), the new program contains core elements of GTRI's test and training tool suite, used for evaluating communications effectiveness on today's battlefield. Other tools and capabilities will be added as NeTTS continues to develop.

Joshua Davis, a research scientist who is a key member helping to shape the NeTTS vision, described the project as an evolutionary advance. Inspired by civilian open-source models, NeTTS will provide a cooperative code base that will speed development and increase usability.

"We're developing a framework to give engineers throughout GTRI an infrastructure, one that will allow upgrades and improvements to become available to the entire organization as well as end users," Davis said.

Since 1997, GTRI has developed test and training tools for distributed, "network-centric" environments of the military's Command, Control, Communications, Computers and Intelligence (C4I) environment. The work has been funded largely under the Department of Defense's Resource Enhancement Program.

The first of these tools, the Realistic Operational Communications Scenarios (ROCS) System, pioneered a systematic approach to C4I testing, focusing on ground combat elements. Successor systems – the Commander's Air Defense Environment Test Tool (CADETT) and the Integrated Broadcast Service Test and Analysis Tool (ITAS) – focused on air operations and intelligence systems.

These related tools have been used in developmental and operational test and evaluation performed for all four military services and other DoD agencies.


*Members of the NeTTS development team.*

Originally conceived by GTRI principal research engineer Fred Wright, NeTTS offers the same capabilities as the earlier programs – as well as the new training components.

But NeTTS will be much less costly to maintain and upgrade, as ongoing development becomes significantly more flexible and transparent, Davis said. The centralized code base will allow rapid deployment of updated code, new plug-ins and drivers, new development language versions, trouble-shooting and other changes.

The NeTTS training component will emphasize realism. This approach will focus on software that can merge training with actual tactical communications systems to offer a true hands-on experience.

"We're putting the emphasis on constant improvement," Davis said. "Just as in a business, if you're not improving, you're falling behind."

# PROVIDING
## Low-Cost, Rangeless EW Training

Engineers at GTRI are helping Air Force crews rehearse for enemy attack. The Virtual Electronic Combat Training System (VECTS), an in-flight training program, can mimic enemy threats with both realism and convenience.

Working with the Advanced Airlift Tactics Training Center (AATTC) in St. Joseph, Mo., researchers are providing VECTS technology that simulates enemy threats using an aircraft's built-in electronic warfare (EW) warning devices.

Such "rangeless" EW training works without the need for the aircraft to fly over an electronically equipped military range. This approach lets crews experience and react to apparent enemy attacks during otherwise routine training flights.

"Rangeless tactical training allows aircrews to drill on EW systems that they usually don't ever see operating," said Joe Brooks, a GTRI principal research engineer. "Generally, crews don't have much interaction with their defensive systems because they're not part of normal flying."

Traditionally, Air Force crews have used handheld flash cards to initiate a defensive-system drill during flight, an approach that lacks realism. Alternatively, aircrews trained while flying over military ranges that electronically stimulated the aircraft's onboard EW systems. But range flyovers are costly and involve availability and scheduling issues, resulting in limited training opportunities for many aircrews.

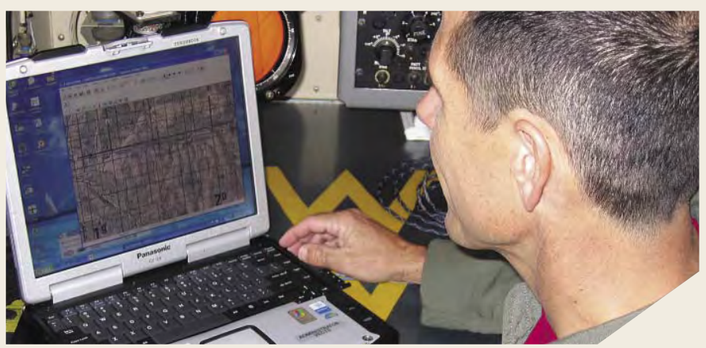
By contrast, VECTS is low-cost and allows flexible training schedules. It also uses existing on-aircraft defensive-system displays and audio.

Currently, VECTS is being deployed or prepared for deployment on three different front-line military aircraft, and is being considered for use on additional platforms.

VECTS training simulations are hosted on a military-approved laptop computer that records data used for debriefings, and also serves as a planning station for training missions using FalconView, a GTRI-developed program. Alternatively, VECTS can be embedded into an aircraft's onboard operational flight program.

Either way, VECTS is the training component of the aircraft's vital defensive system.

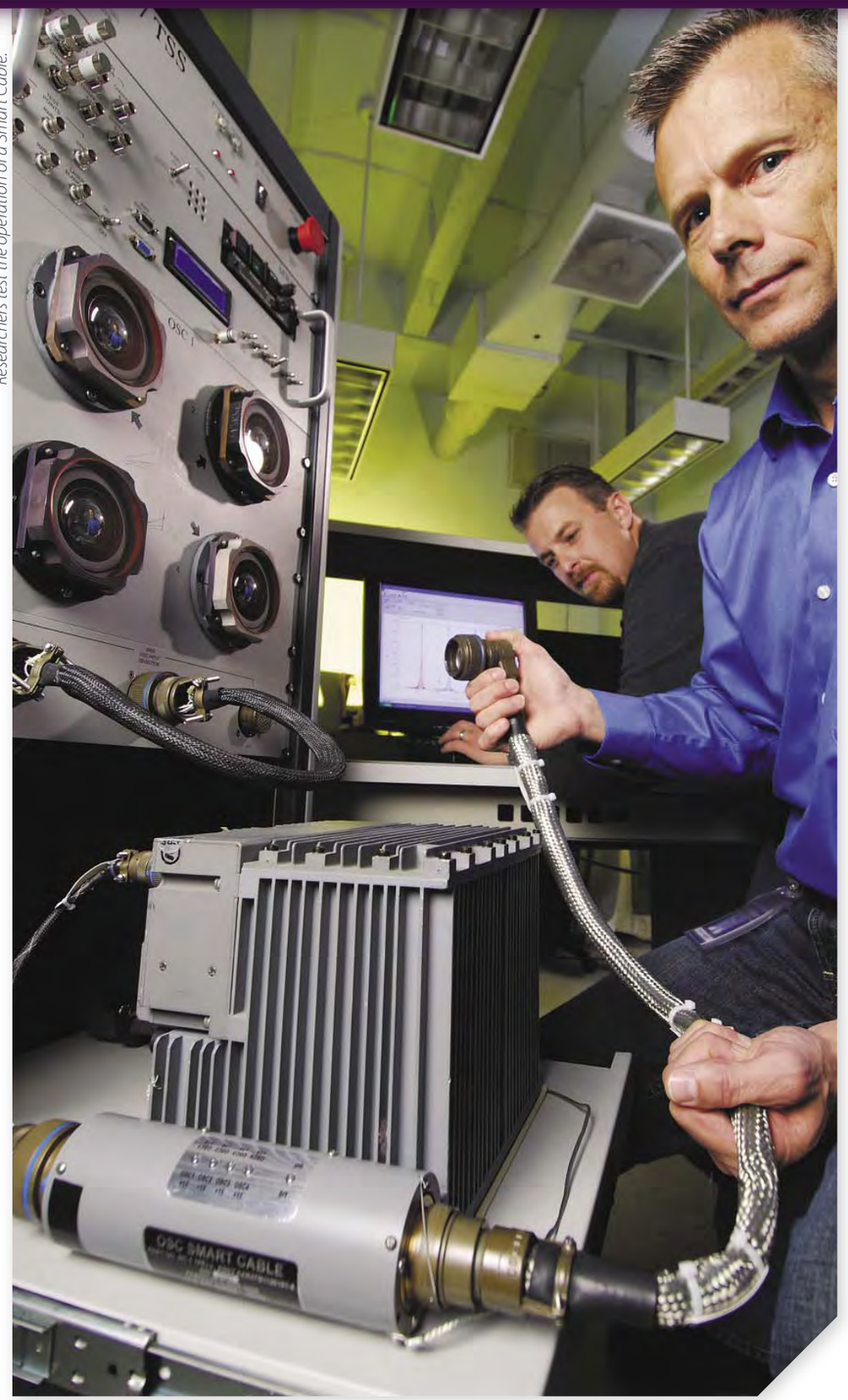
"VECTS provides realistic training. When aircrews see threat symbols on their display and hear the threat audio, it is as though there is a real threat on the ground," said Linda Viney, a GTRI senior research engineer who serves as program manager for VECTS. "It simulates exactly what the threat system is doing, whether it's just out there searching, or it's tracking an aircraft -- or it's actually launching a missile."




*The VECTS system helps crews train for enemy attacks.*



INTEGRATED SYSTEMS DEVELOPMENT




*Researchers test the operation of a Smart Cable.*

# HIGH-PRIORITY
## Aircraft Defense Upgrade

Working on a tight deadline, GTRI engineers developed a device that enhances the capabilities of the missile warning system of many military aircraft flown by the United States and its allies.

Called the Smart Cable, the device plugs into the existing AAR-47 missile-warning system used on hundreds of military aircraft. Today, the device is doing its job aboard U.S.-made airplanes throughout the world.

"Normally a development like this would take 12 to 18 months, but this was highly accelerated," said Jeff H. Hallman, a GTRI principal research engineer. "We knew that we needed to make this enhancement as quickly as possible."

In 2003, Air Force flight tests indicated that a significant improvement in the performance of the AAR-47 missile-warning system could be made. GTRI had been involved in maintenance and upgrade of the AAR-47 for a decade, and GTRI engineers were among those asked by Robins Air Force Base, the Air Force's lead maintenance center for the AAR-47, to examine the issue.

GTRI engineers began to test solutions and were soon ready with a proposal. The AAR-47 Air Force Tiger Team weighed a long list of proposed solutions and decided to fund the GTRI approach.

GTRI gave this project high priority because the Air Force needed to implement a solution on many planes quickly. GTRI engineers designed and built a prototype Smart Cable in two months, from February to April 2004.

The prototype was delivered on time, and flight tests on an Air Force C-5 transport aircraft at Eglin Air Force Base showed that the GTRI concept made the enhancement.

The Smart Cable aids the AAR-47's efficiency, increasing the probability of detecting an incoming missile and successfully alerting the crew.

A combination of cables and electronics, the Smart Cable is particularly suited to a rapid upgrade situation because of its ability to simply plug into the existing system. A black-box approach would likely have taken longer because of testing and approval requirements.

The Warner Robins Air Logistics Center at Robins Air Force Base has manufactured hundreds of Smart Cables for various Air Force, Navy and allied aircraft – including the C-17, C-5 and C-130. When needed, GTRI has also manufactured the devices to keep up with demand. Today there are about 600 Smart Cables in service.

# HELPING Technologists and Policy-makers Communicate

*Researchers are helping the Georgia General Assembly with technology issues.*

Technology and public policy may seem like strange bedfellows, but theirs is a long-standing affair. Scientific innovations often spark changes in public policy, and conversely, our country's laws, regulations and funding programs can affect what goes on in technology circles.

This give-and-take has only grown stronger in recent years because of the accelerated pace of technology, observed Randy Case, director of GTRI's Information Technology and Telecommunications Laboratory (ITTL). "Today, we need to give policy-makers more details about emerging technologies," he said. "We also need to better inform our researchers about the direction of public policy, and any constraints it might have on their projects."

In response, GTRI launched the Office of Policy Analysis and Research (OPAR) in 2004. Among its services, OPAR provides briefings that give researchers a high-level view on specific issues, agencies or pieces of legislation; outreach that connects subject-matter experts with policy-makers; information about funding opportunities and public policy assistance to technology projects.

"Policy research isn't something that scientists and engineers typically are interested in - or equipped to handle," said Brett Walkenhorst, a GTRI research engineer whom OPAR assisted this spring with a proposal to fund a project that involves multiple antenna processing and cognitive radio.

Although scientists and engineers may intrinsically understand technology's potential impact on government activities, putting that into language that resonates with policy analysts is difficult. "Having a resource like OPAR really fills in the gaps," Walkenhorst added.

In late 2005, OPAR began working with the Georgia General Assembly. In her role as a legislative fellow, GTRI research associate Marlit Hayslett provides policy analysis through issue briefs and expert testimony to the House Science and Technology Committee. She also serves as a conduit to GTRI and Georgia Tech by identifying scientists to testify on topics under the committee's consideration. For example, in 2005, the House Science and Technology Committee heard testimony on the role of nanotechnology in economic development, Internet safety for children and K-12 science and math education.

In November 2006, OPAR hosted a legislative roundtable previewing technology issues that may emerge in Georgia's upcoming 2007 legislative session. Five state legislators served on a moderated panel before an audience of more than 60 members of industry, government and academic sectors. New areas for the future will include health information technology, alternative energy and identity management.





# BUILDING Better Sanitation Systems for Developing Countries

Forty percent of the world's population (approximately 2.6 billion people) has no sanitation. For those with sanitation in developing countries, a toilet is frequently a pit dug in the ground surrounded by a brick outhouse. Although this is better than nothing, this type of facility can contaminate the groundwater and is not a viable option for areas that flood or have rocky soil.

As part of a collaboration with Emory University's Center for Global Safe Water, researchers from GTRI are developing a new dry sanitation system that will use solar energy to generate enough heat to kill harmful microorganisms in human feces. Kevin Caravati, a senior research scientist at GTRI, is leading the project with Dr. Christine Moe and Robert Dreibelbis from Emory, who are advising from the public health side. Researchers from the Georgia Tech School of Civil and Environmental Engineering, Georgia Tech College of Architecture, Georgia Tech College of Management and Georgia Tech Engineering Students Without Borders are also participating.

Constructing an outdoor sanitation system means building a brick chamber about 2 feet high. When half of the chamber fills up, the other side is used until it's full. During storage, the feces turn into compost and are eventually removed and shoveled onto fields as fertilizer. Problems arise if the compost hasn't been heated to temperatures over 140 degrees Fahrenheit because pathogens such as the parasitic worm *Ascaris* will not be killed.

"We are not trying to dispose of the feces, we're trying to cook it," said Caravati. "To get the temperature high enough to kill the harmful microorganisms, we had to stop thinking about toilets and more about solar ovens that reach temperatures over 300 degrees Fahrenheit."

This past summer, Brad Davis, an undergraduate building construction student and Calvin Johnson, an undergraduate management student and wide receiver on the Georgia Tech Yellow Jackets football team, studied existing solar latrines and designed two new prototypes that produced enough heat to kill the microorganisms. The students placed a Plexiglas® sheet on top of the pit to allow heat to enter the chamber and trap it inside. The researchers also positioned tin panels around the outside to reflect available sunlight into the chamber and used a Fresnel lens to concentrate the solar light to reduce the amount of time needed to kill the organisms. Fresnel lenses have been used in lighthouses and as solar collectors for photovoltaic cells.

To keep the cost of each latrine under $100, the prototype systems were designed with materials available in most villages, such as wood and brick. At Georgia Tech, the researchers used bicycle tubes for gaskets and other easily-obtainable parts such as bleach bottles and scrap wood.

In early 2006, the Emory research team, in collaboration with the Centers for Disease Control and Prevention's Office of Global Health and Sumaj Huasi (a nonprofit organization in Bolivia dedicated to improved housing), won a Development Marketplace Award from the World Bank to develop and implement better, affordable sanitation options for Bolivia. Emory investigators asked Caravati and his colleagues for engineering expertise to help meet this challenge. The collaborative team plans to travel to Bolivia in early 2007 and work with local sanitary engineers to build demonstration models in communities in the Andes Mountains, about 14,000 feet above sea level.

*Research team with prototype solar-heated dry sanitation system.*

# AUTOMATING the Endoscope

Although colon cancer is a leading cause of cancer deaths, it can be cured if detected early, which makes the colonoscopy a critical procedure.

Yet existing endoscopes – the medical devices used to inspect a colon – are cumbersome instruments that require multitasking. Doctors must guide the endoscope through the patient's colon by pushing the endoscope and controlling the orientation of the instrument's tip while simultaneously watching a video monitor that displays images captured by the endoscope's camera.

"Because the colon has several 90-degree turns, it's not easy to navigate," said Gary McMurray, a GTRI senior research engineer who likens the process to pushing a wire through conduit. "If doctors push too hard, it's possible to tear the colon, which could mean emergency surgery."

Leading a team of robotics experts, McMurray is developing a new breed of endoscope that will allow doctors to focus their attention on inspecting the colon rather than manipulating the medical device. In this project, the Georgia Tech team is collaborating with Dr. C. Daniel Smith and Dr. Edward Lin at Emory University, who are providing insights into the clinical side of the problem.

Researchers initially are tackling two tasks: developing automated control for the tip of the endoscope and adding sensors along the sides of the device to detect force and deflection. Both improvements would minimize stress on the colon and reduce risk of tearing tissues.

*An automation project may improve endoscope operation for physicians.*

### The longer-term goals are:

- Correlating data collected in a virtual colonoscopy (done without an endoscope via a spiral CT scan over the abdomen) to the real procedure – something that isn't possible with existing tools.
- Establishing virtual markers to help doctors return to the same spot in the colon months after surgery to biopsy the area.
- Incorporating multispectral imaging. Existing endoscopes use visible light; whereas multispectral imaging would provide far more information, especially about cancer lurking beneath the surface of tissue.
- Creating a complete system that would enable doctors to perform colonoscopies from a remote location.

"If we can automate the endoscope as planned, then it's only a small step to telemedicine," McMurray said. Especially for more difficult cases, such as young children and elderly adults, it's important to have a skilled physician perform the colonoscopy, he explained, but not every town has a resident expert.

"We're not trying to replace the doctor," McMurray stressed. "Yet an automated endoscope will let doctors do what they do best – inspection and analysis. Everything else is a robotics problem."





# LEARNING from the Nation's Worst Chlorine Spill

*Researchers examine textile machinery components damaged by chlorine.*

The United States' worst-ever chlorine gas spill killed nine people and injured 250. Eighteen months later – despite efforts to clean and restore the textile mill affected by the spill – 4,000 people lost their jobs, and a longtime, family-owned textile company went out of business.

Perhaps the only good thing to come out of the disaster is that, if such an accident occurs again, authorities will have better guidelines for first responders and cleanup crews. These guidelines will be the product of two years of testing and research by scientists and engineers at the Georgia Tech Research Institute (GTRI) and the Georgia Institute of Technology.

They became involved in cleanup efforts within a few days after the train wreck that caused the release of 70 to 80 tons of chlorine gas on Jan. 6, 2005 in the small town of Graniteville, S.C. The corrosive gas – and acid formed from its interaction with moisture – heavily damaged equipment in facilities owned by textile company Avondale Mills and utility company South Carolina Electric & Gas. Both companies hired GTRI to conduct materials testing and an assessment of restoration efforts.

"Basically, you had items sitting in an acid bottle for days," said Lisa Detter-Hoskin, a GTRI senior research scientist who led the research and helped coordinate the mill's expert evaluations. "Chlorine corrosively ate away at surfaces and moved inward like a cancer in the human body. Much of the mill's equipment was beyond repair because of the severity of the acid attack and the result of ineffective cleaning and restoration attempts."

Detter-Hoskin compiled all of the research and recommendations into a report for Avondale. That report is now the basis for a white paper Detter-Hoskin is writing for the U.S. Department of Homeland Security. She will explain what researchers have learned about the relationship between acid concentration, exposure effects and possible degrees of material damage. She also will document cleaning protocols most effective to decontaminate and restore an area affected by an aggressive chlorine spill. Detter-Hoskin believes the paper ultimately will become a handbook for first responders, disaster cleanup companies and the chemical industry.

GTRI and Georgia Tech have a unique database of information resulting from 18 months of testing and assessment of samples from Avondale's Graniteville facilities. This information may be able to help in the event of another accident, or even a terrorist attack, Detter-Hoskin said.

# REDUCING Aircraft Noise

Business travelers often have to deal with congested airports that delay flights at major air transportation hubs.

One proposed solution is for travelers taking shorter, regional trips to fly on 4- to 10-passenger advanced aircraft based at smaller, municipal airports. Such an air transportation system could improve safety, efficiency, reliability and affordability. But communities surrounding these facilities sometimes object.

"Noise is a big concern for these communities," said acoustics expert Krishan Ahuja, a Georgia Tech Research Institute (GTRI) Regents Researcher and Regents Professor of Aerospace Engineering. "Finding ways to make aviation quieter in these areas is the focus of some of my research."

Ahuja is involved in four initiatives that are addressing the future of aviation, including noise issues. He and his colleagues at GTRI and Georgia Tech are contributing their expertise, while seeking potential research opportunities.

In particular, researchers hope to design a helicopter-based transportation system using an aircraft tracking technology demonstrated by GTRI during the 1996 Centennial Olympic Games in Atlanta. Called Heli-Star (Helicopter Short-Haul Transportation and Aviation Research), the project showed for the first time that communications and navigation equipment based on the Global Positioning System could be used to reliably track aircraft operating in large metropolitan areas without the need for a ground-based radar infrastructure.

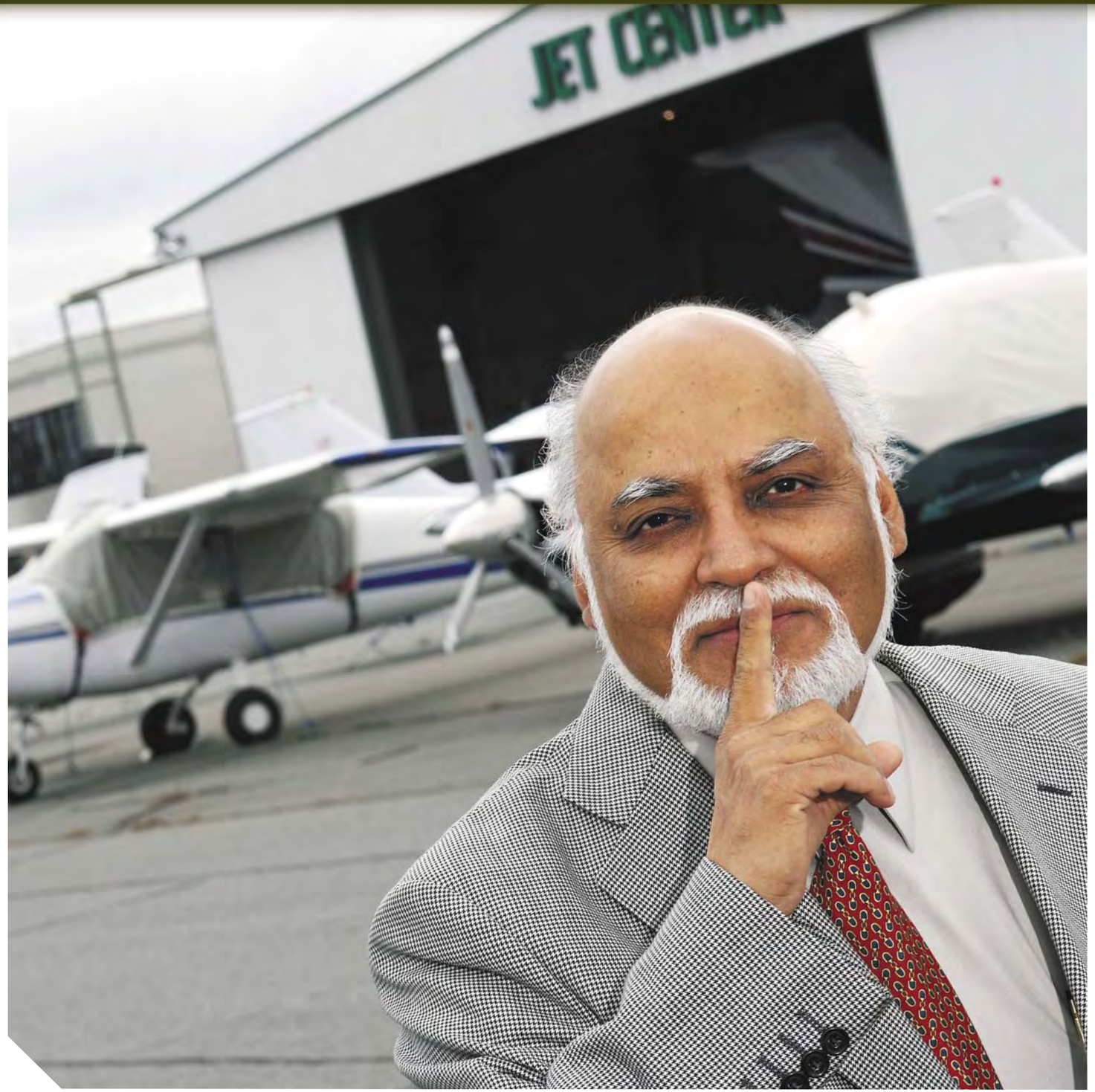
But noise is an obstacle. One solution could be the construction of helicopter-landing pads near highway ramps, where noise is not as big of an issue, Ahuja said.

Ahuja brings such ideas, along with his expertise, to his involvement with NASA's Small Aircraft Transportation System (SATS), which is developing "a safe travel alternative, freeing people and products from transportation system delays by creating access to more communities in less time."

He is also an appointed member of the Next Generation Air Transportation System (NGATS) Institute, federally funded by the Joint Planning & Development Office. The goal is to streamline all aspects of future aviation.

In another effort, Ahuja is providing acoustics expertise to Groen Brothers Aviation, which is developing an aircraft that combines features of airplanes and helicopters. The DARPA-funded vehicle, called a Heliplane, takes off like a helicopter and then flies like an airplane.

In addition, the National Academy of Engineering (NAE) invited Ahuja in 2005 to participate in its workshop titled "Technology for a Quieter America." Now, he is serving on a recently formed subcommittee on NAE's consensus study group focused on this goal.




*GTRI researchers are reducing aircraft noise to facilitate new air travel options.*



SERVICE TO SOCIETY

# MEASURING Shrinkage in Dental Fillings

Polymer dental-filling material tends to shrink when it's cured in a tooth, which can lead to failure of the repair and a number of problems including a cracked tooth or bacteria penetrating the tooth and causing new decay.

To better understand the issue of filling failure, researchers from GTRI and the Medical College of Georgia are collaborating on a new test methodology that could lead to more durable fillings. Shayne Kondor, a GTRI senior research engineer, is working with Dr. Dan Chan, a professor at the Medical College of Georgia, who is advising from the clinical side.

Researchers usually study shrinkage by measuring changes in the volume of a drop of material, cured outside of a cavity. Yet this approach doesn't provide a comprehensive picture of what happens in a tooth cavity, Kondor said.

"The form of the cavity preparation has a lot to do with how the filling material adheres to its floor and walls," he explained. "What's more, the penetration of the curing light also has an effect on shrinkage. If you don't replicate that, then you're not going to see exactly how the filling material flows."

To observe shrinkage in a more realistic setting, Kondor has developed an optical measurement system. He first simulates a cavity by drilling a 5-millimeter hole in a plate of aluminum. Then he pours dental-filling material that contains tracking particles (called "probe" particles) into the hole, using a blue light to both cure the material and provide illumination under the microscope. Spatial displacements of the tracking particles are optically measured throughout the curing process to determine deformation fields on the surface.

*Researchers test shrinkage in polymer dental-filling materials.*

In essence, Kondor is transferring particle image velocimetry, an aerospace technology used to study flow fields around aircraft wings and how air loads cause the wing structure to deform over time. "This technique can be easily adapted to dentistry because you can detect very small deformations that occur over time," Kondor explained. "Shrinkage is really a liquid flow problem. Like ice freezing, the filling material is first a liquid that turns into a solid."

Kondor is first studying shrinkage at the surface level, but he also plans to take measurements in a cross-section simulation to determine how filling material flows inside the cavity preparation as it cures. "Then we can look at different cavity preparation shapes to see which ones cause less stress," Kondor said.

"Most practitioners are aware of the shrinkage problem, but don't understand its magnitude," observed Chan. "Our method will help them better visualize shrinkage – we can show it in real-time media and also calibrate the force and direction of shrinkage, which is unique."

In addition to helping dentists find ways to prevent and remedy shrinkage, the optical measurement system will help manufacturers design better materials, Chan added. In fact, the researchers recently signed an agreement with an industrial partner to evaluate a new filling material.





# HUNTING DOWN Workplace Hazards

Although workplace safety has come a long way since the Industrial Revolution, occupational hazards remain a challenge for U.S. employers, especially smaller companies with fewer resources. In response, Georgia Tech's Safety & Health Consultation Program provides technical expertise and training to help Georgia companies reduce illness and injuries for workers.

In 2005, GTRI consultants visited more than 350 companies and identified 3,838 serious hazards, saving employers about $3.8 million in potential penalties from the U.S. Occupational Safety and Health Administration (OSHA). "Yet that's just the tip of the iceberg," said Dan Ortiz, manager of the consultation program which is housed in GTRI. "It's hard to put a number on costs because any accident has far-reaching effects that go beyond workers' compensation and lost time," he explained.

Funded by OSHA, Georgia Tech's safety-and-health consultation services are free to companies with fewer than 250 workers. What's more, the program is confidential. There's just one requirement: companies must agree to correct all hazards and provide written verification of their actions within a reasonable time frame.

**When consultants arrive on the scene, they focus on three key areas:**

- Safety issues like fire protection, machine hazards, electrical safety and fall protection and machine hazards.
- Health hazards, such as exposure to chemicals, noise and blood-borne pathogens.
- Ergonomic problems that can cause musculoskeletal disorders.

Consultants also evaluate safety programs that may already be in place and help strengthen them.

Workplace safety is constantly changing because of new technologies and regulations. Demographic shifts have also introduced new challenges in worker safety, such as the increasing number of Spanish-speaking immigrants in Georgia's labor force.

"These are primarily Mexican workers and though many have previously worked in construction, Mexico's regulatory framework isn't comparable to OSHA in the United States," said Art Wickman, a GTRI senior research scientist who supervises the consultation program's industrial hygienists. "So the concept of safety standards is new for them and requires a lot of education."

To help increase awareness, consultants have been translating many of OSHA's training materials into Spanish and offering free safety-training seminars in Spanish.

Partnerships have become an important tool for outreach. For example, in May 2004 Georgia Tech teamed with Brasfield & Gorrie, the general contractor for the Georgia Aquarium, a $200 million project that required several hundred workers. By the time the project was completed in late 2005, there were no fatalities, and the injury rate had dropped from 7.5 to 2 per 100 workers – with average cost per injury falling from $11,000 to $3,000.

*Safety and health consultants help companies identify potential hazards.*

# IMPROVING Cultural Awareness and Understanding

In an early-stage project, researchers in the Georgia Tech Research Institute (GTRI) are leading a Georgia Tech initiative to integrate the university's expertise in foreign cultures and technology development to improve cultural competence among the military and law enforcement.

"We're combining our subject matter expertise for cultural competence with the development of tools to increase the speed and ease of deliverability for both training and intelligence analysis," said Jennie Lincoln, a GTRI principal research associate.

"Both the Department of Defense and law enforcement agencies recognize there is a critical deficit in cultural understanding as we're faced with diversified threats," Lincoln explained. "Our key question as researchers is how we can increase cultural awareness and understanding to contribute to a more efficient response to these new threats."

Training tools such as computer simulations often don't include any cultural aspects, said Margaret Loper, chief scientist for GTRI's Information Technology and Telecommunications Laboratory. Some existing technologies – both those developed at GTRI and elsewhere – could be modified to include cultural differences, while some training and decision-making tools will require development from the ground up, Loper added.

To begin this "grassroots" initiative, Lincoln, Loper and several other GTRI researchers are evaluating current DoD cultural training tools and related research at DoD's request. They are also tapping the expertise of six other researchers from Georgia Tech's Ivan Allen College of Liberal Arts and the College of Computing.

The goal of cultural competency in the military is necessitated by what Lincoln calls the 21st century's new battlefield. Few troops – from the youngest soldiers to the senior decision-makers in the field – have had extensive training in cultural interactions; yet they frequently interact with local people, especially in Iraq and Afghanistan, Lincoln noted.

"It's one thing to secure a battlefield and quite another thing when your troops have to deal with the local people, which we're doing in these post-conflict situations," she said. "Instead of winning the battle and going home, we're staying to work on building a nation. You have to be able to work with the local people across language and cultural barriers. It requires a new approach to training and learning in cross-cultural communication."

The need for increased cultural competency in the military and law enforcement agencies is immediate, Loper said, but this project will be one for the long term. "With the so-called 'flattening' of the world, people in all walks of life will need more education to understand other cultures," she added.

*U.S. military personnel are often called on to interact with people from different cultures.*





Several interdisciplinary research centers report through the Georgia Tech Research Institute (GTRI). They include:

### The Military Sensing Information Analysis Center (SENSIAC)

www.sensiac.gatech.edu

SENSIAC is one of the newest information analysis centers (IACs) serving the U.S. Department of Defense (DoD). It replaces IRIA, a center that focused primarily on infrared technologies and was initially founded at the University of Michigan's Willow Run Laboratories. SENSIAC has a much broader mission and scope than IRIA, providing information on all sensing-based technologies related to defense activities, including infrared, laser, radar, acoustic, electro-optical, aroma, chemical and many other sensors.

In addition to being a clearinghouse for information, SENSIAC conducts research projects and educational programs. The Center draws upon experts across the Georgia Tech campus, as well as seven other universities that serve as SENSIAC team members.

## Other interdisciplinary research centers include:

**Center for Geographical Information Systems (GIS)**
www.coa.gatech.edu/cgis/

**Center for International Development and Cooperation**
www.gtri.gatech.edu/seal/cidc.html

**Center for Optimization of Simulated Multiple Objective Systems (COSMOS)**
eosl.gtri.gatech.edu/centers/cosmos.jsp

**Commercial Product Realization Office**
www.gtri.gatech.edu/cpro/

**Criminal Justice Science and Technology Center**
www.gtri.gatech.edu/ittl/csit/facil_cjstc.html

**Dental Technology Center (DenTeC)**
www.dentec.gatech.edu/

**Environmental Radiation Center**
eosl.gtri.gatech.edu/index.jsp

**Center for Innovative Fuel Cell and Battery Technologies**
www.fcbt.gatech.edu/

**Logistics and Maintenance Applied Research Center (LandMARC)**
landmarc.gtri.gatech.edu/

**Modeling and Simulation Research and Education Center**
www.msrec.gatech.edu/

**Phosphor Technology Center of Excellence (PTCOE)**
eosl.gtri.gatech.edu/centers/phos.jsp

**Severe Storms Research Center**
www.gtri.gatech.edu/seal/radar/facil_ssrc.html

**Space Technology Advanced Research Center (STAR)**
www.star.gatech.edu

**Test and Evaluation Research and Education Center (TEREC)**
www.terec.gatech.edu/

# TWO LONG-TERM RESEARCH PROGRAMS JOIN GTRI

Two long-term Georgia Institute of Technology research programs migrated to the Georgia Tech Research Institute in the fall of 2005, adding to its areas of expertise the fields of air quality and environmental radiation monitoring.

Both programs have compiled valuable, long-term research databases that are meeting the needs of Georgia's state government and revealing significant insights that help direct both research and policy.

In GTRI's Environmental Radiation Center directed by Bernd Kahn, researchers have 30 years of data analysis on the state's drinking water and various samples from nuclear energy facilities in Georgia. The testing fulfills Georgia's regulatory mandates and provides peace of mind to the public, said GTRI senior research scientist Robert Rosson.

Researchers, who were previously based in the Office of Interdisciplinary Programs, continue to analyze 1,400 drinking water samples a year to screen for contamination by naturally occurring radiation in the environment.

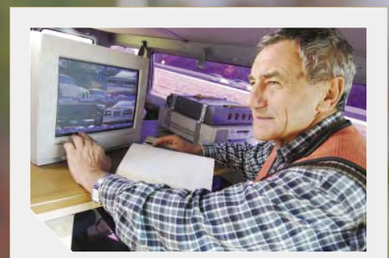
"We're making sure everything is safe," Rosson said. "We have found a few problems through the years, including some areas of the Piedmont that are at higher risk because of natural radioactive material in the granite, which can leach into aquifers and contaminate drinking water. In some cases, the state has had to shut down wells and drill new ones because of our findings."

Rosson and his colleagues also annually test numerous air, water, fish and produce samples taken from sites near Georgia's nuclear energy facilities. They look for radioactive contaminants from both natural and industrial sources. In some cases, they have found cause for concern that has led to additional monitoring activities, particularly near the U.S. Department of Energy's (DOE) Savannah River Site near Augusta, Ga., Rosson noted.

In addition to this monitoring work, the Environmental Radiation Center has conducted radioactive materials testing for DOE and the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry. One of the center's significant contributions was an approved methodology for monitoring radium in drinking water, Rosson added. Also, Kahn and his staff will soon publish a radioanalytical chemistry textbook and laboratory manual based on their 30 years of research in the field.


*Researchers screen drinking water for radiological hazards.*







*Remote sensing monitors Atlanta-area air pollution emissions.*

Michael Rodgers, a principal research scientist in GTRI's Aerospace, Transportation and Advanced Systems Laboratory, began monitoring vehicle emissions in 1991 in metro Atlanta with a pilot program, which began in the Georgia Tech School of Earth and Atmospheric Sciences. With funding from the Georgia Department of Natural Resources, he and his staff designed the Continuous Atlanta Fleet Evaluation (CAFÉ) study and have systematically collected this data using remote sensing technology since the spring of 1993.

The study continues to validate the effectiveness of the state's vehicle emissions inspection program in a 20-county area in and around Atlanta, Rodgers said. Residents in the region spend about $80 million a year on vehicle inspections and repairs to fix emissions problems found in the checkups.

"That's a major chunk of change, so you want to make sure the inspections program is working," Rodgers said. "We've found that it is indeed reducing vehicle emissions in the region. The state is investing less than 1 percent of the cost of the program to monitor it. So that's a cost-effective solution."

In addition to its inspections program monitoring value, the vehicle emissions database continues to reveal some interesting trends, Rodgers noted.

"It's important to gather systematic data over a long period of time so you can better understand how things change," he said. "For example, we've found that the newer, cleaner-burning fuels have had a very positive effect – comparable to the inspections program – in reducing vehicle emissions."

# GTRI AROUND THE WORLD


## GTRI RESEARCH FACILITIES, FISCAL YEAR 2006

| | |
|---|---|
| On-campus research space | 322,803 square feet |
| Off-campus research space | 152,543 square feet |
| **Total** | **475,346 square feet** |

### ☆ GTRI Headquarters
Atlanta, Georgia
400 10th Street N.W.
Centennial Research Building
Georgia Institute of Technology
Atlanta, GA 30332-0801
404.407.7280
comminfo@gtri.gatech.edu

### Cobb County Research Facility
Smyrna, GA
770.528.7000

### (1) Albuquerque Field Office
Albuquerque, NM
Joseph S. Accetta, Manager
505.246.0058
joe.accetta@gtri.gatech.edu

### (2) Washington Field Office
Arlington, VA
W. Ed Eagar, Manager
703.528.0883
ed.eagar@gtri.gatech.edu

### (3) Dayton Field Office
Fairborn, OH
David G. Erickson, Manager
937.427.0125
dave.erickson@gtri.gatech.edu

### (4) Eglin Field Office
Shalimar, FL
A. Neil Christianson, Manager
850.609.0955
neil.christianson@gtri.gatech.edu

### (5) Huntsville Research Laboratory and Field Office
Huntsville, AL
Barry Bullard, Lab Director
256.876.1301
barry.bullard@gtri.gatech.edu
Chuck Nickey, Field Office Manager
256.716.2200
chuck.nickey@gtri.gatech.edu

### (6) Jacksonville Research Operations
Jacksonville, FL
Lee Simonetta, Manager
904.226.4832
lee.simonetta@gtri.gatech.edu

### (7) Orlando Field Office
Orlando, FL
Steve Gordon, Manager
407.482.1423
steven.gordon@gtri.gatech.edu

### (8) Panama City Research Operations
Panama City, FL
Andrew Dykes, Manager
850.890.2020
andrew.dykes@gtri.gatech.edu

### (9) Quantico Research Operations
Quantico, VA
Ron Smith, Manager
703.630.2400
ron.smith@gtri.gatech.edu

### (10) San Diego Research Operations
San Diego, CA
Todd Moore, Manager
760.898.1605
todd.moore@gtri.gatech.edu

### (11) Tucson Research Operations
Tucson, AZ
Ken Pullen, Manager
520.295.6903
kenneth.pullen@gtri.gatech.edu

### (12) Warner Robins Field Office
Warner Robins, GA
Lee Evans, Manager
478.953.5004
lee.evans@gtri.gatech.edu

### (13) Georgia Tech Ireland
Athlone, Co Westmeath
David E. Parekh, Executive Director
404.407.7369
353.90.648.6541
david.parekh@gtri.gatech.edu



## GTRI Intergovernmental Personnel Assignments

### Huntsville, Alabama
- U.S. Army Lower Tier Project Office/ Program Executive Office, Air, Space, and Missile Defense

### Redstone Arsenal, Alabama
- U.S. Army Aviation and Missile Research, Development, and Engineering Center (ARMDEC) (2)
- U.S. Army Program Executive Office, Missiles and Space (PEO MS)
- Threat Systems Management Office, PEO STRI

### Eglin Air Force Base, Florida
- Air Armament Center Capabilities Integration Directorate

### Wright Patterson Air Force Base, Ohio
- Advanced Strategic Command Center/ Campaign, Simulation, & Missile Analysis Branch
- National Air & Space Intelligence Center (NASIC) Engineering Division (2)

### Arlington, Virginia
- Washington Headquarters Services (WHS), Human Resources Directorate (HRD); Executive & Political Personnel Division

### Chantilly, Virginia
- National Security Space Office (NSSO)

### Norfolk, Virginia
- U.S. Joint Forces Command, Command, Control, Communications, and Computer (C4) Systems Directorate (USJFCOM/J6)

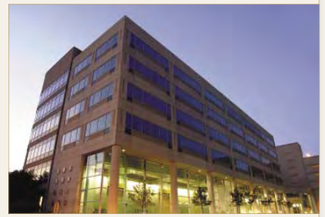
### Washington, D.C.
- National Academies / Institute of Medicine

The Georgia Tech Research Institute (GTRI) is headquartered on the Georgia Tech campus in Midtown Atlanta, where four of the organization's seven research laboratories are also located. Two laboratories operate at a major off-campus research facility approximately 15 miles north of Atlanta in Cobb County, adjacent to the Dobbins Air Reserve Base. Additionally, GTRI operates a laboratory in Huntsville, Ala. On-site research and business services also take place at a number of GTRI offices around the nation, with locations in Alabama, Arizona, California, Florida, Georgia, New Mexico, Virginia, Ohio, and at GTRI's newest location in Athlone, Ireland.

# NEW RESEARCH FACILITIES

## Information Technology and Telecommunications Lab

During fiscal year 2006, GTRI's Information Technology and Telecommunications Laboratory left its longtime campus home in the Electronics Research Building, which was demolished to make way for Georgia Tech's new Nanotechnology Research Center. The lab now resides in a beautiful 88,434-square-foot facility several blocks from the main campus. The building features state-of-the-art research labs, a 10,000-square-foot conference facility available to research sponsors, and a multimedia production studio supporting research projects and communication activities.



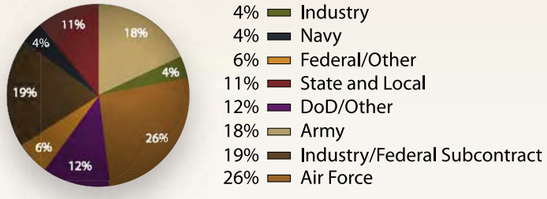
## International Location in Athlone, Ireland

Georgia Tech's newest international campus – Georgia Tech Ireland – is based at the Garrycastle Business & Technology Park in Athlone, Ireland. The headquarters has both office and laboratory space, which includes a digital media lab that will serve as a testbed for Internet Protocol Television (IPTV) capable of sourcing both linear and video-on-demand (VoD) content to industrial and academic researchers, as well as students in Irish colleges and universities. The lab will serve dual roles as both a cultural and educational network to the student body and a platform for IPTV research.

# GTRI BY THE NUMBERS

During the 2006 fiscal year, GTRI reported $112.7 million in contract awards and grants. Major customers for GTRI research included U.S. Department of Defense agencies, the state of Georgia, non-defense federal agencies and private industry. Overall, contracts and grants from Department of Defense agencies accounted for nearly 80 percent of GTRI's total funding.

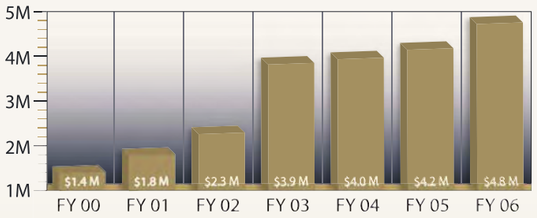
## FY 06 Major Customers




## Independent Research and Development

GTRI's independent research and development program supports the GTRI Strategic Plan through investment in programs with anticipated long-term return. Independent research investment is intended to expand capability and sustain a competitive position in critical research areas. It also fosters exploration and accelerates entry into new areas that may have high payoff for GTRI's stakeholders and potential customers.

## Independent Research and Development Funding




## GTRI Fellows Council

The GTRI Fellows Council assesses future technological directions and makes recommendations for GTRI's research program. Composed of the organization's most senior and distinguished research faculty, the council also evaluates proposals for funding through GTRI's independent research and development program. Members are nominated by their GTRI colleagues and elected by current fellows and laboratory directors. The council is also an internal advisory board for GTRI's senior leadership on research-related items.

**Current Members:**

- **Krishan Ahuja,** Aerospace, Transportation and Advanced Systems Lab
- **Eric Barnhart,** Information Technology and Telecommunications Lab
- **Ron Bohlander,** (Chair), Information Technology and Telecommunications Lab
- **Betty Whitaker,** Information Technology and Telecommunications Lab
- **Mike Harris,** Electro-Optical Systems Lab
- **Tom Fuller,** Aerospace, Transportation and Advanced Systems Lab
- **Larry Corey,** Sensors and Electromagnetic Applications Lab
- **Dennis Folds,** Electronic Systems Lab
- **Lon Pringle,** Signature Technology Lab

## Supporting GTRI : Investing in the Future

GTRI has been an integral part of Georgia Tech for almost 75 years. As the largest employer of co-op students, GTRI has helped to launch the careers of several generations of engineers and scientists and has been the catalyst for research that has made profound changes in the way we interact with our world.

Today, GTRI is looking for partners who want to help it inspire, motivate, equip and energize the people who will lead us to new research frontiers we can't even imagine today. The goal in the next five years is to raise money to support students and early-stage researchers and subject area experts who have remarkable ideas with great potential, but who need significant resources to pursue promising research. This past year, GTRI dedicated more than $4 million to independent research and development. We need to do more. For the first time in 2006, GTRI began to aggressively pursue philanthropy as a source of revenue. Opportunities are now available to make investments in people and research in health care, energy and technology in the United States and Ireland.

## For more information, please contact:


**Betsy Plattenburg**
Director of Development & Corporate Relations
betsy.plattenburg@gtri.gatech.edu
404.407.7889




# GTRI IN THE NEWS

**The Georgia Tech Research Institute attracts local, state, national and international news coverage in media ranging from top-tier outlets such as *National Geographic Magazine*, *Technology Review*, CNN and *The Economist* to technical media such as *Electronic Engineering Times*, *National Defense* and *Mechanical Engineering* to influential online media such as Scientific American.com, MSNBC.com and LiveScience.com. Below are a few examples of coverage received by GTRI's cutting-edge research.**

Test flights of a fuel-cell powered unmanned aerial vehicle generated attention in broadcast, online and technical media. Powered by compressed hydrogen, the 22-foot-wingspan UAV made several flights of up to a minute in duration. It was designed and built by students and researchers from Georgia Tech's Aerospace Systems Design Laboratory and GTRI. The *Atlanta Journal-Constitution*, *Defense News*, MSNBC, Scientific American.com, LiveScience.com and Discovery Channel Canada covered the work. Atlanta TV station WGCL (CBS 46) and Dish Network's HD News also reported on it.

**(See the article on page 16 of this annual report).**

*National Defense*, *Law Enforcement Technology* and United Press International were among the news outlets reporting on GTRI's Chemical Companion, a PDA-based system designed to help first responders identify chemicals spilled at the site of an accident – or potential terrorist attack. Beyond helping to quickly identify the spilled chemicals, Chemical Companion also recommends steps to be taken in treating victims, protecting the area and cleaning up the problem.

**(See the article on page 11 of this annual report).**

GTRI's involvement in evaluating the impact of a major chlorine spill and recommending remediation steps was reported in a number of key newspapers throughout the Southeast. The work took place, in part, in Graniteville, S.C., where a train accident resulted in the release of as much as 80 tons of the gas. Outlets reporting on the project included *The Atlanta Journal-Constitution*, *Charlotte Observer*, *Charleston Post & Courier* and *Columbia State*.

**(See the article on page 24 of this annual report).**

A new environmental test chamber large enough to accommodate full-sized office furnishings drew media attention from technical and trade publications – as well as the Web site for *National Geographic Magazine*. The chamber is helping manufacturers meet increasingly strict requirements regarding emissions from products, and is also helping advance knowledge of indoor air quality issues.

**(See the article on page 8 of this annual report).**

*Technology Review*, *Electronic Engineering Times*, *InfoWorld*, *Network World* and *Machine Design* were among the media outlets reporting on a project known as "Guard Dog," which developed several rapid erasure techniques for removing sensitive information from magnetic storage media. The work, done in collaboration with L3 Communications Corp., resulted from an incident in which a U.S. aircraft was forced to land in China. Using high-strength permanent magnets, the prototype systems can quickly and completely erase VHS tapes, floppy disks, data cassettes and small computer hard drives.

**(See the article on page 12 of this annual report).**

More than 150 news outlets covered GTRI's work on improving accessibility of products and technology for disabled persons. The work, done for the Arthritis Foundation and other sponsors, seeks to make ordinary products such as coffee-makers, golf clubs, photocopiers, cell phones and other devices usable by persons with disabilities. GTRI's Accessibility Evaluation Facility was described in an Associated Press wire service article that reached news outlets around the world. Key media reporting on the work included *The Atlanta Journal-Constitution*, *Arthritis Today*, CBS News.com, CNN.com, *Newsday*, MSNBC.com, the *Los Angeles Times*, *The Washington Post* and *USA Today*.

Vein Finder, an ultrasound-based medical device developed in collaboration between GTRI and Georgia Tech's School of Mechanical Engineering, drew considerable media attention. Outlets reporting on development of the prototype device included CNN, *The Economist*, *The Times of London*, *Electronic Design News*, *R&D Magazine* and LiveScience.com. The device would help emergency medical technicians quickly locate a vein for administering injections and drawing blood samples.

GTRI's EAS Medical Device E3 Test Center gained attention in technical and trade publications. The Center tests implantable medical devices to help their manufacturers protect them against potential interference from inventory control systems and other emitters of electronic signals. The Center's work was reported in *Mechanical Engineering*, *Medical Design* and *Medical Product Manufacturing*.

## Aerospace, Transportation and Advanced Systems Laboratory (ATAS)

**James McMichael,** laboratory director

770.528.7826

ATAS develops advanced systems concepts, performs research and develops technologies related to aerospace and ground transportation systems, power and energy systems, threat systems, intelligent autonomous systems, food processing systems and systems engineering methodologies. Current research areas include aerodynamics and flow control, aeroacoustics, computational aeroelasticity, wind tunnel testing, aircraft structural analysis, rotorcraft, intelligent systems, fuel cell and battery technologies, biofuels, smart small-scale projectiles, unmanned aerial vehicles, machine vision, automated highway maintenance and air quality.

The lab also performs applied research and development of radar-related technologies in support of national defense preparedness. The lab's prototype development capabilities span the spectrum from mechanical and electronics design and fabrication to full system integration, including embedded computing and control systems. ATAS has also achieved a national reputation for its expertise in threat systems, advanced transmitter technology, radar system development and weapon systems interpretation.

ATAS conducts significant research directed toward improving the production and quality of food while minimizing the environmental impacts of the industry. This program is designed to enhance the productivity of Georgia's agribusiness and the competitiveness of Georgia's food processing by applying computer vision, robotics, plant ergonomics, biosensors and wearable computer technology. The lab also conducts air quality and transportation research related to monitoring and reducing the environmental impact of vehicular emissions.

## Electronic Systems Laboratory (ELSYS)

**Thomas McDermott,** laboratory director

404.407.8240

ELSYS focuses on systems engineering solutions in electronic defense; modeling, simulation and analysis; countermeasures technique development; sensors performance analysis; electronic warfare systems integration; standardized test procedures; flight test support; laboratory support stations and test systems; missile warning system improvements; technology insertion and human systems engineering.

The lab's researchers are nationally recognized for their contributions to national defense in countermeasures technique development, employing an end-to-end approach to countermeasures development. ELSYS provides high-quality software solutions using software development processes and practices that were assessed as Software Engineering Institute's Capability Maturity Model Level 3 in a Software Capability Evaluation (SCE V3.0) conducted in 2003.

ELSYS human systems research includes support to key U.S. government agencies in the areas of aircraft crew station design, traffic management and first responder actions. ELSYS performs commercial product evaluations to determine their accessibility to the widest user community.

The lab offers programs of technical assistance on-site at private and public facilities, along with research and development of cost-effective solutions. ELSYS also specializes in areas of detailed mathematical modeling and analysis of dynamic systems, specialized instrumentation and real-time simulation.

ELSYS sensor performance analysis includes intercept receiver analysis, advanced radar concepts analysis, electronic countermeasures analysis, specialized instrumentation and real-time simulation. Over the past decade, ELSYS has supported flight tests covering all aspects of airborne testing.

## Electro-Optical Systems Laboratory (EOSL)

**Gisele Bennett,** laboratory director

404.407.6100

EOSL performs cutting-edge research in electro-optical modeling and analysis, microelectronics and nanotechnology, and remote sensing in a wide spectrum from acoustics to UV light. The lab's researchers are organized into agile and flexible technology working groups to enable multidisciplinary teams to focus on solutions.

Technology areas of pre-eminence include LIDAR systems development; hyperspectral and multispectral imaging; ultraviolet/infrared stimulator development; EO countermeasures technology and analysis; wide band-gap semiconductors; and advanced packaging for transmit/receive modules used in active phased array radars. The lab also performs applied research in the growth and application of carbon nanotubes, multifunctional materials, RFID and optical tagging and tracking atmospheric modeling and validation using field data collection and analysis; geospatial information systems and analysis; environmental impacts on human health; waste-to-energy conversion and human vision modeling.

In addition, EOSL has specially configured research centers: 1) Sensors and Sensing Systems Information and Analysis Center (SENSIAC), serving the military sensor community as a repository of information, provider of symposia and specific technical tasks related to sensing technology; 2) Logistics and Maintenance Applied Research Center (LandMARC), formed to provide analysis and solutions to support complex systems; 3) Phosphor Technology Center of Excellence, performing research and development of phosphor-based light-emitting materials, devices, and displays; 4) Environmental Radiation Center performing radiation monitoring of drinking water supplies; 5) Center for Optimization of Simulated Multiple Objective Systems (COSMOS), with expertise in the use of genetic algorithms for task optimization; 6) Center for Geographical Information Systems; and the 7) National Guard Technology Program Office, a technology resource center for the National Guard Counter Drug Operations.



## Huntsville Research Laboratory (HRL)

**Barry Bullard,** laboratory director

205.876.1301

Located in Huntsville, Ala., this laboratory primarily supports the U.S. Army Aviation and Missile Research, Development and Engineering Center (USA AMRDEC) in its aviation and missile R&D efforts. The laboratory's multidisciplinary research skills include battlefield command and control simulation and analysis, analysis and modeling of complete air and missile defense systems, sensor and fuze simulation and analysis, and aviation mission planning software engineering. Other research involves field and hardware-in-the-loop testing of air defense weapons equipment, war gaming and force-on-force simulations, guidance and control simulations, and tactical software development.

## Information Technology and Telecommunications Laboratory (ITTL)

**Randolph Case,** laboratory director

404.407.6456

ITTL conducts a broad range of research in areas of computer science and information technology, communications and networking, and develops commercial products from university research. ITTL conducts research that solves complex problems involving information processing, storage, representation and exchange; Internet and database technologies and applications; information security and assurance; privacy, knowledge management, data visualization, mapping/geographical information, distributed simulation and enterprise information systems. Researchers work in broadband telecommunications, wireless access systems, network security, multimedia information systems, tactical communications, communications surveillance and disruption, information warfare and assurance, communications networks and network management, technology assessment, application integration and software radio systems.

In commercial product realization, multidisciplinary research teams drawn from across GTRI and Georgia Tech apply product research and development toward product commercialization. Other researchers provide policy monitoring and assessment to facilitate responsiveness to changes in the technological research environment. ITTL also provides C4I capabilities and functional requirements analysis to various service components across the Department of Defense in northern and eastern Virginia.

## Sensors and Electromagnetic Applications Laboratory (SEAL)

**Bill Melvin,** laboratory director

770.528.7915

SEAL researchers investigate and develop RF sensor systems, with particular emphasis on radar systems, electromagnetic environmental effects, radar system performance modeling and simulations, signal and array processing, and antenna technology. Radar programs focus on the development, analysis and performance evaluation of radar systems; reflectivity and propagation measurement characterization; electronic attack and protection techniques; avionics integration; target identification; tracking and sensor fusion; vulnerability analysis; signal processing techniques; space-time adaptive processing; ground and airborne moving target indication; synthetic aperture radar; and system sustainment tool development. Antenna-related research programs characterize antenna gain characteristics, develop phased-array antenna concepts, and develop various kinds of reflector-type and lens antennas.

In the field of electromagnetic environmental effects, SEAL researchers analyze, measure and control the electromagnetic interactions among elements of an electronic system and between the system and its environment. Additional research areas include sensor development for ballistic missile defense, physical security, meteorology, space-based surveillance and detection, transportation applications, and engineering data analysis and modeling for sustainment of complex electronic systems. SEAL also provides customer-tailored short courses in electronic defense.

## Signature Technology Laboratory (STL)

**John Meadors,** laboratory director

404.894.2539

STL's main focus is the development of technologies for the management and control of multispectral signatures of objects under observation by sophisticated sensor systems. STL conducts research and development over a broad range of topics, including electromagnetic materials and structures, electromagnetic apertures and scattering, optical and infrared physics and phenomenology, secure information systems, signal processing and geolocation of emitters, passive ranging, advanced waveforms for electronic attack and protection, terahertz sources, magnetic erasure of high-density data storage media and the integration of quantum information systems. The laboratory maintains world-class numerical modeling and measurement capabilities to cover EM phenomena from quasi-static to UV wavelengths.

Extensive facilities are devoted to optical measurements specializing in laser and white-light scatterometry, electromagnetic materials characterization, radar cross-section measurements, antenna characterization and computational electromagnetics. These are applied to the design, fabrication and testing of thin, broadband antennas with tailored performance and controlled impedance surfaces for management/control of signature characteristics from systems level to components. Numerical modeling has recently been extended to nano- and micro-magnetics phenomena. Novel techniques for correlating optical and infrared scattering properties with material composition have been developed and modeled for application to paint and photographic film characterization, optical signature control, and the evaluation of sensors and image-based tracking algorithms. The lab's secure information systems work is nationally recognized for the design, development and deployment of enterprise information systems requiring state-of-the-art database, platform and Internet security.

## GTRI STUDENT EMPLOYEES

| | |
|---|---|
| Graduate Research Assistants and Graduate Students in Georgia Tech's Cooperative Education (Co-Op) Program | 36 |
| Undergraduate Co-Op Students | 117 |
| Student Assistants/Interns | 107 |
| **Total** | **260** |

### OUR PEOPLE:

The Georgia Tech Research Institute hires, equips and supports the best research faculty and support personnel in the business. GTRI's staff has expertise in most recognized fields of science and technology. As of June 2006, GTRI had 1,290 employees, including 547 full-time engineers and scientists. Among GTRI's full-time researchers, 70 percent hold advanced degrees. Other employees include additional faculty members, students and consultants who work in the research program on a part-time basis.

There were also 270 full-time professional staff members who have administrative duties and assist both GTRI researchers and customers. They include skilled technical specialists and others working in the areas of business services, budgeting, information technology, security, communications, facilities, property control and administration.

### OUR STUDENTS:

GTRI is the largest employer of bright and eager Georgia Tech graduate and undergraduate students who work alongside full-time researchers, making unique contributions to real projects for real sponsors.

Many of the highly skilled researchers now employed by GTRI began their careers as student employees. Each year, as many as a quarter of GTRI's new full-time researchers are hired from among former Georgia Tech students. GTRI also has relationships with other prominent universities, providing opportunities for their students to work with Georgia Tech researchers to gain practical engineering experience.

# PEOPLE PROFILES

## Rebecca Caravati



### First "Rate" Singer

Rebecca Caravati, GTRI's rate management manager, has been singing her entire life. At only four years old, she was a soloist at her church. In college, she received an accounting degree, but also studied music. After graduation, she traveled across the state with the Miss Georgia Superstars performance troupe. She has even made a brief appearance on NBC's Today Show, but the most exciting experience in her musical career was singing with the Peter Duchin orchestra. Rebecca has recorded her very own Christmas CD, and currently lends a hand to the children's music program at St. Anne's Episcopal Church in Atlanta.

## Rusty Embry



### Keeping Buzzy

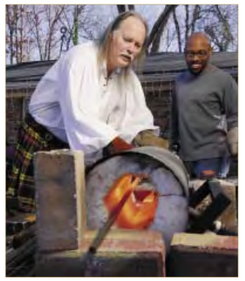
GTRI Maintenance and Construction Manager Rusty Embry may be a Georgia Tech Yellow Jacket fan, but he's also a top-notch beekeeper. For nearly a year, he has tended to his buzzing buddies who live in two hives at his home in the Atlanta suburb of Powder Springs. Starting with only 2,000 bees, his hives now have more than 80,000 bees. He says bees are fascinating creatures and are surprisingly gentle – unless you get them upset – which he admits he learned the hard way. The hives produce about 20 gallons of honey each year, which usually makes its way into care packages for family and friends.

## Grover Richardson



### Scorching Heavy Metal

Nearly 24 years ago, GTRI Electronics Specialist Grover Richardson attended a blacksmithing event at the Atlanta History Center and he's been bending hot metal ever since. As a member of the Alex Bealer Blacksmith Association of Georgia, he travels around the Southeast teaching seminars and giving demonstrations. You can say he's literally written the book on blacksmithing – it's called *Impressions, Blacksmithing Made Easy*. Grover says he does it because it's fun and, "hand-forged iron will last a lifetime, and if well maintained, a little bit longer."



## Dennis Crain



### Racking Up the Miles

Dennis Crain really loves his job as budget manager for GTRI, and the mileage on his car proves it. He lives in Columbus, N.C. – 200 miles from his office on the Georgia Tech campus in Midtown Atlanta. He travels to town on Tuesday morning and heads home on Thursday evening. He's kept up the routine for four years and has plans to keep on trucking. He says his commute "isn't really that bad" and only puts 23,000 miles a year on his trusty 1988 Acura.

## Bobby Golden



### Rock Star Researcher

In 1972, several musicians got together and after a few jam sessions the band Stillwater was born. In fact, Cameron Crowe, writer for *Rolling Stone* magazine, went to several of Stillwater's gigs and wound up using the name for the fictional band in his movie "Almost Famous." Stillwater released two albums on Capricorn records: "Stillwater" (1977) and "I Reserve the Right" (1978). The top-40 single "Mindbender" was released in 1977 and was number one in Atlanta. Stillwater guitarist Bobby Golden now devotes his time to his work in electronic warfare at GTRI and to an occasional Stillwater concert.

## Dave Roberts



### A Passion for Pictures

Senior Research Scientist Dave Roberts has always been fascinated by art, especially art dealing with the natural world. He says photography allows him to interact with the subject more than other art forms, and his specialty is nature photography. "It's a very creative activity and parallels the creativity that I have to bring to my work," Dave said. "It also helps that photography involves optics, which I am passionate about and is the focus of much of my research." He's been snapping away for 10 years and hopes to see his work hanging in galleries some day. Some of his pictures have already graced the pages of GTRI publications.

# GTRI MANAGEMENT

**Stephen E. Cross, Ph.D.**

Vice President,
Georgia Institute of Technology

Director, Georgia Tech Research Institute

Professor,
Stewart School of Industrial and Systems Engineering

Professor, College of Computing

404.407.7401

steve.cross@gtri.gatech.edu

**David E. Parekh, Ph.D.**

Associate Vice Provost for Research,
Georgia Institute of Technology

Deputy Director - Research,
Georgia Tech Research Institute

Professor,
Woodruff School of Mechanical Engineering

404.407.7369

david.parekh@gtri.gatech.edu

**Lisa Sills**

Deputy Director – Support Operations

404.407.8957

lisa.sills@gtri.gatech.edu

**Tom Horton**

Chief of Staff, Government Relations, Industry

404.407.8110

tom.horton@gtri.gatech.edu

**Ronald A. Bohlander, Ph.D.**

Commercial Product Realization

404.407.6836

ron.bohlander@gtri.gatech.edu

**George B. Harrison**

Strategic Initiatives

404.407.7136

george.harrison@gtri.gatech.edu

**John F. Maguire**

Federal Program Development

404.407.7742

john.maguire@gtri.gatech.edu

**Jeffrey Sitterle, Ph.D.**

Chief Scientist

404.407.7369

jeff.sitterle@gtri.gatech.edu



# GTRI LAB DIRECTORS

**Gisele Bennett, Ph.D.**

Director,
Electro-Optical Systems Laboratory (EOSL)

Professor,
School of Electrical and Computer Engineering

925 Dalney Street
Atlanta, GA 30332-0834

404.407.6155

gisele.bennett@gtri.gatech.edu

**Barry D. Bullard, Ph.D.**

Director,
Huntsville Research Laboratory (HRL)

P. O. Box 9162
Huntsville, AL 35812

256.876.1301

barry.bullard@gtri.gatech.edu

**Randolph M. Case**

Director,
Information Technology and
Telecommunications Laboratory (ITTL)

250 14th Street, N.W.
Atlanta, GA 30318

404.407.8965

randolph.case@gtri.gatech.edu

**Thomas McDermott**

Director,
Electronic Systems Laboratory (ELSYS)

400 10th Street, N.W.
Atlanta, GA 30332-0840

404.407.8240

tom.mcdermott@gtri.gatech.edu

**James M. McMichael III, Ph.D.**

Director,
Aerospace, Transportation and
Advanced Systems Laboratory (ATAS)

7220 Richardson Road
Smyrna, GA 30080

770.528.7826

james.mcmichael@gtri.gatech.edu

**William Melvin, Ph. D.**

Director,
Sensors and Electromagnetic Applications
Laboratory (SEAL)

7220 Richardson Road
Smyrna, GA 30080

770.528.3274

bill.melvin@gtri.gatech.edu

**John G. Meadors, Ph.D.**

Director,
Signature Technology Laboratory (STL)

400 10th Street, N.W.
Atlanta, GA 30318-5712

404.894.2539

john.meadors@gtri.gatech.edu

**For general information:**

GTRI Communications Office

400 10th Street, N.W.
Atlanta, GA 30332-0801

404.407.7280

comminfo@gtri.gatech.edu

www.gtri.gatech.edu

# GTRI EXTERNAL ADVISORY COUNCIL

Composed of leaders from both government and industry, GTRI's External Advisory Council brings an outside perspective to the organization's management. The Council helps GTRI stay current with industry trends and meet the changing needs of government contractors. Council members include:

**The Hon. Kathleen (Kathy) B. Ashe**
Georgia State Representative, District 46

**Dr. Robert S. Cooper**
President & CEO,
Atlantic Aerospace Electronics Corporation

**Mr. Alan J. McLaughlin,**
**(External Advisory Council Vice Chair)**
Director, Lincoln Labs/MIT, Ret., Strategic Planning & Technology Consultant

**Mr. John C. Bacon**
**(External Advisory Council Vice Chair)**
President & CEO, Intellectual Property Partners, LLC

**Ms. Susan M. Coughlin**
President & CEO,
Aviation Safety Alliance

**Mr. Glen P. Robinson Jr.**
Chairman & CEO, LaserCraft

**Dr. Bart Barthelemy**
Director & CEO, Wright Brothers Institute

**Mr. Ben J. Dyer**
President, Innovations Publishing, LLC

**Dr. Joseph A. Saloom**
Technology Consultant

**VADM Herbert A. Browne, (USN, Ret.)**
President & CEO, Armed Forces Communications & Electronics Association (AFCEA) International

**Dr. H. Allen Ecker**
Executive VP, Scientific-Atlanta

**The Hon. James W. Tysinger**
Former Georgia State Senator

**Dr. John F. Cassidy Jr.,**
**(External Advisory Council Chair)**
Senior VP of Sciences & Technology, United Technologies Corporation, Ret., Consultant

**The Hon. Jack Hill**
Georgia State Senator, District 4

**Mr. John J. Welch Jr., (USAF, Ret.)**
Technology Consultant

# PRODUCTION CREDITS


**Project Director:** Kirk Englehardt, GTRI Communications Office

**Managing Editor:** John Toon, Georgia Tech Research News & Publications Office

**Designer:** Chip Evans, Point Seven Design Studio

**Principal Photographer:** Gary Meek, Gary W. Meek Photography

**Writers:** T.J. Becker, Kirk Englehardt, Rick Robinson, Jane Sanders, John Toon, Abby Vogel

**Proofreading:** Lincoln Bates, Martha Farley, Kathryn Knox, John Maguire, Rick Robinson, Jane Sanders

**Other Content:** Terry Bridges, Rebecca Caravati, Dennis Crain, Paul Hawley, Todd Phillips and Betsy Plattenburg.

**Other Photography:** Anders Danielsson (P17), Rob Felt (PP41-42), Georgia Department of Economic Development (P9), iStock Photo (P13), Stanley Leary (P34), John Slemp (P14), U.S. Air Force (P19), U.S. Army (P29), U.S. Missile Defense Agency (P10).

**Printing:** Seiz Printing

**Sponsor Review:** Leslee Littleton, Harry Andrews, Dale Blair, Lee Evans






# THE 2006 GTRI TEAM

David Aalfs
Freeland Abbott
Linda Abercrombie
Joseph Accetta
Guillermo Acosta
James Acree
Joseph Adams
Ethan Adler
Vito Adragna
Diane Aenchbacher
Sean Ahonen
Vicki Ainslie
Marlene Aldridge
Brian Alexander
Neal Alexander
John Alford
Azita Alizadeh
Richard Allen
Stephanie Allen
Sarah Allen
A. Allison
James Ams
Patricia Anderson
Dinal Andreasen
Katherine Andrews
Harry Andrews
Diana Antoni
Chadwick Arnold
Odell Arrington
Anthony Arrington
Oscar Asbell
William Asher
Billy Atcheson
Moses Attrep
Wayne Austin
Thomas Autrey
John Baden
Shakeela Bader
James Baer
Robert Baggerman
Mary Bailey
Gary Bailey
Joshua Bailey
Christopher Bailey
Bradford Baker
Gayathri Balasubramanian
William Ballard
Sara Ballard
Justin Balsam
Jeanne Balsam
Scott Banks
Tanah Barchichat
Andrew Bardagjy
Nathaniel Barish
Theodore Barna
Tim Barnes
Brett Barnett
Eric Barnhart
Robert Barrett
Oliver Barrett
Steve Barton
Marsha Barton
Ann Batchelor
Danielle Bayer
Charlene Bayer
Roderick Beard
Robert Beardsworth
Larry Beasley
Carl Beasley
Robert Beasley
Andrew Beck
James Beisner
Anthony Bell
William Bell
Kristen Bellamy
Harold Belyeu
Ehren Bendler
Sky Bennett
Gisele Bennett
Malachi Bennett
Beau Bennett
Scott Berger
Alex Berkobin
Mark Berkobin
Charles Berkowitz
Juwan Bernard
James Bertoglio
Arpan Bhattacharya
Anita Bhavnani
Linda Bigham
Carlee Bishop
Tammy Blair
William Blair
Stephen Blalock
Melissa Blanchard
Samuel Blankenship
Julie Blankenship
Austin Blochberger
Carl Blunt
Robert Bock
Catherine Bodurow
William Bohaboy
Ronald Bohlander
William Borland
Richard Boyd
Kenneth Boyle
Benjamin Brackett
Thomas Bradley
Matthew Bradley
Michael Brainin
Lisa Brezee
Terry Bridges
Michael Brinkmann
Douglas Britton
Joseph Brooks
Robert Brooks
Ralph Brooks
Mark Brothers
Terrell Brown
Marguerite Brown
James Brown
Ida Brown
George Brown
Katherine Brown
C. Brown
Charles Brown
Paul Brown
Joseph Bruder
Christopher Bruhn
William Bryan
Tamika Bryant
Xavier Bryant
Jerry Bryson
Denis Bueno
Pamela Buggs
Barry Bullard
William Bullard
Ramon Burke
Laura Burkhart
Paul Burns
Chris Burton
William Butler
John Cabaniss
Rodney Cagle
Gary Caille
Frank Caldwell
Thomas Callis
Rodolfo Camacho-Aguilera
Kenneth Camann
Stephen Camp
Demetrius Campbell
Norma Campbell
Daniel Campbell
Daniel Campbell
Derek Campbell
Jason Candler
James Cannady
Kevin Caravati
Rebecca Caravati
Gerald Carey
Todd Carnahan
Clarence Carney
Ann Carpenter
Clayton Carpenter
Steven Carr
Linda Carroll
Charles Carstensen
Jessica Cartensen
Reginald Carter
Nicholas Carter
Randolph Case
Daniel Cash
Justin Cathcart
James Cathcart
James Chaloupka
Travis Chambers
Glenn Champion
Rajeswari Chandrasekaran
Kenneth Chaney
Cynthia Channell
Clarence Charleswell
Brenda Cheeks
Stephen Cross
Michael Crowe
David Crowe
Scott Crowgey
Carol Croy
Nicholas Currie
William Cutts
John Daher
Wayne Daley
Gwyneth Dalton
Jimmie Dalton
Carlos Davila
Shelton Davis
Bradley Davis
Donald Davis
Rodger Davis
Joshua Davis
James Davis
Kyle Davis
Walter Davis
Alyssa Daya
Thomas Dean
Bartholomew Debacker
Sami Deen
Victor DeJesus
Lee Dellenbaugh
James Demmers
Jonathan Denalsky
Douglas Denison
Dennis Denney
Hugh Denny
Lisa Detter-Hoskin
Phillip Detweiler
Douglas Devine
Harry Dewhurst
Roger Dickerson
Benedict DiFrancesco
Raenard Dillard
Misty Dirksen
Ry Doolittle
Jennifer Doss
John Doss
Sean Doublestein
Patrick Dowdy
Robert Downs
William Doyle
Jennifer Drake
Jennifer Dubose
Angela Dubose
Kristen Dudley
Susan Dugas
Daniel Duke
Ann Dunehew
Michelle Dunham
Andrew Dykes
William Eagar
Jerry Eaves
Clifford Eckert
Sandra Edge
Lisa Ehrman
Jared Eisner
Norman Ellingson
James Ellis
Russell Embry
John England
Robert Englar
Kirk Englehardt
Mark Entrekin
David Erickson
Kenya Ervin
Bernardo Espinosa-Santos
John Etherton
Jeffrey Evans
Lee Evans
Karen Everson
George Ewell
Traci Ewers
Walter Fain
Mary Fairbairn
Kathleen Falconer
Michael Fanuele
Julie Fariss
Martha Farley
Shannon Fatehi
Nickolas Faust
Donna Favors
Geoffrey Feld
Alice Fellabaum
David Fentem
Paula Ferguson
Louis Fertig
William Fishbein
Jason Fleming
Kathryn Fletcher
Brian Fleuridor
Ashley Flick
Jack Flicker
D. Flowers
Julianne Flowers
Timothy Floyd
Mikhail Fogelson
Dennis Folds
Renita Folds
Shaohui Foong
Brian Foster
Tina Fountain
Christopher Fowler
David Fowler
Justin Fox
James Fraley
Alan Freeland
Kyle French
Paul Friederich
Laura Friederich
James Froelich
Mark Frost
Richard Fuller
Thomas Fuller
Omar Fung
Robert Funk
Annette Gaddis
Philip Gadomski
Richard Gaeta
James Gaines
Enoch Gamble
Dayne Gardner
Jeff Garmon
Jeffrey Garnett
Allen Garrison
Sean Garrison
Molly Gary
Stephen Gaw
Gregory Gearman
Melissa Gegenheimer
Johnathan Geisheimer
Jennifer Geist
Mark Georges
Jeffrey Gerth
Eric Geter
Vincent Gibson
Charles Gibson
Kathryn Gilbreath
Edward Gilmore
Gary Gimmestad
Akilu Giorges
Bruce Glasgow
Samuel Glidewell
Roy Glover
Kelly Goad
Joni Gober
Robert Golden
Alan Golivesky
Robert Goodman
Steven Gordon
Jill Gostin
L. Gostin
David Gottfried
Cleo Graves
Gary Gray
Janice Green
Sarah Greenwood
William Gregory
Eugene Greneker
Ayana Gresham
Brian Greve
Tamar Grimes
Alexander Groleau
Greta Guentcheva
Thomas Guinn
Wallace Gustad
Joseph Guster
Kevin Guthrie
Andrew Guyton
William Guzak
Matthew Habib
Hal Hagemeier
Stephen Hague
Walter Haines
Keesah Hall
Johnny Hall
Louis Haller
Milton Halley
Jeffrey Hallman
Stanton Halpern
James Hampton
Herschel Haneline
John Hankinson
Gregory Hanlon
David Hanson
Terence Haran
Johncie Harbert
Simeon Harbert
Jeffrey Harding
Scott Harlan
Juan Harrell
Kyle Harrigan
Adrienne Harrington
David Harris
Herbert Harris
Anika Harris
Grace Harrison
Margaret Harrison
George Harrison
Judy Harrison
Jack Hart
Edward Hart
Alexa Harter
Lynn Hartley
Paul Hawley
Comas Haynes
Marlit Hayslett
Michael Heard
Ted Heath
Michael Heiges
Benjamin Heiskell
Anne Helton
Christopher Hemphill
Robert Hemphill
Andrew Henderson
Mary Henderson
Christopher Henderson
Robert Hendry
Andrew Henshaw
Ralph Herkert
Catherine Herrington
Ryan Hersey
Morris Hetzler
Richard Hicks
Melinda Higgins
Tina Higgins
James Higgins
Alice Hightower
Stephen Hilber
Terry Hilderbrand
Melanie Hill
Alex Hill
Brenda Hill
Kendal Hinton
Robert Hochman
Patrick Hodges
Mark Hodges
David Hodges
Wiley Holcombe
Ernest Holder
Simon Holley
William Holm
Ryan Holman
Johnathan Holmes
Mariah Hoover
Edward Hopkins
Glenn Hopkins
Walter Horne
Margaret Horst
Tom Horton
Andrew Howard
Robert Howard
Richard Howland
James Howry
Jacob Huang
Brian Hudson
Kenneth Hudson
Claudia Huff
J. Huggins
Stanley Hughes
Clarence Hughes
Walter Hughey
Gary Hulsey
Wayman Humphrey
Kellie Hunter
Nathaniel Hunter
Helen Hunton
Joseph Hurst
Steven Hurst
Ashley Hutchinson
Beverly Hutchinson
Leslie Hutchinson
Clayton Hutto
Richard Ingle
Charlotte Irvine
Shelia Isbell
Ricky Ivey
Aaron Jackson
Gautam Jadhav
Vineet Jain
Jonathan James
Elisa James
Calvin Jameson
Ann Jaudon
Aaron Jaynes
Gregory Jenkins
Jeffery Jenkins
Burt Jennings
Jeffrey Jo
Calvin Johnson
Allan Johnson
Lucy Johnson
Rita Johnson
David Johnson
Kenneth Johnson
Valerie Johnson
Erma Johnson
Roger Jones
Michael Jones
William Jones
Bobby Jones
Corissa Jones
Sujay Joshi
Jared Julian
Bernd Kahn
Jesse Kallman
John Kalter
Kevin Kamperman
Heewon Kang
Zhitao Kang
Raymond Kangas
Daniel Karnik
Jason Kau
Joshua Kayse
Robert Kearney
Byron Keel
Rashard Kelly
Olga Kemenova
Jeff Kemp
Lauren Kempema
Paul Kemper
Karen Kendall
Brian Kent
William Kenyon
Kirsten Kepple
James Kerce
Andrew Kerr
Robert Kerr
Morris Kesler
Gregory Kiesel
Amanda Killebrew
Manion Kilpatrick
Alvan Kimbrough
Kimberly Kimmel
Mark Kindl
James King
Sandra Kirchoffer
Kathleen Kirk
Donald Kitchen
Randy Knight
Diane Knobloch
Michael Knotts
Kathryn Knox
Sharon Koberg
James Koch
Stan Komsky
Shayne Kondor
Michael Kopp
Jeffrey Krug
Victor Kumsomboone
Matthew Kurjanowicz
Eric Kuster
Brett Labrecque
Valerie Lafond-Favieres
Cynthia Lagesse
Jeffrey Lahr
David Lai
Sandra Laib
Quimin Lam
Darrell Lamm
Jeffrey Landgren
John Landgren
David Landgren
Teddy Lane
Garrett Langley
Neil Lareau
Danial Laubler
Peter Lawrence
Victor Lawson
Daniel Leatherwood
Matthew Leblanc
James Lee
Steven Lee
Warren Lee
Morris Leesang
Sanford Leffingwell
James Lentini
Stephen Leonard
Jerry Lett
Jacob Leverett
Richard Levin
Zdzislaw Lewantowicz
James Lewis
Christopher Lewis
Qiang Li
Jun Li
Andrew Licausi
Susan Liebeskind
Deborah Light
Douglas Lilley
Cheryl Lilly
Amy Lin
Jennie Lincoln
Kathryn Lindsey
Elena Linn
Marie Little
Malik Little
Robert Loebach
Maurice Long
Daniel Longhurst
Kim Longshore
Margaret Loper
Andre Lovas
Benjamin Lowers
John Lowrey
Scott Loyd
Chen-Chaing Lu
Kristin Lum-Young
Sharon Lyons
Stephen Macke
Paul Mackie
Reid Mactavish
John Maguire
Richard Maier
Keith Main
Shawn Malone
Lorann Malone
James Maloney
Frederick Mann
Raymond Marceau
Miroslav Marek
James Marks
James Maroney
Harold Marshall
William Marshall
Robert Martin
Linda Martin
Michael Martin
Jonathan Martin
Douglas Martin
James Martino
Joshua Mason
Armand Masse
Derek Massey
Dawn Massey
Douglas Massey
Kevin Massey
Michael Matthews
Chris Matthews
John Matthews
James Matthews
Scott Maurer
Brett Mauro
Doresa May
David Maybury
Brian Mayhew
Bettie McAddoo
Kyle McCaffrey
Mark McCans
Tara McCart
Tim McClure
Leigh McCook
Roy McCord
Adam McCorkle
Julie McCoy
Russell McCrory
Charles McCullough
Adam McDaniel
Thomas McDermott
Lisa McDonald
Jennifer McDonald
Marqus McDuffie
Maria McGaha
Robert McGahee
Jason McGarr
Parker McGee
Akilah McIntyre
Paul McKellar
Mary McKenna
Patrick McKeon
Angus McLean
Trevor McLeod
Brandon McMahan
James McMichael
Gary McMurray
Shawn McNutt
Patrick McPherson
Starlyss McSlade
John Meadors
Phyllis Means
Benjamin Medlin
Christina Medlin
Nanette Meeks
Antonette Melvin
William Melvin
H Menhorn
Hicham Menkara
Jason Merkel
Paul Miceli
Robert Michelson
David Millard
Sarah Millard
William Miller
Thomas Miller
Matthew Miller
Sarah Milway
Brent Minter
Mark Mitchell
Natalie Mitchell
Barry Mitchell
Robert Mobley
Gregory Mohler
Dan Molino
Angela Montesanti
Ricky Moore
Todd Moore
Thomas Moore
Larry Moore
Adam Morber
Mark Moreno
John Morris
Robert Morris
Andrew Morris
Richard Morrison
David Morton
Jordan Moseley
Richard Moser
Richard Moss
Matthew Moyer
Benjamin Mullenix
Albert Mullikin
Suwana Murchison
Tam Muto
Andrew Muzio
Brent Myers
Virginia Myers
Robert Myers
James Mykytyn
Jason Nadler
Richard Nakasato
Donald Nance
Kim Nara
Arun Nayyar
Valyncia Neal
Patrick Neely
Jennifer Nelson
Michael Nelson-Palmer
Josh Nessmith
Daniel Neuberger
Binh Nguyen
Veit Nguyen
Joseph Nichols
Charles Nickey
William Nipper
Damon Nix
Donald Noble
Delores Nogradi
Matthew Noury
Maurice Novembre
Kelly Oconnor
Joel Odom
Michael Odom
David Odom
Richard Odom
Terrence Ogle
Didem Okutmantas
Dara O'Neil
Gary O'Neill
Michael O'Neill
Michael Orr
Daniel Ortiz
Daniel Osiecki
Brian Ouellette
Christopher Owens
Michael Owens
Arkadas Ozakin
Eddie Paige
Timothy Palmer
Raelle Panchoo
Vasilios Pantazopoulos
Chrysanthos Papanicolopoulos
David Parekh
Brian Parise
Deborah Park
Glenn Parker
Joe Parks
Judy Parks
Jonathan Parks
Chris Parnin
Jason Parrish
Aram Partizian
Gautam Patel
Pratiq Patel
Jessica Pater
Duane Patterson
Edward Patterson
Anita Pavadore
Nicholas Payne
Kristen Pealer
James Pearson
Mark Pellegrini
Kirk Pennywitt
Martha Perdue
Ulrich Perleberg
Brandon Perry
Benjamin Perry
Thomas Perry
Raymond Perry
Samuel Peters
Andrew Petry
Gordon Phillips
Michael Phillips
Heather Phillips
Michael Pieper
Miriam Pierce
John Pierson
Lawrence Pihera
Samuel Piper
Charles Pippin
Jeffrey Pitcher
Betsy Plattenburg
Nicholas Pomponio
Benjamin Poole
David Poskevich
S. Powell
Ronald Prado
Thomas Pratt
Richard Presley
Julian Price
David Price
Lon Pringle
Paul Pritchett
Erin Prowett
Kerry Pullen
Kenneth Pullen
David Pyne
Margaret Quiggle
Eric Rader
Gerald Radovich
Mindy Rakestraw
Peter Ralston
Bobby Ramey
Susan Ramos
Don Ranly
Kimberly Ransom
Justin Ratner
Mohammed Rauf
Ekkehart Rausch
Richard Ray
Jerry Ray
William Ready
Gabriel Rebeiz
Erin Reddick
Edward Reedy
Deeann Reese
Jason Reeves
Andrew Register
David Reid
George Reinhardt
Bryce Remesch
Larry Respress
Paul Reynolds
Richard Reynolds
Jacob Rhodes
Robert Rhodes
Matthew Rhodes
Robert Rice
Doris Rich
Grover Richardson
David Richardson
Kirk Riedling
Douglas Rigdon
Ashley Riley
Jon Riling
David Rimmer
Gerald Rivard
Eyvonne Roberson
Webb Roberts
Cynthia Roberts
Russell Roberts
David Roberts
David Roberts
Steven Robertson
William Robinson
Michael Rodgers
Kevin Rodkey
Matthew Rodriquez
Don Rogers
Gregory Rohling
Patricia Rose
David Roselius
James Ross
Robert Rosson
Stefan Roth
Francis Rotoloni
Kevin Ruffin
Barbara Russell
Alan Russell
Elizabeth Rybacki
James Saffold
Philip Safir
Adam Sakautzky
Darryl Sale
Alexander Samoylov
Robert Sandford
Jean Sands
Betty Sanford
Juan Santamaria
Robert Santiago
Spiro Sarris
Joseph Saur
Sandra Saxon
Larry Schaefer
James Scheer
Cecilia Scheer
Daniel Schiff
Katharine Schlag
Adam Schlesinger
Paul Schlumper
Melissa Schmidt
David Schmieder
Robert Schmitter
Michael Schork
Hilarie Schubert
John Schultz
Robert Schultz
Stephen Schulze
Brad Schwagler
John Scott
Gaynell Scott
Randy Scott
Melanie Scoville
John Scoville
Shemerra Searcy
Michael Seelhorst
Evan Seguin
D. Senn
Antonio Serna
Jerry Sexton
Timothy Shands
Christine Shapiro
Christopher Shappert
Barry Sharp
Steven Sharpe
Daniel Shaw
Charles Sheets
Albert Sheffer
Luther Sheffield
Leland Sheiner
Wilburn Shell
Gregory Sheridan
Donald Sherman
James Sherrill
Frances Shiflett
Brian Shirley
R Showman
Gregory Showman
Yevgeniy Shrom
David Shumaker
Jagjeet Sidhu
Breck Sieglinger
Scott Sillence
Lisa Sills
Erwin Simmons
Louis Simonetta
Christopher Simpkins
Robert Simpson
Dean Singley
Jeffrey Sitterle
Valerie Sitterle
Eric Sjoberg
Paige Skidmore
Gregory Slagle
Christopher Slater
Matthew Slater
Lauren Slavich
Brenda Smart
Jeffrey Smart
Leslie Smee
Michael Smith
James Smith
Christopher Smith
Mark Smith
Ronnie Smith
Steven Smith
Thomas Smith
Gerald Smith
Palla Smith
Brian Smith
Michael Smith
Bryan Smith
Robert Smock
Lawrence Snead
Scott Snyder
Stephanie Sodipo
Hungsun Son
Eric Soto
Eric Southard
Thomas Spangler
Norman Speakman
Lillian Spearman
Scott Spencer
Jonathan Spencer
Melissa Spiers
Chris Spivey
Kristi Spivey
Mark Sponsler
Carl Springer
James Stalvey
Jeffrey Stamper
Charles Stancil
Michael Stankiewicz
Richard Stanley
Russell Stanton
William Stark
Jeffrey Starker
David Starling
Stancil Starnes
Monti Staton
Roger Steines
Kelly Stevens
Brian Stevens
Donald Stevens
William Stewart
John Stewart
Dana Stocks-Douglas
Herbert Stokes
Timothy Strike
Erich Stuntebeck
Weilian Su
Michael Suckow
Jon Suggs
Joseph Sugrue
Susheel Sukhtankar
Sandra Sullivan
Vikki Sutton
Jean Swank
Donald Swank
Jonathan Swarner
Robert Swistak
Vincent Sylvester
Daniel Tabor
Alan Talley
Eric Tart
Duane Tate
Jennifer Tate
Drew Taylor
Kyle Teague
Sean Thomas
Steven Thomas
Hannah Thompson
Marianne Thompson
Liz Thompson
Stephen Thompson
Joe Thompson
Lane Thompson
William Thompson
Brian Thurmond
George Thurmond
Terry Tibbits
Adam Tichelaar
Brian Tippins
Roland Tisdale
Nicholas Titus
Kimberly Toatley
Tedd Toler
Wusheng Tong
Chris Tonnessen
Elwood Toph
Marchelle Towns
Anya Traille
Hoa Tran
Tan Minh Tran
Duc Tran
Than-Nha Tran
Victor Tripp
John Trostel
Rochie Tschirhart
John Tuck
Adile Tugtas
Stephan Turano
Therese Turman
Myrtle Turner
Ian Turner
Charles Twiggs
Tonya Tyner
William Underwood
Matthew Underwood
Colin Usher
Robert Ussery
Joseph Vandegrift
William Vander Meer
Gabriel Vannice
Maria Vasquez
Mary Vaughn
Aleksandr Vayner
Luis Velez
Brian Vento
Linda Viney
Albert Vineyard
Vivian Viverito
George Vogel
Curtis Volin
Sreerajesh Vuchatu
Brent Wagner
Brett Walkenhorst
Joshua Walker
Clinton Walker
Jack Wallace
Tracy Wallace
Robert Wallace
Larry Waller
Lorenzo Walters
John Wandelt
Charles Wang
David Ward
Barry Ward
Shelly Ward
Emily Warlick
Tyler Warnock
Walter Warren
Bill Warren
Carolyn Warren-Gray
Roy Washington
Anthony Wasilewski
Arelle Watson
Todd Watson
Marianne Weber
Micah Wedemeyer
Lora Weiss
Lisa Wells
Robert Werka
James Wert
Philip West
Tracy West
Leanne West
Mark Wheeler
Elizabeth Whitaker
Anthony White
Rosemarie White
Thomas Whitfield
George Whitley
Emma Whittaker
Paul Wickersham
Arthur Wickman
Mark Wiederhold
Judith Wiesman
Paula Wilcox
Jeffery Wilkie
Elreginald Williams
Allan Williams
Jennifer Williams
Stephen Williams
Frank Williamson
Michael Willis
William Wilson
James Wilson
Thomas Wilson
Bobby Wilson
Carol Wilson
Frank Wilson
James Wiltse
Debbie Winn
Patrick Wiseman
Michael Witten
Jack Wood
Elliot Wood
Kim Wood
Stephen Woodall
Tracy Woods
Brian Woods
Jimmy Woody
Ethel Word
Matthew Worley
Robert Worrall
George Wright
Darrell Wright
Mansfield Wrotto
Eric Wylie
Joseph Wyvill
Jie Xu
Shao-Me Yang
Jin Yao
Behnam Yavari
Virginia York
Elaine Young
Alan Young
Debao Zhou
Robert Zimmer
Carol Zlatovich
David Zurn
Theodore Zwicker

Georgia Tech Research Institute

Georgia Tech Research Institute
Georgia Institute of Technology
400 10th Street, N.W.
Atlanta, GA 30332-0801
404.407.7280

# 2006 ANNUAL REPORT

## RESEARCH FOR THE REAL WORLD

www.gtri.gatech.edu