Follow the “Roadmap”
Software tracks critical electronic countermeasure systems to help keep military aircraft safe.

With United States military aircraft facing danger each day, keeping key systems up to date is critical. Engineers from the Georgia Tech Research Institute (GTRI) are using powerful software tools along with engineering and analytical skills to help ensure that the F-16 fighter and other aircraft fly safely.

Engineers from GTRI's Electronic Systems Laboratory develop “roadmaps” for the U.S. Air Force — detailed schedules for the maintenance and upgrade of key aircraft systems. In this case, the key systems in question are the electronic countermeasures devices, such as radar-jamming pods, that shield aircraft from enemy attacks.

“GTRI’s method for developing a roadmap is to break a system into components, analyze them, and then document all known deficiencies,” explains project director David Brown. “We look for deficiencies in cost, reliability, obsolescence or capability, and give recommendations on mitigating those deficiencies.”

GTRI has already completed a roadmap for the ALQ-131 and ALQ-184, electronic-countermeasures jamming pods used to protect the A-10 and F-16 aircraft from incoming radar-guided weapons such as missiles.

Brown and fellow research engineer Scott Silence are pursuing work on roadmaps for electronic countermeasure systems on other U.S. military aircraft.

To develop a roadmap, GTRI engineers analyze four areas.

• Sustainability — detailing the repairs, costs and availability of components needed to keep a system combat-ready;
• Threat susceptibility — assessment of the jamming pod’s capability to deal with current threats, pinpointing areas that need improvement;
• Functionality — engineering better functionality into the system, a process guided by customer suggestions, as well as engineering analysis; and
• Intelligence/political issues — assessment of threat proliferation in countries of interest, leading to a timeline of needed capability improvements.

In charting sustainability issues for aircraft jamming pods, the GTRI engineers are using a software tool appropriately called SUSTAIN. Developed by a team of GTRI engineers led by Powers Garmon in the Sensors and Electromagnetic Applications Laboratory, the SUSTAIN tool integrates diverse government data sources to report current parts inventories, and it also predicts whether obsolescence or other factors will affect future parts availability.

Another team of GTRI engineers led by Steve Barton and Richard Fuller analyzes threat susceptibility with a GTRI software tool called SPAM — for Self-Protection Analysis Model — to judge how well the jamming system is doing its job. The SPAM tool gives researchers a wealth of data by simulating interactions between U.S. military aircraft and a radar-directed weapon system.

The researchers look closely at “reduction in lethality” — that is, how well the pod’s electronic countermeasures increase the survivability of the host aircraft.

Though software can identify many issues, eventually an engineer has to take over and decide the most effective way to deal with them.

“Someone has to go through and say: ‘We’re going to have to redesign this system in order to fix that obsolescence problem — and if we’re smart about the way we design it, we can also fix that capability problem at the same time!’” Brown explains.

While software highlights sustainability and threat issues, researchers say that actually talking with the customer is key to functional analysis. This analysis allows the engineers to make the system work more smoothly and effectively.
Roadmap engineers also look at current intelligence to predict when and how countries of interest might upgrade their threat systems. This information is used to devise a time line for getting U.S. systems ready to deal with coming threats.

GTRI’s completed roadmap spells out deficiencies in all four areas and provides recommendations. Such roadmaps offer a multi-year development plan and time line, citing extensive data sources to explain which changes should take priority.

— Rick Robinson

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Georgia Manufacturing Survey

A new study of nearly 650 Georgia manufacturing companies underscores the importance of innovation as a competitive strategy — at a time when international outsourcing continues to impact Georgia’s manufacturing community.

The 2005 Georgia Manufacturing Survey shows that companies basing their competitive strategies on the development of innovative products or processes enjoy higher returns on sales, pay better wages and have less to fear from outsourcing than do manufacturers relying on other competitive strategies.

Georgia manufacturers that rely on innovation for their competitive edge reported returns on sales 50 percent higher than companies that compete by providing low cost products — a gap that grew substantially since the last survey in 2002. Innovative companies paid workers a third more than the average Georgia manufacturer and were 40 percent less likely to lose work to outsourcing than were companies competing on low cost.

The survey of Georgia manufacturers — part of a periodic study begun more than a decade ago — was conducted by the Office of Economic Development and Technology Ventures and the School of Public Policy at the Georgia Institute of Technology.

“Innovation, whether in products or processes, or in organization or services to customers, is one of the main paths through which manufacturers can become more distinctive, secure market premiums, satisfy customers, expand sales, reward workers and improve their bottom line,” explains Phil Shapira, a professor in Georgia Tech’s School of Public Policy and a study co-author. “Companies that do not continuously innovate will find themselves under increasing pressure from low-cost producers in the United States and globally.”

Offering innovative products gives companies a competitive edge that provides protection against outsourcing and allows them to charge a premium — which creates higher margins and allows higher wages, notes co-author Jan Youtie, a researcher in Georgia Tech’s Office of Economic Development and Technology Ventures.

“If a company competes on the basis of innovation, that usually means only a few other companies are offering similar products,” she says. But innovation isn’t limited to products and processes. Companies can also compete using innovative marketing strategies and organizational approaches, she says.

“The benefits to innovation are pretty much across the board for companies,” Youtie notes. But there are barriers to innovation that involve costs, capabilities and risks that may keep some companies away.

The relatively low priority placed on innovation doesn’t bode well for the state’s manufacturing community.

“Without more innovation in Georgia, manufacturers abroad will steadily out-compete us by having better products and more efficient processes,” Shapira warns. “This is a particular concern for Georgia’s base of small and mid-sized companies. While we have many excellent small firms in the state, we lack the large base of innovative, specialized and flexible small manufacturers seen in some other advanced industrial economies.”

— John Toon

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Low-Visibility Landing

Aircraft facing low-visibility conditions have traditionally been dependent on ground-based navigational aids to guide them to a safe landing. Even then, there were limits on the visibility conditions under which pilots were allowed to land.

Georgia Tech Research Institute (GTRI) engineers are investigating the use of millimeter-wave imaging radars that would allow aircraft crews to generate a pilot-perspective image of a runway area even in zero-visibility conditions and without ground support. Such a radar could be combined with other sensors to provide a sensor suite that could help aircraft land in virtually any condition.

“The Air Force wants to field an onboard system that allows aircraft to land in any type of weather condition, whether it be rain, fog, snow, a dust storm, day or night,” says Byron Keel, a GTRI research scientist.

Called the Autonomous Approach and Landing Capability Program, the project is directed by the Air Force Research Laboratory at Wright-Patterson Air Force Base for the Air Mobility Command and is funded by the U.S. Transportation Command. GTRI is working collaboratively with BAE Systems, MMCOM Inc. and Goleta Engineering, and the Air Force Research Laboratory.

The U.S. Air Force is interested in autonomous-landing technology for several reasons. In Europe, where U.S. forces often prepare for deployment, dense fog conditions can prevent landings for days. Moreover, when U.S. planes land in primitive areas, they can face unpredictable landing conditions.

When radar senses a runway environment, what a layman might call distance from the airfield is measured in “range.” Width is associated with “azimuth” or “cross-range,” and height is associated with “elevation.”

GTRI began about two years ago to look for radar systems with the potential for supporting low-visibility landings. They found a BAE Systems Inc. experimental, two-dimensional system. It measured azimuth and range using millimeter-wave technology at 94 GHz, a frequency at which radar can see effectively through fog and dust.

The 2D system, however, does not measure elevation, a potential shortcoming.

In trying to measure both azimuth and elevation, researchers face the problem that an aircraft has a limited area in which to place an antenna.

To support elevation measurements, BAE Systems has developed a new approach that uses an interferometer to measure elevation angle to objects in the runway area and along the glide slope.

GTRI has supported the Autonomous Approach and Landing Capability Program with extensive pretest analysis and test planning of BAE Systems’ new 3D hardware. Keel took part in non-flight testing of the new hardware.

Initial test results were encouraging, Keel says. Still, he adds, researchers are busy enhancing the system. Flight tests of the radar’s effectiveness in low-visibility landings are planned for the latter part of 2006.

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Natural Solutions

Scientists and engineers collaborate to apply nature's design to human problems.

Copying the ideas of others is usually frowned upon, but when it comes to the work of Mother Nature, scientists are finding they can use nature as a template.

An interdisciplinary group of scientists and engineers at the Georgia Institute of Technology recently formed the Center for Biologically Inspired Design (CBID) with the goal of capitalizing on the rich source of design solutions present in biological processes. The researchers believe nature can inspire design and engineering solutions that are efficient, practical and sustainable and thus have the potential to greatly enhance new technologies, materials and processes.

“Biology can be a powerful guide to understanding problems in design and engineering,” says Associate Professor of Biology Marc Weissburg, CBID co-director. “In comparative physiology, we teach that every animal has to solve a particular problem to survive, so every animal is a design solution for a particular problem.

“They can provide solutions for more efficient manufacturing and design of materials with new capabilities, for example. These are things the biological world has solved, and if you study them, you have the opportunity to apply that knowledge in the human sector. You can also extend that reasoning to ecological processes. These are guiding principles behind the Georgia Tech Center for Biologically Inspired Design.”

CBID’s mission is to promote world-class interdisciplinary research and education at Georgia Tech in biologically inspired design. CBID researchers also want to communicate to government and industry officials that nature can provide unique design solutions to the problems they must address.

The idea for the center began with discussions between CBID director and Professor of Biology Jeannette Yen and Weissburg. Weissburg’s interest grew out of his research for the Office of Naval Research on understanding olfactory guidance in crabs. The Navy was interested in this process because it wanted to build autonomous devices with a similar capability, he explains.

Then, in spring 2005, Yen, Weissburg and Professor of Industrial and Systems Engineering Craig Tovey studied with Bioneer and biomimicry expert Janine Benyus for 10 days in Costa Rica. “We wanted to see how nature does things like gathering and transporting energy, and then see if we can translate those processes for human applications,” Yen says. “Georgia Tech is a great place to do this kind of research. It provides engineers who want to apply their expertise with biologists a new way to design solutions to problems.”

After this experience, the idea for the center developed further with the help of a biological metaphor — that of an “invasive” species, with the Center as the new species and Georgia Tech as the established community that is productive and successful.

“Invasive species can have a negative connotation, but we’re not talking about disrupting the community,” Weissburg explains. “We’re talking about augmenting it and adding to its functionality and activity. We used the analogy of a new species trying to fit into a community as a way to think about what our center could do to increase the productivity of the Tech ‘ecosystem.’”

— Jane M. Sanders

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Read more at: gtresearchnews.gatech.edu/newsrelease/cbid.htm

BELOW: To study the chemical signals involved in copepod mating, Professor of Biology Jeannette Yen and her students use several techniques to visualize and track the transparent or semi-transparent animals in the lab.

ABOVE: Researchers at Georgia Tech have observed that when blue crabs get a whiff of odor from potential prey, they will move upstream into the current to pursue the cue. As they navigate, they use their legs as an extended sensing array to steer through the flow toward the odor.
In Sync
Physicists show coherence of Bose-Einstein condensates extends to spin states of their atoms.

New research shows that the unique properties of atomic Bose-Einstein condensates extend to the internal spin states of the atoms from which the condensates are formed. Bose-Einstein condensates are an unusual form of matter in which all particles exist in the same quantum state.

Beyond fundamental physics interest, the work could provide a foundation for future research with potential implications for quantum information systems.

Bose-Einstein condensates are formed by cooling gas atoms to a fraction of a degree above absolute zero. At that temperature, the atoms all drop into the same quantum state. That makes them coherent, all possessing the same quantum wave function, a state comparable to that of photons in laser systems.

In a paper published in the November 2005 issue of the journal Nature Physics, researchers at the Georgia Institute of Technology reported experimental evidence that this coherence also extends to the internal spin degrees of freedom in condensate atoms, which in this case had three different spin states, denoted by 1, 0 and -1.

“The question had been whether the coherence of Bose-Einstein condensates extended to what was going on in the internal states of the atoms,” explains Michael Chapman, a professor in Georgia Tech’s School of Physics. “The major message of our work is that it does. We have seen manifestation that this Bose-Einstein coherence extends to the spin degrees of freedom. This gives us a much richer system to study.”

The research was sponsored by the National Science Foundation and NASA.

Coherence in condensate spin states had been predicted theoretically, and research teams — including Chapman’s — had been seeking experimental confirmation. While the results have no immediate practical applications, they provide a foundation for future experiments that could ultimately have important real-world uses.

Chapman plans to use the experimental system to study how relatively small condensates — those containing between 10 and 100 atoms — interact in a quantum way. Researchers understand the quantum behavior of small numbers of atoms, while semi-classical physics explains how large atomic ensembles work. Chapman wants to learn about the behavior of atomic groups in between those two size extremes.

“We are really interested in this regime in which quantum yields to classical,” he explains. “The interest is similar to that of nanotechnology because we’re asking the same basic questions. It’s fundamentally interesting because while we can write down the exact quantum solution for one or a few atoms, the semi-classical approximations for a large group of atoms, we can’t specify what will happen for this in-between region.”

Chapman also hopes the small-scale condensate systems will be useful to understanding the atomic analogue of quantum optics or quantum atom optics, where physicists are interested in the behavior of just a few atoms. In condensates containing a million atoms, adding or removing one atom would make a substantial difference to the properties of the condensate.

Chapman notes that internal spin degrees of freedom can exhibit quantum entanglement in a phenomenon known as “spin squeezing.” Understanding that effect in Bose-Einstein condensates could be useful to researchers studying quantum information systems and quantum computing.

“Quantum entanglement is the bread-and-butter of quantum information and quantum computing,” he said. “From the first time that people realized you could make a condensate that has spin degrees of freedom, people knew that would be interesting because if it really behaves this way, we could use this entanglement to make systems that might have applications to quantum information.”

— John Toon
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Huge Return on Investment

Georgia's public colleges and universities have a combined economic impact of more than $23 billion a year on the state's economy and are responsible for the creation of more than 130,000 jobs in Georgia, according to the final report of a task force appointed by Board of Regents Chair J. Timothy Shelnut to determine the University System of Georgia's total impact in Georgia. The report was presented to the Regents during their January meeting.

Georgia Tech President Wayne Clough, who chaired the Total Impact Task Force, says the $23.3 billion was 15 times more than the state's appropriation of $1.6 billion for higher education that year. But the University System's total impact on the state must be measured in more than numbers, Clough says.

Georgia's public colleges and universities are supplying qualified teachers for classrooms all over the state, healthcare professionals for Georgia hospitals, clinics, pharmacies and medical offices and law enforcement officers, he notes. Moreover, each college and university contributes to the quality of life by offering cultural and athletic events, facilities for public use, continuing-education courses, lifelong-learning opportunities and ongoing community service projects.

In addition, a wealth of valuable research is under way in Georgia's public colleges and universities, including work on treating sickle-cell anemia, understanding Alzheimer's disease, preventing infectious diseases and engineering tools to diagnose and fight cancer, Clough says.

"The University System of Georgia truly is Georgia's best investment," he adds. "What other appropriation of state funding gives you this kind of a return?"

— Arlethia Perry-Johnson

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Alcohol Overpouring

Your eyes can play tricks when it comes to pouring drinks. People — even professional bartenders — inadvertently pour 20 to 30 percent more alcohol into short, wide glasses than tall, slender ones of the same volume, according to research recently published in the British Medical Journal.

"People focus their attention on the height of the liquid they are pouring and insufficiently compensate for its width," explains Koert van Ittersum, an assistant professor of marketing at the Georgia Institute of Technology College of Management.

Even educating people about this human perceptual tendency and encouraging them to be careful doesn't eliminate alcohol overpouring, report van Ittersum and Brian Wansink, a professor of marketing, applied economics and nutrition science at Cornell University, in their study, "Reducing Alcohol Overpouring and Underreporting."

They consider their findings relevant to policymakers and law-enforcement officials who want to increase public safety, groups wanting to promote responsible drinking and decrease alcohol abuse, and people in the hospitality industry who want to cut costs (via serving size) without decreasing customer satisfaction, they say.

"If short tumblers lead people — even bartenders — to pour more alcohol than highball glasses, then there are two easy solutions," van Ittersum says. "Either use tall glasses or ones with alcohol-level marks etched on them as is done in some European countries."

The researchers conducted their study using 198 students of legal drinking age at the University of Illinois at Urbana-Champaign, who poured mock mixed drinks into both tall and short glasses from liquor bottles filled with water or tea instead of alcohol. Study subjects also included 82 bartenders in Philadelphia who had an average of 6.3 years of bartending experience.

Even 10 rounds of practice didn't make close to perfect for students involved in the study. More career experience led bartenders to pour less alcohol into shorter glasses, but they still overpoured.

"This tendency is not sufficiently reduced by education, practice, concentration, or experience," van Ittersum says.

— Brad Dixon

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Terahertz Switching

By using electromagnetic waves instead of electrical current for switching, researchers have operated an optical modulator at terahertz frequencies — an accomplishment that could one day facilitate data transmission rates in the trillions of bits per second.

The work represents a key step toward a new generation of optical communication systems that would be as much as 100 times faster than current technology, bringing closer such applications as real-time telemedicine and movies on demand.

While operating their terahertz modulator, the research team observed an effect that is well known in atomic physics — but until now hadn't been seen in the semiconductor materials that make up optical modulators.

"This is just one piece, but potentially a very important piece, of a very high bit-rate optical communication system for telecommunications and other applications," says David Citrin, an associate professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology. "The point of the experiment was to show that we can operate a modulator at terahertz frequencies, though we are still a long way from a practical device."

Supported by the National Science Foundation, the research was reported in the October 28, 2005 issue of the journal Science.

To gain those higher rates, Citrin and colleagues at the University of California-Santa Barbara and the NASA Ames Research Center used very high-frequency waves from a free-electron laser to control the modulator. These electromagnetic waves consist of an oscillating electric field and have the advantage of being able to move through free space without the need for circuitry.

Because terahertz oscillation is difficult to measure directly with existing technology, the researchers used indirect means to verify the modulation speed.

Before this approach can lead to faster communication systems, the modulation must be optimized — and the remainder of the system advanced to terahertz speeds.

— John Toon

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Many of today’s U.S. military aircraft entered service decades ago, and keeping them mission-ready can be a challenge.

HAWKEYE, a software tool aimed at supporting complex electronic and mechanical systems, was recently completed by four researchers at the Georgia Tech Research Institute’s (GTRI) Sensors and Electromagnetic Applications Laboratory (SEAL) — Mark McCans, Molly Gary, Jeff Smart and Powers Garmon. HAWKEYE focuses on mitigating the effect of part obsolescence on system availability.

“HAWKEYE allows users to initiate and maintain their own system configuration, inventory and repair data,” Smart says. “It lets them update databases as often as they want and construct different ‘what-if’ scenarios themselves.”

HAWKEYE is a software tool supported complex electronic and mechanical systems.

HAWKEYE’s developers say the generic design of the new software is meant to appeal to the U.S. military services, as well as to private contractors and the foreign military.

“With HAWKEYE, the customer has absolute control of his system bill of material, inventory information and repair actions, and his obsolescence status,” Garmon explains.

GTRI researchers got the idea for HAWKEYE from discussions with potential commercial customers at meetings and conferences. Using independent research and development funds, they decided to develop a generic approach to resolving logistics and supportability issues.

This move was founded on the perception that many contractors and others in the logistics and maintenance community are reluctant to let outsiders view the information they gather. Moreover, contractors often prefer to do database upkeep themselves, unlike custom software clients, who typically contract with GTRI to refresh their databases on a quarterly basis.

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HAWKEYE, which is a software tool that operates in Microsoft Windows, works with the Microsoft Access and SQL server databases. It also allows users to import Excel spreadsheets and text files, and create tables from scratch.

In addition to HAWKEYE software, GTRI will continue to offer turnkey custom technology insertion software and services.

Read more at: gtresearchnews.gatech.edu/reshor/rh-w06/hawkeye.html.