GRAPHENE: A SUCCESSOR TO SILICON?
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– Ronald Arkin, Regents professor in the School of Interactive Computing

“A device like this could quickly detect in individuals the gene mutations that are indicative of cancer and then determine what would be the optimal treatment. There are a lot of potential applications for this that cannot be done with current analytical and diagnostic technology.”

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“We have basically developed a whole scheme for making electronics out of graphene. We have set down what we believe will be the ground rules for how that will work, and we have the key patents in place.”

– Walt de Heer, professor in the School of Physics
This is the beginning of what will be a very complicated effort to develop the tools and approaches that will allow us to simulate a sufficiently useful caricature of a cell. From that, we will be able to learn the biological principles at work, and then study some ‘what if’ scenarios.

– Jeffrey Skolnick, professor in the School of Biology

This strategy allows an aircraft to be flying at a very low speed, while the wing is seeing much higher relative wind speeds on its curved upper surface due to this blowing and thrust-entraining combination.

– Robert Englar, GTRI principal research engineer

One of the things that makes Georgia Tech different from many other universities is that economic development has been very consciously put into the mission statement.

– Wayne Hodges, retired vice provost of the Enterprise Innovation Institute
Researchers at the Georgia Tech Research Institute (GTRI) have developed an advanced approach to enabling autonomous collaboration among dissimilar robotic vehicles. The collaborative approach demonstrates an “auction” system that selects the best vehicle for a given project based on capabilities.

The GTRI system, called the Collaborative Unmanned Systems Technology Demonstrator (CUSTD), employs two small-scale aircraft and a full-size automobile to perform a complex, interactive mission without human intervention. The demonstration system uses onboard computers running advanced collaborative-vehicle software – along with novel sensors and open standards-based communications and interfaces – to create an autonomous system with unique capabilities.

GTRI’s CUSTD system took part in Robotics Rodeo 2010, held Oct. 12-15, 2010, at Fort Benning, Ga. The event was hosted by the U.S. Army Tank Automotive Research, Development and Engineering Center.

“We believe our system represents the leading edge of demonstrating collaborative autonomous vehicle capabilities,” said Lora Weiss, a principal research engineer who is a member of GTRI’s Unmanned and Autonomous Systems team. “This system demonstrates not only the collaborative interoperability possible among dissimilar vehicles, but also the numerous sensing technologies that can be included onboard as interchangeable payloads – chemical and infrared sensors, still and video cameras, and sophisticated signal- and data-processing.”

The GTRI system uses two unmanned aerial vehicles (UAVs) that have nine-foot wingspans, seven-pound scientific-instrument payloads, and global positioning systems (GPS) for navigation. The unmanned ground vehicle (UGV) is a full-size Porsche Cayenne.

The aircraft require human guidance during takeoff, but while aloft they become autonomous for both navigation and target-locating tasks. The Porsche – the same “Sting” vehicle entered by Georgia Tech in the DARPA Urban Challenge – is fully autonomous.

“The vehicles’ very dissimilarity helps them collaborate effectively,” said Charles Pippin, a GTRI research scientist who led the CUSTD effort. Fast-moving unmanned air vehicles, he explained, can find targets over a wide area, but their altitude and the limitations of their lightweight sensors can lessen the quality of gathered data. However, the UAVs can call in an unmanned ground vehicle – equipped with large, complex sensors and cameras – to analyze the target location more fully.

Personnel from several GTRI units have participated in the CUSTD effort, said Pippin, who, like Weiss, is a member of GTRI’s Unmanned and Autonomous Systems team. CUSTD’s current capabilities are based on extensive research and testing, including more than 50 test flights conducted at Fort Benning and other locations throughout the past year.

In a typical CUSTD scenario, the two aircraft search for an existing target over a wide area. When one plane spots the target, it radios its location using...
GPS coordinates to the unmanned ground vehicle, which then finds its way around buildings and along roads to the target.

At the same time, the unmanned air vehicle over the target can ask the second aircraft to fly to the target and use its sensors to further analyze the situation. Such flexibility can be important, Pippin said, because UAVs are often outfitted with different sensors due to weight and cost considerations.

One technique that is still under development at GTRI—and is proving valuable for vehicle collaboration—is called market-based auctions, Pippin said. This approach uses an “auction” type of algorithm that lets robotic vehicles “bid” on a given task. Using this method, unmanned vehicles can autonomously divide up work on the spot in the most efficient way.

In an auction-technology scenario, an unmanned air vehicle over a target might send out a bid to other nearby UAVs, asking which among those aircraft that are outfitted with a particular sensor is closest to the target. The UAV that best complies with both requirements—equipment and proximity—wins the bid.

In a GTRI experiment, unmanned air vehicles using a market-based approach reduced the travel required to complete a task by nearly 50 percent. The result was a substantial saving in both time and fuel.

Weiss explained that GTRI’s CUSTD system is standards compliant, an important consideration in current defense-technology development.

“By developing these systems to be compliant, we’re building in future interoperability with other unmanned systems produced by different vendors,” Weiss said. “If upcoming systems are going to be able to communicate, as well as operate with the control-system designs now being developed, they’ll need to be standards compliant.”

— Lora Weiss, GTRI principal research engineer
Move over silicon. There's a new electronic material in town, and it goes fast.
That material, the focus of the 2010 Nobel Prize in physics, is graphene – a fancy name for extremely thin layers of ordinary carbon atoms arranged in a ‘chicken-wire’ lattice. These layers, sometimes just a single atom thick, conduct electricity with virtually no resistance, very little heat generation – and less power consumption than silicon.

With silicon device fabrication approaching its physical limits, many researchers believe graphene can provide a new platform material that would allow the semiconductor industry to continue its march toward ever-smaller and faster electronic devices. Georgia Tech researchers pioneered the use of epitaxial graphene for high-performance electronic devices, and they continue developing new techniques for utilizing the material.

A team of Georgia Tech researchers led by Professor Walt de Heer has pioneered techniques for fabricating electronic devices from epitaxial graphene. The material can be patterned using standard microelectronics techniques. The high-vacuum equipment shown behind de Heer is used to study graphene properties.
llow the semiconductor industry to continue its march toward ever-smaller and faster electronic devices – progress described in Moore’s Law. Though graphene will likely never replace silicon for everyday electronic applications, it could take over as the material of choice for high-performance devices.

And graphene could ultimately spawn a new generation of devices designed to take advantage of its unique properties.

Since 2001, Georgia Tech has become a world leader in developing epitaxial graphene, a specific type of graphene that can be grown on large wafers and patterned for use in electronics manufacturing. In a recent paper published in the journal Nature Nanotechnology, Georgia Tech researchers reported fabricating an array of 10,000 top-gated transistors on a 0.24 square centimeter chip, an achievement believed to be the highest density reported so far in graphene devices.

In creating that array, they also demonstrated a clever new approach for growing complex graphene patterns on templates etched into silicon carbide. The new technique offered the solution to one of the most difficult issues that had been facing graphene electronics.

“This is a significant step toward electronics manufacturing with graphene,” said Walt de Heer, a professor in Georgia Tech’s School of Physics who pioneered the development of graphene for high-performance electronics.

“This is another step showing that our method of working with epitaxial graphene grown on silicon carbide is the right approach and the one that will probably be used for making graphene electronics.”

**Unrolled Carbon Nanotubes**

For de Heer, the story of graphene begins with carbon nanotubes, tiny cylindrical structures considered miraculous when they first began to be studied by scientists in 1991. De Heer was among the researchers excited about the properties of nanotubes, whose unique arrangement of carbon atoms gave them physical and electronic properties that scientists believed could be the foundation for a new generation of electronic devices.

Carbon nanotubes still have attractive properties, but the ability to grow them consistently – and to incorporate them in high-volume electronics applications – has so far eluded researchers. De Heer realized before others that carbon nanotubes would probably never be used for high-volume electronic devices.

But he also realized that the key to the attractive electronic properties of the nanotubes...
was the lattice created by the carbon atoms. Why not simply grow that lattice on a flat surface, and use fabrication techniques proven in the microelectronics industry to create devices in much the same way as silicon integrated circuits?

By heating silicon carbide – a widely-used electronic material – de Heer and his colleagues were able to drive silicon atoms from the surface, leaving just the carbon lattice in thin layers of graphene large enough to grow the kinds of electronic devices familiar to a generation of electronics designers.

That process was the basis for a patent filed in 2003, and for initial research support from chip-maker Intel. Since then, de Heer’s group has published dozens of papers and helped spawn other research groups also using epitaxial graphene for electronic devices. Though scientists are still learning about the material, companies such as IBM have launched research programs based on epitaxial graphene, and agencies such as the National Science Foundation (NSF) and Defense Advanced Research Projects Agency (DARPA) have invested in developing the material for future electronics applications.

Georgia Tech’s work on developing epitaxial graphene for manufacturing electronic devices was recognized in the background paper produced by the Royal Swedish Academy of Sciences as part of the Nobel Prize documentation.

The race to find commercial applications for graphene is intense, with researchers from the United States, Europe, Japan and Singapore engaged in well-funded efforts. Since awarding of the Nobel to a group from the United Kingdom, the flood of news releases about graphene developments has grown.

“Our epitaxial graphene is now used around the world by many research laboratories,” de Heer noted. “We are probably at the stage where silicon was in the 1950s. This is the beginning of something that is going to be very large and important.”

Silicon “Running Out of Gas”

A new electronics material is needed because silicon is running out of miniaturization room.

“Primarily, we’ve gotten the speed increases from silicon by continually shrinking feature sizes and improving interconnect technology,” said Dennis Hess, director of the Materials Research Science and Engineering Center (MRSEC) established at Georgia Tech to study future electronic materials, starting with epitaxial
Georgia Tech graduate student Baiqian Zhang (left) and undergraduate student Holly Tinkey observe the growth of graphene in a furnace. The technique for growing epitaxial graphene on silicon carbide wafers was developed in the laboratory of Walt de Heer.
graphene. “We are at the point where in less than 10 years, we won’t be able to shrink feature sizes any farther because of the physics of the device operation. That means we will either have to change the type of device we make, or change the electronic material we use.”

It’s a matter of physics. At the very small size scales needed to create ever more dense device arrays, silicon generates too much resistance to electron flow, creating more heat than can be dissipated and consuming too much power.

Graphene has no such restrictions, and in fact, can provide electron mobility as much as 100 times better than silicon. De Heer believes his group has developed the roadmap for the future of high-performance electronics – and it is paved with epitaxial graphene.

“We have basically developed a whole scheme for making electronics out of graphene,” he said. “We have set down what we believe will be the ground rules for how that will work, and we have the key patents in place.”

Silicon, of course, has matured over many generations through constant research and improvement. De Heer and Hess agree that silicon will always be around, useful for low-cost consumer products such as iPods, toasters, personal computers and the like.

De Heer expects graphene to find its niche doing things that couldn’t otherwise be done.

“We’re not trying to do something cheaper or better; we’re going to do things that can’t be done at all with silicon,” he said. “Making electronic devices as small as a molecule, for instance, cannot be done with silicon, but in principle could be done with graphene. The key question is how to extend Moore’s Law in a post-CMOS world.”

Unlike the carbon nanotubes he studied in the 1990s, de Heer sees no major problems ahead for the development of epitaxial graphene.

“That graphene is going to be a major player in the electronics of the future is no longer in doubt,” he said. “We don’t see any real roadblocks ahead. There are no flashing red lights or other signs that seem to say that this won’t work. All of the issues we see relate to improving technical issues, and we know how to do that.”

Making the Best Graphene

Since beginning the exploration of graphene in 2001, de Heer and his research team have made continuous improvements in the quality of the material they produce, and those improvements have allowed them to demonstrate a number of physical properties – such as the Quantum Hall Effect – that verify the unique properties of the material.

“The properties that we see in our epitaxial graphene are similar to what we have calculated for an ideal theoretical sheet of graphene suspended in the air,” said Claire Berger, a research scientist in the Georgia Tech School of Physics who also has a faculty appointment at the Centre National de la Recherche Scientifique in France. “We see these properties in the electron transport and we see these properties in all kinds of spectroscopy. Everything that is supposed to be occurring in a single sheet of graphene we are seeing in our systems.”
Key to the material’s future, of course, is the ability to make electronic devices that work consistently. The researchers believe they have almost reached that point.

“All of the properties that epitaxial graphene needs to make it viable for electronic devices have been proven in this material,” said Ed Conrad, a professor in Georgia Tech’s School of Physics who is also a MRSEC member. “We have shown that we can make macroscopic amounts of this material, and with the devices that are scalable, we have the groundwork that could really make graphene take off.”

Reaching higher and higher device density is also important, along with the ability to control the number of layers of graphene produced. The group has demonstrated that in their multilayer graphene, each layer retains the desired properties.

“Multilayer graphene has different stacking than graphite, the material found in pencils,” Conrad noted. “In graphite, every layer is rotated 60 degrees and that’s the only way that nature can do it. When we grow graphene on silicon carbide, the layers are rotated 30 degrees. When that happens, the symmetry of the system changes to make the material behave the way we want it to.”

Epitaxial Versus Exfoliated

Much of the world’s graphene research – including work leading to the Nobel – involved the study of exfoliated graphene: layers of the material removed from a block of graphite, originally with tape. While that technique produces high-quality graphene, it’s not clear how that could be scaled up for industrial production.

While agreeing that the exfoliated material has produced useful information about graphene properties, de Heer dismisses it as “a science project” unlikely to have industrial electronics application.

“Electronics companies are not interested in graphene flakes,” he said. “They need industrial graphene, a material that can be scaled up for high-volume manufacturing. Industry is now getting more and more interested in what we are doing.”

De Heer says Georgia Tech’s place in the new graphene world is to focus on electronic applications.

“We are not really trying to compete with these other groups,” he said. “We are really trying to create a practical electronic material. To do that, we will have to do many things right, including fabricating a scalable material that can be made as large as a wafer. It will have to be uniform and able to be processed using industrial methods.”

Resolving Technical Issues

Among the significant technical issues facing graphene devices has been electron scattering that occurs at the boundaries of nanoribbons. If the edges aren’t perfectly smooth – as usually happens when the material is cut with electronic beams – the roughness bounces electrons around, creating resistance and interference.

To address that problem, de Heer and his team recently developed a new “templated growth” technique for fabricating nanometer-scale graphene devices. The technique involves etching patterns into the silicon carbide surfaces on which epitaxial graphene is grown. The patterns serve as templates directing the growth of graphene structures, allowing the formation of nanoribbons of specific widths without the use of e-beams or other destructive cutting techniques. Graphene nanoribbons produced with these templates have smooth edges that avoid electron-scattering problems.
Studying Graphene’s Properties

Through known for developing epitaxial graphene, Georgia Tech groups are also exploring the theoretical nature of the material and investigating the specific electronic properties that future device designers will need to understand.

Mei-Yin Chou, a professor and department chair of the Georgia Tech School of Physics, uses supercomputer calculations to study the key properties of graphene. In collaboration with assistant professor Markus Kindermann, her group recently examined how placing metallic contacts onto graphene would change the electron transport properties.

“Graphene devices will have to communicate with the external world, and that means we will have to fabricate contacts to transport current and data,” Chou said. “When they put metal contacts onto graphene to measure transport properties, researchers and device designers need to know that they may not be measuring the intrinsic properties of pristine graphene.”

In a paper published in Physical Review Letters in November 2010, Kindermann analyzed the scattering from one-dimensional defects in graphene, finding that repulsion between electrons can actually enhance their transport.

In Georgia Tech’s Nanotechnology Research Center, senior research engineer Raghunath Murali has been studying the properties of graphene from an electrical engineering perspective. He and his collaborators found that in nanoribbons as narrow as 16 nanometers, graphene has a current-carrying capacity approximately a thousand times better than copper – while offering improved thermal conductivity.

“Graphene nanoribbons exhibit an impressive breakdown current density that is related to the resistivity,” he said. “Our measurements show that these graphene nanoribbons have a current-carrying capacity at least two orders of magnitude higher than copper at these size scales.”

Murali has also experimented with a one-step process for producing both n-type and p-type doping on large-area graphene surfaces. The doping technique can also be used to increase conductivity in graphene nanoribbons used for interconnects.

Other faculty members are looking at the commercialization of graphene as part of the Nanotechnology Research and Innovation Systems Assessment group with Georgia Tech’s Program in Science, Technology and Innovation Policy. Philip Shapira, a professor in Georgia Tech’s School of Public Policy, and Jan Youtie, a principal research associate in Georgia Tech’s Enterprise Innovation Institute, have launched a project to study how the revolutionary material is likely to be commercialized in electronics and other sectors.

Their current research is assessing small firm business strategies to commercialize graphene-related applications and the implications for innovation policy. This research is examining similarities and differences in the plans, programs and approaches in the commercialization of graphene-related applications in the United States, China, the United Kingdom and other countries. The work is sponsored by the National Science Foundation Center for Nanotechnology in Society at Arizona State University, and a U.S.-U.K. Collaboration Development Award from the British Consulate in the United States.
“Using this approach, we can make very narrow ribbons of interconnected graphene without the rough edges,” said de Heer. “Anything that can be done to make small structures without having to cut them is going to be useful to the development of graphene electronics because if the edges are too rough, electrons passing through the ribbons scatter against the edges and reduce the desirable properties of graphene.”

In nanometer-scale graphene ribbons, quantum confinement makes the material behave as a semiconductor suitable for creation of electronic devices. But in ribbons a micron or so wide, the material acts as a conductor. Controlling the depth of the silicon carbide template allows the researchers to create these different structures simultaneously, using the same growth process.

“The same material can be either a conductor or a semiconductor depending on its shape,” noted de Heer. “One of the major advantages of graphene electronics is to make the device leads and the semiconducting ribbons from the same material. That’s important to avoid electrical resistance that builds up at junctions between different materials.”

After formation of the nanoribbons, the researchers apply a dielectric material and metal gate to construct field-effect transistors. While successful fabrication of high-quality transistors demonstrates graphene’s viability as an electronic material, de Heer sees them as only the first step in what could be done with the material.

“When we manage to make devices well on the nanoscale, we can then move on to make much smaller and finer structures that will go beyond conventional transistors to open up the possibility for more sophisticated devices that use electrons more like light than particles,” he said. “If we can factor quantum mechanical features into electronics, that is going to open up a lot of new possibilities.”

Collaborations with Other Groups

Before engineers can use epitaxial graphene for the next generation of electronic devices, they will have to understand its unique properties. As part of that process, Georgia Tech researchers are collaborating with scientists at the National Institute of Standards and Technology (NIST). The collaboration has produced new insights into how electrons behave in graphene.

In a recent paper published in the journal *Nature Physics*, the Georgia Tech-NIST team described for the first time how the orbits of electrons are distributed spatially by magnetic fields applied to layers of epitaxial graphene. They also found that these electron orbits can interact with the substrate on which the graphene is grown, creating energy gaps that affect how electron waves move through the multilayer material.

“The regular pattern of magnetically-induced energy gaps in the graphene surface creates regions where electron transport is not allowed,” said Phillip N. First, a professor in the Georgia Tech School of Physics and MRSEC member. “Electron waves would have to go around these regions, requiring new patterns of electron wave interference. Understanding this interference would be important for some bi-layer graphene devices that have been proposed.”

Earlier NIST collaborations led to improved understanding of graphene electron states, and the way in which low temperature and high magnetic fields can affect energy levels. The researchers also demonstrated that atomic-scale moiré patterns, an interference pattern that appears when two or more graphene layers are overlaid, can be used to measure how sheets of graphene are stacked.

In a collaboration with the U.S. Naval Research Laboratory and University of Illinois at Urbana-Champaign, a group of Georgia Tech professors developed a simple and quick one-step process for creating nanowires on graphene oxide.

“We’ve shown that by locally heating insulating graphene oxide, both the flakes and the epitaxial varieties, with an atomic force microscope tip, we can write nanowires with dimensions down to 12 nanometers,” said Elisa Riedo, an associate professor in the Georgia Tech School of Physics and a MRSEC member. “And we can tune their electronic properties to be up to four orders of magnitude more conductive.”

A New Industrial Revolution?

Though graphene can be grown and fabricated using processes similar to those of silicon, it is not easily compatible with silicon. That means companies adopting it will also have to build new fabrication facilities – an expensive investment. Consequently, de Heer believes industry will be cautious about moving into a new graphene world.

“Silicon technology is completely entrenched and well developed,” he admitted. “We can adopt many of the processes of silicon, but we can’t easily integrate ourselves into silicon. Because of that, we really need a major paradigm shift. But for the massive electronics industry, that will not happen easily or gently.”

He draws an analogy to steamships and passenger trains at the dawn of the aviation age. At some point, it became apparent that airliners were going to replace both ocean liners and trains in providing first-class passenger service. Though the cost of air travel was higher, passengers were willing to pay a premium for greater speed.

“We are going to see a coexistence of technologies for a while, and how the hybridization of graphene and silicon electronics is going to happen remains up in the air,” de Heer predicted. “That is going to take decades, though in the next ten years we are probably going to see real commercial devices that involve graphene.”


A robot deceives an enemy soldier by creating a false trail and hiding so that it will not be caught. While this sounds like a scene from one of the Terminator movies, it's actually the scenario of an experiment conducted by Georgia Tech researchers as part of what is believed to be the first detailed examination of robot deception.

“We have developed algorithms that allow a robot to determine whether it should deceive a human or other intelligent machine, and we have designed techniques that help the robot select the best deceptive strategy to reduce its chance of being discovered,” said Ronald Arkin, a Regents professor in the Georgia Tech School of Interactive Computing.

The results of robot experiments and theoretical and cognitive deception modeling were published online on Sept. 3, 2010, in the International Journal of Social Robotics. Because the researchers explored the phenomena of robot deception from a general perspective, the study’s results apply to robot-robot and human-robot interactions. This research was funded by the U.S. Office of Naval Research.

In the future, robots capable of deception may be valuable for several different areas, including military and search-and-rescue operations. A search-and-rescue robot may need to deceive in order to calm or receive cooperation from a panicking victim. On the battlefield, robots with the power of deception could successfully hide and mislead the enemy to keep themselves and valuable information safe.

“Most social robots will probably rarely use deception, but it’s still an important tool in the robot’s interactive arsenal because robots that recognize the need for deception have advantages in terms of outcome compared to robots that do not recognize the need for deception,” said the study’s co-author, Alan Wagner, a research engineer at the Georgia Tech Research Institute (GTRI).

For this study, the researchers focused on the actions, beliefs and communications of a robot attempting to hide from another robot to develop programs that successfully produced deceptive behavior. Their first step was to teach the deceiving robot how to determine whether it should deceive a human or intelligent machine. The researchers used algorithms that helped the robot select the best deceptive strategy to reduce its chance of being discovered. A situation had to satisfy two key conditions to warrant deception – there must be conflict between the deceiving robot and the seeker, and the deceiving robot must benefit from the deception.

Once a situation was deemed to warrant deception, the robot carried out a deceptive act by providing a false communication to benefit itself. The technique developed by the Georgia Tech researchers based a robot’s deceptive action selection on its understanding of the individual robot it was attempting to deceive.

To test their algorithms, the researchers ran 20 hide-and-seek experiments with two autonomous robots. Colored markers were lined up along three potential pathways to locations where the robot could hide. The “hider” robot randomly selected a hiding location from the three location choices and

Crafty Machines:

Researchers Give Robots the Capability for Deceptive Behavior

By Abby Robinson
moved toward that location, knocking down colored markers along the way. Once it reached a point past the markers, the robot changed course and hid in one of the other two locations. The presence or absence of standing markers indicated the hider's location to the "seeker" robot.

“The hider’s set of false communications was defined by selecting a pattern of knocked over markers that indicated a false hiding position in an attempt to say, for example, that it was going to the right and then actually go to the left,” explained Wagner.

The hider robots were able to deceive the seeker robots in 75 percent of the trials. The failed experiments resulted from the hiding robot’s inability to knock over the correct markers to produce the desired deceptive communication.

While there may be advantages to creating robots with the capacity for deception, there are also ethical implications that must be considered to ensure that these creations are consistent with the overall expectations and well-being of society, according to the researchers.

“We have been concerned from the very beginning with the ethical implications related to the creation of robots capable of deception and we understand that there are beneficial and deleterious aspects,” explained Arkin. “We strongly encourage discussion about the appropriateness of deceptive robots to determine what, if any, regulations or guidelines should constrain the development of these systems.”

This work was funded by Grant No. N00014-08-1-0696 from the Office of Naval Research (ONR). The content is solely the responsibility of the principal investigator and does not necessarily represent the official view of ONR.

“We have developed algorithms that allow a robot to determine whether it should deceive a human or other intelligent machine, and we have designed techniques that help the robot select the best deceptive strategy to reduce its chance of being discovered.”

— Ronald Arkin, Regents professor in the Georgia Tech School of Interactive Computing
New biosensing technology, including disposable arrays containing thousands of tiny electronic sensors connected to powerful processors, could help realize the dream of personalized medicine. This new technology could make possible real-time disease diagnosis – potentially in a physician’s office – and help doctors select individualized therapeutic approaches.

The new sensing system could replace the multi-welled microplate, long a standard tool in biomedical research and diagnostic laboratories. Essentially arrays of tiny test tubes, microplates have been used for decades to simultaneously test multiple samples for their responses to chemicals, living organisms or antibodies. Fluorescence or color changes in labels associated with compounds on the plates can signal the presence of particular proteins or gene sequences.

By merging biology with advanced microelectronics, the new technology could dramatically accelerate diagnosis, help pinpoint the most appropriate treatment, and automate many key processes.

“This technology could help facilitate a new era of personalized medicine,” said John McDonald, chief research scientist at the Ovarian Cancer Institute in Atlanta and a professor in the Georgia Tech School of Biology. “A device like this could quickly detect in individuals the gene mutations that are indicative of cancer and then determine what would be the optimal treatment. There are a lot of potential applications for this that cannot be done with current analytical and diagnostic technology.”

Papers describing the biosensing device were presented at the Electronic Components and Technology Conference and the International Interconnect Technology conference in June 2010. The research has been supported in part by the National Nanotechnology Infrastructure Network (NNIN), Georgia Tech’s Integrative BioSystems Institute (IBSI), Texas Instruments through the Semiconductor Research Corporation, the Deborah-Nash Harris Endowment Fund and the Robinson Family Foundation.

Fundamental to the new biosensing system is the ability to electronically detect markers that differentiate between healthy and diseased cells. These markers could be differences in proteins, mutations in DNA or even specific levels of ions that exist at different amounts in cancer cells. Researchers are finding more and more differences like these that could be exploited to create fast and inexpensive electronic detection techniques that don’t rely on conventional labels.

“We have put together several novel pieces of nanoelectronics technology to create a method for doing things in a very different way than what we have been doing,” said Muhannad Bakir, an associate professor in Georgia Tech’s School of Electrical and Computer Engineering. “What we are creating is a new general-purpose sensing platform that takes advantage of the best of nanoelectronics and three-
dimensional electronic system integration to modernize and add new applications to the old microplate application. This is a marriage of electronics and molecular biology.

The three-dimensional sensor arrays are fabricated using conventional low-cost, top-down microelectronics technology. Though existing sample preparation and loading systems may have to be modified, the new biosensor arrays should be compatible with existing workflows in research and diagnostic labs.

“We want to make these devices simple to manufacture by taking advantage of all the advances made in microelectronics, while at the same time not significantly changing usability for the clinician or researcher,” said Ramasamy Ravindran, a graduate research assistant in Georgia Tech’s Nanotechnology Research Center and the School of Electrical and Computer Engineering.

A key advantage of the platform is that sensing will be done using low-cost, disposable array components, while information processing will be done by reusable conventional integrated circuits connected temporarily to the arrays. Ultra-high-density, spring-like mechanically compliant connectors and advanced “through-silicon vias” will make the electrical connections while allowing technicians to replace the biosensor arrays without damaging the underlying circuitry.

Separating the sensing and processing portions allows fabrication to be optimized for each type of device, notes Hyung Suk Yang, a graduate research assistant also working in the Nanotechnology Research Center. Without the separation, the types of materials and processes that can be used to fabricate the sensors are severely limited.

The sensitivity of the tiny electronic sensors can often be greater than current systems, potentially allowing diseases to be detected earlier. Because the sample wells will be substantially smaller than those of current microplates – allowing a smaller form factor – they could permit more testing to be done with a given sample volume.

The technology could also facilitate use of ligand-based sensing that recognizes specific genetic sequences in DNA or messenger RNA. “This would very quickly give us an indication of the proteins that are being expressed by that patient, which gives us knowledge of the disease state at the point-of-care,” explained Muhannad Bakir.

“A device like this could quickly detect in individuals the gene mutations that are indicative of cancer and then determine what would be the optimal treatment. There are a lot of potential applications for this that cannot be done with current analytical and diagnostic technology.”

— John McDonald, professor in the Georgia Tech School of Biology
Associate professor Muhannad Bakir (left), from Georgia Tech’s School of Electrical and Computer Engineering, holds a prototype electronic microplate, while Professor John McDonald, from the School of Biology, holds an example of the conventional microplate it will replace.
Ken Scarberry, a postdoctoral fellow in McDonald’s lab.

So far, the researchers have demonstrated a biosensing system with silicon nanowire sensors in a 16-well device built on a one-centimeter by one-centimeter chip. The nanowires, just 50 by 70 nanometers, differentiated between ovarian cancer cells and healthy ovarian epithelial cells at a variety of cell densities.

Silicon nanowire sensor technology can be used to simultaneously detect large numbers of different cells and biomaterials without the labels that have traditionally been used.

Beyond that versatile technology, the biosensing platform could accommodate a broad range of other sensors— including technologies yet to be invented. Ultimately, hundreds of thousands of different sensors could be included on each chip, enough to rapidly detect markers for a broad range of diseases.

“Our platform idea is really sensor agnostic,” said Ravindran. “It could be used with a lot of different sensors that people are developing. It would give us an opportunity to bring together a lot of different kinds of sensors in a single chip.”

Genetic mutations can lead to a large number of different disease states that can affect a patient’s response to disease or medication, but current labeled-sensing methods are limited in their ability to detect large numbers of different markers simultaneously.

Mapping single nucleotide polymorphisms (SNPs), variations that account for approximately 90 percent of human genetic variation, could be used to determine a patient’s propensity for a disease, or their likelihood of benefitting from a particular intervention. The new biosensing technology could enable health care providers to produce and analyze SNP maps at the point-of-care.

Though many technical challenges remain, the ability to screen for thousands of disease markers in real time has biomedical scientists like McDonald excited.

“With enough sensors in there, you could theoretically put all possible combinations on the array,” he said. “This has not been considered possible until now because making an array large enough to detect them all with current technology is probably not feasible. But with microelectronics technology, you can easily include all the possible combinations, and that changes things.”

Postdoctoral fellow Kenneth Scarberry uses bioconjugate techniques to bind ligands to silicon nanowires, while graduate research assistant Ramasamy Ravindran observes.
Traffic in Cells:

Modeling Shows Factors Beyond Crowding Affect How Molecules Interact Within Cells

By John Toon

Using large-scale computer simulations, Georgia Tech researchers have identified the most important factors affecting how molecules move through the crowded environment inside living cells. The findings suggest that perturbations caused by hydrodynamic interactions – similar to what happens when the wake from a large boat affects smaller boats on a lake – may be the most important factor in this intracellular diffusion.

A detailed understanding of the interactions inside cells, where macromolecules can occupy as much as 40 percent of the available space, could provide important information to the developers of therapeutic drugs and lead to a better understanding of how disease states develop. Ultimately, researchers hope to have a complete simulation of these cellular processes to help them understand a range of biological issues, from metabolism to cell division.

Sponsored by the National Institutes of Health, the research was reported Oct. 11, 2010, in the early online edition of the journal *Proceedings of the National Academy of Sciences*.

“We found that hydrodynamics – perturbation of the solvent with eddies and wakes created by molecules in this crowded environment – may be the dominant effect in intermolecular dynamics within cells,” said Jeffrey Skolnick, director of the Center for the Study of Systems Biology at Georgia Tech. “The correlations created between molecules through this process have a lot of functional consequences for how collections of these molecules interact.”

The motion of macromolecules within cells is normally random, occurring through Brownian motion that causes the molecules to diffuse through the cellular cytoplasm, which has viscosity similar to that of water. Researchers have studied the movement of fluorescent protein molecules injected into *E. coli* cells, but don’t yet understand the forces affecting that motion. However, the measurements show that the fluorescent molecules move about 15 times more slowly inside the cell than they do in a test tube.

Using simulations that allowed them to adjust the impacts of natural forces, Skolnick and collaborator Tadashi Ando analyzed the activity of 15 different molecules in a portion – just one one-thousandth – of an *E. coli* cell. By altering those simulated forces in the computer, they attempted to determine what may cause the reduction in diffusion speed.

The most logical reason for that slowed movement is the crowded nature of cells, but Skolnick and Ando found that bumping into other molecules accounted for only a third of the reduced molecular diffusion.

The researchers then studied the hydrodynamic forces exerted by molecules on one another. These forces are comparable to the way in which the wake of a large boat on a lake affects smaller boats, or how a swimming whale might effect a school of small fish. The interaction causes correlated motion, which was known to be important in the movement of polymers and colloids.

By turning off the other forces at work in their silicon world, the Georgia Tech researchers found that this correlated motion accounted for much more of the diffusion reduction than did the crowding.
"The hydrodynamic interactions create cooperative motion between the molecules," explained Skolnick, who is Georgia Research Alliance eminent scholar in computational systems biology. "We see long-lived correlations between the molecules, independent of size, in space and time. This suggests that these correlated motions may be extremely important in the dynamics of molecules."

The researchers also studied other possible causes for the slow-down but found that repulsion between molecules, variations in molecular shape and "stickiness" between molecules could not account for the dramatic reduction in diffusion rate.

The real importance of the findings may be in setting the stage for larger studies that would include the thousands of molecules known to be important to cellular operations. Researchers ultimately hope to model everything happening in the cell, including interactions with the cell membrane.

"This is the beginning of what will be a very complicated effort to develop the tools and approaches that will allow us to simulate a sufficiently useful caricature of a cell," Skolnick said. "From that, we will be able to learn the biological principles at work, and then study some 'what if' scenarios."

Those "what if" questions might one day help drug designers better understand how therapeutic compounds work within cells, for instance, or allow cancer researchers to see how cells change from a healthy state to a disease state.

"It would be great if we could study new drugs in a model set of cells to very quickly see what might be the side-effects and cross interactions to understand how we might minimize these problems," Skolnick noted. "The nice thing about a computer simulation is that if it is a reasonably faithful caricature, you can ask a lot of questions – and get answers that help you understand what's going on."

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— Jeffrey Skolnick, professor in the School of Biology
Research under way at the Georgia Tech Research Institute (GTRI) could enable fixed-wing jet aircraft to take off and land at steep angles on short runways, while also reducing engine noise heard on the ground. Aircraft of this type — called cruise-efficient, short takeoff and landing (CESTOL) aircraft — could use runways at much smaller airports, allowing expansion of commercial jet service to many more locations.

Enabling commercial jets to take off and land in ever-shorter distances is an ongoing goal for aircraft designers, and several approaches are under development. GTRI’s research could result in a CESTOL aircraft comparable to a Boeing 737 in size, with a similar ability to carry 100 passengers at up to 600 miles per hour.

“Cruise efficiency, short takeoff and landing,” said Robert J. Englar, a principal research engineer who is leading the GTRI effort. “The problem is that flying slowly decreases the lift available for taking off and landing. What’s needed is a powered-lift approach that combines low air speed with the increased lift capability required for successful CESTOL operation.”

The work is part of the NASA Hybrid Wing-Body Low-Noise ESTOL Program. This four-year program, funded by NASA and led by California Polytechnic State University, includes GTRI and several other team members. GTRI’s current work involves leadership of the aerodynamic and acoustic design for the program, along with development of large-scale models that will be used for wind-tunnel testing at government facilities.

At the heart of GTRI’s powered-lift design is circulation control wing — also known as blown-wing — technology. In this type of system, high-speed jets of air are ejected over the upper surface of the wings during takeoff and landing, creating an unprecedented lift capability.

“Our design has to incorporate several trade-offs, yet the entire wing-engine powered-lift system has to perform all of its functions well,” said Englar, who leads the aerodynamics portion of GTRI’s work. Specifically, he said, the new design must:

• Generate a very high lift capability on takeoff and landing to allow short ground rolls and steep climb-out or approach flight angles;
• Yield lower drag at cruising speeds to achieve good fuel efficiency;
• Simplify the wing and downsize it for more efficient cruise performance;
• Produce noise levels that are lower than a conventional passenger jet; and
• Be less complex overall than conventional designs.

To satisfy those requirements, the GTRI team placed turbo-fan engines above the wing of the conceptual CESTOL aircraft, rather than below the wing as on most commercial aircraft, explained Rick Gaeta, a
former GTRI senior research engineer who had led the acoustic portion of the research.

Over-the-wing placement is a key design element because it enables very high lift while still providing the engine thrust necessary for takeoff and high-speed level flight. It also offers important reduced-noise benefits.

Based on this engine placement, the team’s powered-lift design maximizes performance using several interrelated elements.

**Novel Blown-Wing Design**

In most fixed-wing aircraft, Englar explained, the upper surface of the wing is curved. That curvature forces air to flow faster over the top of the wing, which reduces pressure on the upper surface of the wing, increasing wing lift. Mechanical flaps increase aft curvature, enlarging the wing during takeoff and landing, and augmenting lift by deflecting the ambient wind stream flowing over the wing.

But the lift generated by conventional wings isn’t sufficient for the low flight speeds and steep ascents and descents required by CESTOL aircraft. The essential element in such extreme lift is circulation control/blown-wing technology. This approach can far exceed mechanical flaps in achieving high lift coefficient (a lift coefficient is a number that relates an aircraft’s total lift to its wing area and flight speed).

The GTRI team has designed a blown wing that is relatively simple mechanically. Unlike a conventional wing, which uses multiple flap elements, GTRI’s design uses only one small, relatively simple flap.

However, that single wing flap is used in tandem with a novel element based on circulation-control technology. A narrow slot, capable of pneumatically blowing out air, runs along the entire trailing edge of each wing, just—Robert Englar, GTRI principal research engineer

“This strategy allows an aircraft to be flying at a very low speed, while the wing is seeing much higher relative wind speeds on its curved upper surface due to this blowing and thrust-entraining combination.”

GTRI researchers Graham Blaylock, Nicholas Moore and Robert Englar (l-r) assemble a test aircraft’s fuselage onto the blown wing assembly, while also measuring the height of the blowing jet exit slot, and confirming jet turning on the blown flap.
above the flap. This system is powered by its own compressed air source located inside the wing.

The wing flap, which forms a sharp trailing edge during level flight to reduce drag, rotates downward on takeoff and landing. When thus rotated, it forms a highly curved aft surface; then air from the slot can be blown over that curved surface to generate high lift. This procedure, called flap-blowing, performs two functions: it increases air velocity over the top of the wing, and it deflects the ambient wind stream downward so that it curls under the wing. The combined forces generate a lift coefficient that can be two to four times higher than a conventional mechanical flap.

**Entrainment Jet Exhaust**

To achieve even higher lift than flap-blowing alone, the GTRI design takes advantage of an additional phenomenon – the interaction between the air coming from the wing slot and the exhaust of the airplane's over-the-wing jet engines.

During takeoff and landing, air flow from the slot interacts with the engine exhaust and pulls this powerful exhaust blast down onto the wing. This process, called entraining the exhaust, greatly increases the velocity of the air passing over the wing and results in highly augmented upward suction and lift.

“This strategy allows an aircraft to be flying at a very low speed, while the wing is seeing much higher relative wind speeds on its curved upper surface due to this blowing and thrust-entraining combination,” Englar said. “We have measured lift coefficients between 8.0 and 10.0 on these pneumatic powered-lift wings at a level flight condition during testing. The normal lift coefficient on a conventional wing at a similar flight condition is less than 1.0.”

**Reduced Noise**

The benefit of an above-the-wing engine configuration is not limited to providing good short takeoff and landing (STOL) performance. It also provides two potential sources of noise reduction: engine-noise shielding and reduced noise footprint in the community.

Gaeta explains the noise-shielding issue by noting that today’s commercial jets have their engines under the wings. During takeoff and approach, a great deal of noise from these engines propagates downward unimpeded, while engine sound that does travel upward bounces off the wing and then reflects downward.

“By putting the noise source above the wing, there is the potential to shield the ground from engine noise, at least partially,” Gaeta said.

The critical design choice in noise shielding involves where to place the engine relative to the wing, he explained. Closer to the wing helps takeoff and landing performance, but it increases noise.
due to viscous rubbing of the jet exhaust stream acting along the wing upper surface. Further away from the wing is better from a noise perspective, but not as effective for takeoff and landing performance.

Finally, to the extent that placing the engine above the wing can shield exhaust noise, the engine needs to be placed as far forward as possible because maximum jet noise occurs at the exhaust exit, Gaeta said. Moreover, all of these design choices must not detract from the crucial issue of cruise performance.

The very nature of a STOL flight trajectory – steep takeoff and approach angles – offers another potential noise benefit. This trajectory keeps much of the offending noise closer to the airport environs.

Explained Gaeta: “By virtue of steeper takeoff and approach angles, the STOL aircraft can potentially keep its most offending noise within the airport boundary because it is farther from the ground when it passes over communities.”
Georgia Tech Researchers’ Work is Covered in the News Media

In the future, robots capable of deception may be valuable for several different areas, including military and search-and-rescue operations. A search-and-rescue robot may need to deceive in order to calm or receive cooperation from a panicking victim. On the battlefield, robots with the power of deception could successfully hide and mislead the enemy to keep themselves and valuable information safe. Georgia Tech researchers have developed algorithms that allow a robot to determine whether it should deceive a human or other intelligent machine, and designed techniques that help the robot select the best deceptive strategy. That research has produced more than a hundred articles, in such outlets as The Wall Street Journal, Time Magazine, National Defense, CBS News, The Daily Telegraph, Discovery News, Engadget, MSNBC.com, Wired, Discover Magazine, Popular Science, New Scientist – and even The Colbert Report. (See the article on page 14 of this issue of Research Horizons magazine).

Researchers at the Georgia Tech Research Institute (GTRI) have developed an advanced approach to enabling autonomous collaboration among dissimilar robotic vehicles. The GTRI system, called the Collaborative Unmanned Systems Technology Demonstrator (CUSTD), employs two small-scale aircraft and a full-size automobile to perform a complex, interactive mission without human intervention. It was demonstrated at a recent “Robotics Rodeo” at Fort Benning, Ga. A number of media outlets covered the demonstration, including Aviation Week & Space Technology, Scientific American, National Defense, Communications of the ACM and R&D Magazine. (See the article on page 4 of this issue of Research Horizons magazine).

Georgia Tech physicists have developed a new “templated growth” technique for fabricating nanometer-scale graphene devices. The method addresses what had been a significant obstacle to the use of this promising material in future generations of high-performance electronic devices. The technique involves etching patterns into the silicon carbide surfaces on which epitaxial graphene is grown. The patterns serve as templates directing the growth of graphene structures, allowing the formation of nanoribbons of specific widths without the use of electron beams or other destructive cutting techniques. Dozens of media outlets covered the development, including Technology Review, Scientific American, Electronics Weekly, ZDNet, ECN, Nanotechwire, SMT Magazine, Compound Semiconductor and R&D Magazine. (See the article on page 6 of this issue of Research Horizons magazine).

Graphics processing units (GPUs) can provide almost supercomputer-level power to computers, thanks to new programming tools that allow them to be used for a broad range of tasks. But there is a risk that the power of these GPUs can be used for harmful purposes, such as brute-force attacks on the passwords protecting computer networks. Georgia Tech researchers have studied that possibility and concluded that greater password security is needed — at least 12 characters, instead of the seven-character security now recommended. More than 100 news outlets picked up on the research, including the BBC, MSNBC.com, PC World, Government Computer News, Electronics Weekly, InformationWeek, Engadget, PC Pro, Network World, Sky News, Scientific American and TechJournal South.
School of Physics associate professor Alex Kuzminch became an American Physical Society Fellow.

Mustafa Aral, professor in the School of Civil and Environmental Engineering, has been elected a Fellow of the American Society of Civil Engineers.

School of Mechanical Engineering associate professor Jeffrey Strater became a Fellow in both the American Society of Mechanical Engineers and the Society of Tribologists & Lubrication Engineers.

GTRI principal research engineer Tracy Wallace, senior research engineers Steve Barton and Carlos Davila, and research engineer Ryan Holman were named senior members of IEEE.

School of Chemistry and Biochemistry assistant professor Raquel Lieberman was named a 2010 Pew Scholar in the Biomedical Sciences and received a Doc Blanchard Fellowship.

Gary Gimmestad, GTRI principal research scientist, became a senior member of The Optical Society of America.

The Hudgens Center for the Arts announced College of Architecture artist-in-residence Ruth Dusseault was among five finalists for the Hudgens Prize visual arts competition.

GTRI researchers Bob Beasley, Dave Erickson, Richard Fuller, Thomas Spangler and Phil West were inducted into the 2010 Association of Old Crows Technology Hall of Fame.

College of Management marketing professor Ajay Kohli received the 25-year Consortium Fellow Excellence Award from the American Marketing Foundation.

School of Industrial Design professor Abir Mullick was awarded the 2010-11 Fulbright-Nehru Fellowship from the United States-India Educational Foundation.

Charles Ume, School of Mechanical Engineering professor, won the Excellence in Mechanics Award from the American Society of Mechanical Engineers Electronics and Photonic Division.

2002beat Sprite, an iPhone app developed by Director of Music Technology Gil Weinberg and his team, was a finalist for the 2010 Billboard Music App Award.

School of Mechanical Engineering professor Andrei Fedorov received the 2010 American Society of Mechanical Engineers-Pi Tau Sigma Gustus L. Larson Memorial Award.

The GTRI Communications Office was named as a Top Place to Work in PR by PR News. The office was also awarded three Marcom Awards and five awards from the International Association of Business Communicators Atlanta Chapter for the 75th Anniversary GTRI Annual Report.

College of Architecture professor emeritus Elizabeth Meredith “Betty” Dowling’s exhibition and catalogue One Hundred Years of Architectural Education, 1908-2008, received the Southeastern College Art Conference Award for Outstanding Exhibition and Catalogue of Historical Materials.

Jun “Jim” Xu, associate professor in the School of Computer Science, was named an Association of Computing Machinery Distinguished Scientist.

School of Earth and Atmospheric Sciences faculty members L. Gregory Huey, Athanasios Nenes, Carol Paty, Yuhang Wang and Rodney Weber received the NASA Group Achievement Award.

Sigma Xi awarded School of Biology professor Mark Hay and associate professor Julia Kubanek, and School of Chemistry and Biochemistry associate professor Facundo Fernandez its Faculty Best Paper Awards; School of Physics assistant professor Daniel Goldman its Young Faculty Award; and School of Physics professor Kurt Wiesenfeld its Sustained Research Award.

Ioannis Brilakis, assistant professor in the School of Civil and Environmental Engineering, received the American Society of Civil Engineering Associate Editor Award.

School of Electrical and Computer Engineering assistant professor May-sam Ghovanloo won the inaugural “Leo” People’s Choice Award at the 2010 da Vinci Awards.

Annalisa Bracco, School of Earth and Atmospheric Sciences associate professor, received the Nicholas P. Fofonoff Award from the American Meteorological Society.

GTRI principal research scientist Margaret Loper was named Woman of the Year in Technology for medium-sized businesses at Women in Technology’s 2010 awards competition.

Director of the Georgia Tech Packaging Research Center Rao Tummala was awarded the 2011 IEEE Components, Packaging, and Manufacturing Technology (CPMT) Award.

Mikulas Fabry, assistant professor in the Sam Nunn School of International Affairs, received the Campus Teaching Award from the American Political Science Association and Pi Sigma Alpha.

Georgia Trend magazine named Santosh Vempala, distinguished professor in the School of Computer Science, to its 2010 “40 Under 40” list of high-performing individuals under 40 from around the state.

School of Mechanical Engineering assistant professor Dirk Schafer was awarded the title of International Engineering Educator from the International Society for Engineering Education.

George Biros, associate professor in the Coulter Department of Biomedical Engineering and the School of Computational Science & Engineering, won the Association for Computing Machinery’s Gordon Bell Prize.

GTRI principal research engineer John Schultz was awarded the Education Award by the Materials Measurement Working Group.

School of Computational Science & Engineering assistant professor Nick Feamster was recognized by Technology Review magazine as one of the world’s top innovators under the age of 35 for his research in computer networks.

Don Giddens, dean of the College of Engineering, was elected to serve as president-elect of The American Society of Engineering Education for 2010-2011.

GTRI principal research engineer Zdzislaw “Stan” Lewantowicz received a 2010 Modeling and Simulation Award from the Kittyhawk Chapter of the Association of Old Crows.

The High Museum of Art’s catalogue for John Portman Art and Architecture, co-authored by College of Architecture professor Robert Craig, received the Southeastern College Art Conference Award for Outstanding Exhibition and Catalogue of Contemporary Materials.

GTRI principal research engineer Fred McKeeen received the Missile Defense Agency’s Contractor Honor Roll Award.

Regents professor Jean-Luc Brédas from the School of Chemistry and Biochemistry received the Charles H. Stone Award from the American Chemical Society.
When it’s time for classes to change at the Georgia Institute of Technology, the campus hears not a bell but a factory whistle. That distinctive blast is an hourly reminder that Georgia Tech is rooted in the world of business and industry.

In 1960, the Georgia General Assembly mandated direct outreach to business in the form of an Industrial Extension Service within the Engineering Experiment Station (today known as the Georgia Tech Research Institute). This year marks the 50th anniversary of the creation of that mission, now performed by elements of the Enterprise Innovation Institute (EI2), Georgia Tech’s primary economic development and business assistance organization.

In the technology transfer arena, the Advanced Technology Development Center (ATDC) – located within EI2 – has begun its fourth decade of serving technology entrepreneurs. The startup company accelerator based at Georgia Tech was recently named to Forbes magazine’s list of 10 top technology incubators.

Peterson recently took steps to improve the coordination of Georgia Tech’s multifaceted research, business assistance and economic development initiatives. He chose Stephen E. Cross, director of the Georgia Tech Research Institute (GTRI) since 2003, for the newly created position of executive vice president for research. (See sidebar story, “Coordinating Georgia Tech’s Research Activities.”)

Led by EI2, Georgia Tech’s principal economic development efforts include:

- Technical, energy and other support services for Georgia manufacturers, technology entrepreneurs and other businesses.
- An industry-recruitment team that works with a variety of state agencies to help attract top companies – such as recent arrival NCR Corp. – to Georgia.
- Technology transfer programs that have converted Georgia Tech research discoveries into hundreds of startup companies and more than 1,000 licensing agreements.
- Assistance to city, county and state governments on economic and policy issues.

The growing link between research innovation and economic development is producing economic development results in the state, said Stephen Fleming, Georgia Tech vice president and executive director of EI2.

“Our range of services represents all the capabilities of Georgia Tech, which are there for everyone, from the mom-and-pop business to the big manufacturing plant,” Fleming said. “Georgia Tech is a resource for the state of Georgia.”
Statewide Support:
Helping Georgia Businesses Compete

By Rick Robinson

- When Super Lawn Technologies Inc. of Fort Valley, Ga., needed assistance with manufacturing issues, Enterprise Innovation Institute (EI2) personnel applied lean manufacturing principles and design engineering expertise to help the fast-growing company develop a lighter, stronger and more efficient hydraulic ramp system for the specialized trucks it builds for landscaping companies.
- Struggling in a down economy, Sustainable Resources Group of Savannah turned to the Georgia Tech Procurement Assistance Center (GTPAC) to learn about winning government contracts. Today, the six-employee construction business is thriving financially and planning to add more workers.
- Seeking to make its laboratory processes more efficient via process improvement principles, Athens Regional Laboratory focused on improving its operations.

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Photo: Gary Meek

Tony Bass (left), owner of Super Lawn Technologies, talks with Georgia Tech’s Bob Wray (center) and Alan Barfoot about design points of the specialized trucks that Bass’s company manufactures in Fort Valley, Ga.
Medical Center in Athens, Ga., worked with the Healthcare Performance Group at EI² to decrease fluid-processing times by 66 percent, saving thousands of dollars.

- When Georgia food industry companies wanted to reduce product loss due to processing variations, engineers at the Georgia Tech Research Institute (GTRI) developed a camera-based system to ensure proper meat cooking, reducing waste and promoting food safety.

  “We have a brick tower here at Georgia Tech, not an ivory tower,” said Stephen Fleming, Georgia Tech vice president and executive director of the Enterprise Innovation Institute. “We use Georgia Tech’s expertise in science, technology and innovation to support Georgia businesses around the state.”

A Half-Century of Outreach

The Georgia Manufacturing Extension Partnership (GaMEP) in EI² was chartered in its original form in 1960 to help the state’s industry. It began its existence as the Industrial Extension Service of the Engineering Experiment Station, which is now GTRI.

The GaMEP provides a broad set of services for improving the competitiveness of Georgia manufacturing companies. It offers direct technical and engineering assistance, as well as continuing education courses and networking opportunities.

GaMEP’s staff of 30 engineers and other professionals work from nine Georgia Tech regional offices throughout the state. They offer broad expertise to client companies, and can also tap the extensive resources and expertise at the main campus.

“In fiscal 2009, EI²’s Manufacturing Extension team helped manufacturing companies reduce operating costs by $67 million, increase sales by $143 million, and create or save 1,150 jobs,” said Chris Downing, P.E., a mechanical engineer who directs of EI²’s Industry Services unit.

“In addition to providing direct expertise, we take advantage of academic and research units such as the Georgia Tech Research Institute and the Manufacturing Research Center,” Downing added. “That helps us improve Georgia companies’ competitiveness through innovative solutions.”

Lean and Green

Lean enterprise techniques can help Georgia companies achieve major savings, said Larry Alford, director of the Georgia Tech Lean Consortium, a service of the GaMEP.

“A lean enterprise focuses on eliminating waste throughout the business – waste that costs time and money but adds no value for your customers,” Alford said.

Building flexible, predictable and capable processes increases the resources that can be redirected into growth and innovation strategies.

“When you’re sure of your ability to meet customers’ needs, it’s amazing how much time you have to be creative,” he added.

Rotary Corp., a Glennville, Ga., manufacturer, employs 450 people and recently turned out its 150 millionth lawnmower blade. Working with Robert Wray of EI², the company participated in an initiative to identify new ideas and approaches to help the company grow.

Rotary was able to evolve new product ideas and improve its ordering system. Ed Nelson, Rotary’s president, credits the process with substantial benefits including $1.5 million in increased sales, $2 million in retained sales and 50 retained jobs. He adds that the company avoided $262,000 in unnecessary investments as a result of Georgia Tech’s assistance.

Collaboration between Georgia companies is an important new direction that can translate into waste-eliminating process improvements, Alford said. He points to Kason Industries Inc. of Newnan, which is working with other Georgia enterprises through the Lean Consortium.

Kason is participating in reciprocal meetings and plant tours with two other Newnan-area companies, E.G.O. North America Inc. and Bonnell Aluminum Inc. Currently, 34 organizations across the state are advancing their knowledge and use of lean principles through shared training and peer-to-peer relationships.

“In going through different factories and facilities, we’re able to learn new ideas and then try to expand on them within our own facilities,” said Skipper Schofield, continuous improvement manager for Kason.

Energy and environmental management are also areas where companies can readily cut waste and become leaner. The Bostik plant in Calhoun, Ga., a facility belonging to a large adhesive and sealant maker, recently worked with EI² energy specialist Jessica Brown to reduce its energy consumption.

According to production manager Dan Conetta, Brown’s help allowed Bostik to reduce its energy consumption by some 56 percent, saving $40,000 annually.

“We needed to move to a more sustainable mode of operation,” Conetta said. “The level of expertise and the availability make the Enterprise Innovation Institute a valuable resource.”

In fiscal year 2009, EI² helped more than a dozen Georgia hospitals adopt process improvement techniques that reduce costs and improve service. With funding from Healthcare Georgia Foundation, EI² is helping Peach Regional Medical Center in Fort Valley improve service quality and reduce costs with process-improvement techniques adapted from manufacturing.

Peach Regional’s emergency department has already noted a 20 percent decrease in patients’ average length of stay, said Nancy Peed, the hospital’s CEO.

“I think of Georgia Tech as the world-class university with the local focus,” said Dene Sheheane, Georgia Tech’s director of governmental relations. “I love the fact that we are consciously reaching out to towns and businesses throughout the state and saying to them, ‘We’re here for you – how can we collaborate with you?’”

CONTINUED ON PAGE 33
Faculty in Georgia Tech’s School of Public Policy, School of International Affairs, Enterprise Innovation Institute (EI2) and other units conduct research aimed at analyzing Georgia’s economy – and finding new approaches that can benefit the state.

Cultivating Clusters – Dan Breznitz, an associate professor with appointments in the School of International Affairs and College of Management, is investigating why clusters of high technology companies form in specific locations. By examining successful company clusters in California’s Silicon Valley, Israel and elsewhere, Breznitz has spotlighted specific approaches that could help Georgia build on successes such as the Advanced Technology Development Center (ATDC) startup accelerator at Georgia Tech.

“We need to add to the things we have already achieved,” Breznitz said. “We have a great technological university and university system, and we rank fourth nationally in terms of absolute numbers of R&D dollars moving to our area.”

Still, from studying other technology clusters, Breznitz has concluded that Georgia should add additional economic development elements, including:

• A rich support network that emanates from an area’s existing corporations, especially from major companies that are not technology competitors. Direct mentoring by established business leaders, including participation in the company boards of startup ventures, is critical.

• Additional involvement by government, not necessarily in terms of increased dollar investment, but in the form of actions taken by government to emphasize, legitimize and inspire small technology companies. In successful high technology nations like Finland and Israel, government has provided invaluable non-monetary stimulus.

“We must create a true community of high-tech firms embedded in Atlanta,” he said. We want them to resist calls to relocate. Otherwise we will never enjoy the full economic growth potential of our own investment in innovation.”

Innovation Hubs – Philip Shapira, a professor in the School of Public Policy, conducts research in economic and regional development, industrial competitiveness and innovation, technology transfer, and the role of science and technology policy in regional development. Shapira frequently collaborates with Jan Youtie, an EI2 principal research associate who is also an adjunct professor in the School of Public Policy. Georgia is often their “laboratory” for examining challenges and good practices in innovation-based development.

Shapira and Youtie have published numerous articles,
including “Building an Innovation Hub: A Case Study of the Transformation of University Roles in Regional Technological and Economic Development” in the journal Research Policy. In this article, they discussed how universities have evolved from knowledge factories and repositories to innovation hubs.

Looking at Georgia Tech, they highlighted the university’s significant role in state economic growth, which involves not only conventional teaching and research but also development of “boundary-spanning” programs and organizations in such areas as entrepreneurship, incubation, industrial extension and university-industry partnerships.

They note that university-based R&D, startups and other knowledge-related activities, while highly important, are by themselves not enough to change a local economy. Also needed is a broadly based, statewide framework that includes such elements as improved school and training systems, access to capital, and mechanisms to foster R&D and innovation capabilities in mature as well as high tech industries.

To address these gaps, Shapira and Youtie co-founded the Georgia Tech Program in Science, Technology, and Innovation Policy (STIP), co-sponsored by EI² and the School of Public Policy. This program brings together faculty, students and practitioners to promote and exchange new thinking about research-based, economically driven policies in science, technology and innovation.

**Customized Research** – Georgia Tech’s Enterprise Innovation Institute conducts customized research for state, local and regional industry needs. A broad range of services helps local and state governments and economic developers find ways to sustain technology-based economic development, balanced growth and fiscal sustainability.

“Our team includes economists, planners, policy analysts and other research professionals with well over 100 years of combined economic development research experience,” said Robert Lann, director of Community Policy and Research Services (CPRS) for EI².

EI²’s Community Innovation Services was recently called in by Troup County community leaders after Kia chose the area for a 2,200-acre car manufacturing complex. The Georgia Tech team helped the county assess its situation and supported ongoing efforts to deal with growth issues.

In 2006, CPRS launched WebLOCI™, a Web-based version of the nationally recognized LOCI™ fiscal impact tool for localities. WebLOCI allows local areas to calculate the community-wide financial impact of a given economic development proposal. It is licensed to hundreds of local governments, chambers of commerce and economic development agencies in Georgia and other states.

– Rick Robinson

Researchers from the Georgia Tech Research Institute are evaluating a new system that uses lasers to project symbols onto substandard food products. The system allows technicians to keep their eyes on the processing line.
Opening Doors for Business

Learning to navigate the procurement processes of federal, state and local governments can be a challenge for small- and medium-size businesses. Smaller outfits can also have trouble keeping up with industry standards concerning manufacturing and business processes, as well as government health and safety regulations.

The Georgia Tech Procurement Assistance Center (GTPAC), an EI2 unit, approaches the issue head-on. Working from nine locations throughout the state, GTPAC counselors provide classes and other services to Georgia businesses that address the ins and outs of becoming a government vendor.

GTPAC also maintains an online electronic bid-match service that collects contracting opportunities from more than 1,200 websites where government agencies post their needs. GTPAC e-mails clients with potential business opportunities daily. (See sidebar story on page 42, “Helping Georgia Do Business with Government.”)

Smaller Georgia manufacturers and businesses can be handicapped if they don’t comply with worldwide industry standards such as ISO 9000 quality standards or with federal and state regulations governing workplace health and safety.

“A lot of our work is helping smaller companies become certified in standards such as ISO 9000,” said Alan Barfoot, an EI2 senior research engineer who supports businesses in central Georgia. “It isn’t new technology, but it’s often critical for these companies to become certified to get new customers and grow their businesses.”

When Thermal Ceramics, an Augusta insulation manufacturer, needed to revamp its quality management system, EI2 professionals helped the company streamline procedures and become fully ISO-certified. As a result, the company increased sales by $6 million while saving $2 million in costs.

EI2 also works with the Occupational Health and Safety Program at the Georgia Tech Research Institute (GTRI) to help hundreds of Georgia businesses comply with requirements of the federal Occupational Safety and Health Administration (OSHA).

“It can be challenging for smaller businesses to deal with OSHA and state requirements, and we’re here to help them comply fully and stay safe,” said Daniel Ortiz, a GTRI principal research scientist who directs the OSHA programs at Georgia Tech.

Meanwhile, many regional manufacturers are facing intense competition from imported products. The Southeastern Trade Adjustment Assistance Center (SETAAC), based at EI2 and funded by the U.S. Department of Commerce, supports turnaround strategies for such companies.

In FY 2009, SETAAC helped 11 Georgia companies with 21 projects. The result was an increase in sales revenues of more than $1.7 million and the retention of 230 jobs.

SETAAC’s work has also resulted in gains in the seven other Southeast states that it serves. In the last three years, SETAAC’s clients have increased sales by 26 percent and improved productivity by 28 percent.

When Thomaston, Ga.-based Criterion Technology, an injection-molding company, was hit by intense import competition, Mark Hannah, a SETAAC project manager, helped the company prepare...
an application for the Department of Commerce. The resulting funding allowed Criterion to make research, training and equipment investments that helped company sales rebound.

“When we perform a diagnostic review of the company, we are looking for areas that can help the company improve,” Hannah said. “We develop a list of strategic projects that will have the biggest impact on the firm.”

Supporting Small Businesses

The Georgia Minority Business Enterprise Center (GMBEC), another EI² unit, concentrates on aiding minority-owned businesses. It places special emphasis on firms that have potential for rapid growth and high economic impact.

The GMBEC is sponsored by the U.S. Department of Commerce’s Minority Business Development Agency. MBEC’s project director, Donna Ennis, was recently named one of Atlanta’s Top 100 Black Women of Influence by the Atlanta Business League.

“Minority business enterprises are growing faster in our state than the general business community, and in the past seven years GMBEC has helped these companies garner more than $400 million in contracts, financing and sales while creating more than 3,200 jobs,” Ennis said. “While these businesses do have the challenges of raising capital and penetrating markets, they’re making real progress – and we’re here to help them deal with those challenges and grow their Georgia businesses.”

In another effort, Georgia Tech has teamed with the University of Georgia (UGA) in the Georgia Entrepreneur and Small Business Outreach Program (GESBO), funded by the OneGeorgia Authority to focus on smaller businesses outside metro Atlanta.

Through GESBO, Georgia Tech provides technical and government procurement consultation to Georgia manufacturers and other businesses. UGA focuses on providing these companies with marketing support such as website development and e-commerce guidance.

Karen Fite, who directs Georgia Tech’s regional network and is based in Athens, Ga., also leads GESBO for Georgia Tech. Among the program’s new directions, she said, is a series of CEO forums, which are formal mentoring events where company leaders meet in a confidential environment to discuss business issues.

“During our first fiscal year of operation, we served approximately 1,000 companies in the smaller cities and rural areas of Georgia,” Fite said. “Companies reported more than 440 new jobs, $42 million in new revenue, $11 million in new investments and $2 million in operational improvements.”
Helping Georgia Do Business

The Georgia Tech Procurement Assistance Center (GTPAC) helped Georgia companies win $664 million in government contracts in fiscal 2009, producing an estimated 13,679 jobs statewide.

“We’re teachers, mentors, coaches,” said Chuck Schadl, GTPAC’s manager. “We help Georgia businesses identify, compete for and win federal, state or local government contracts.”

Working from nine locations throughout the state, GTPAC counselors provide free classes to businesses on the often complex process of becoming a government vendor. Counselors also advise individual clients on negotiating the bid process.

GTPAC maintains an online bid-match service that collects contract opportunities from the more than 1,200 websites where government agencies post their needs. The center then e-mails relevant opportunities to its clients – mostly smaller Georgia businesses – on a daily basis.

GTPAC, which receives major funding from the U.S. Department of Defense, has some 2,400 Georgia client businesses, Schadl said. That total includes hundreds of companies outside the Atlanta metro area.

Some recent success snapshots include:

Sustainable Resources Group of Savannah, a six-person civil-construction company, has won several government contracts since joining GTPAC in 2009. That work has helped the firm thrive in a challenging economy, said company co-owner Jimmy C. Gulle.

Smith & Carson, an investigative services firm, won an important federal contract six months after becoming a GTPAC client, said Mary Podgorny, the company’s vice president of government services. The Atlanta-based firm was selected by the U.S. Air Force to locate family members of service personnel unaccounted for during their service.

Division 2 Construction Group LLC, a small construction firm in Jasper, won a significant Army contract just two months after starting with GTPAC, said Sherry Blue, company president.

Supporting Industry at the Georgia Tech Research Institute (GTRI)

Georgia Tech’s industry outreach program started in the Georgia Tech Research Institute (GTRI) when it was known as the Engineering Experiment Station. Today, GTRI is still involved in Georgia Tech’s industry support and economic development missions through research for a variety of Georgia industries, including poultry, carpet and digital media.

Some highlights include:

The Food Processing Technology Division, operated with the poultry industry and other Georgia agribusiness, develops new technologies and adapts existing ones to specialized industrial needs through the Agricultural Technology Research Program.

GTRI is a host of FutureMedia™, a Georgia Tech initiative to help Georgia become a global pioneer and leader in digital, social and mobile media. The four-day FutureMedia Fest 2010 was held in Atlanta in October 2010.

Each year, GTRI’s Occupational Health and Safety Program helps hundreds of Georgia businesses comply with federal Occupational Safety and Health Administration (OSHA) requirements. GTRI professionals provide free, on-site safety and health consulting to smaller companies – those with fewer than 500 employees. They also teach at Georgia high schools and at the college level. In addition, the OSHA Training Institute Education Center at Georgia Tech offers safety and health courses in more than 20 topics.

The Foundations for the Future (F3) program, led by GTRI, supports development of a skilled workforce by helping Georgia schools utilize educational Internet applications. The F3 effort has led to programs such as Direct to Discovery, a high-definition (HD) videoconferencing approach that is bringing truly interactive classroom instruction to Georgia school systems.

GTRI is a major participant in Georgia Tech’s professional education program, which supports business and industry, as well as national defense, through classroom and distance-learning courses in 39 subjects and disciplines. Among recent developments is the Professional Master’s Degree in Applied Systems Engineering (PMASE) that is available to working engineers and other professionals throughout the state.

– Rick Robinson
For out-of-state companies, Georgia’s appeal includes a positive business environment, good transportation system, an extensive workforce, abundant land and a temperate climate. Many businesses are also attracted by a statewide system of 35 colleges and universities that includes Georgia Tech, a highly regarded technological university ranked among the 10 best U.S. public universities.

When NCR Corp. announced last year that it was moving its headquarters to Georgia and also expanding its manufacturing presence there, the company’s top management cited the University System of Georgia and Georgia Tech as significant factors in the move.

“The opportunity to partner with top-tier academic institutions such as Georgia Tech was one reason among many that we made this decision,” said Bill Nuti, NCR’s chairman and CEO.

Partners in a Process

NCR’s decision wasn’t the work of a single day, said Greg King, with the Strategic Partners Office at Georgia Tech’s Enterprise Innovation Institute (EI2). NCR’s connections to Georgia Tech go back many years to include collaboration between NCR’s technology development group and several centers and labs on campus, in addition to the recruitment of Georgia Tech graduates.

Over the years, NCR’s early presence in Georgia gave company management a chance to become familiar with the state’s resources. In 2008, the corporation announced it would establish a global center of excellence in Peachtree City.

King, who also serves as a program director for the University System’s Intellectual Capital Partnership Program (ICAPP), recalls a meeting with NCR managers to outline the scope of Georgia’s educational and research resources.

“ICAPP represents the University System to companies looking to relocate to Georgia, as well as to existing companies in Georgia,” King said. “A company can locate anywhere in the state and be confident that it can find the right resource for the right need at one of our 35 campuses.”

With ICAPP and Georgia Tech’s help, NCR identified Georgia Tech’s School of Industrial and Systems Engineering, College of Computing, Health Systems Institute and College of Management, among others, as potential collaborators. The corporation also identified five other Georgia schools it wanted to work with throughout the state.

In June 2009, NCR announced it would relocate its headquarters from Ohio to Duluth, Ga., and would also build a 350,000-square-foot manufacturing plant in the west Georgia city of Columbus. The move brings an eventual total of approximately 3,000 new jobs into the Peach State.

GE Energy Expands

This year, GE Energy announced and opened a new Smart Grid Technology Center of Excellence near the company’s existing headquarters in Marietta, Ga. The decision is expected to result in a $15 million investment in Georgia and create 400 jobs over three years.

GE Energy also said it would increase its existing cooperation with Georgia Tech on smart-grid research. Among other collaborators are the Georgia Tech Research Institute (GTRI), Georgia Tech College of Engineering, Strategic Energy Institute and Georgia Tech’s Distance Learning and Professional Education, which manage the Professional Master’s Degree in Applied Systems Engineering (PMASE) program. These groups are working with GE Energy to develop a special professional master’s degree in smart-grid systems and technologies.

“GTRI researchers as well as academic faculty members are working with us to adapt the current PMASE program by including smart-grid projects throughout the courses and in the final capstone course,” said Carlee Bishop, a GTRI research engineer who helped develop the PMASE degree in cooperation with the College of Engineering.
Carl Rust, director of the Strategic Partners Office in EI², explained that bringing companies to Georgia demands close collaboration among a broad array of institutions and agencies.

“Successes like these are excellent examples of how Georgia Tech works with other state organizations – the Georgia Department of Economic Development, the University System of Georgia’s ICAPP program and the Georgia Research Alliance – to support investment and growth,” he said.

Wooing companies is highly labor-intensive, Rust admitted. In the most recent fiscal year, Strategic Partners interacted with 188 different companies and worked on 21 different economic development projects.

The effort was worth it, he said. The Strategic Partners Office played a key role in $78 million of capital investment and 4,481 new Georgia jobs, as well as in $3.6 million in industry contracts received by Georgia Tech.

Critical Mass in Technology Square

Much of Georgia’s economic development outreach starts on Georgia Tech’s east campus in the Technology Square complex.

The Centergy Building in Technology Square is home to the Enterprise Innovation Institute, its outreach operations and many of its startup companies. It’s also home to the Georgia Department of Economic Development, the Technology Association of Georgia and ICAPP, among other organizations.

That clustering of economic development expertise was no accident, said Wayne Hodges, who retired recently as vice provost of EI² after 40 years in the state’s economic development outreach effort. Georgia Tech economic development leaders, he said, wanted a center for the technology community – one that would house entrepreneurs, startup incubators, graduate startups, venture capitalists, investors and support organizations in the same building.

When the public-private Technology Square project was announced in 2000, Hodges and others began to talk with state agencies and Georgia companies about using the new building as a physical center for the state’s economic development efforts. The reaction, he recalls, was highly enthusiastic.

Thus, when Technology Square opened in 2003, the Centergy Building housed the headquarters for Georgia Tech’s Economic Development and Technology Ventures (soon to become the Enterprise Innovation Institute), its Advanced Technology Development Center (ATDC) startup incubator, its Manufacturing Extension Partnership and other business assistance units. It soon became home also to the Georgia Department of Economic Development, the Technology Association of Georgia, the Georgia Power Company economic development headquarters and other offices and agencies.

The result, said George Israel, formerly president of the Georgia Chamber of Commerce, is unique. “When the state of Georgia brings business prospects to Technology Square, the message those prospects get is that technology is a priority in Georgia,” Israel said. “All economic development groups of the three major electric utility companies are located in the Centergy Building.”

Supplying a Workforce

Once companies decide to locate in the state, the Georgia Quick Start Program can help them assemble an effective workforce. Based in the Centergy Building, the workforce training program has four other offices in Columbus, LaGrange, Savannah and Vidalia – to provide customized worker training for new or existing Georgia businesses.
Quick Start is an important draw to outside companies, said Derek Woodham, region manager in Georgia Tech's West Region office, which serves 23 west Georgia counties. For one thing, the size of its undertakings can be very large.

In March 2008, Kia Motors America Inc. and Georgia officials opened the $20 million Kia Georgia Training Center near a new Kia manufacturing plant site in West Point in west Georgia. The Quick Start program collaborated with the new center, and by the time the main plant was completed in March 2009, trained workers were ready to move in.

In May 2010, solar-products maker MAGE Solar announced it would establish its North American headquarters in Dublin, Ga., saying it will invest $30 million and could employ 350 people within five years. The MAGE announcement added to a fast-growing cluster of Georgia alternative-energy companies, including Suniva Inc., which spun out of Georgia Tech's School of Electrical and Computer Engineering, GE Energy and a number of other companies and startups in energy technology areas.

Recently added to that cluster was Belgium-based solar-panel maker Effinity Corp., which announced it would open a North American headquarters in metro Atlanta. ICAPP and other agencies are working with Effinity to find areas in which Georgia Tech and other University System institutions can provide support.

“That’s the beauty of the Georgia Tech approach,” said Alan Barfoot, manager of Georgia Tech’s Central Region office in Dublin. “When we help recruit companies, then we already have relationships with those companies. So after they get here, we typically continue to work with them on a variety of different projects such

Coordinating Georgia Tech’s Research Activities

Stephen E. Cross, director of the Georgia Tech Research Institute (GTRI) from 2003 to 2010, assumed the new post of executive vice president for research (EVPR) on May 1, 2010. Cross became Georgia Tech’s principal research officer, leading the Institute’s $500 million-per-year research operation and coordinating that effort with its economic development and business assistance programs.

The EVPR position involves direct oversight of the Institute’s interdisciplinary research centers, the Enterprise Innovation Institute (EI), GTRI and the Georgia Tech Research Corporation. Cross is also working closely with the academic colleges, their affiliated units and the faculty.

Cross is a member of Georgia Tech’s new executive leadership team, led by President G.P. “Bud” Peterson and also including Steven Swant, the executive vice president for administration and finance, and Rafael Bras, Georgia Tech’s provost and executive vice president for academic affairs. Cross has been meeting with senior administrators and faculty, conducting a review of budgets and research operations and developing a plan for moving ahead.

Cross recently emphasized the importance of a shared understanding between Georgia Tech’s research and academic programs.

“It is critical that the EVPR work with the academic provost to proactively support faculty hiring and retention. We have to be anticipatory, based upon solid planning with clear objectives,” Cross said.

Among those objectives, he said, “we need to focus on how we can better utilize technology that is produced at Georgia Tech.”

As vice president and director of GTRI, Cross led a period of unprecedented growth, with GTRI’s overall research awards topping a record $200 million in fiscal year 2009, up from $109 million in 2006.

— Rick Robinson

Stephen E. Cross, formerly director of the Georgia Tech Research Institute, has assumed the new post of executive vice president for research. As Georgia Tech’s principal research officer, he leads a $500 million-per-year research operation.
as plant design and construction, manufacturing issues, workforce development, energy audits – whatever they need.”

**Dealing with Growth**

When South Korean automaker Kia announced in 2006 that it had selected West Point as the site of its first North American manufacturing facility, officials in nearby Troup County were elated. But they also believed that the 2,200-acre Kia complex would challenge the county’s infrastructure and affect the area’s way of life.

City officials in LaGrange, the Troup County seat, asked the Community Innovation Services group in EI to help them assess the situation and identify strategies to deal with the expected growth.

“Troup County was already growing due to expansion at Fort Benning and other factors, and then Kia increased the pressure,” said Joy Wilkins, who managed the Community Innovation Services group during the project. “So the issues involved more than growing the economy – they included how the cities and the county could prepare and connect their workforce to the new opportunities, and also how they could deal with land use and infrastructure matters such as roads.”

Georgia Tech professionals helped Troup identify opportunities that made sense for it, Wilkins said. They also supported the county’s efforts to develop an organizational framework that could deal with growth issues long after the Georgia Tech team had left.

“Troup County community leaders were wise in selecting Georgia Tech to assist the community in developing a plan to strategically guide its growth,” said Kay Durand, executive director of the Troup County Center for Strategic Planning. “The Georgia Tech team provided resources to give us an excellent foundation, and they continue to be a resource as we work on the challenges of making a quality, sustainable life for our citizens.”

Indeed, growth issues must be faced quite deliberately if the U.S. is to sustain quality of life through the coming decades of growth, argued Catherine L. Ross, Harry West Professor in the Georgia Tech College of Architecture and director of the Center for Quality Growth and Regional Development.

In the book *Megaregions*, edited by Ross, contributors address issues involved as the U.S. becomes a nation of mega-regions – meaning networks of metropolitan centers and surrounding areas linked through environmental, economic and infrastructure interactions.

“Unless city and regional planners and policymakers take an active role in guiding growth in the light of sustainability, economic competitiveness and social equity, the U.S. will come up short in the areas of housing, transportation and infrastructure,” Ross said.

“Georgia’s public and private sectors and its research universities need to work together to ensure that our economy and our quality of life grow together.”

**Georgia Tech’s Cooperative Education Program** allows students to get real-world experience at companies – and allows companies to identify and train the students they want to hire after graduation. To read more about this program, please visit [http://bit.ly/huw1q1](http://bit.ly/huw1q1).
Technology Transfer:

Converting Research to Economic Benefits in Georgia

By Rick Robinson

- Suniva Inc., a Georgia solar cell maker that began production in December 2008, recently announced plans to expand its 73,000-square-foot plant in Norcross and add more workers to its payroll of 150. The company reports it has booked nearly $1 billion in international sales.

- CardioMEMS Inc., a developer of implantable wireless devices that help manage cardiovascular disease, recently completed a successful clinical trial of its CHAMPION device – the company’s second commercial medical product. The firm also raised $37.9 million in additional capital.

These fast-growing companies have two things in common. Both are based on Georgia Tech research. And both are graduates of the Advanced Technology Development Center (ATDC), a Georgia Tech startup company accelerator that has produced more than 120 new enterprises since 1986, including 31 initial public offerings and acquisitions.

Forbes magazine recently named ATDC to its list of “Ten Technology Incubators Changing the World.” ATDC, which celebrated its 30th anniversary in 2010, was selected from more than 300 incubators in the United States.

“If you are a Georgia technology entrepreneur, we will help you no matter where you are located in the state or what your background is,” said Stephen Fleming, a Georgia Tech vice president and executive director of the Enterprise Innovation Institute (EI2), ATDC’s parent unit. “In addition to our brick-and-mortar facilities in Atlanta and Savannah, we are spreading across the rest of the state, which is part of our mandate.”

Nearly a year ago, ATDC opened its membership to all technology companies in Georgia. It now has some 320 members, Fleming said, making it in all probability the world’s largest technology incubator.

Even in a down economy, ATDC companies have raised a total of more than $150 million in venture capital during the past year, he added. Scores of companies and entrepreneurs take advantage of the office and laboratory space that ATDC makes available at its headquarters in the Centergy Building in Atlanta’s Technology Square and in the ATDC Biosciences Center on the central campus.

Since 1999, companies associated with ATDC have raised more than a billion venture capital dollars. Six that graduated this year – three Internet ventures, two semiconductor companies and a developer of homeland security technology – raised more than $50 million in venture capital while in the incubator.

“One of the things that makes Georgia Tech different from many other universities is that economic development has been very consciously put into the mission statement,” said Wayne Hodges, the recently retired vice provost of EI2. “And Georgia Tech presidents have promoted it from the top down, ever since Joseph Pettit came here in 1971 from Stanford University, where he had seen numerous companies develop out of that university.”

From Research to Resource

Harnessing research innovations for economic development is rarely an overnight process, argued Robert Knotts, Georgia Tech’s director of federal relations.

Suniva’s seemingly rapid success, he said, actually involved many years of U.S. Department of Energy investments in the University Center of Excellence for Photovoltaic Research and Education at Georgia Tech. The founder of that center, Regents professor Ajeet Rohatgi, is also founder and chief technology officer of Suniva.

“We never know which research dollars will turn into a great company like Suniva and contribute jobs and growth to our economy,” Knotts said. “And it’s usually not something that happens quickly – high-quality innovation takes time.”

One key element that ATDC’s business veterans can provide is objective advice. Rohatgi recalls he was hesitant in 2006 when representatives from ATDC and from the New Enterprise Associates (NEA) venture-capital firm urged him to start a company. He believed he should continue to tweak the efficiency of his innovative solar cells.

“I wanted to wait for 20 percent efficiency, but ATDC and NEA
executives convinced me that we already possessed a unique balance of efficiency and cost," he said.

**320 Startup Companies**

ATDC is home to many startup companies working to turn research innovations into successful products – some 320 startups in all. Among many examples of startups based on Georgia Tech research are:

- Sentrinsic LLC, which uses technology developed in the Georgia Tech School of Mechanical Engineering to address the need for cost-effective displacement-sensing technology. Sales have doubled in the past two years, said COO David Beck, and are on track to double again in 2010. The company’s first product is a device that cuts by half the energy used by industrial pumps. Sentrinsic is partnering with Northbrook, Ill.-based IDEX Corp. – a company with a market capitalization of $2.63 billion – on production and sales of the industrial pump product. Other position-sensing products are in the pipeline at Sentrinsic.

- Axion BioSystems is commercializing technology that lets scientists interact directly with live brain or nerve tissue. The flagship product, developed at Georgia Tech, allows drug companies to test the effectiveness and safety of potential drugs on electro-active tissues such as those found in the brain and heart. The company, located in the ATDC Biosciences Center, currently has beta units in the field and expects to begin commercial production in 2010, said CEO Tom O’Brien. At Georgia Tech’s academic colleges, activities relating to technology transfer or other economic development work are increasingly included among the roles that faculty are expected to perform, said Gary S. May, professor and Steve W. Chaddick School Chair in the School of Electrical and Computer Engineering (ECE). "In ECE, as in a number of other academic units, professors are encouraged to list activities such as patents received as part of the annual review data they submit to the school," May said. "And a significant number of our faculty members are active in the formation of companies or other technology transfer efforts."

**License – or Startup?**

The history of successful startups at Georgia Tech goes back many decades. In 1952, several researchers from the Engineering Experiment Station, now known as GTRI, formed a startup they named Scientific Atlanta. The company grew exponentially to become a major supplier of satellite Earth stations and cable television equipment. It was acquired for $6.9 billion by Cisco Systems Inc. in 2006.
Helping Georgia Do Business with Government

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GTPAC, which receives major funding from the Defense Logistics Agency, a unit of the U.S. Department of Defense, has some 2,700 Georgia client businesses, Schadl said. That total includes hundreds of companies outside the Atlanta metro area.

Some recent success snapshots include:

• Sustainable Resources Group of Savannah, a six-person civil-construction company, has won several government contracts since joining GTPAC in 2009. That work has helped the firm thrive in a challenging economy, said company co-owner Jimmy C. Gulle.

• Smith & Carson, an investigative services firm, won an important federal contract six months after becoming a GTPAC client, said Mary Podgorny, the company’s vice president of government services. The Atlanta-based firm was selected by the U.S. Air Force to locate family members of service personnel unaccounted for during their service.

• Division 2 Construction Group LLC, a small construction firm in Jasper, won a significant Army contract just two months after starting with GTPAC, said Sherry Blue, company president.

• The Fuel Desk LLC, a four-person firm in Cumming, has won 20 contracts to supply aviation fuel for air shows since becoming a client. “It has been a great experience to work with GTPAC,” said Shirley Gunn, Fuel Desk’s president. “You feel like they’re always there for you.”

– Rick Robinson

Chuck Schadl, director of the Georgia Tech Procurement Assistance Center (GTPAC), teaches company officials how to compete for and win contracts with local, state and federal government agencies.
The Georgia Tech Research Corporation (GTRC), working with Georgia Tech’s Office of Sponsored Programs, administers more than $500 million in research contracts that flow into the university every year. Among other things, it manages Georgia Tech’s intellectual property and oversees the Office of Technology Licensing (OTL).

GTRC has a strong history in facilitating startup companies – more than 125 to date, said Kevin Wozniak, OTL’s director.

However, Wozniak explains, most research discoveries aren’t suited to become the foundations for a startup company. The vast majority of innovations reach the marketplace through technology licensing agreements, which means existing corporations pay a fee to use specific intellectual property.

Today, academic institutions can utilize their research discoveries thanks to the Bayh-Dole Act of 1980, which gives universities, small businesses and non-profits control over the intellectual property they develop using federal funding. Most states subsequently passed legislation giving their public universities the green light to take advantage of Bayh-Dole.

Georgia Tech’s OTL began operating full time in 1991, focusing on the evaluation and commercialization of innovations developed at the university as a result of research funding. Over the past five years, Wozniak said, OTL has entered into 240 agreements allowing Georgia companies to utilize Georgia Tech research results. That figure includes 33 Georgia-based startups.

Overall, he said, Georgia Tech’s licensing agreements return an average of about $3 million a year to Georgia.

“Most of the universities that have realized larger licensing revenue have a medical, veterinary or agricultural school,” Wozniak said. “Yet if you compare Georgia Tech in terms of startups, patents and licensing to the biggest-name research universities like Stanford, we actually beat them – after adjusting for the research base.”

**Seeding Georgia’s Economy**

Seed grants – smaller sums of money that help promising companies get off the ground – can be the difference between life and death for startups. Many such grants are available on a competitive basis from the federal Small Business Innovation Research and the similar Small Business Technology Transfer programs (SBIR/STTR).

Through SBIR/STTR, 11 U.S agencies set aside 2.5 percent of their external research budgets for early-stage R&D projects at small companies that are developing technology of interest to the agencies. The largest of those agencies, the Department of Defense, allocates more than $1 billion annually for SBIR/STTR grants. The National Institutes of Health (NIH), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) each offer more than $100 million in awards annually.

These cash infusions are often vital to the success of ATDC’s research-intensive startups. For instance, in May 2010 three ATDC companies – AuditMyBooks, ZoozMobile and Whisper Communications – were awarded SBIR grants from NSF, while Prospect Photonics received an NSF STTR Phase II grant.

Any small company in Georgia is eligible to apply to the SBIR/STTR programs, said John Mills, an EI2 professional who helps companies throughout the state become familiar with and qualify for these grants.

“The amounts involved are significant – some DoD grants can go as high as $1.15 million, though some awards are less,” Mills said. “But even a $70,000 grant at the right time can make all the difference to a small Georgia technology company.”

In fiscal 2009, EI2 provided assistance to Georgia companies in preparing 76 proposals that won more than $7 million in SBIR grants, Mills added.

For several years, EI2 has worked with the Carpet and Rug Institute in Georgia, supporting flooring initiatives through partnerships with NASA, the NSF and Georgia Tech. Part of that effort involves Novana Inc., a small Georgia company with an innovative concept for recycling carpet waste. EI2 helped Novana secure a recent NSF SBIR/STTR grant to fund project research.

The Georgia Research Alliance (GRA) also provides important support for fledgling companies in the state. Since 1990, GRA has helped fund the launch of more than 175 companies.

GRA is led by Michael Cassidy, president and CEO, and Susan G. Shows, senior vice president. Over its 20-year history, the Alliance has invested some $600 million at the six leading Georgia research universities in top scientific talent programs, such as the GRA Eminent Scholars and their teams; in research infrastructure; and in research commercialization initiatives, such as the GRA VentureLab program.

Said GRA’s Cassidy: “There’s no doubt that Georgia is among the states that are most serious about technology transfer – and that approaches like ATDC and GRA VentureLab are working. We need to continue to make sure promising technology startups all over Georgia get a clear shot at success.”

![Suniva founder Ajeet Rohatgi (right), and CEO John W. Baumstark display a solar cell product manufactured at the company’s facility in Norcross, Ga.](Photo: Gary Meek)
A team led by Georgia Tech has received a $10 million “Expeditions in Computing” award from the National Science Foundation (NSF) to develop novel computing techniques for measuring and analyzing the behavior of children.

These technologies will enable new approaches for identifying children at risk for autism and other developmental delays, and may improve the delivery and evaluation of treatment.

The award – one of only 10 given out by the NSF since 2008 – provides up to $2 million in funding each year for five years and is designed to push boundaries in computer science. This project is intended to catalyze a new scientific discipline called computational behavioral science, which will draw equally from computer science and psychology to transform the study of human behavior.

“There is a great deal of creativity in the computer science research community today,” said Deborah Crawford, acting assistant director of Computer and Information Science and Engineering at the NSF. “Our intentions with the Expeditions in Computing program are to stimulate and use that creativity to expand the horizons of computing. For example, several of the projects will be exploring new computational approaches to some of the most vexing problems we face in the science and engineering enterprise as well as in the larger society.”

Autism affects one of every 110 children in the United States and the long-term outcomes for a child who is at risk for autism can be significantly improved if the child is treated at an early age. As a result, it is widely accepted that all children should be screened for developmental delays as early in life as possible.

“Direct observation of a child by highly trained specialists is an important step in assessing risk for developmental disorders, but such an approach cannot be easily scaled to the large number of individuals needing evaluation and treatment,” said the project’s lead principal investigator James Rehg, a professor in Georgia Tech’s School of Interactive Computing.

For this project, the researchers will design vision, speech and wearable sensor technologies to analyze child behavior. Data will be collected from interactions between caregivers and children, children playing and socializing in a daycare environment, and clinicians interacting with children during individual therapy sessions. Multiple sensing technologies are necessary to obtain a comprehensive and integrated portrait of expressed behavior.

“People use eye gaze, hand gestures, facial expressions, and tone of voice to convey engagement and regulate social interactions,” said co-principal investigator Gregory Abowd, a professor in the School of Interactive Computing at Georgia Tech. “In addition, physiological responses, such as increased heart rate, can impact the expression of these behaviors.”

Cameras and microphones will provide an inexpensive and noninvasive way to measure eye gaze and facial and body expressions, along with speech and non-speech utterances. Wearable sensors will measure physiological variables such as heart rate and skin conductivity, which contain important clues about levels of internal stress and arousal that are linked to behavior.

The research team will also develop capabilities for synchronizing the signals from the microphones, cameras and on-body sensors. By developing and using models of social interactions, the researchers will analyze the sensor data to quantify engagement.

As part of this award, the researchers will use a behavioral screening instrument called Rapid-ABC, which is currently under development by Emory University School of Medicine assistant professor of psychiatry Opal Ousley, Georgia Tech School of Interactive Computing senior research scientist Rosa Arriaga, and Abowd. The researchers intend to utilize the information gathered to automate some of the scoring for the Rapid-ABC test.

“We hope that by incorporating this screening protocol into well-child doctor visits for children less than two years old, we can reduce the average age of autism diagnosis, which is currently about four years old,” explained Arriaga.

— Abby Robinson

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The Georgia Tech-led Nanomedicine Center for Nucleoprotein Machines has received $16.1 million for five years as part of its renewal by the National Institutes of Health (NIH). The eight-institution research team plans to pursue development of a clinically viable gene correction technology for single-gene disorders and demonstrate the technology’s efficacy with sickle cell disease.

Sickle cell disease is a genetic condition present at birth that affects more than 70,000 Americans. It involves a single altered gene that produces abnormal hemoglobin — the protein that carries oxygen in the blood. In sickle cell disease, red blood cells become hard, sticky and “C” shaped. Sickle cells die early, which causes a constant shortage of red blood cells. The abnormal cells also clog the flow in small blood vessels, causing chronic pain and other serious problems.

“Even though researchers know sickle cell disease is caused by a single A to T mutation in the beta-globin gene, there is no widely available cure,” said center director Gang Bao, the Robert A. Milton Chair in Bio-medical Engineering in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University.

“By directly and precisely fixing the single mutation, we hope to reduce or eliminate the sickle cell population in an individual’s blood stream and replace the sickle cells with healthy red blood cells.”

The center is part of the national network of Nanomedicine Development Centers, which serve as the intellectual and technological centerpiece of the NIH Nanomedicine Initiative. The centers combine nanoscale science — understanding and manipulating cellular nanostructures — with specific medical therapies.

In addition to experts in the Coulter Department and the School of Chemical & Biomolecular Engineering at Georgia Tech, researchers from Medical College of Georgia, Cold Spring Harbor Laboratory, New York University Medical Center, Massachusetts Institute of Technology, Stanford University and Harvard University are also members of the center.

The gene correction approach the researchers propose to use to treat sickle cell disease involves delivering engineered zinc finger nucleases (ZFNs) — which are genetic scissors that cut DNA at a specific site — and DNA correction templates into the nuclei of hematopoietic stem cells isolated from the bone marrow of individuals with sickle cell disease.

The researchers chose hematopoietic stem cells because they are the precursors of all blood cells, including the cells rendered dysfunctional in sickle cell patients. Hematopoietic stem cells possess such potent regenerative potential that transplantation of even a single hematopoietic stem cell is sufficient to rebuild the entire blood system of an organism.

The researchers plan to engineer and optimize the ZFN proteins so they will induce a double-strand break in the DNA near the sickle cell disease mutation, thereby activating the gene for correction. The broken DNA ends will enter the homologous recombination repair pathway, which will use the genetic information provided by the donor template — rather than the original flawed information — to correct the mutation. When the gene-corrected hematopoietic stem cells are injected back in the body, they will produce healthy red blood cells to replace the sickle cells.

“This approach represents a significant paradigm shift in current gene targeting and gene therapy technology in that no viral-based vector or foreign DNA is used,” explained Bao, who is also a Georgia Tech College of Engineering Distinguished Professor. “We think it’s a promising approach because we do not need to fix all of the mutations in all cells; we only need to greatly reduce the sickle cell population by replacing those cells with healthy red blood cells.”

— Abby Robinson

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The National Science Foundation (NSF) has awarded $3 million to Georgia Tech to fund a unique research program on stem cell bio-manufacturing. The program is specifically focused on developing engineering methods for stem cell production to meet the anticipated demand for the cells. The award comes through the NSF’s Integrative Graduate Education and Research Traineeship (IGERT) Program, which supports innovation in graduate education in fields that cross academic disciplines and have broad societal impact.

While stem cell research is on the verge of broadly impacting many elements of the medical field – regenerative medicine, drug discovery and development, cell-based diagnostics and cancer – the bio-process engineering that will be required to manufacture sufficient quantities of functional stem cells for these diagnostic and therapeutic purposes has not been rigorously explored.

“Successfully integrating knowledge of stem cell biology with bioprocess engineering and process development into single individuals is the challenging goal of this program,” said Todd McDevitt, an associate professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University and a Petit Faculty Fellow in the Parker H. Petit Institute for Bioengineering and Biosciences at Georgia Tech.

McDevitt is leading the IGERT with Robert M. Nerem, professor emeritus of the George W. Woodruff School of Mechanical Engineering at Georgia Tech. Nerem is also director of the Georgia Tech/Emory Center (GTEC) for Regenerative Medicine, which is administering this award.

Ph.D. students funded by Georgia Tech’s stem cell bio-manufacturing IGERT will receive interdisciplinary educational training in the biology, engineering, enabling technologies, commercialization and public policy related to stem cells. Their research efforts will focus on developing innovative engineering approaches to bridge the gap between basic discoveries made in stem cell biology and therapeutic stem cell-based technologies.

“This program provides a unique opportunity for engineers to generate standardized and quantitative methods for stem cell isolation, characterization, propagation and differentiation,” said Nerem. “These techniques must be developed in a scalable manner to efficiently produce sufficient numbers of stem cells and derivatives in accessible formats to yield a spectrum of novel therapeutic and diagnostic applications of stem cells.”

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Biomedical engineering associate professor Todd McDevitt is co-leading Georgia Tech’s new research program on stem cell bio-manufacturing, which is specifically focused on developing engineering methods for stem cell production to meet the anticipated demand for stem cells.
Insecure Web browsers and the growing number of complex applets and browser plug-in applications are allowing malicious software to spread faster than ever. Some websites are installing malicious code, such as spyware, on computers without the user’s knowledge or consent.

These so-called “drive-by downloads” signal a shift away from using spam and malicious e-mail attachments to infect computers. Approximately 560,000 websites — and 5.5 million Web pages on those sites — were infected with malware during the fourth quarter of 2009.

A new tool that eliminates drive-by download threats has been developed by researchers at Georgia Tech and SRI International. BLADE — short for Block All Drive-By Download Exploits — is browser-independent and designed to eliminate all drive-by malware installation threats.

“By simply visiting a website, malware can be silently installed on a computer to steal a user’s identity and other personal information, launch denial-of-service attacks, or participate in botnet activity,” said Wenke Lee, a professor in Georgia Tech’s School of Computer Science. “BLADE is an effective countermeasure against all forms of drive-by download malware installs because it is vulnerability and exploit agnostic.”

The BLADE development team includes Lee, Georgia Tech graduate student Long Lu, and Vinod Yegneswaran and Phillip Porras from SRI International. Funding for the BLADE tool was provided by the National Science Foundation, U.S. Army Research Office and U.S. Office of Naval Research.

The researchers evaluated the tool on multiple versions and configurations of Internet Explorer and Firefox. BLADE successfully blocked all drive-by malware installation attempts from the more than 1,900 malicious websites tested. The software produced no false positives and required minimal resources from the computer. Major antivirus software programs caught less than 30 percent of the more than 7,000 drive-by download attempts from the same websites.

“BLADE monitors and analyzes everything that is downloaded to a user’s hard drive to cross-check whether the user authorized the computer to open, run or store the file on the hard drive. If the answer is no to these questions, BLADE stops the program from installing or running and removes it from the hard drive,” explained Lu.

While BLADE is highly successful in thwarting drive-by download attempts, it will not prevent social engineering attacks. Internet users are still the weakest link in the security chain, notes the research team.

“BLADE requires a user’s browser to be configured to require explicit consent before executable files are downloaded, so if this option is disabled by the user, then BLADE will not be able to protect that user’s Web surfing activities,” added Lee.

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Wenke Lee, a professor in Georgia Tech’s School of Computer Science, was part of a team that developed a new tool that eliminates drive-by download threats.
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