Contents

Research Horizons

A publication of the Georgia Institute of Technology

Volume 15, Number 4
Spring 1998

Editor

Jane Sanders
404/894-2214

To receive e-mail notification of new issues of Research Horizons on the Web, please send your e-mail address and request to jane.sanders@edi.gatech.edu. If you subscribe to the print version and would rather view the on-line Web version only, let us know, and we will add you to the e-mail notification list.

Graphic Design

Everett Hullum
Nao Yamashita

A "home information infrastructure lab" at Georgia Tech's Broadband Telecommunications Center demonstrates broadband links to, from and within the home. Instead of typical TV fare, the TV screen in the home infrastructure room is illuminated by a Web page. (See "Home of the Future" below)

On-line Justice

Database provides bigger picture for court officials.

By T.J. Becker

The Home of the Future

Broadband telecommunications will profoundly alter our lives. — Also see related story: **Universal Access**.

By Faye Goolrick

Beyond a Profound and Pervasive Impact

Microelectronics has entered an era of proliferation.

Contributing Writers

Lincoln Bates
T.J. Becker
Faye Goolrick
Jackie Nemeth
Rick Robinson
Pamela D. Rountree
Jane Sanders
John Toon

Photography

Jim Demmers
Stanley Leary
Medical College of Georgia
Gary Meek

Editorial Advisory Board

Charles Brown
Nancy Davis
Gary Poehlein
Edward Reedy

Research News & Publications Office
Georgia Institute of Technology
430 Tenth Street, N.W.
Suite N-112
Atlanta, Georgia 30318
(Telephone: 404/894-6986)

By James D. Meindl

Hatching a Robotics Revolution

Georgia Tech researchers are developing a new breed of robot that will increase efficiency and competitiveness for the poultry industry.

By T.J. Becker

Departments

Research Notes:

Faculty Profile:

Update:

ISSN #1060-6696

Credits

Questions or comments? Please send us e-mail.

Last updated: July 24, 1998

Research Horizons
Georgia Institute of Technology

On-line Justice

Database provides bigger picture for court officials.

by T.J. Becker

THE INFORMATION POOL is getting deeper and wider for officials in Georgia's state, superior and juvenile courts. Beginning this summer, several counties will be the first to get online access to a management information system developed by researchers at the Georgia Institute of Technology. This access will mark the first time Georgia counties have been able to systematically pool information, including that on criminal activity.

Although the Georgia Crime Information Center (GCIC) maintains an electronic database, its information focuses on sentencing and dispositions. The new database goes beyond that, making a wealth of case-related data readily available to Georgia court officials via the Internet. It was designed by senior research scientist Lisa Sills and her team in the Information Technology and Telecommunication Laboratory at the Georgia Tech Research Institute (GTRI). Composed of a TCP/IP network, the database can be used by account holders -- primarily judges and clerks --

photo by Stanley Leary

A new database — designed by senior research scientist Lisa Sills (right) and her team in the Information Technology and Telecommunication Laboratory at GTRI — makes criminal and civil court

anywhere they have Internet access.

case-related information available to Georgia court officials via the Internet. At left is Judge Hilton Fuller.

"The more information we have, the better decisions we can make," says Judge Hilton Fuller, a DeKalb County Superior Court judge and chairman of the Georgia Courts Automation Commission, which is funding the project.

Complete Records

Until now, Georgia courts have not had electronic access to criminal activity information from other counties. With the new database, officials will be able to obtain more complete information about a suspect's record, Sills says. For example, the suspect may have a history of violent behavior or be under warrant for arrest in another county. The database would quickly reveal this, alerting intake officers not to let that person out on bail.

Previously, the only way to get information from another county has been via telephone, which is time-consuming and offers no guarantee of details. "Even if you pick up the phone, there's no way to really know the extent of the problems," Fuller says. "State-collected data, by the nature of the current collection process, is often quite stale and always limited."

Our mobile society also adds to the problems, Fuller adds. "We no longer have to ride a mule to get to south Georgia. It is not unusual for litigants to be or to have been involved in civil or criminal matters in several Georgia counties."

The new database offers information in two major sections: one for juvenile court and one for state and superior courts. Information can be tracked either by a case docket number or the names of the individuals involved. Under case history, the database indicates whether a bench or jury trial was held, specific events of the trial, outcome and any changes in original sentencing. Entries for individuals also include date of birth, gender, known aliases and a complete record of charges.

Juvenile Justice

The juvenile section tracks dates of foster parents along with "interested persons," who might include parents, guardians and attorneys. "It's helpful for officials to know who watches out for a child on a daily basis, something that changes frequently," Sills says. "If kids aren't at one location, this gives an alternative place to look." The database also tracks gang information, which is becoming increasingly important as gang activity spreads, she adds.

Having such information at their fingertips enables officials to view a case from a broader perspective. For example, a juvenile judge might be able to discern that a shoplifting

incident resulted from deprivation rather than delinquency. The net result is that justice is better dispensed, Sills says.

The database also can be used as a "confidence level test," enabling a judge to ask questions about a defendant's history and see if the person is answering truthfully.

Some other aspects of the database are:

- Civil suits are tracked in the state and superior court portion, revealing a complete listing of plaintiffs and defendants. One advantage to having this data is the ability to see whether a particular individual is prone to involvement in lawsuits.

- There's also a prototype of a public component. Certain forms for probate court are being automated, beginning with decedent estate management. This will allow citizens access to forms via the Web so they can fill them out at home rather than having to go to a courthouse.

Sills expects production release of the database to begin in June with six counties on-line in the state and superior courts section, and five in the juvenile court section.

"Our ultimate goal is to have the whole state, but we're targeting the counties with the greatest number of filings," says Sills, noting that 30 of the 159 counties generate 85 to 90 percent of the state's annual filings. "If we can get those counties on line, almost all criminal and civil activity will be tracked."

Because courts throughout Georgia vary in computer sophistication, the database was designed to be user-friendly. "There's a lot of flexibility when searching for information," Sills says. For example, officials can search for cases by either their docket number or by an individual's name. If officials don't know a person's full name, they can still locate the individual by using a partial or phonetic spelling.

Data Collection

Researchers also installed several links to outside agencies and information resources. If an official does not remember what "16-13-31(a)(1)(A)" means, he or she can click on a link to the Official Code of Georgia (Unannotated) and view a full description of that statute. The database can also display telephone and fax numbers for county personnel. "We're trying to make it really easy for people to collect information. There may be times they have to make a phone call, but at least it won't be a blind query," Sills says.

Even though the database uses existing technology and network security, it remains a highly complex project that has been in the works for two years. "The method of capturing

the data was extremely difficult," says Sills, explaining that information had to be imported from existing county systems, which required an automated system to be in place first. "There are many kinds of systems out there. . . . Integrating their data into ours is challenging."

Besides helping to administer justice, the database will assist in a variety of reporting functions, beginning with case counting. Done each year on a county-by-county basis, case counting reflects the changing needs of the courts. Up to now, it's primarily been done manually, which slows the paper chase to a veritable crawl. Now, a standardized electronic system will make reporting faster and more reliable.

"People probably assume this is being done already, but that is not the case," Fuller says. And record-keeping is no trivial matter. "A lot of federal grants depend on statistics. If Georgia doesn't have its statistics in order, then we don't qualify."

Information from the database will also flow back to GCIC. Again, its standardized format will pay off by reducing reporting time and increasing accuracy. With different counties using different software packages, there is greater chance for error. "By bringing some standardization, we can rely better on all the data that comes in," Fuller says.

The database will also serve as a communication system, he adds. "We'll be able to pass information between the courts, as well as the database. That's also an important part of this tool."

For more information, contact Lisa Sills, Information Technology and Telecommunications Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0832 (Telephone: 404/894-8957) (E-mail: lisa.sills@gtri.gatech.edu)

Research Horizons
Georgia Institute of Technology

The Home of the Future

Broadband telecommunications will profoundly alter our lives.

by Faye Goolrick

ONE DAY IN the not-too-distant future, the harried American consumer may have a direct link to an easier lifestyle. In this new, more relaxed future, air quality improves dramatically as telecommuters opt out of the traffic wars; neighborhoods grow closer via locally programmed, closed-circuit interactive TV; and urban sprawl and over-development diminish as consumers conduct more of their personal business — from banking to shopping to entertainment — without leaving their homes.

Our daily lives may be profoundly altered in these and other ways by the emerging technologies of broadband telecommunications. These technologies are the focus of work under way by a team of Georgia Institute of Technology-based researchers and telecommunications industry supporters.

"Within 10 years, we believe that a majority of homes in the United States are going to be equipped with broadband communication pipelines connecting to a host of available services," says Dr. John O. Limb, a Georgia Research Alliance (GRA) Eminent Scholar and director of the Broadband Telecommunications Center (BTC) at Georgia Tech. "The prospect raises fundamental questions. How is this technology going to change how we live and learn and work? What are we going to do with it?"

Under Limb — whose contributions as director of the Multimedia Laboratory at Hewlett-Packard have already helped influence the industry — BTC researchers are tackling these and related questions with a broad, even visionary, approach. A unit of the GRA's Georgia Center for Advanced Telecommunications Technology (GCATT), the BTC brings together industry representatives and academic researchers from Georgia Tech, Georgia State University and the University of Georgia in a unique working relationship. The quest? To explore, in a myriad of ways, the practical, real-life possibilities for creating and delivering universal telecommunications capabilities to consumers in the home.

"The BTC is one of the few places in the country where we have found academic researchers who are really looking at issues like improving high-speed data delivery to consumers at home, integrating computing into people's regular lives and making the Internet accessible at home in a friendly, available manner," says Intel Corporation senior fellow Kevin Kahn, a BTC advisory board member and Intel's director of communications architecture. "BTC is set up so it can offer a multidisciplinary look, using some real solid academic brainpower, to explore some of these very real problems and find real solutions."

photo by Stanley Leary

This "kitchen of tomorrow," called Domisilica, is a Georgia Tech research project that replicates a "home automation house" in the Atlanta home of student Jonathan Somers. Future consumers could maintain an on-line inventory of groceries and control appliances via a Web interface while they work.

21st Century Scenario

In an attractively furnished apartment (actually a former BTC laboratory), an oversized television screen is set into the wall opposite a comfortable couch. This "home information infrastructure lab," which demonstrates broadband links to, from and within the home, is supported by several adjacent testing facilities: a hybrid fiber/coaxial cable lab, a wireless lab and a network application integration lab. Offices throughout the BTC are networked as well.

Instead of typical TV fare, the TV screen in the home infrastructure room is illuminated by a Web page. Click here . . . and step into the future.

In the 21st-century scenario envisioned by Limb and his colleagues, up-to-the- minute information and two-way audiovisual communication is available at your fingertips, wherever you are. Sitting comfortably in your own home, you teleconference with your son's school to see what he's learning today or catch up with him later at basketball practice.

Using point-and-click technology or voice commands and a high-resolution screen, you "attend" meetings with your sales team in Chicago, New York and Tokyo; tour a potential commercial site and talk details with a leasing agent in Arizona; and access the Internet to gather the latest information on federal and state regulations and instructions and application forms for local permits.

Taking a break from work, you program the evening's media — a mix of education and entertainment — for broadcast to specific video sets and times according to your family's interests. (Kim needs SAT review, Dave is planning a vacation itinerary and you need a Seinfeld rerun after a tough day in the office.)

Although somebody drank the last drop of milk this morning, no one has to stop by the grocery store: your kitchen's bar code scanner enumerates the milk and other items you've run out of, enters the list on line and orders everything for home delivery by 6 p.m. Meanwhile, the local utility company flashes a message that lower-priced evening rates are now in effect, and your dishwasher (set to start with the lower rates) begins to fill.

At 8:30 p.m., your mother tunes in from her retirement home on the coast. She had her arthritis checkup — via Internet — with her rheumatologist and got a good report; now she's ready to read a goodnight story to your 2-year-old as he snuggles in his bed.

Fundamental Issues

Though this fanciful scenario may seem far-fetched, much of the technology to perform these tasks is already in use in business settings. For example, interactivity and live video broadcasting are staples for national networks and local cable television stations, and closed-circuit TV has been around for years. Information by Internet is ubiquitous. Time-of-day rates are a recognized method for leveling utilities' peak loads by discounting off-peak hours. Bar code scanners track almost every consumer products purchase in the nation.

Why, then, don't we have these time- and labor-saving conveniences in our homes?

Simply put, equipping a profitable margin of consumers' homes with to-the- home broadband systems connected to appropriate hardware, middleware and software — not to mention an attractive array of services — is an expensive gamble that few in the industry can afford to take. Fundamental issues of technology and applications are yet to be resolved.

Universal Access

Wireless cable is coming to rural and urban schools in Georgia.

School systems throughout Georgia can find reliable, objective advice on accessing the Internet by working with telecommunications experts associated with the Georgia Tech Research Institute (GTRI) and the Broadband Telecommunications Center (BTC) at the Georgia Institute of Technology.

Through a program called "Foundations for the Future," Georgia educators and educational technology experts, including a number of GTRI researchers, assist Georgia school systems as they make crucial decisions about equipping their schools with new technology. The landmark Telecommunications Act of 1996 provided for federal funding and discounted rates from private telecommunications companies, such as AT&T, as part of a national push to provide schools with universal, affordable access to the Internet and related telecommunications technology.

"Both technically and in a business sense, creating a system that will provide universal broadband access for consumers is very complex," Limb says. "Right now, the cable industry is focusing on cable modems, and the telecommunications companies offer asymmetric digital subscriber lines, commonly called ASDL.

In the long term, the dominant method of providing broadband access will probably be fiber, which is not yet economically justifiable."

In the meantime, highly competitive companies driven by shareholder pressures and volatile conditions within the industry turn to outside research and development facilities such as the BTC. Here — positioned strategically within a respected academic institution and backed by the Georgia Research Alliance, a state-funded technology powerhouse — Limb and his research team aim to guide the future of the industry in realistic ways.

With an eye on the short-, mid- and long-term future, BTC researchers work closely with industry representatives. They partner on a myriad of technology and applications needed to carry broadband telecommunications "the last mile" from the street into the home and finally, to functional applications for consumers.

The BTC's supporters and advisors in these endeavors include 17 member companies. Among them are some of the nation's information services leaders: BellSouth, Cox Communications, General Instrument, Hitachi, Intel Corporation, Kodak, Sprint and others, as well as smaller niche companies such as Convergent Systems and Broadcom. The corporate sponsors' membership fees and grants help fund core research, as well as specific proprietary projects, in five broad categories:

(1) Researchers concentrating on the physical aspects of the industry work with technologies for introducing broadband transmissions to and within the home, including twisted pair, coaxial cable, wireless, satellite and optical fiber.

(2) Networking researchers focus on network management, scalability of network resources, new protocols for shared media, and such thorny issues as network security and access control for the home environment.

(3) Researchers concentrating on systems and software are concerned, at this stage, with storage support for scalable systems and new multimedia platforms.

(4) BTC applications research includes a growing list of specific experiments using broadband technology to forge links between home, office, school and community.

(5) Through business impact modeling, BTC researchers assess the economic feasibility and impact of broadband telecommunications in consumer/residential settings. Tools include demographic surveys, cost-benefit analyses, and evaluation of potential demand for new services and applications.

In all these areas, researchers try to find direct-to-the-home solutions that are low-cost and accessible across an entire community, says BTC associate director Daniel Howard, a senior research engineer at the Georgia Tech Research Institute's Information Technology and Telecommunications Laboratory. Among other projects, Howard has recently proposed an experimental community information system using donated "legacy" — used — telecommunications equipment for a mixed-use housing development adjacent to BTC headquarters in downtown Atlanta. As he envisions it, the system could provide e-mail and local area network service, as well as interactive television access, between public school classrooms, homes and community centers — all at minimal cost.

On another front, Dr. Ken Calvert, an assistant professor in the Georgia Tech College of Computing, is tackling a major concern of many prospective broadband enthusiasts: access control. Using the home information infrastructure facility at BTC, he has developed a prototype network component that effectively creates a "firewall" to protect residential broadband gateways from unauthorized intrusion.

While businesses have developed such protocols, he points out, "Business systems are not simple enough to be used in the home environment; they work, but they need a full-time systems manager to maintain them. Home systems must be scalable to millions of homes, and they need to be redesigned so that they're more 'plug and play.'" As broadband access penetrates more residential markets, Calvert anticipates the development of national standards and security codes.

Inside the home, Dr. Gregory Abowd, also an assistant professor in the Georgia Tech College of Computing, envisions the "kitchen of tomorrow." There, consumers maintain an on-line inventory of their groceries, and appliances are controlled via Web interface while homeowners are at work. Called Domisilica, this BTC-based project includes a complete virtual environment that replicates a real "home automation house" occupied by one of Abowd's students in suburban Atlanta.

Future Research Directions

Founded less than three years ago, the Broadband Telecommunications Center is still evolving with its industry. A major proposal now in the works may yield additional funds for more non-commercial, community- and education-oriented applications for broadband technology, researchers say. At the same time, new private-sector projects and liaisons are constantly under consideration. In a fragmented, constantly changing field, the BTC has gained a reputation as a solid player capable of doing work for industry stalwarts such as Cisco, for whom it is testing modem standards, as well as taking on more visionary, long-range tasks.

"I believe very strongly that we can affect our futures, that what we do in our research today can have a major influence on technology in society in the future," Limb says. "But the big challenge within a residential setting is to make the technology disappear. We don't think about the electric motors in our kitchens — they're there in almost every appliance, but they've 'disappeared.' They've become transparent to the user. The information industry is going to have to make the technology much more transparent than it is today."

Looking out over Atlanta's busy downtown streets, he adds: "If we could reach a point where each worker, on average, telecommuted just one day a week, we would see 20 percent fewer cars on the highway. We'd have less congestion and less pollution. This kind of change has the potential to make a lot of difference in people's lives."

For more information, you may contact Dr. John Limb, Broadband Telecommunications Center, Georgia Institute of Technology, Atlanta, GA, 30332-0280 (Telephone: 404/894-9106) (E-mail: john.limb@cc.gatech.edu). Or you may contact Dr. Daniel Howard, Information Technology and Telecommunications Laboratory, Georgia Tech Research Institute, Atlanta, GA, 30332-0821 (Telephone: 404/894-3541) (E-mail: daniel.howard@gtri.gatech.edu).

Funded by a $2 million grant from AT&T, Foundations for the Future is a collaborative program drawing on resources and expertise from Georgia Tech, Morris Brown College, the University of Georgia and an industry liaison called EduLinc Inc. These partners work together on behalf of Georgia's K-12 schools.

At the Georgia Tech Research Institute, researchers Dara O'Neil, Claudia Huff, Jeff Evans and others are key figures working with the BTC and Foundations for the Future to help Georgia educators choose the "best fit" technology for their schools and school systems.

"The schools know about the E-rate (the education discount rate), but they are not sure what to buy," O'Neil says. "They need our assistance in selecting systems that are scalable and suitable to their needs."

In four rural counties in southwest Georgia, for example, O'Neil and other Georgia Tech-based researchers determined the counties could combine three 56K modem connections into one T-1 Internet connection, then use wireless cable to broadcast the signals to all four school systems. (Georgia Board of Regents funding is available for one 56K line for each school system in Georgia.)

O'Neil and Foundations for the Future members then advised local educators on a successful grant proposal explaining the broadband application. The $500,000 grant covers content, curriculum and professional development, as well as technology purchases.

The wireless installation is slated for July 1998, and students in Stewart, Randolph, Quitman and Clay counties may begin accessing the Internet — and its tremendous collaborative educational possibilities around the world — as early as this fall.

— Faye Goolrick

For more information, you may contact Claudia Huff, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA, 30332-0837 (Telephone: 404/894-3941) (E-mail: claudia.huff@gtri.gatech.edu). Or, you may contact Dara O'Neil, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA, 30332-0837 (Telephone: 404/894-8445) (E-mail: dara.oneil@gtri.gatech.edu).
For more information on "Foundations for the Future," see http:maven.gtri.gatech.edu/foundations/forum.html.

Research Horizons
Georgia Institute of Technology

FACULTY COLUMN

Beyond a Profound and Pervasive Impact

Microelectronics has entered an era of proliferation.

by James D. Meindl
Professor, Electrical and Computer Engineering

The genesis of microelectronics can be traced to the invention of the transistor in 1947. This Nobel Prize-winning breakthrough was of unmatched importance to microelectronics. It eliminated the oppressive requirements for several watts of filament power and several hundred volts of anode voltage in vacuum tubes in exchange for transistor operation in the tens of milliwatts range.

A second breakthrough, the invention of the integrated circuit in 1958, provided the capability to fully exploit the superb low-energy assets of the transistor. Although far less widely acclaimed as such, a third breakthrough of indispensable importance to modern microelectronics was the complementary metal-oxide-semiconductor, or CMOS, integrated circuit announced in 1963.

photo by Stanley Leary

"Clearly, microelectronics is in rapid transition to nanoelectronics. To achieve this additional decade of scaling, as in the past, numerous clever inventions will be necessary,"

says Dr. James D. Meindl, a professor of electrical and computer engineering at Georgia Tech.

Early microelectronic integrated circuits used the so-called bipolar junction transistor invented in 1947. A salient feature of these circuits is their continuous energy consumption, regardless of whether they are operating in an active state — i.e., performing a binary switching transition, the canonical computing operation — or in a quiescent state, waiting to undergo a switching transition.

In contrast, CMOS integrated circuits use a second generic type of transistor, the so-called metal-oxide-semiconductor field effect transistor or MOSFET. It was invented in 1933, but undemonstrated until the early 1960s. In computing operations, CMOS' quintessential feature is integrated circuits that consume significant amounts of energy only during switching transitions and dissipate virtually zero energy during quiescent periods.

The benefits of this near-zero quiescent energy consumption — in terms of both reduced heat generation and battery energy drain — have sufficiently enabled CMOS technology to dominate microelectronics during the current decade. This dominance is expected to continue for the foreseeable future.

Throughout the past four decades, both the productivity and performance of microelectronics have advanced at exponential rates unmatched in technological history. The number of transistors per microchip has skyrocketed by a factor of about 100 million, while the cost of a chip has remained virtually constant. And the amount of energy consumed in a binary switching transition has been reduced by more than five decades!

Consequently, microelectronics has become the principal driver of the modern Information Revolution. And the ubiquitous microchip has had a profound and pervasive impact on our daily lives — enabling such advances as microelectronic wristwatches, hearing aids, implantable cardiac pacemakers, pocket calculators, personal computers, wireless cellular telephones, optoelectronic- fiber networks, communication satellites and the Internet.

Perhaps the single event that most emphatically describes the degree to which the microchip has changed the world and its economy was the selection of Intel's chairman and CEO, Andy Grove, as 1997 Man of the Year by Time magazine.

In the real world, exponential advances in metrics such as productivity and performance do not continue endlessly.

Consequently, the paramount question now facing the microelectronics industry is: Just how much longer can we expect these advances to persist? What lies beyond the profound and pervasive impact that microelectronics has already delivered to society?

In brief, the physical laws governing MOSFET behavior support the projection that critical device dimensions — which began at 25 micrometers in 1960 — can be scaled down from present values in the 0.25 micrometer range to the 0.025 micrometer or 25 nanometer range by the year 2020. Clearly, microelectronics is in rapid transition to nanoelectronics.

To achieve this additional decade of scaling, as in the past, numerous clever inventions will be necessary. Perhaps the most challenging collection of these must provide the intellectual basis for development of a post-optical microlithography technology capable of printing the 25 nanometer patterns necessary for manufacturing future microchip transistors and their interconnects.

Extreme ultraviolet (EUV) or soft X-ray projection lithography using reflective "optics" at 13.4 nanometer wavelength is a leading approach to meet this imposing challenge.

Assuming a successful EUV microlithography technology, the proliferation of terascale integration or trillion transistor microchips can be projected during the 2020s. Consequently, prospects are promising for microelectronics' continued exponential productivity advances. Thus, it will serve as the principal driver of the Information Revolution during the early 21st century.

To sustain an exponential rate of performance improvement, the minimal historic microchip material set of silicon, silicon dioxide and aluminum must proliferate in the future.

It will have to include such new materials as: silicon-based compound semiconductors, particularly for optoelectronics; both low- and high-permittivity insulators, such as silicon dioxide aerogels and ceramics, respectively; and copper alloy conductors.

The modern microchip manufacturing process sequence is the most complex and unforgiving volume production technology ever successfully practiced. To date, the precise material deposition, micropatterning and removal processes in microchip fabrication have been used almost exclusively to generate microelectronic products.

Imagine a wristwatch that is also a cellular telephone-computer terminal with color display and a built-in real-time language translator for point-to-point worldwide communication. The prospect is indeed fascinating and not an unrealistic future expectation for microelectronics.

But the prospects of applying microfabrication technology to the challenges of other non-electronic engineering and scientific disciplines are in many respects even more

fascinating.

Imagine, for example, the notion of a self-navigating sub-sonic jet airplane — with a 12-inch wingspan. Or envision "biochips" coated with millions of DNA probes in microscopic checkerboard patterns. They are optically scanned to expedite exact medical diagnoses that would otherwise be prohibitively expensive and time-consuming!

These images epitomize the potential proliferation of microfabrication technology in non-electronic applications. Such applications could embrace virtually all engineering and scientific disciplines of interest to Georgia Tech.

Send questions and comments regarding these pages to Webmaster@gtri.gatech.edu

Last updated: June 30, 1998

Research Horizons
Georgia Institute of Technology

Hatching a Robotics Revolution in the Poultry Industry

Georgia Tech researchers are developing a new breed of robot that will increase efficiency and competitiveness for the poultry industry.

by T.J. Becker

ROBOTS HAVE BEEN A BOON in the automotive and electronics industries for many years, but the food industry, particularly poultry processing, has not embraced this type of flexible automation.

"One reason is that robotic systems on the market aren't completely compatible with poultry needs," says J. Craig Wyvill, director of Georgia Tech's Agricultural Technology Research Program. "Existing robotic systems tend to be overkill. They're too complex, which makes them expensive to purchase and expensive to maintain. Compounding the problem, the industry needs robots that can withstand the rigors of the food

photo by Stanley Leary

The Intelligent Integrated Belt Manipulator (IIBM) robot

processing environment, which typically adds to their cost."

tackles a common food industry task by removing items from a conveyor belt and transferring them into a packing carton for shipping. It is undergoing field testing at a ConAgra poultry plant in Gainesville, Ga.

Many of the jobs in poultry processing consist of materials handling tasks, such as moving products from a conveyor belt to a box or another conveyor belt. These are areas where robots are ideal substitutes for human hands. Although poultry plants are using simple forms of fixed automation, these machines have very limited capabilities.

"Our goal was to develop a low-cost robot that could perform materials handling with the same speed and dexterity as a human," says Gary McMurray, a senior researcher in the ATRP and a project director for the robotics initiative.

Enter the Intelligent Integrated Belt Manipulator (IIBM). This robot tackles a common food industry task by removing items from a conveyor belt and transferring them into a packing carton for shipping.

Operational Overview

Conceived in 1992, IIBM has gone through several redesigns and refinements over the years. The first-generation robot was powered exclusively by pneumatics, attractive because of its low costs and ease of use. "Speed was good, but the accuracy was not up to expectations," says McMurray, noting that the prototype fluctuated up to an inch in position when picking up items. Although poultry processing requires less accuracy than, say, chip insertion in an electronics plant, "an inch was still too much," McMurray says. The robot could still pick up product, but might misplace it in the shipping carton.

The "new and improved" IIBM is a hybrid of pneumatics and electro-servo drives. Two pneumatic axes and two electro-servo axes allow motion in four different directions: up and down, parallel with the conveyor belt, perpendicular across the conveyor belt, and a 90-degree rotational pivot.

In automotive and electronics industries, parts are consistently shaped and easy for robots to handle. Yet in the poultry business, products vary considerably in size and shape, making grasping demands another challenge for the IIBM. Physical dimensions of the tray pack remain constant, but the poultry pieces inside vary the contours of the package's top by as much as two inches, causing weight and center of gravity to shift.

"Therefore, the IIBM's end effector had to be constructed with some flexibility," McMurray says. Suction cups made from bellows material compress up to three- quarters of an inch. A spring mechanism attached to the suction cups provides another inch of compliance, allowing the grippers to conform to different contours of product.

Gainesville Field Test

After four months of lab testing, the current IIBM prototype is now being tested on the factory floor in a ConAgra (producers of Butterball and Country Pride products) plant in Gainesville, Ga. Speed and accuracy will be the main focus of the field test.

"In the lab, we don't have 1,000 different tray packs available to run through at a time to get a true indication of accuracy," McMurray says. Tray packs in the lab are manually fed onto the conveyor belt, with the same group of product being used over and over. This type of lab testing allows researchers to check on major design elements. But it can't take into account variability among product or the plant environment, which may affect the robot's performance.

Case in point: The tray packs coming out of a freezer can attract moisture in the packing room and generate frost on the package surface — affecting how well the robot's grippers adhere to the surface.

Early field test results have been encouraging. In lab trials, the IIBM's average cycle time was clocked at 2.1 seconds — comparable with a human worker — and the research team has been able to sustain this time in the plant. More importantly, the pick-up rate of the robot has improved significantly. During lab testing, the robot occasionally would drop a tray pack, but missed pickup has been almost non-existent in the plant.

Costs and Benefits

McMurray estimates that final commercial costs of the IIBM will range between $30,000 and $40,000 — about half the price of existing industrial robotic systems. Also, the IIBM is attractive because it is simple, both to install and maintain. The robot can be operating after supervisors program only a few physical dimensions, such as the size of tray packs, the location of packing cartons and the height of the conveyor belt.

In contrast, traditional robotic systems require as many as 300 positions to be programmed individually. "Most food processing companies don't have the technical base to support that type of machine," McMurray says.

Wyvill hopes to have the technology commercialized within the next two years. And this prototype is merely the beginning, McMurray says. Next, he will enhance the system with a vision system. This vision system would help develop hand/eye coordination for the robot and allow it to operate by merely seeing a picture of the product, eliminating the need for task-specific software and programming.

Upgrading the Industry

Does this mean a triumph of machine over man? Hardly, says Wyvill, stressing that robotics is not about making humans obsolete. Indeed, flexible automation creates a better workplace for humans by upgrading job skill requirements to a higher level. "The nice thing about this type of automation is that it can eliminate low-skill labor activities which the industry has the greatest difficulty filling on a day-to-day basis," McMurray says.

"In many of these material handling jobs, people have become extensions of machines, which is not a good situation for the worker in most cases," Wyvill adds. "Robotics make sense in these situations, freeing up a limited labor pool and allowing humans to do what they do best — think."

There's also the issue of safety concerns. Many of these jobs are highly repetitive, putting workers at risk for cumulative trauma disorders such as carpal tunnel syndrome. Automation can reduce injuries.

These and other benefits of materials handling robots are needed throughout the food industry, Wyvill says. "We're already focusing on other ways of bringing robotics to a level that can be widely applied across food industry lines. It will open up a whole new world of opportunity for food equipment manufacturers and the robotics industry."

For more information, you may contact Gary McMurray, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0823. (Telephone: 404/894-8057) (E-mail: gary.mcmurray@gtri.gatech.edu); or Craig Wyvill, Agricultural Technology Research Program, Georgia Tech Research Institute, Atlanta, GA 30332-0823. (Telephone: 404/894-3412) (E-mail: craig.wyvill@gtri.gatech.edu).

Research Horizons
Georgia Institute of Technology

Research in Cyberspace

An on-line technical journal debuts to highlight engineering and science at GTRI.

Scientists and engineers at the Georgia Tech Research Institute have long used the Internet to conduct research. Now they can publish the results there and present their work in a more timely manner.

An online technical journal featuring the work of the Georgia Tech Research Institute (GTRI) debuted this spring. The *Journal of Technology*, is on the World Wide Web at http://www.gtri.gatech.edu/jot/, and can also be reached through GTRI's primary Web page. The JOT targets scientists, engineers and research sponsors. It will be updated quarterly.

An on-line technical journal featuring the work of the Georgia Tech Research Institute (GTRI) debuted this spring. The *Journal of Technology* will features technical articles on GTRI work, such as this traffic management center simulator.

"The *Journal of Technology* is a more scholarly presentation of the work of our research personnel than found in *Research Horizons*, a magazine for Georgia Tech's entire research community," explains Dr. Edward K. Reedy, GTRI's vice president and director. "Besides being a practical communication of our research work, this new journal is an effort to test and develop new ways to communicate knowledge by electronic means, rather than printed paper."

Whereas most technical journals are highly specialized in content, the *Journal of Technology* showcases the broad gamut of GTRI research, ranging from information technology to defense electronics and simulation to materials and manufacturing.

Articles in the first edition include the following:

- "Development of Pneumatic Aerodynamic Concepts for Control of Lift, Drag and Moments plus Lateral/Directional Stability of Automotive Vehicles," a research program evaluating a pneumatic concept for improving aerodynamic problems of automobiles.

- "Automating Information Exchange Between Self-Describing Databases," a look at the development of a tool that allows two different databases to exchange information seamlessly.

- "Object-Oriented Design Techniques Applied to an Integrated Support Station," a process that simplifies interfaces, increases system integrity and enhances software reliability.

- "Effect of the Inner Scale of Turbulence on the Atmospheric Modulation Transfer Function," how turbulence in the atmosphere affects optical imaging, which includes telescopes, military systems, and other tracking and pointing systems.

The publication features both abstracts and full text of articles along with photographs, charts and illustrations. Authors' biographical information and e-mail addresses are provided along with links to the home pages of their respective laboratories.

Planned for future editions is an archival database that would allow readers to search for past papers, relevant commentary and connected material.

"It's been challenging to produce a technical publication in a Web format," says Henry Paris, editor of the new journal and associate director of GTRI's Electro-Optics, Environment and Materials Laboratory. "In spite of recent improvements in Web authoring software, conversion of equations, halftone images and line drawings from diverse word processor files is still cumbersome."

Yet Paris notes that the interactive possibilities of the new technical journal are particularly exciting. "It's an opportunity to explore entirely new ways of creating and accessing written information and ideas," he says.

For years, publishing in the scientific community has been a highly formalized process requiring lengthy review and approval, he explains. Although this system ensures a high

degree of accuracy, it also has a major drawback: By the time ideas finally hit the public forum, it might be two or more years from when they were first put on paper, he says.

The Internet could revolutionize technical publishing by balancing accuracy with timeliness. Paris envisions technical articles being published and reviewed on-line with reviewers' comments available to readers, who might even be the reviewers themselves.

"Sometimes the formal review process can enforce the perceptions of reviewers and suppress novel or controversial ideas," Paris says. "Treating the technical article as a 'work-in-progress' by preserving an article's evolution through the review process would provide greater synergy of content and critique."

For more information, contact Henry Paris, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0826. (Telephone: 404/894-3688) (E-mail: henry.paris@gtri.gatech.edu)

— T.J. Becker

Liotta Appointed New Vice Provost for Research

Regents professor will oversee graduate programs, industry relationship

Dr. Charles Liotta, Regents Professor of Chemistry and Biochemistry, has been appointed Vice Provost for Research and Dean of Graduate Studies at the Georgia Institute of Technology.

Dr. Charles Liotta

In this position, Liotta oversees the Office of Interdisciplinary Programs, managing Georgia Tech's relationship with the Georgia Tech Research Corporation and the Graduate Studies Office. He also coordinates the various programs involved in interacting with the Georgia Research Alliance.

Other duties include managing the cost-sharing and matching resources available to Georgia Tech. "He will be working with graduate coordinators in the schools and colleges to ensure that we are competitive in attracting the top graduate students and working to solidify and expand the recent successes we have had in contracting with industry," says Provost Mike Thomas.

Liotta has a distinguished 34-year career at Georgia Tech in teaching and research, and,

with Dr. Charles Eckert, he has been instrumental in developing the Specialty Separations Center.

Liotta is a past recipient of Georgia Tech's Outstanding Teacher Award, Outstanding Faculty Award given by student government and the Sigma Xi Research Award. He also chaired the Georgia Tech Executive Board. Liotta is still active in research with a group of seven graduate students and two post-doctoral associates.

Interchanging Components

Manufacturing Research Center project could cut electronics assembly costs.

Developing a framework for interchanging electronics assembly equipment and software from different vendors is the focus of a new project at the Georgia Institute of Technology's Manufacturing Research Center (MARC). This "plug and play" capability could yield substantial savings in the cost of manufacturing circuit board assemblies for a wide range of applications.

The work began earlier this year after the National Electronics Manufacturing Initiative (NEMI) chose MARC's printed circuit board electronics assembly facility to be a demonstration test bed site. The task leader for the project is Andrew Dugenske, a research manager in MARC.

"Plug and play" technology project leader Andrew Dugenske examines equipment in the Center for Board Assembly Research at Georgia Tech's Manufacturing Research Center.

MARC's printed circuit board electronics assembly facility began operation recently, after Georgia Tech-funded construction was completed. Personnel in the Center for Board Assembly Research (CBAR) in MARC operate the electronics assembly facility, which initially received more than $3 million in equipment and software from numerous vendors. The CBAR facility contains a state-of-the-art integrated surface mount/direct die attach printed wiring board assembly line with extensive automated in-line post-process inspection capability.

It is NEMI's Factory Information Systems Working Group that is helping make Georgia Tech's MARC facility a demonstration test bed for new advancements in information and

control systems for surface mount electronics assembly. NEMI is a consortium of electronics suppliers and manufacturers whose primary purpose is to improve the competitiveness of North American manufacturers.

In addition to the NEMI "plug and play" project, other activities involving Georgia Tech's CBAR facility include: flip chip processing, equipment interfacing, high-speed high-precision assembly, process monitoring and control, line-level supervisory control and Web-based monitoring.

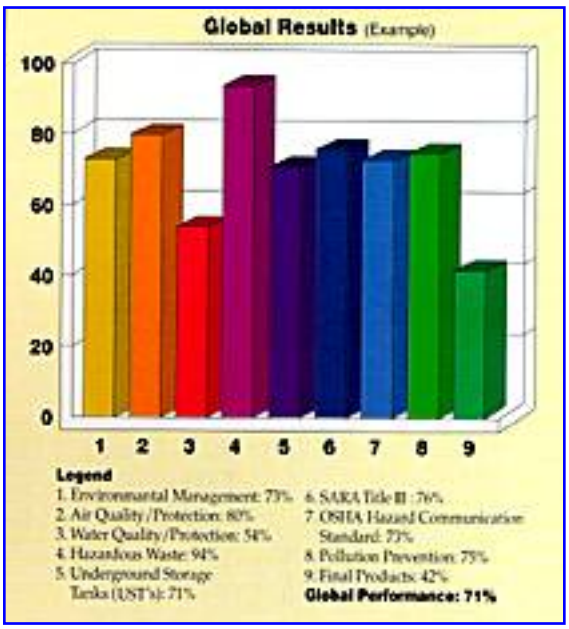
*— **Pamela D. Rountree***

Benchmarking On-line

Environmental management software targets small manufacturers.

Smaller manufacturers in Georgia, and eventually the nation, stand to benefit from new environmental performance software developed at the Georgia Tech Research Institute (GTRI).

A self-assessment tool and benchmarking guide, the software was recently beta tested nationally and is undergoing further refinements, according to project director Roc Tschirhart in GTRI's Electro-Optics, Environment and Materials Laboratory (EOEML). Called Eco.Diagnosis, the software should be available this summer to companies across Georgia.



Click on graphic to see larger version (51k).

Launched in 1996, the EOEML project adapted successful French software to the American business and regulatory environment. Arranged in a "Yes/No" format, it covers 10 topic areas — environmental management, air quality, water quality, hazardous waste, storage tanks, Superfund Amendments Reauthorization Act: Title III, occupational safety and health, pollution prevention, risk management and the impact of a firm's products on the environment. A graphical scoring of responses to several hundred questions indicates a firm's level of environmental management and compliance. This score enables the firm to compare itself against industry norms and measure its own progress.

"Smaller companies often lack the time and resources to address crucial environmental

concerns," says Tschirhart, adding that currently available environmental management software tools are typically too expensive and complex for small and mid-size companies, and they tend to be too narrow in scope. "Ours will apply broadly and be easy to use. It will allow manufacturers to see what regulations apply to their facilities and give them a European perspective on labeling, product lifecycle and ongoing environmental management."

In addition, the tool will contain an Internet-based benchmarking component to allow companies to compare their level of performance with that of other firms. The tool also can provide guidance on how to remedy deficiencies.

Eco.Diagnosis is similar to an expert system, Tschirhart says, in that it draws on and is linked to the experience and expertise of specialists in EOEML's Safety, Health and Environmental Technology Division.

The National Institute of Standards and Technology (NIST) is sponsoring development of the software, which eventually will be made available to NIST's 65 Manufacturing Extension Partnership centers for distribution to firms across the country.

For more information, contact Roc Tschirhart, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0837. (Telephone: 404/894-8045) (E- mail: roc.tschirhart@gtri.gatech.edu)

— Lincoln Bates

A Meeting of the Minds

Packaging Research Center establishes international high-tech collaboration.

The Packaging Research Center (PRC) at the Georgia Institute of Technology has established a partnership with seven international universities, positioning itself to become a world leader in the next generation of electronics packaging research and education.

"The Georgia Tech PRC is not only the center with strength in electronics packaging, and we want to take advantage of the world-class expertise of other universities around the globe," said Dr. Rao R. Tummala, director of the PRC.

Funded by a $900,000 grant from the National Science Foundation, this new collaboration strengthens the already impressive array of expertise at the PRC. "This seven-university partnership adds technical expertise in areas where the PRC is weak or is just getting

started," Dr. Tummala said. "Well-coordinated university collaboration in electronics packaging is necessary to support the projected electronics industry growth from the current $800 billion to $2 trillion within the next seven years. We aim to help with industry's need for the next generation of packaging collectively."

Researchers participating in the PRC partnership were chosen from a university collaboration workshop in early 1997. They will add their universities' research capabilities and prototype facilities to the PRC. They will also work with PRC faculty and students with similar interests and will have access to its facilities, which include $30 million of research and prototype integration research laboratories. This spring, Dr. Tummala expects to double the number of universities involved in the collaboration.

*— **Jackie Nemeth***

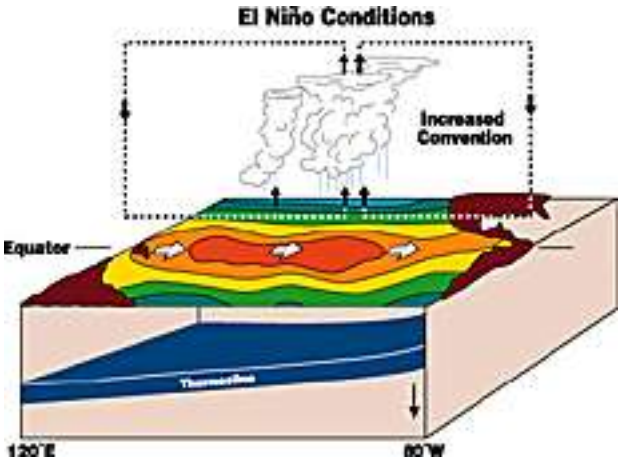
Saving money with weather predictions

El Nino forecasting benefits agriculture.

Taxpayers may be doing better than Wall Street investors when it comes to rate of return on their investments.

A cost benefit analysis of government-funded research on the El Nino weather phenomenon indicates the annual rate of return on that taxpayer investment is at least double the government's minimum acceptable standard, says the study's co-author, Dr. Peter Sassone, an associate professor of economics at the Georgia Institute of Technology.

The study found that the Tropical Ocean Global Atmosphere (TOGA) climate research program provides an economic return on investment to the United States of at least 13 to 26 percent annually. And that range is conservative because it only includes benefits to the U.S. agricultural industry, researchers say. The government's minimally acceptable rate of return on an investment is 7 percent; it is based on the marginal pre-tax rate of return of an average recent investment in the priate sector.



Click on graphic to see larger version (25k).

The National Oceanic and Atmospheric Administration (NOAA) funded the study to determine whether its climate research is a

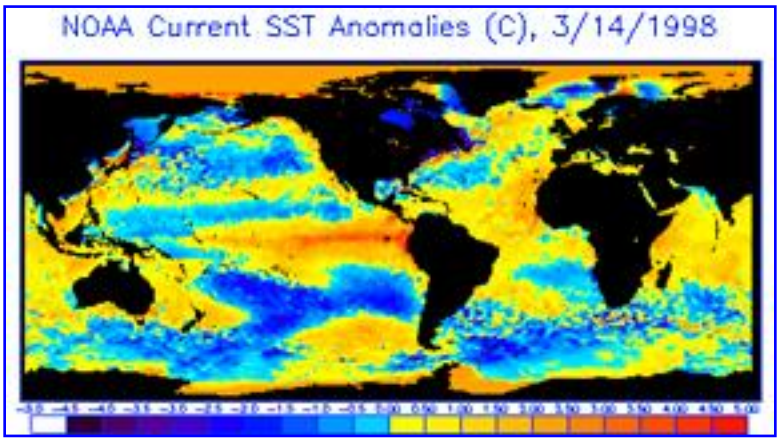
significantly beneficial investment and worthy of continued support, says NOAA chief economist Dr. Rodney Weiher. He and Sassone conducted the research using TOGA as the case study.

TOGA was a successful 10-year scientific effort to understand and model the El Nino/ Southern Oscillation (ENSO) weather phenomenon. It involved deployment of an array of ocean-observing buoys. Now, climate models can predict El Nino events, such as the current one, a year or so in advance. El Nino is the abnormal warming of sea surface temperatures in the tropical Pacific Ocean; it has important consequences for weather around the globe. Among these are increased rainfall across California and the southern United States.

"We concluded that the TOGA program was a sound use of public resources, and that additional funding of climate forecasting R & D efforts — at both the national and international levels — merits serious consideration," the researchers say in their just-published paper in the book "Operational Oceanography: The Challenge for European Cooperation."

In the cost benefit analysis, researchers focused on the benefits of TOGA to the U.S. agricultural sector because it is probably more affected by weather than other sectors, Sassone says. The estimated annual dollar benefits to agriculture are $240 million to $266 million (in 1995 dollars). The estimated benefits are a measure of the gain in consumers' and producers' surplus associated with improved weather information. The actual benefits are dependent on the accuracy of the forecasts, which range from 60 to 80 percent correctness, and the farmers' acceptance of the forecasts.

"I think the $266 million figure is closer to being right, though it's probably a little optimistic," Sassone says. But this figure doesn't include the benefits to other economic sectors, such as water resource management, he adds.



NOAA Current SST Anomaly Chart based on satellite data. (Click on graphic to view most recent version of chart.)

In essence, this analysis says, "If farmers learned what the El Nino forecast was and abided by it over the course of a decade or so, and made whatever adjustments they could, on average they would be better off than if they didn't," Sassone explains. Such adjustments include planting earlier or later, using a different variety of seed or altering

the mix of crops planted.

The researchers arrived at that simple conclusion in a not altogether simple way. "While cost benefit analysis is a highly refined and widely accepted tool used frequently by economists to evaluate alternative public sector investments, there are certain characteristics of climate prediction investments which render them inherently more difficult (than conventional public investments such as roads, bridges, buildings) to assess," the researchers explain.

Those difficulties include: uncertainty about the actual costs of the forecasting program; uncertainty about the ultimate success of the proposed research; the dependence of benefits on the actual climate that occurs; the creation of a baseline scenario that predicts what forecast would be issued without the proposed research; and the behavioral responses to forecasts.

The researchers overcame some of these difficulties by focusing their analysis on a case study of TOGA and its future, they say. They had facts on the TOGA study's scientific success and could estimate its future costs with confidence because the resulting forecasting program is being implemented soon. Also, they could make inferences from this information about the value of other climate research.

Sassone and Weiher feel confident about their rate of return estimates because their analysis considered several key variables. They are: the accuracy of forecasts (ranging from 60 to 80 percent); the time horizon over which benefits are counted (10 and 20 years from now); farmers' acceptance of El Nino forecasts; and the future costs of the El Nino observing system.

Researchers set slow, moderate and immediate rates at which farmers would accept El Nino forecasts over a decade. Those rates ranged from 10 percent in the first year of the slow category to 95 percent in the "immediate" category.

"Farming has become a high-tech industry," Sassone says in explaining the study's assumptions. "Farmers are continually incorporating new technology, such as better fertilizer, seeds and pesticides.... While El Nino forecasts are a somewhat different kind of 'technology' than farmers are accustomed to, we assumed here that the adoption and use of such forecasts by mainstream agriculture will not be remarkably different from farmers' adoption of other new technologies."

The result of this analysis yielded the researchers' benefit estimate of 13 to 26 percent. And it led them to recommend future research on the benefits of climate research to economic sectors other than agriculture. That research has, in fact, already begun, and preliminary results may be available next year.

For more information, contact Dr. Peter Sassone, School of Economics, Georgia Institute of Technology, Atlanta, GA 30332-0515. (Telephone: 404/894-4912) (E-mail: peter.sassone@econ.gatech.edu)

— ***Jane Sanders***

Outstanding Researchers

Tech faculty members receive recent honors

An illustration by **Dr. G. Paul Neitzel**, a professor of mechanical engineering, was published on the cover of the January 1998 issue of Physics Today. The journal is the monthly publication of the American Institute of Physics. His article (co-authored with Pasquale Dell'Aversana), "When Liquids Stay Dry," was published in the same issue (vol. 51, no. 1, pp. 38-41).

* * *

The American Institute of Chemists (AIC) recently elected **Dr. William S. Rees Jr.** a fellow of the Institute. Rees, a professor of materials science and engineering, is the second chemist in Georgia to join the ranks of this prestigious membership category.

Rees is the director of the Molecular Design Institute. His research interests are the synthesis and characterization of inorganic and organometallic compounds for use in the preparation of electronic materials.

* * *

Dr. Dmitris N. Mavris, an assistant professor of aerospace engineering, recently received the Boeing Aerospace Co.'s A.D. Welliver Summer Faculty Fellowship and a National Science Foundation Career Award.

The fellowship promotes stronger ties between industry and academia. Mavris won the four-year NSF award for his proposal titled "A Stochastic Approach to Designing Affordable, Environmentally Acceptable Systems."

* * *

Dr. April S. Brown and **Dr. John B. Peatman** were recently named fellows of the Institute of Electrical and Electronics Engineers (IEEE).

Associate Professor Brown was elected as ECE's first female IEEE Fellow for contributions toward the development of lattice-matched and pseudomorphic high electron mobility field effect transistors.

Peatman, a professor of computer engineering, was elected for contributions as an educator in the design of digital systems.

* * *

Dr. Jerry H. Ginsberg, professor of the School of Mechanical Engineering, recently received the 1998 Archie Higdon Distinguished Educator Award from the Mechanics Divison of the American Society for Engineering Education. The award recognizes his distinguished and outstanding contributions to the field of mechanics education.

* * *

Dr. Richard Neu, an assistant professor of mechanical engineering, recently won the 1998 Outstanding New Mechanics Educator Award from the Mechanics Divison of the American Society for Engineering Education. The award recognizes his outstanding effort and achievement as a new mechanics educator.

* * *

Dr. Timothy A. Salthouse, a Regents' Professor in the School of Psychology, has been elected a William James Fellow of the American Psychological Society (APS) for 1998. It is the highest award offered by the APS.

Salthouse's research addresses the relations of aging on various aspects of cognitive functioning.

* * *

Send questions and comments regarding these pages to Webmaster@gtri.gatech.edu

Last updated: June 30, 1998

Research Horizons
Georgia Institute of Technology

FACULTY PROFILE

Professor Now

Relevancy is the key issue for civil engineering associate professor Dr. Jorge Vanegas.

by Jane M. Sanders

AN IMPORTANT QUESTION constantly replays itself in the mind of Dr. Jorge Vanegas.

"Is what I'm doing relevant?"

The associate professor of civil and environmental engineering at the Georgia Institute of Technology asks himself this question often and in every aspect of his life.

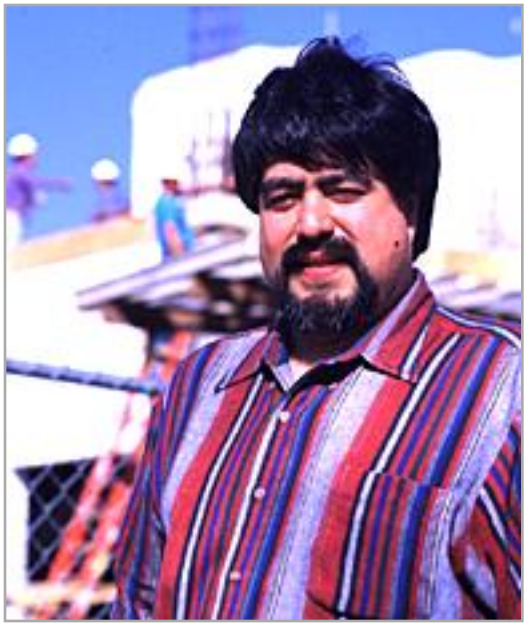
What Vanegas does must be relevant. Why? It's all about change. If you're not relevant, you can't change things, he explains.

photo by Stanley Leary

"It sounds corny, tacky and cliche," Vanegas admits, "but what I really want to do is change things. What really makes me tick is change — change toward the better."

A career develops

Vanegas' life mission developed early in his native Bogota, Colombia. He was an architect, and architects generally drive the construction industry there. But Vanegas found his education did not prepare him technically for the job he was doing.



Dr. Jorge Vanegas

In 1983, Vanegas enrolled in the graduate civil engineering program at Stanford University with one year of funding in hand. At year's end, he lacked one course to complete his degree, but had no money to stay.

"As I was about to leave, I asked my professor about financial aid," Vanegas recalls. "He was starting a project . . . if I wanted to do research. And I said, 'Oh, I've always wanted to do research.' Then I went to ask around, 'What is research?' Then he said it was in the area of constructability. And I said, 'Oh, I've always wanted to do constructability.' Then I went to ask around, 'What is constructability?' It turns out it was a very, very serendipitous coincidence where I used my background in architecture, engineering and construction."

The research, funded by the Construction Industry Institute, involved Vanegas in all aspects of the industry and established the basis for his doctoral dissertation.

"Once I started on the research path, there was no turning back.... " Vanegas says. "When I did my first proposal to do my master's thesis, it was too big, and my advisor said, 'This looks more like a Ph.D. proposal.' So on the spot, I asked him, 'Do you think I have what it takes?' He said yes. So I said, 'OK. Sign me up.' "

The path that followed took Vanegas across the United States to pursue "rich" research opportunities within some of the largest companies in the country. While having as much fun as "a little kid in a candy store," Vanegas realized the valuable role research could play in the real world, he says. After completing his Ph.D. in 1988, Vanegas joined the faculty at Purdue University as an assistant professor. There, he taught, conducted research and advised minority students. Vanegas wanted to do it all and give 100 percent to everything.

"So I broke a lot of rules. You're supposed to just get in your office, publish, do your research, establish yourself as an expert in one single area," Vanegas says. "But I think teaching, research and service feed into a continuum."

Changes begin

With this philosophy firmly entrenched, Vanegas began to see many opportunities for change. He became involved in educational innovation at Purdue. And a five-year National Science Foundation Young Investigator Award allowed Vanegas to implement a research and education program in integrated design and construction for infrastructure rehabilitation. That award and the encouragement of a former Purdue mentor opened the doors of Georgia Tech to Vanegas.

At the urging of Dr. Jean Lou Chameau, now dean of the Georgia Tech College of Engineering, Vanegas joined the Tech faculty as an associate professor in 1993. Within six months, he received three more grants, including $925,000 from General Electric. Those allowed him to pursue his research and curriculum development interests, particularly in the interdisciplinary area of sustainable development and technology.

"We were fortunate to 'steal' Jorge away from Purdue," Chameau says. "He brought his creativity and enthusiasm to the construction management program (which Vanegas manages) in the School of Civil and Environmental Engineering. In addition, he is a strong contributor to Georgia Tech's initiative in sustainable technologies.... Jorge's work is a perfect example of the integration of research ideas into curriculum development."

This collaboration of ideas and disciplines is necessary to achieve the change that makes Vanegas "tick," he says. Though he is sure of the means to achieve change, Vanegas is constantly searching for the right end to those means. "I heard a quote about the difference between effectiveness and efficiency.... I want to be efficient in being effective. In other words, I want to do things right and at the same time do the right thing."

Georgia Tech has encouraged Vanegas to do the right thing, he says. "Being in a place that has shown such a respect for the concept of sustainability tells me there is a respect for society, a respect for the environment, a respect for the world. You don't find that in many places. So here I have found a conscience that I didn't think I had, and it has come alive."

In his work with Georgia Tech's Center for Sustainable Technology and the Construction Research Center, which he co-directs, Vanegas employs his hallmark multidisciplinary approach to problem solving and change. It is in collaboration that change ultimately occurs, Vanegas says.

"I will never make a claim that what I have done or will do will be on my own," he says. "I have just been quite lucky at making the right type of connections.... I have a tremendous ability to visualize possibilities, develop strategic plans, concepts and approaches, to make that vision a reality.... So I can act like a catalyst for things to happen."

Vanegas' colleague Leigh McElvaney, a research associate at the Georgia Tech Research Institute, concurs with his self-evaluation. "Jorge has a strong vision for the future and the passion to try to reach that vision. His enthusiasm for the topic — whether it be the general context of sustainability or the dream of pulling together a research agenda in environmentally conscious design and construction — is contagious. It can be hard to keep up with him!"

The big picture comes into focus

This year is the last of Vanegas' research supported by the Young Investigator Award. The grant has helped Vanegas: understand the problems of facilities and civil infrastructure systems; develop a framework for integration in the architecture/engineering/construction industries; and develop several strategies, mechanisms and tools to enhance the performance and sustainability of the built environment. Now, it's time to put his results into action, he says. So again, he is exploring collaborative projects.

The NSF research is providing the cornerstone for other projects, as well. The Georgia Research Alliance recently awarded Vanegas a grant to purchase video conferencing equipment for a "virtual lab." It will bring together a team of experts on environmentally conscious design and construction of facilities and civil infrastructure systems. And it will establish a research effort in sustainable architecture, engineering and construction. Vanegas plans to leverage this initiative toward Georgia Tech-initiated economic development opportunities in Georgia and beyond.

photo by Stanley Leary

Dr. Jorge Vanegas maintains a busy teaching schedule at Georgia Tech, where he wants students to grasp the big picture, while being firmly grounded in construction fundamentals.

On another front, Vanegas continues his "best practices" research. He wants to make the delivery of capital projects more cost effective. Working with an industry task force, Vanegas studied how one innovative company approached capital projects. This work led to a generic model to help other companies increase their productivity. The difficulty, Vanegas says, is getting companies to implement unconventional cost-effective practices. He is applying these "lessons learned" to his work at Tech's Construction Research Center.

"We will try to pursue more initiatives and implement research thrusts that are going to lead to tangible products that will affect change," Vanegas says. "We want to change the way the industry operates."

Vanegas also wants to initiate change on the educational front. He teaches professional-level continuing education courses for many organizations, including the Construction Industry Institute, which named him Instructor of the Year in 1995.

And he maintains a busy teaching schedule at Tech, where he wants his students to grasp the big picture, while being firmly grounded in the fundamentals of construction. He stresses integration of design and construction to make capital projects effective, efficient and sustainable. Though some students never grasp the big picture, Vanegas admits, he is gratified by the minority he reaches and inspires toward leadership in the industry.

The leaders Vanegas envisions are well versed in their field of expertise, but also have abilities in other arenas. "Engineers are extremely language impaired," Vanegas says. "They are great at science and math, but yet they cannot speak the languages that make society move.... They need to speak the language of Madison Avenue so they can market themselves better."

Somewhat lightheartedly, Vanegas says he knows he will have affected such change when: companies spend $10 million on engineering research instead of a 30-second Super Bowl commercial; "L.A. Engineer" is as successful a television series as "L.A. Law"; and when Congressional ranks include as many engineers as lawyers and business people.

Though his own leadership ability is not defined in these ways, Vanegas has learned to speak the "languages" of finance and sales, he says. And those skills have allowed him to initiate change.

An effective researcher re-evaluates

Now at what he calls a crossroads, Vanegas must decide which of his many interests are most worthy of the limited time he has. To continue to successfully change things, he must focus on the most pressing issues.

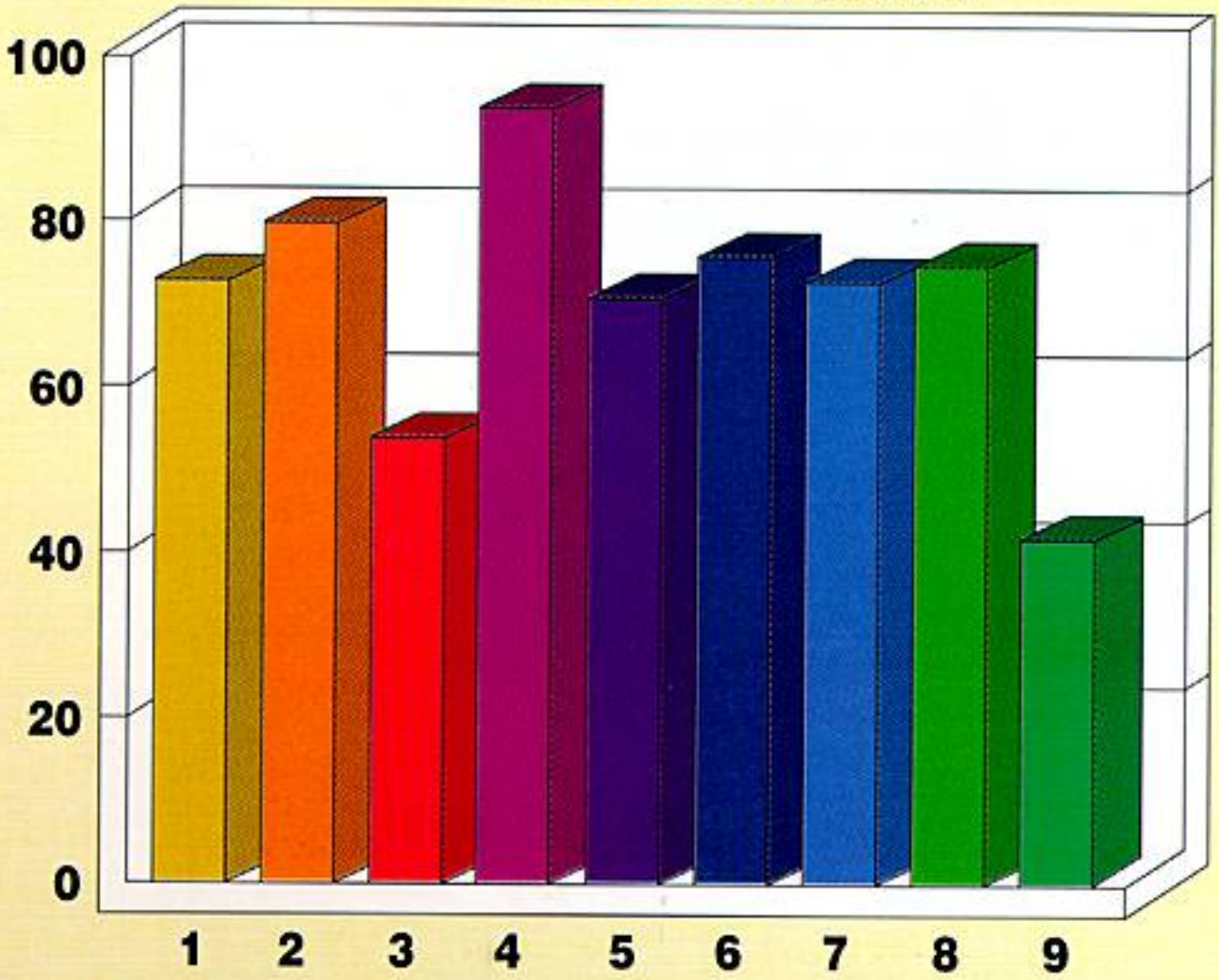
Again, he returns to the quote that is his motto. "I must do things right, but also do the right thing," Vanegas explains. "It is a simple truism that will guide me at this turning point."

For more information, contact Dr. Jorge Vanegas, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 30332-

0355. (Telephone: 404/894-9881) (E-mail: jorge.vanegas@ce.gatech.edu)

Last updated: June 30, 1998

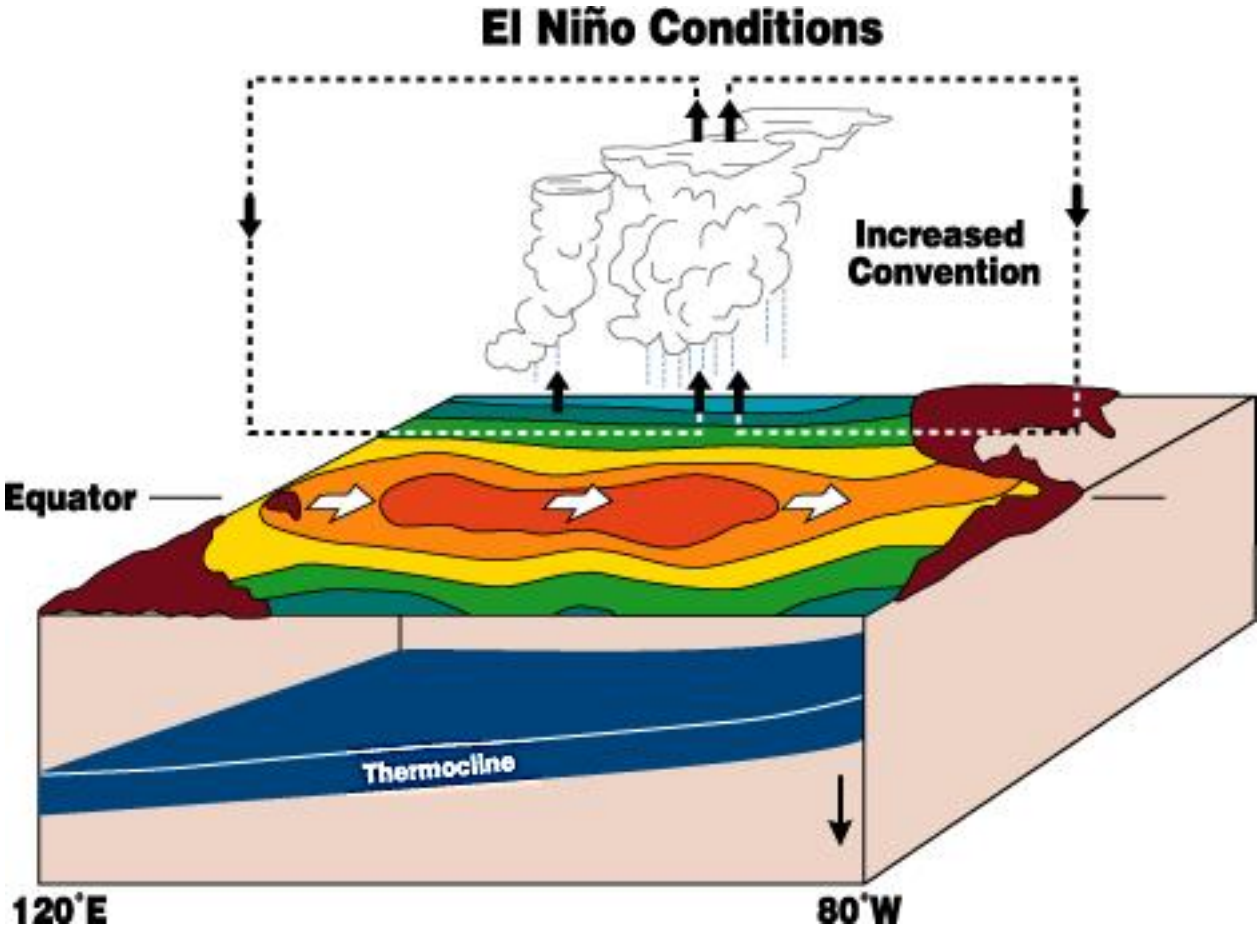
Global Results (Example)



Legend

1. Environmantal Management: 73%
2. Air Quality/Protection: 80%
3. Water Quality/Protection: 54%
4. Hazardous Waste: 94%
5. Underground Storage Tanks (UST's): 71%
6. SARA Title III : 76%
7. OSHA Hazard Communication Standard: 73%
8. Pollution Prevention: 75%
9. Final Products: 42%

Global Performance: 71%


El Niño Conditions
Increased
Convention
Equator
Thermocline
120˚E
80˚W