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Research Horizons

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World-class researchers; cognitive perspectives on aging; Mobile Sources Center of Excellence; on-line banking; helping small businesses; disorder tames chaotic systems.

Research Personality

Jean-Lou Chameau, Georgia Tech's new vice provost for research, is committed to helping the institute forge additional research links with industry.

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Research Horizons
Georgia Institute of Technology

Research for the Games

Georgia Tech has forged strong ties to Atlanta's 1996 Olympic Games

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Compiled by Lea McLees

Contributors: Rick Robinson, Mark Hodges, David Kennedy, Susan McDaniel, Toni Mills, Jackie Nemeth, Victor Rogers

IT'S LATE JULY 1996, and a tired but excited visitor is among 2 million people arriving at Hartsfield Atlanta International Airport. She's spent a long day in her New York office, but is ready to work, entertain and enjoy the Olympic Games with some of her firm's clients.

Our visitor stops at an information kiosk in the airport to determine the best way to reach her hotel. On her second evening in town, she receives some brochures from her boss that arrived in Atlanta via a helicopter landing at a vertiport. Later in the week she wows her clients with tickets to a diving competition. She plans a second trip to the city in late August, to watch a friend compete in the Paralympics track and field competition.

Each of this imaginary visitor's diverse activities has one thing in common: Georgia Tech research. The Olympics will showcase not just Georgia Tech's role as Home of the Olympic Village and site of the boxing and swimming/diving venues; Georgia Tech's mission of conducting world-class research for the global village will be highlighted as well. Read on for examples of Georgia Tech's research contributions to the Olympics and the Paralympics. (For Olympic timeline, see **The Olympic Games In History)**

In the Beginning

Georgia Tech's research role in the 1996 Summer Olympics began long before Atlanta won the bid to host the games.

With assistance from Georgia State University and several private companies, researchers in 1989 created a high-tech multimedia interactive program for the 1990 final proposal to the International Olympic Committee in Tokyo. The presentation won a Computerworld Smithsonian Award in 1992 and a New Media Invision Award in 1994 for its innovative use of information technology.

The presentation featured computer-generated renderings of proposed buildings with realistic textures of brick, grass and other materials. Viewers saw the proposed Olympic Village from an altitude of about 500 feet. The presentation also allowed them to "fly" around the buildings and visit their imagined furnished interiors, as well, says Michael Sinclair, director of Georgia Tech's Interactive Multimedia Technology Center.

"As far as we knew, nothing like this had been done before for a major marketing effort," Sinclair recalls. "We started with [head of the Atlanta Committee for the Olympic Games] Billy Payne's crazy, long-shot idea, very little time and money, and really no idea of what we were going to do -- but it had to be high tech, and it had to provide a lot of information in an entertaining and interactive fashion."

Using the creative minds of the project members and many volunteers, the researchers put together two interactive systems.

"The first was a flight simulator that allowed you to fly around Atlanta via a trackball, visit the proposed venue sites and tour them," Sinclair explains. "The second system was a wide angle 'wrap around' affair that featured the proposed Olympic village/Georgia Tech campus."

The interactive part of the second system was a small plastic three-dimensional model of the village illuminated with computer graphics. It pulled up specific vignettes about a day in the life of an athlete when a particular building or area was touched.

The Olympic projects relied on cutting-edge computing technology, incorporating three videodisc players, three computers, computer-composed music, digitized narration and the touch-sensitive interaction system. A Commodore Amiga computer controlled the presentation, along with an Apple Macintosh IIcx and a smaller computer interface device.

"Computer technology has come a long way since the Olympic effort," Sinclair says. "Back then, we had to program our own multimedia authoring system, as there were virtually no multimedia presentation systems capable of orchestrating in real time the many processes required."

Computers are also much faster, and more affordable today, allowing video to be played directly from a hard disk instead of from expensive videodisc players, he notes.

"Sophisticated authoring systems take a lot of the drudgery out of producing an interactive media presentation," Sinclair explains. "High-end computer graphics are no longer relegated to the high-priced workstations, but can now be developed on low-cost PCs. Future hardware and software multimedia development systems will make it much easier to author productions, freeing the creative producer from having to possess intimate knowledge of inner workings of the hardware and software. The lower cost and increased power of tomorrow's computers should make the playback and interaction much faster, smoother and more enjoyable."

Shining Light

A team of Georgia Tech engineering professors and graduate students breathed life and fire into the conceptual design of the 1996 Olympic torch. Based on an artistic design by Malcolm Gear Associates, the engineers developed a 3.5-pound torch that will burn for 45 minutes without refueling and will be able to withstand wind, rain and dramatic temperature and elevation changes along its 15,000-mile journey to Atlanta.

The team included mechanical engineering professors Dr. Sam Shelton and Dr. Lee Durbetaki, industrial design professor Lee Payne, and graduate students Andy Delano, Kevin Berry and David Craig.

"Each of the past 21 Olympic torches is different," Shelton said. "The host city has a lot of pride of ownership in the creation of the torch. Other than the winning athletes' medals, it will be the most tangible symbol taken away from the 1996 Atlanta Olympics."

The 1996 torch is about 32 inches tall and 2.25 to 3.5 inches around. Its crown comprises 22 outwardly spread prongs, representing reeds -- one for each of the 21 previous Olympic host cities and one for Atlanta. The handle is made of Georgia pecan hardwood, capped with two gold rings on each end. Two gold collars bind the upper reed body and lower Greek column; one collar lists the host cities and one features the Olympic "quilt of leaves" motif.

The torch is further secured by a threaded tube feeding the fuel from the propane tank in the lower body column up to the burner in the crown at the top. A burner system ensures that the 12-inch flame resists wind and other natural elements.

Most parts will be aluminum and gold-plated brass, but some interior fuel valve components will be injection-molded plastic, to keep the torch lightweight.

The first five prototype torches were made on campus. Now, American Meter in Erie, Penn., is assembling more than 10,000, so each torch relay runner can purchase the torch he or she carries.

Tracking Traffic

The Olympics will bring more street vehicles than usual to Atlanta -- cars, delivery trucks, buses, bikes and more -- but the city is getting ready, with help from Georgia Tech. The Institute is participating in development and evaluation of the Atlanta Driver Advisory System (ADAS) and Advanced Traveler Information System that will operate during the 1996 Games. This public/private project is headed by Scientific Atlanta, Inc., with major participation by the Georgia Department of Transportation (GDOT), and sponsorship by the Federal Highway Administration.

Under ADAS, 200 specially equipped vehicles supplied by GDOT and Federal Express will receive information about congestion, incidents, weather and special- events data over RF links. A network of 220 Mhz transceivers and a subcarrier from a commercial FM broadcast station will provide the links. The data will originate in the Advanced Traffic Management System being developed by GDOT, says Bill Youngblood, deputy director of Georgia Tech's Transportation Research and Education Center.

"While this is mostly a technology evaluation, we also will be looking at whether the ADAS can contribute to improved mobility of these drivers, and whether it can provide useful traffic flow information to the ATMS during the Olympic period," says Youngblood, a Georgia Tech Research Institute (GTRI) senior research engineer.

GTRI is providing testing, analysis and modeling of the 220 Mhz propagation in rural, suburban and urban environments, as well as development, implementation and analysis of error- correction techniques for use in the 220 Mhz transceivers. The Transportation Research and Education Center is leading the evaluators in the operational test of ADAS:

- GTRI is providing a systems performance evaluation.
- Concord Associates of Knoxville, Tenn., is evaluating user acceptance.
- Clark Atlanta University is evaluating institutional and business issues.

This material is based on work supported by the Federal Highway Administration under Grant No. DTFH61-95-X-00015. Opinions, findings, conclusions or recommendations expressed are those of the authors and do not necessarily reflect the FHA's views.

High-Tech Traveling

Need to know how to reach your hotel, the airport or an Olympic venue in Atlanta? By this summer, you'll be able to get the information you need from a computerized kiosk.

The kiosks will provide services such as notification of traffic congestion and incidents on Atlanta interstates; route planning via highway and MARTA; special events information such as Olympic venues and sports scores; and weather, travel and tourism information for the area.

Georgia Tech's Transportation Research and Education Center is leading evaluation of the system of traveler advisory kiosks to be installed in Georgia in time for the 1996 Olympic Games.

"We will be looking at several characteristics," says Bill Youngblood, deputy director of the center. Among those characteristics:

- Concord Associates of Knoxville, Tenn., is evaluating user acceptance.
- Georgia Tech Research Institute (GTRI) will conduct the technical performance evaluation.
- Georgia Tech's School of Civil and Environmental Engineering is evaluating transportation benefits of the system.
- Clark Atlanta University is evaluating institutional and business issues.

The system is being developed by JHK & Associates in Norcross, Ga., and San Diego- based Science Applications International Corp., under the guidance and program management of the Georgia Department of Transportation (GDOT). The kiosk system will be owned and operated by GeorgiaNet, an authority that will centrally market and sell electronic access to authorized public information to public and private consumers.

Flying High

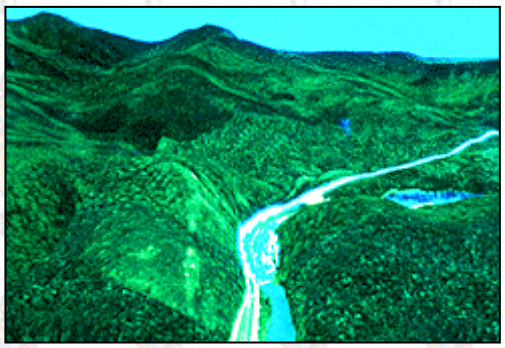
Atlanta will be a haven for helpful helicopters during the 1996 Olympics. The Georgia Tech Research Institute's (GTRI) Aerospace Sciences Laboratory is a partner in a Federal Aviation Administration (FAA)-sponsored project to explore the operation of helicopters in a

congested urban area. These helicopters will be equipped with a Global Positioning System for navigation, tracking and communication. Helicopters will take off and land from Atlanta- area "vertiports," providing local and regional transportation of packages, documents and a limited number of passengers.

The vertiports will accommodate commercial as well as law enforcement and emergency evacuation aircraft. The Olympics period is expected to provide an excellent simulation of urban transportation requirements during peak periods -- offering a good test environment for gathering operational data, says senior research engineer Chuck Stancil.

Working with the FAA and NASA, GTRI investigators will plan flight trajectories and approaches to selected landing sites. They also will position acoustic sensors for collecting noise data. Collecting aircraft acoustic footprints and analyzing and documenting the resulting data will help establish FAA certification criteria for vertical flight infrastructure in urban areas.

Almost Like Being There



If you watch the whitewater events on television this summer, you may see one of the fruits of Georgia Tech's computer simulation capabilities: A "fly-through" of the Olympic whitewater events venue has been completed by the Center for Geographical Information Systems and Spatial Analysis Technology, housed within the Georgia Tech Research Institute (GTRI).

The full-color simulation, sponsored by the Cherokee National Forest, is expected to be seen extensively on network television. It will orient viewers whenever Olympics coverage shifts from Atlanta-area sports venues to the whitewater venue in the Ocoee River region of Southeastern Tennessee.

GTRI developers integrated data from the LANDSAT satellite, high- altitude and low- altitude photography, and U.S. Geological Survey elevation information into the simulation. In addition to depicting the whitewater course as it will appear for the 1996 Games, the simulation accurately displays roads, towns and other topographical features -- this will help travelers who are new to North Georgia/Southeastern Tennessee.

IOC Research: A Longtime Partner

Olympics research is a familiar pursuit for Dr. Robert Gregor, professor of Health and Performance Sciences. He has been a member of the Subcommission on Biomechanics and Physiology of the International Olympic Committee's Medical Commission since 1981. Gregor and Georgia State University colleague Dr. Ben Johnson, liaison to the Subcommission for the 1996 Summer Olympic Games, are directing 14 sports research projects to be conducted this summer by researchers from institutions all over the world. They are working with the Atlanta Committee for the Olympic Games.

"We have projects in swimming and diving, gymnastics, track and field, equestrian events, tennis, baseball and softball -- a number of different things are going on," he said. "All the projects are different. Some involve simulation, while others involve standard biomechanics research protocols."

IOC research findings are shared with athletes all over the world via publications and/or videotapes supplied for educational purposes. Data from one Olympics research project resulted in improved landing mat standards for gymnastics competitions, for example. Olympic divers, on the other hand, may study another set of data collected on 1,000 dives to evaluate their performance under varying conditions -- in training and competition -- and improve their skills.

Diving into Simulation

Divers who spring off the 10-meter platform in Georgia Tech's Aquatics Center during the Games will not only wow spectators with their skill and control -- they will provide scientists such as Dr. Jessica Hodgins, College of Computing assistant professor, with some important data.

Hodgins is part of a research team lead by Dr. Doris Miller from The University of Ontario's Department of Kinesiology. With doctoral student Wayne Wooten, Hodgins has completed a computer simulation of a platform diver performing a pike, a somersault and a twisting dive.

As athletes begin their dives, a force-measuring device -- the first used in a summer Olympic event -- will record the forces the divers exert on the platform as they generate angular momentum and height for their dives. Hodgins will use this data to refine her simulations, by comparing the forces seen in the simulations to those exerted by the Olympic divers.

Hodgins' simulation was developed at Georgia Tech's Graphics, Visualization and Usability Center. Combined with Motion Interactive (MINT) visualization software written by Michael Sinclair and colleagues in Georgia Tech's Interactive Multimedia Technology Center, her work will help coaches and athletes in future games see how changes in diving technique might affect performance.

Staying Grounded for Track and Field

When Paralympic athletes practice track and field events like javelin and discus throwing, they may use camping or other tools -- such as ropes and tent spikes -- to immobilize the chairs they sit in. But when competition time comes, an alternative is necessary: Ropes and tent spikes are no match for a concrete slab in a stadium carpeted with artificial turf.

Enter Georgia Tech's Center for Rehabilitation Technology. For the 1996 games, the center's engineers sandwiched a slice of marine-grade plywood between an aluminum skin and a collection of strategically placed runners' cleats. This stabilizing plate is laid on the ground. Each athlete's chair is attached to the aluminum-covered side with industrial- strength suction cups the size of an adult's palm, which are connected to length-adjustable hooks that grip the chair, said research engineer Riley Hawkins.

"The throwing chairs athletes will use are coming from all over the world," Hawkins said. They may have been designed in an athlete's garage in Australia, or in a prestigious European university -- but on all configurations, our clamps have to work."

The plate's adjustment mechanisms must work quickly and easily, too, Hawkins added.

"Many events will be staged in one coliseum," he explained. "We have to get an athlete into position in seconds, so that she or he can throw for a few minutes and then get out of the way for the next athlete."

The plate is about 100 pounds lighter than the round metal disks used in the 1992 Paralympics in Barcelona. As a result, volunteers can easily maneuver it and attach athletes' chairs to it. CRT is producing 10 plates and 50 clamps for the 1996 Paralympics, with funding from the Atlanta Paralympic Organizing Committee.

Ultra-Accessible Kiosk

Try accessing the average information kiosk while you're seated in a chair -- in some cases, you may have difficulty seeing the computer screen or even using the keyboard. For the 1996 Paralympic Games kiosk, Georgia Tech's Center for Rehabilitation Technology built a cabinet at a height accessible to seated and standing persons.

Initially it was thought that two kiosks would be needed. When the project came to CRT, designer Alan Harp explained that CRT could build one kiosk that would serve almost everyone.

"One kiosk at this height and screen angle will meet the needs of 95 percent of people, regardless of height and whether they are seated or standing," he said.

The prototype kiosk is in the lobby of the Atlanta Paralympics Organizing Committee headquarters. A total of 180 kiosks are in production at the Georgia prison systems' Phillips and Alto correctional facilities. The wood for the kiosks is recycled -- it comes from an Atlanta landmark, the old Sears building on Ponce de Leon Avenue.

The Art of Engineering

A collaboration between The Atlanta Ballet and Georgia Tech's Interactive Media Technology Center (IMTC) will close the Olympics Art Festival scheduled in conjunction with the 1996 Olympic Games.

The Dance Technology Project's performance will feature world premieres combining ballet and computer animation techniques, says IMTC director Mike Sinclair.

"In the performance slated for the Olympics, the audience will see what we refer to as video costuming," Sinclair explains. "That is, a camera and computer system will track the motions of the dancers on stage while a second graphics computer creates their 'virtual costumes' which are projected onto them, in exact registration to their body orientations -- even as they dance. Other activities will include computer generated dancers intermingling with real dancers, and computer- generated art 'created' by the dancers as the performance progresses."

For the first Dance Technology composition, choreographed in 1994, researchers used Motion Interactive (MINT) -- a special motion-capture program they developed -- to translate dance into computer animation. Two video cameras captured the movement of reflective markers at 27 points on a dancer's body. The researchers digitized the video, using it to create a computer model of the dancer.

For the second performance, the researchers employed infrared cameras to track emitters hidden on a dancer's costume. Computed and fed into a high-speed graphics workstation in real time, the animation video resulted in animated trails of the dancer's movements by projection of real-time graphics onto a translucent screen.

Future applications will include motion capture and visualization for dance analysis and injury prevention. This work is sponsored by Georgia Tech and The Atlanta Ballet.

Medical Care from a Distance

Researchers and medical doctors around Georgia will team up to demonstrate the viability of telemedicine during the Olympics.

With support from the Defense Advanced Research Projects Agency, AT&T, Panasonic, IBM and Kodak, doctors and researchers will simulate medical emergencies to show how computer, video and telephone technology can be used to care for patients who can't be readily transported to a medical facility or doctor's office.

The researchers will demonstrate telemedical care:

- at an Olympics event on the Georgia Tech campus.
- at an Olympics event at a remote venue.
- in Centennial Park.
- on an interstate highway.

The scenarios will include use of a wide-bandwidth wired and wireless telecommunications network among major medical centers in Georgia and Georgia Tech's Student Health Services Center; a van with equipment supporting wireless, wide-bandwidth videoconferencing; and a computerized language translator.

Participants include Georgia Tech, Emory University School of Medicine, Georgia Baptist Medical Center, Morehouse School of Medicine, the Medical College of Georgia and Eisenhower Army Medical Center, all members of the Southeast Telemedicine Alliance.

An Air Quality Opportunity

Like many cities its size and larger, Atlanta never sleeps. With the exception of Christmas, traffic flows remain pretty constant day-to-day, week-to-week. For atmospheric scientists, that constancy means few chances to measure city air quality during varied traffic conditions.

But the 1996 Summer Olympics offers atmospheric scientists a rare measurement opportunity: Atlanta brimming over with activity, says Dr. Mike Rodgers.

"We can see what happens when a city of reasonable size suddenly greatly increases its activities over a defined time," explains Rodgers, director of Georgia Tech's Air Quality Laboratory. "We want to collect data and make measurements to find out how well our models

predict what will happen under those conditions. We also plan to compare the 1996 results to measurements made in Atlanta since 1992."

Before, during and after the Olympics, Georgia Tech researchers will gather data with colleagues from the Environmental Protection Agency and the U.S. Department of Energy. They will use tethered and free-floating balloons that hoist measuring devices into the air, emissions- tracking equipment set up along streets and interstates, and stationary measuring devices at sites around the city.

The instruments will record air quality at different levels in Atlanta's atmosphere this summer, as well as mobile source emissions -- substances generated by a sample of about 60,000 to 90,000 cars, trucks and buses. Meteorological data also will be recorded, since weather conditions influence air conditions.

Along with the Electric Power Research Institute, Emory University and the national Centers for Disease Control and Prevention, the Georgia Tech researchers also will chart human health effects of ozone pollution, correlating asthma cases with air quality.

For more information on air quality research at Georgia Tech, see the Air Quality Laboratory's home page: http://aql.eas.gatech.edu.

Georgia Tech Aquatic Center to Showcase Solar Energy

When Olympic water events come to the Georgia Tech Aquatic Center this summer, great accomplishments will not be limited to athletics. Georgia Tech researchers will be putting on a stellar performance of their own with the operation of the United States' largest rooftop photovoltaic (PV), or solar-powered, system.

The system was designed by Dr. Ajeet Rohatgi and Dr. Miroslav M. Begovic, both professors in the School of Electrical and Computer Engineering, along with Richard Long, project support manager in Tech's Office of Facilities. Georgia Power Co., the U.S. Department of Energy and Georgia Tech are sponsoring the project. The $5.2 million PV system is expected to provide about 25 percent of the electrical energy needed for the Aquatic Center, Rohatgi says, and will save Georgia Tech almost $30,000 a year in energy bills.

The system includes two arrays totalling 345 kilowatts (kW) of power. It consists of a 340 kW array, located on the center's rooftop, and 5 kW of 240-watt PowerWall architectural AC modules covering the roof of the center's entrance walkway. Connected to an electric grid supplied by Georgia Power, the larger array will supplement grid power for the aquatic activities.

Installation of the solar panel modules began in December 1995. The 340 kW array consists of 2,856 DC modules. Each module is 1.1 square meter and produces 120 watts of power. The PV array will produce 440,000 kW per hour of electrical energy per year, and according to Rohatgi, that amount of energy is sufficient to provide power to about 70 homes.

After the PV rooftop power system is installed, a data acquisition system will be put into place. Accurate tracking of environmental and weather conditions, operating performance and reliability record will be required, according to Begovic. Two data loggers, driven by uninterruptible power supplies, will be used. One, on the roof of the center, will collect weather-related data such as wind speed, solar insolation and temperature. The second data logger, placed in the inverter room, will collect data related to the system's performance. Both data loggers will supply information in tables of 15-minute averages of measurements repeated every 15 seconds, to both the display computers and a remote computer.

This solar energy project is a major research initiative for the University Center of Excellence for Photovoltaics Research and Education (UCEP), of which Rohatgi is director. A PV tutorial at the natatorium will cover the fundamentals of solar energy. It also will supply data on the on-line performance of the PV system, such as kilowatts produced per hour.

"The PV tutorial will provide an opportunity to educate a large number of people at an international event about photovoltaics, and increase their awareness of PV as a viable energy source," Rohatgi said. "Increased awareness and level of interest are important factors in helping to make solar power a more affordable energy source. We have a unique opportunity to do those things at this summer's Olympics."

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Georgia Institute of Technology

Defense In A Changing World

Tech researchers are contributing to a new anti-ballistic missile system

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By Lea McLees

MEL BELCHER doesn't wear a uniform. He didn't attend boot camp, and he doesn't fly helicopters, drive tanks or go into battle.

But he and colleagues at the Georgia Tech Research Institute are making vital contributions to U.S. defense -- by evaluating and applying the latest technology to missile defense radar development.

Their target? Ballistic missiles.

Mel Belcher (left) and Tracy Wallace display solid state transmit/receive modules for THAAD radar.

"The Gulf War was the first confrontation in which U.S. forces were really worried about ballistic missiles -- the "Scuds" [SS-1 missiles] the Iraqis shot," says Belcher, a senior research engineer in the Sensors and Electromagnetic Applications Laboratory. "My job, and that of the people who work with me, is helping the U.S. develop a defensive system that would counter those kinds of long-range threats."

More than 20 countries have ballistic missiles, according to figures from Lockheed Martin Missiles & Space -- and some are equipped with nuclear weapons.

Major Defense Project For Late '90s

One U.S. strategy for countering ballistic missile threats is the Theater High Altitude Area Defense (THAAD) program. THAAD researchers and engineers have planned, assembled and now are testing the world's first endo-exoatmospheric system designed specifically to defend against ballistic missiles. The system will intercept threatening missiles at altitudes more than 60 miles above the earth and is expected to have ranges of hundreds of kilometers, according to reports in Aviation Week magazine. The U.S. Army THAAD Project Office is based in Huntsville, Ala., and Lockheed is the prime contractor.

In addition to being the first system of its kind, THAAD also includes the most complex solid state radar ever built -- it incorporates 25,000 solid state modules. The project should be initially operational by the year 2002.

Belcher and his GTRI colleagues are helping develop THAAD's state-of-the-art, X-based phased-array radar, which will spot and track targets, as well as perform target acquisition, target tracking, determine if a target is destroyed after interception, and identify and classify threats. The GTRI team includes 10 to 15 specialists in antenna, receiver, solid state and signal processing technologies. Assembled at GTRI over the last 11 to 12 years, the researchers look at contractors and designs, suggest improvements, and support testing, analysis and modeling of different parts of the radar system.

"There were a lot of areas where we were pushing the envelope on what technology could do to get the resolution, accuracy and sensitivity required for missile defense," Belcher says. "GTRI has been very active in identifying key devices and components, determining what the specifications were and testing prototypes."

The team's analysis was instrumental in incorporating features into the THAAD radar system that now are recognized as essential to missile defense missions. Members are involved in THAAD testing at White Sands Missile Range, N.M.

THAAD differs from the Patriot missile system, familiar to many because of its role in the Gulf War. The new system is based on "hit-to-kill" philosophy -- the defending missile rams into the attacking ballistic missile.

"Most air defense missiles don't try to hit their targets," Belcher says. "They try to explode near them and spray them with fragments. That usually works efficiently. But what we found during the Gulf War was that you could pelt the Scuds with fragments, and they'd still come down and explode."

THAAD also is designed to intercept targets at higher altitudes than the Patriot system used during the Gulf War, thus keeping debris away from population centers and military assets. The new system could defend theaters as large as small nations, rather than the single airfields the Patriot defends.

A Career Devoted to Defense

Belcher began his career working in intelligence, looking at the former Soviet Union's missile defense systems. Over time, he switched to developing U.S. missile defense systems.

"It is truly one of the most challenging systems engineering problems out there," he says of his field. "When you are defending against attacking ballistic missiles, the aggressors may develop countermeasures and do other things that will degrade our capability of countering them."

Belcher's role at Georgia Tech is to expand programs in missile defense. In addition to expanding U.S. Army programs, he also has involved GTRI in the U.S. Air Force's early warning radar work.

He and his colleagues not only work on research projects -- they frequently are called upon to apply their radar expertise in other settings. At the request of the Ground Based Radar Project Office, Belcher and principal research engineer Dr. Larry Corey traveled to Iraq in 1994 with two colleagues from Dynetics, Inc. to inspect a radar the United Nations discovered in that country.

"The radar had an interesting history that deserved investigation," Belcher explained. "We served on a U.N. inspection team that negotiated with the Iraqis, inspected the radar and ultimately specified how it should be destroyed.

"These are all folks who could certainly be doing other things," Belcher says of the GTRI team. "However, we are motivated. I think everyone working on the project is keenly aware of the ultimate aims, and wants to see U.S. forces protected."

Looking to the Future

Belcher and the missile defense radar development group want to increase the amount of work they do on projects similar to THAAD. They plan to expand their participation on short range missile defense systems, as well as on studies on the feasibility of defending the continental United States.

The group also is working to establish an international cooperative research program in adaptive digital beam-forming (ADBF) between the

United States and the United Kingdom. ADBF allows engineers to adapt antenna patterns by steering the null portion of the pattern toward sources of interference and away from potential targets. That ability maximizes the gain, energy and sensitivity directed toward the target, and thus provides the radar user more information.

"Adaptive digital beam-forming is promising for two reasons: The world has gotten nastier -- electronic countermeasures jamming has become more sophisticated, targets are smaller, aggressors have gotten better at masking target returns -- but at the same time, digital electronics have gotten a lot cheaper," Belcher explains.

"Given the proliferation of missile technology to third-world countries, it is important that the U.S. field a viable missile defense system in the near future," Belcher noted. "GTRI is helping the Army bring to fruition the defense of its forces in the field from ballistic missile attack."

Further information is available from Mel Belcher, Sensors and Electromagnetic Applications Laboratory, Georgia Tech Research Institute, Cobb County Facility, 7220 Richardson Road, Smyrna, GA 30080. (Telephone: 770/528-7751) (E-mail: mel.belcher@gtri.gatech.edu)

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Flourishing New Franchises

Starting your own business? Learn the characteristics of successful new franchises

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By Lea McLees

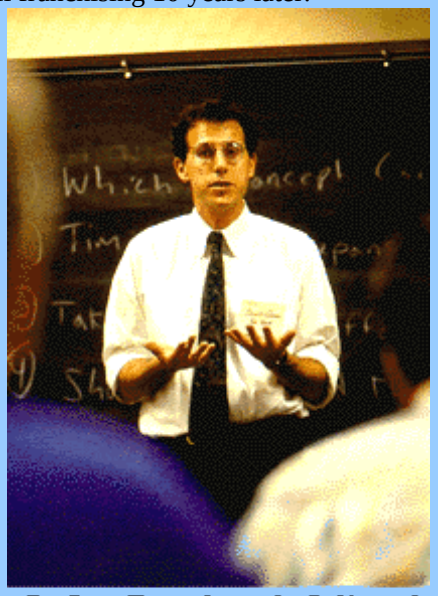
MUCH BUSINESS LITERATURE characterizes buying a franchise as inherently less risky than starting an independent firm. The franchisor offers a proven concept, recognized name, guidelines and training in return for an up-front fee and a percentage of what the franchisee, the buyer of a franchise, makes each year.

However, new franchise systems don't necessarily succeed more often than non-franchised businesses do, a study by a Georgia Institute of Technology researcher shows. Dr. Scott Shane, director of the Georgia Institute of Technology's DuPree Center for Entrepreneurship and New Venture Development, studied the 1983 crop of new franchisors to determine how many were still franchising 10 years later.

"The failure rate of new franchise systems is roughly the same as that of all new businesses," said Shane, an assistant professor in Georgia Tech's School of Management and director of Georgia Tech's Corporate Venturing Program. "By the end of 1993, less than one quarter of the initial cohort of franchisors was still franchising.

"If you buy a new franchise from a new franchisor, there is a 75 percent chance the person who sold it to you won't be around to support you in 10 years," Shane explains. "So, it's very important that people thinking of buying a franchise outlet differentiate from long-standing franchisors and those that just started this year or last year."

With support from the U.S. Small Business Administration (USSBA), Shane has explored factors that the surviving franchisors have in common. His findings not only offer guidance to potential franchisees; they can help potential franchisors decide when they are ready to grow, as well.



Dr. Scott Shane shares the findings of his franchising research with business people via executive education programs.

History of Franchising

The word "franchise" is of French origin and initially had meanings similar to "freedom" or "free." It is associated with the granting of a privilege by an individual or group -- a government, for example, providing its citizens a constitutional or statutory right to vote, or a company offering to others the right to sell its services or products.

Franchising first became popular in the United States after World War II, when several gasoline companies adopted this method of doing business. Singer Sewing Machine Co. was the first business in the United States to use franchising.

Today one new franchise outlet opens every eight minutes of each business day, according to the International Franchise Association. Sales from franchised establishments account for a third of all retail sales, the USSBA says -- and that figure is expected to grow to 50 percent by the year 2000.

Franchisees pay initial fees ranging from under $10,000 to $575,000. Once in business, they generally pay monthly royalties to the

franchisor of between 1.5 and 12 percent of gross sales, according to the USSBA.

Why are franchises so popular? In addition to the perception, for business people, of carrying less risk, franchises fulfill the wants of the modern consumer by providing consistent goods and services of recognized quality.

Successful New Franchisors

Shane collected data from the 1983 new franchisors' Uniform Franchise Offering Circulars -- documents providing information about a franchisor and its new franchise system to potential purchasers. That data shows that most of the 138 new franchisors in 1983 were eating places -- 17 percent. The rest ranged from lumber and building, computer and camera stores to employment agencies, data processing schools, and grocery, music, retail and photocopying stores. The businesses had operated an average of 3.5 years when they began franchising, and most had 3.5 outlets at that time.

"Interestingly, that decade [from 1983 to 1993] was one of significant growth for entrepreneurship in general, and was one of outstanding growth for franchising," Shane notes. "Employment by business format franchisors increased from 5.2 to 8 million."

Shane found that surviving franchise systems tended to be older and larger than non- surviving systems when they began franchising. They also had higher franchise fees and higher levels of initial investment, although these differences were not always statistically significant.

Franchise systems that survived during the first four years -- when 57 percent of their cohort went out of business -- shared several characteristics that directly influenced their survival:

- Expansion Through Franchising: The surviving businesses emphasized growth via franchises, rather than through company ownership of retail outlets. Emphasizing franchising growth resulted in faster expansion and economics of scale in purchasing, administration and distribution.

- Initial Growth in Company-Owned Outlets: Surviving franchisors opened most of their company-owned, as opposed to franchised, outlets during their first two years. They stopped adding company-owned outlets after their first six years of business. This strategy allowed them to learn the business by operating their own outlets initially, and then concentrate on expansion using franchises and the advantages they offer.

- Knowledge Transfer to Franchisees: Surviving businesses spent more time training franchisees; provided more help in the form of operating manuals, financing and marketing assistance; and required a higher investment from franchisees in signs and equipment.

- Lack of Franchisor-Specific Assets: Franchisors whose advertising fees were higher than the industry average, and who transferred proprietary equipment to franchisees, didn't survive as often as franchisors who avoided these practices. Why? They introduced bilateral bargaining problems -- the franchisor becomes dependent on the franchisee, who can withhold advertising funds or refuse to return equipment, for example, in exchange for what he or she wants.

Five to 10 years into franchising, factors that predict survival of a system were similar to those important during the first four years -- except for one. Knowledge transfer in later years seemed to decrease a franchise system's chances of survival, Shane found.

"Competitors pay significantly more attention to new franchise systems after they have survived for four years," he explains. "[At that point], competitors often become interested in discovering what knowledge the new franchisor is transferring to franchisees, in hopes of copying or offsetting that information advantage."

Among the factors that Shane's study shows do not influence new franchise survival are the amount of royalty rates and franchise fees, and the growth rate of the franchisor's industry.

"High- and low-priced systems were equally likely to be in existence across all periods investigated," Shane said. "Quality and strategy of the franchise system was of such great importance that overall industry growth rates did not matter very much."

Future Study

Franchising is still a relatively new area of investigation -- and it poses its own special challenges, Shane says.

"The biggest issue is that you are studying organizations, most of which are dying," he says. "It's very hard over time to track performance because you have to get people to talk about failure, or get the records of companies that fail, both of which are very difficult to do."

In the meantime, Shane and colleagues in the School of Management are sharing their findings with business people via executive education programs, as well as with Georgia Tech graduate and undergraduate students. Georgia Tech hosted a scholarly conference on franchising research in January, the results of which will appear in a special issue of the Journal of Business Venturing. And Shane notes that findings on franchising may be applicable to other business practice areas, as well. Issues faced in licensing technology, for example, are similar to those franchisors face.

"From our point of view, franchising has contributed to research, community outreach and executive education -- there are practical applications of the research, so it's really quite valuable," Shane notes.

In the future, Shane plans to study additional franchising-related topics: The "appropriateness" of franchising for a particular business, the effects of good and poor management or advice, and the quality of support offered to franchisees. He also is interested in the ability of the franchisor to share knowledge with franchisees while concealing it from competitors; franchisee selection; management of franchisee turnover; the optimum mix of franchised and company-owned outlets; and overseas expansion of franchises.

Further information is available from Scott Shane, School of Management, Georgia Institute of Technology, Atlanta, GA 30332-0520. (Telephone: 404/894-3979) (E-mail:scott.shane@mgt.gatech.edu)

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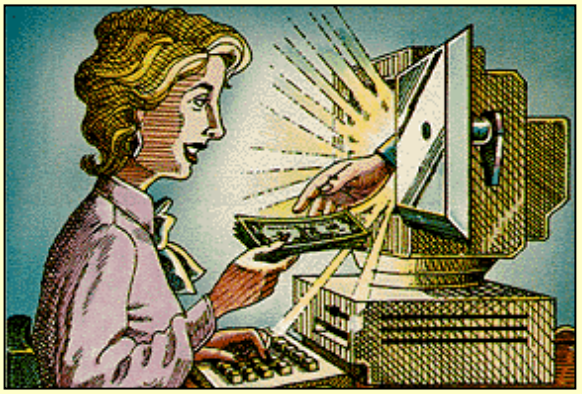
Georgia Institute of Technology

RESEARCH NOTES

GTRI Tests Security for First On-Line Bank



The first on-line bank on the Internet, Security First Network Bank, began operations in cyberspace in mid-October with help from Georgia Tech Research Institute (GTRI) computing experts.

GTRI researchers Myron Cramer of the Electronic Systems Laboratory and Jay Harrell of the Information Technology and Telecommunications Laboratory conducted an independent verification of the bank's security before it went on-line.

Cramer and Harrell helped the bank optimize its computer configuration, and verified that its systems properly restricted access to user accounts. Based on their review, the bank received final permission from the U.S. Office of Thrift Supervision to begin Internet operations.

Unlike any other attempt at Internet commerce, Security First provides special multilayered secure software that creates an individual "bank vault" for each customer's account. SecureWare Inc. of Atlanta developed the trusted operating system Security First uses. Deposits at Security First are insured by the Federal Deposit Insurance Corp. (FDIC), just as they would be in a traditional brick-and-mortar bank.

Further information is available from:

- **Myron Cramer, Electronic Systems Laboratory, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, GA 30332. (Telephone: 404/ 894-7292) (E-mail:myron.cramer@gtri.gatech.edu)**

- **Jay Harrell, Information Technology and Telecommunications Laboratory, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, GA 30332. (Telephone: 404/894-8953) (E-mail:jay.harrell@gtri.gatech.edu)**

Understanding Aging: A Cognitive Perspective

Memory loss -- it's a common experience for many of us as we age. We notice that we can't remember things as well as when we were younger; some of us begin to find making certain decisions or solving some problems more difficult.

Researchers in the relatively new field of cognitive aging, such as Georgia Tech's Timothy Salthouse, are attempting to understand the causes of these age-related differences. Causes are of two types, he says.

"Distal causes relate to factors such as childhood nutrition, educational experiences or other factors that originate earlier in life, but somehow influence cognitive performance when it is assessed," Salthouse explains. "Proximal causes are evident when one is older. They correspond to behavioral differences observed at the time of testing that may affect level of performance. Examples are the strategy used to remember information, or how quickly a person can carry out relevant processing operations."

Salthouse and his colleagues have investigated both types of causes of age-related differences in memory and other cognitive activities.

"In recent years my students and I have examined the extent to which experience in a particular activity may reduce age-related decline in performing closely related tasks," he explains. "One project investigated spatial abilities in a sample of architects. A student currently is working on a project examining relationships between age and memory for music among musicians."

Neither of these projects' findings supported the popular "use it or lose it" interpretation. Even the very experienced people exhibited age-related declines performing tasks relevant to their experience.

Despite this outcome, Salthouse always encourages people to remain intellectually active as long as possible. Almost certainly no harm comes from it, he says, and future research may eventually reveal real benefits.

"Although I have confidence in the results of these projects, I still believe that continued activity must be associated with higher levels of performance," Salthouse maintains. "The problem may be that we just haven't found the right way to evaluate the true benefits of experience."

Among the proximal factors Salthouse has investigated as potential causes of age-related memory problems are working memory and speed of processing. These terms are roughly analogous to random access memory and clock cycle time in a computer, and are measured with fairly simple tasks. Working memory is often measured by how many items one can remember while carrying out some other task -- looking up a telephone number and answering a question from another person before dialing it, for example.

Processing speed is measured by simple tests such as deciding as quickly as possible whether pair of letters or line patterns are the same or different.

Salthouse's research consistently shows that measures of working memory and processing speed appear to be responsible for 75 percent or more of the age-related differences in memory and other cognitive activities.

"This implies that a large proportion of the age differences in memory seems to be attributable to declines in cognitive system operating efficiency," Salthouse suggests. "It's almost as if older adults are to young adults as the computers of five or 10 years ago are to current computers."

Further information is available from Dr. Timothy Salthouse, School of Psychology, Georgia Institute of Technology, Atlanta, GA 30332-0170. (Telephone: 404/894-6069) (E-mail:tim.salthouse@psych.gatech.edu)

Mobile Sources Center of Excellence Established at Georgia Tech

Ever wonder how much the car or truck you depend on for transportation contributes to air pollution?

Georgia Tech researchers plan to find out. They have won a five-year cooperative agreement with the U.S. Environmental Protection Agency (EPA) to develop the next generation of mobile source emission models. Such models are based on research findings, and explain vehicle emissions' effects on air quality in different driving, population and environmental conditions.

Georgia Tech will provide research data for developing a new mobile source emissions model, in addition to helping improve existing mobile source emission modeling approaches.

The agreement is a partnership between the EPA; Ford Motor Co.; General Motors; Toyota; Georgia Tech's schools of Earth and Atmospheric Sciences, Public Policy and Civil Engineering; and the City Planning Program in the College of Architecture.

As part of the $5 million agreement, Georgia Tech researchers will collaborate with the EPA and automobile manufacturers to improve existing mobile source emission modeling approaches. They also will provide research data for developing a new mobile source emissions model. This research ultimately will lead to innovations in air quality assessment and evaluation of alternative air quality control methods in urban environments.

Teaming up to Help Small Businesses

Georgia Tech and Georgia Power have formed what may be a first-of-its-kind partnership providing practical information to small and medium-sized companies who want to use technology for improved productivity.

The university, the utility and the National Institute of Standards and Technology's Manufacturing Extension Partnership Program established the Center for Manufacturing Information Technology (CMIT) to help industries apply computer-based solutions to manufacturing problems. CMIT representatives help manufacturers choose appropriate technologies for streamlining operations; integrating accounting systems; using CAD/CAM, robotics, database technology and wireless networks; barcoding; collecting shop floor data; and more. In addition, CMIT shows firms how to use the Internet and World Wide Web to advertise services and place bids, says Ned Ellington, group director of management services for Georgia Tech's Economic Development Institute.

"The idea is to respond to manufacturers' needs for off-the-shelf information about hardware and software in an understandable format -- whether their budget allows for an investment of $200 or $200,000," he says. "We provide a non-threatening environment, teach them the concepts they need to know, then either partner them with vendors or teach them how to shop around for technology. We transfer the technology by educating them, and then link them with the consulting community for implementation."

Initial CMIT consultations are free. The center also offers continuing education courses, some of which are free.

CMIT is next door to Georgia Power's Technology Applications Center (TAC), which gives customers a chance to test emerging technologies that might apply to their products, says TAC director Gary Birdwell.

"Through TAC, industrialists can evaluate production equipment before they spend a penny of capital," Birdwell says.

Georgia Tech began providing technical assistance to small and medium-size companies 35 years ago, when it opened the first of several industrial extension service offices around the state. For most of those years, Georgia Tech also has had an informal working relationship with Georgia Power, Ellington notes.

Further information is available from:

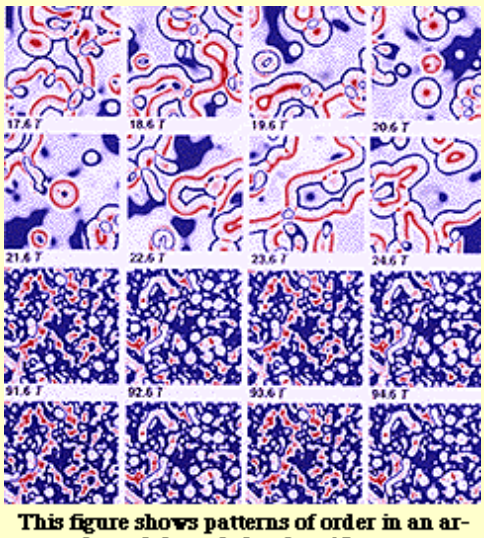
- **Ned Ellington, Economic Development Institute, Georgia Institute of Technology, Atlanta, GA 30332-0640. (Telephone: 404/894-3950) (E-mail:ned.ellington@gtri.gatech.edu).**

- **Gary Birdwell, Georgia Power Technology Applications Center, 1575 Northside Drive, Bldg. 400/Ste. 440, Atlanta, GA 30318-4204. (Telephone: 404/526-3685).**

Creating Order with Disorder

Bringing order out of chaos can require a little disorder. That's the conclusion drawn by a team of physicists who report that adding variability and disorder to certain complex systems can help tame their chaotic behavior.

This unexpected finding could require scientists and engineers to take a new look at the operation and interaction of natural and artificial nonlinear systems. It could ultimately lead to ways of improving electronic systems performance by exploiting variations in their components. It also might result in new techniques for controlling disease processes, such as epilepsy, by restoring proper amounts of disorder.

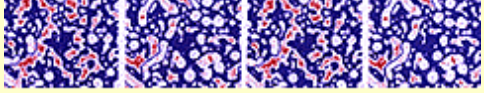


This figure shows patterns of order in an ar-

"We have found that nature utilizes disorder to create organization, and that there are situations where the lack of disorder will create disorganization," said William Ditto, assistant professor of physics at the Georgia Institute of Technology. "We think many patterns we see in nature are aided by randomness and disorder. This will lead us to think about systems in dramatically different ways."

Ditto and colleagues John Lindner of The College of Wooster and Yuri Braiman of Emory University used computer simulations to study a variety of coupled nonlinear systems, including a series of chaotic pendula and a system with 100 identical oscillators. The systems exhibited chaotic behavior over both time and space (spatiotemporal chaos), and the activity of each individual element could affect the behavior of others.

To see what would happen if they increased the disorder and variability of the chaotic systems,



This figure shows patterns of order in an array of coupled pendula when 10 percent or 20 percent variability is added to the system.

the researchers made each pendulum a different length, and programmed each oscillator to respond in a slightly different way.

"We expected that we would get even more disorder and even more turbulent behavior, but what we got was organized behavior patterns coming out of the systems," explained Ditto, director of Georgia Tech's Applied Chaos Laboratory. "The diversity or disorder provided a mechanism by which the systems could organize themselves."

How the process works to control chaos isn't fully understood yet, but Ditto believes the disorder may help move groups of chaotic elements into similar modes of behavior. Neighboring elements then begin to lock into the same mode, and "a local domino effect" spreads that behavior. The result is an organized system of individual elements that repeats its behavior in a complex but regular way.

But not just any amount of disorder will do. The researchers found that a 30 percent variation in the length of pendula or behavior of oscillators produced the most regular behavior patterns. Small amounts of disorder could not prompt changes in the system, while more disorder simply "overwhelmed" it.

The work was published in the Nov. 30 issue of the journal ***Nature***.

Further information is available from:

- **Dr. William Ditto, School of Physics, Georgia Institute of Technology, Atlanta, GA 30332-0430. (Telephone: 404/894-5216) (E-mail:wditto@ACL1.physics.gatech.edu)**

- **John Lindner, The College of Wooster. (Telephone: 216/263-2120, Lindner) (Fax: 404/894-5201, Ditto). (E-mail: jlindner@chaos.wooster.edu)**

Researchers Win Accolades

Georgia Tech is known worldwide for its excellent faculty. Following is a selection of recent honors:

- **Dr. Thomas H. Sanders Jr.** was named a Fellow of the American Society of Materials. Sanders is a regents' professor in the School of Materials Science and Engineering.

- **Dr. Peter Freeman** and **Dr. Timothy Salthouse** were named Fellows of the American Association for the Advancement of Science at its February annual meeting. Freeman is dean of the College of Computing and Salthouse is a professor in the School of Psychology (see related brief on his work on understanding aging).

- **Dr. Paul Crutzen**, adjunct professor in the School of Earth and Atmospheric Sciences, shared with two other scientists the Nobel Prize for Chemistry awarded October 11, 1995.

- Eight researchers were named Fellows of the Institute of Electrical and Electronics Engineers in December 1995. Three of the researchers work in the Georgia Tech Research Institute's Sensors and Electromagnetic Applications Laboratory: chief scientist and principal research engineer **Don Bodnar**; principal research engineer **Nick Currie**; and senior research engineer **Guy Morris**.

Additional recently named IEEE Fellows include **Ian F. Akyildiz**, professor, and **Petros Maragos**, associate professor, School of Electrical and Computer Engineering; **Peter Freeman**, dean, College of Computing; **Wayne Book**, professor, and **William Black**, regents' professor, School of Mechanical Engineering.

-- Leisha DeHart Davis, Ray Moore, Lea McLees

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