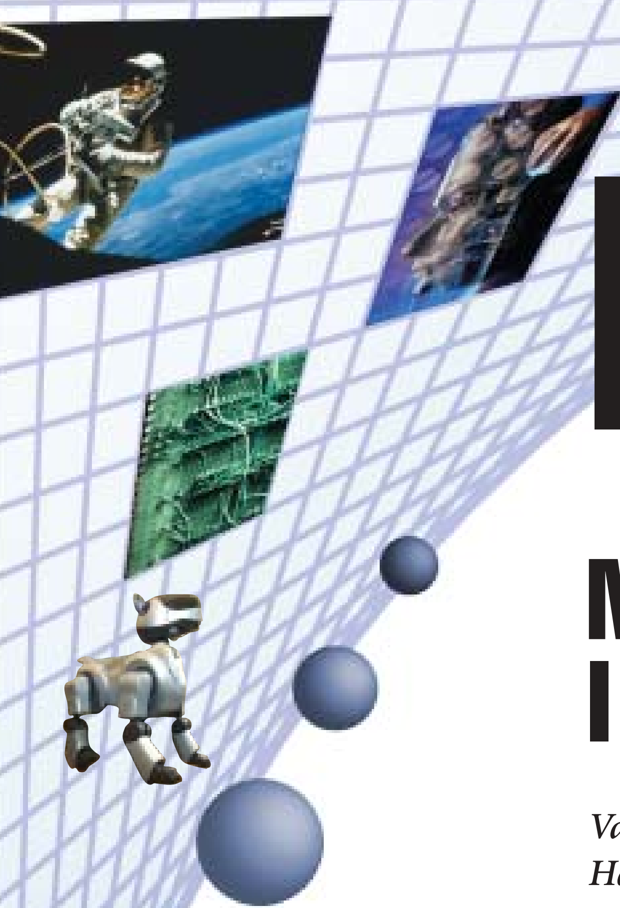
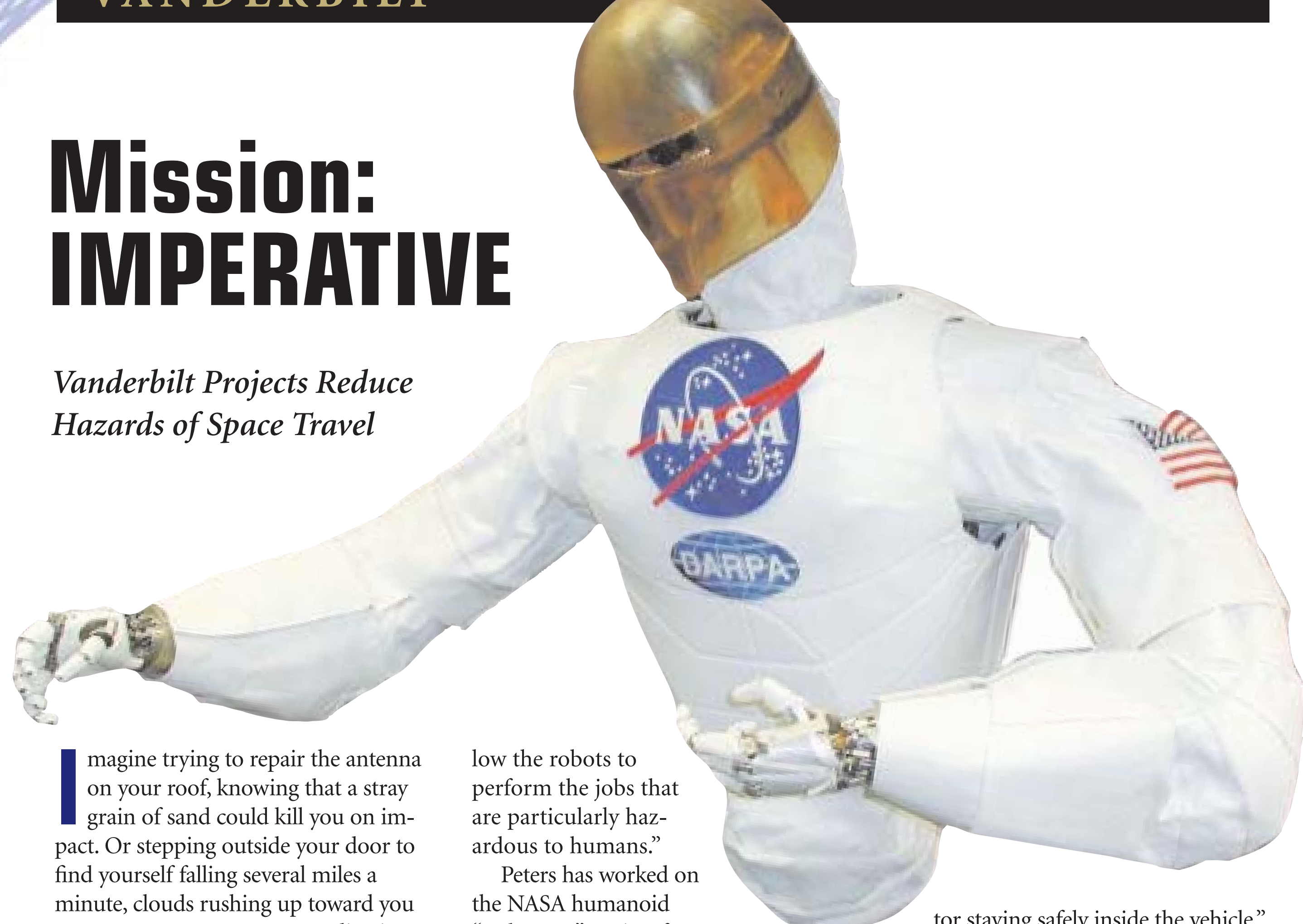


VOLUME 44, NUMBER 1, 2003

ENGINEERING
VANDERBILT

Mission: IMPERATIVE

Vanderbilt Projects Reduce Hazards of Space Travel



IN THIS ISSUE

Imagine trying to repair the antenna on your roof, knowing that a stray grain of sand could kill you on impact. Or stepping outside your door to find yourself falling several miles a minute, clouds rushing up toward you as you try to concentrate on adjusting a complex piece of equipment.

Nightmare? It's the everyday reality of an astronaut orbiting earth.

Even under optimal conditions, all systems "go" and all personnel performing at their peak, space is a harsh, unforgiving environment, full of radiation, cosmic rays, broiling hot sunlight, merciless cold in the shadows, and deadly meteoric rocks hurtling faster than you can see them coming.

A space walk is no stroll in the park for humans, but it's not too safe for equipment, either. Radiation from the sun and deep space, unmitigated by the atmosphere, bombards delicate, microscopic computer chips and confuses their circuitry. Just one cosmic ray can bring down an entire computer system in a nanosecond.

Vanderbilt engineers are at the forefront of efforts to deflect and control the hazards of space. Researchers are ushering in a new generation of space exploration and travel, helping to make space travel safer for humans by designing space-worthy humanoid robots, vehicles that can hold their own in space as well as in the punishing launch and re-entry parts of a mission, and computer chips that can protect themselves in a radiation-choked environment.

Robots in Space

The deaths of the seven Columbia astronauts have heightened interest in using unmanned robots in space flights, rather than risking human life. Alan Peters, associate professor of electrical engineering and computer science, says that a human-robot team approach is a more likely solution.

"There is definitely a place for both human beings and robots in space exploration," he says. "In low orbit, it makes more sense to use people because they can do so much more than robots. An optimal approach is to develop human-robot teams. This will allow the robots to perform the jobs that are particularly hazardous to humans."

Peters has worked on the NASA humanoid "Robonaut" project for several years. He is developing the software to enable the Robonaut, pictured above, to perform tasks, learn new ones, and adapt intelligently to new conditions.

He is developing a new approach to robotic programming called Natural Intelligence. The robot is trained by a human being who teleoperates the robot through the stages of a task. The robot records how the task "feels" as it goes through the motions, logging pressure, speed, position, and other feedback information. After five or six trial runs with the human operator, the robot can compile the information to discern patterns that will serve as guides when the robot tackles the task alone.

"This method teaches the robot much the same way that people learn a physical task," Peters says. "It's a natural process to get a 'feel' for a task, which people do mostly subconsciously through practice."

Part of the process is allowing robots to "dream" or process the data to make new connections and patterns, Peters says. This period of consolidating and interpreting information may be similar to what the human brain does during dream sleep.

Peters has demonstrated that the Robonaut learning method he has devised empowers the robot to perform purposeful, directed motion and grasping autonomously.

His next step is to demonstrate that the robot can handle variations in the task. Specifically, he will show that the robot can grasp a horizontal object after being taught to grasp the object in a vertical position. This flexibility, he says, will make robotic assistance during space walks (Extravehicular Activity, or EVA) more feasible.

"It takes a minimum of two hours for an astronaut to suit up for an EVA," Peters explains. "A robot can stay out there indefinitely without protective gear or coffee breaks, with the human operator staying safely inside the vehicle."

If all goes reasonably well, Peters expects the Robonaut to be able to act as an intelligent assistant to astronauts in three to five years.

Next-Generation Space Launch

Since no one expects robots to replace human beings in earth orbit in the near future, NASA is continuing to push toward finding ways to improve vehicle safety, reliability and affordability through its Space Launch Initiative (SLI).

Professor of Civil and Environmental Engineering Sankaran Mahadevan is spearheading SLI-related research to help NASA develop the next generation of reusable launch vehicles.

Mahadevan and his multidisciplinary teams have developed a set of techniques to predict safety and reliability of structures and equipment with a high degree of confidence. These techniques can lead to improved maintenance and repair schedules and safer, more reliable and cost-efficient designs.

He just completed the first phase of a project for NASA Advanced Systems and Concepts to include reliability and risk concepts in next-generation space-launch vehicle design. The aim is to help designers achieve the performance goal of 1 in 10,000 risk of crew loss, and 1 in 1,000 risk of vehicle loss.

NASA engineers are learning to apply some of these reliability techniques in a variety of space shuttle applications. A pioneer in integrating physics, probability theory, optimization methods, mechanical and structural engineering, computer techniques and other disciplines, Mahadevan has taught many of these comprehensive and predictive analytical tools to NASA engineers.

In addition to training and writing instructional texts for NASA on reliability, Mahadevan also applied the methods to the shuttle propulsion system

(continued on page 3)

"There is definitely a place for … robots in space exploration"

—*Professor Alan Peters*

FROM THE DEAN

Young engineers are not easy to pick out in a crowd. They dress the same, have the same culinary tastes, and listen to the same types of music as their counterparts in other academic disciplines. No, if you want to tell an engineering student from the others, just throw an Engineers Week contest where first prize is a new Dell laptop computer. Or post a flier announcing undergraduate research opportunities for engineering students.

At Vanderbilt, our engineering students come in every conceivable size, shape, gender, race and religious background. They are interested in everything from genetics to next-generation space shuttle design. But they do have something in common with the engineers who came before them: They want to invent new things; they want to study how things work so they can design things that work better.

This deep-seated pragmatism is at the heart of every engineering discipline and distinguishes engineering from its close cousin, the sciences. That holds true even though an engineering laboratory is usually indistinguishable from a science laboratory, and even though our students must share the same fundamental knowledge base as the science majors. In many ways, engineers sit at the intersection between scientific abstraction and physical reality, needing to understand and maneuver in both worlds.

No wonder educating an engineer has always been such a challenge — for educators as well as students. There is a great deal of knowledge to amass and a wide range of professional skills to be taught. As knowledge explodes across all engineering disciplines, that challenge gets even more intense.

The Vanderbilt School of Engineering is fortunate to have a cadre of excellent engineering professors. Their research and scholarship are widely respected, and indeed the School's research program awards have more than doubled from $8 million to $19 million in six years. The perception of the school as a great place to study engineering continues to rise, and as its reputation increases, so do the academic successes of our students and faculty.

Research is important, not only to increase knowledge but also to raise our profile throughout the national engineering community. But every engineering faculty and staff member on this campus knows that our core business is to give our students the preparation that they need to be productive citizens and to help solve the tough problems of the future.

We are excited about our core business as educators of new engineers. The School of Engineering is expanding, refining and rethinking how we prepare our students, and our faculty are developing educational innovations such as our wired/wireless laptop network, TransIT, and the challenge-based engineering educational products we are pioneering in the biomedical field.

In this new, redesigned and renamed *Vanderbilt Engineering*, we intend to let our alumni know more about and become more involved in our core business. We plan to do this through more stories about engineering students, bigger and better photographs, and articles that show the relevance of our faculty research to the world in which you live and work. Your awareness of what we are doing and the goals we are trying to reach can make a difference in our ability to achieve our mission.

We know that meeting the challenges of the future as engineers will be a team effort. Thank you for your participation in the successes of the School of Engineering. We look forward to tackling the future with you.

In many ways, engineers sit at the intersection between scientific abstraction and physical reality, needing to understand and maneuver in both worlds.

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Robonaut photo courtesy of NASA

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Please send news items and changes of address to the editor at VU Station B 357703, 2301 Vanderbilt Place, Nashville, TN 37235-7703

Faculty Notes

BIOMEDICAL ENGINEERING

Associate Professor **Paul H. King** was an invited participant in the Forum on Innovation and Entrepreneurship in Biomedical Engineering Education at Stanford University in January.

CHEMICAL ENGINEERING

John R. Hall Professor **Peter T. Cummings** served on a National Research Council workshop organizing committee and has been appointed to serve on the council's "Challenges for Chemical Sciences" workshop for next fall.

CIVIL AND ENVIRONMENTAL ENGINEERING

Visiting Associate Professor **Sanjiv B. Gokhale** was elected to the board of directors of the North American Society for Trenchless Technology.

Assistant Professor **Eugene J. LeBoeuf** presented the keynote address to the 20th Anniversary Conference of the International Humic Substances Society held in July in Boston.

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Associate Dean for Research and Professor **Daniel M. Fleetwood** was elected vice-chair of the Forum on Industrial and Applied Physics for The American Physical Society.

At the 2002 IEEE Nuclear and Space Radiation Effects Conference (NSREC), awards were given to three papers that included Vanderbilt authors. The Outstanding Conference Paper was co-authored by Professor **Fleetwood**. He and Professor **Ronald D. Schrimpf** also co-authored two of three papers selected as Meritorious Conference Papers out of more than 100 presented.

Dean and Professor **Kenneth F. Galloway** was elected a Fellow of the American Physical Society.

MECHANICAL ENGINEERING

Centennial Professor **Arthur M. Mellor** was elected a Fellow of the American Institute of Aeronautics and Astronautics.

Research Funding Up

Associate Dean for Research Dan Fleetwood almost had to rub his eyes to make sure he wasn't seeing things when the half-year report landed on his desk.

The report revealed that the School of Engineering brought in more than $14.3 million in research dollars in the first half of fiscal year 2003. That figure is 47 percent more than the $8.6 million received at the halfway point of the previous fiscal year, which was also a record-breaker.

This momentum has continued into the third quarter of the year; by mid-March, the school had received more than $20.5 million. That figure eclipsed last year's record-breaking total of $19.3 million in new awards by more than $1 million, with more than three months left in the fiscal year.

"The expansion of our research program greatly benefits our students, undergraduates, and graduate students," Dean Fleetwood says. "We do research because it develops the faculty, attracts better and more visible educators, and strengthens our educational program."

There are many reasons for the increase, he says. "The faculty won several very large awards and are engaged in exciting areas of research across the school. They have a great attitude and their hard work is gaining national recognition."

"Other factors in the increase," he says, "are the stronger budgets of the U.S. Department of Defense, the National Institutes of Health, and the National Science Foundation." Some of the new research is related to post-September 11 needs, but most address ongoing needs of the nation. "This is a case of preparation meeting opportunity."

The Vanderbilt Academic Venture Capital Fund is supporting some of the research growth, and Fleetwood also cites the School of Engineering's investments in research projects that would not be funded by agencies without the school's matching investment.

Fleetwood says that the research program's growth will provide a wide range of benefits for the School of Engineering. "Our faculty's success this year will accomplish those goals as well as raising our profile nationally and internationally as a top school of engineering. Their work is the foundation for a future of balanced and sustainable growth."

Other NASA-Sponsored Research

Mars mission: Doug LeVan is developing equipment to convert carbon dioxide in the Martian atmosphere into oxygen and carbon monoxide; John Roth and Ken Debelak are developing a process using supercritical carbon dioxide to dissolve and extract minerals, water and other substances from Martian soil.

Robotics: A Vanderbilt team consisting of Kazuhiko Kawamura, Alan Peters, Nilanjan Sarkar and Robert Bodenheimer is developing software to enable robots to assist human beings in space through the Robonaut program. They are partners with NASA-JSC and several universities in the DARPA's MARS 2020 program to make the Robonaut work with astronauts more autonomously.

Pharmaceutical development: Taylor Wang, former shuttle astronaut, is developing capsules containing insulin-producing cells to treat diabetes, using a microgravity simulator partly sponsored by NASA.

Materials processing: A.V. Anilkumar is examining the dynamics of bubbles, under imposed temperature gradients, during melting and solidification. The experiments, which are being conducted on the International Space Station, will provide insights into improving the quality of materials processed in a microgravity environment.

Metal solidification kinetics: William Hofmeister and Robert Bayuzick are studying the fundamental physics of metal solidification to devise ways to improve metal fabrication processes to optimize desirable properties such as strength, conductivity and resistance to corrosion.

Energy capacitors and sensors: Jim Davidson and W.P. Kang are applying their diamond-film techniques to devise efficient energy storage units for satellite thrusters and rugged sensors and accelerometers that can function under extreme conditions.

Next-generation NASA scientists: Al Strauss heads up the NASA-sponsored Tennessee Space Grant Consortium to promote space and science education throughout the state at all educational levels.

Mission: IMPERATIVE *(continued from page 1)*

and main engine components as well as the solid rocket booster skirt. His team is analyzing the problem of reusable solid rocket boosters being damaged by splashdown in the ocean after separation from the shuttle during its ascent.

He and his team are continuing to work on next-generation vehicle design methods and are applying reliability and optimization techniques that integrate multiple factors such as structures, aerodynamics, propulsion, mass and geometry.

Rad-Hard Computers

Tiny computer circuitry is especially vulnerable to the abundant radiation in space, sometimes losing critical data or even failing catastrophically. This vulnerability is intensified as microelectronic devices get smaller.

Vanderbilt's Institute for Space and Defense Electronics, the largest of its kind in the United States, is studying the performance of advanced integrated circuit systems in space.

The institute's team includes Ron Schrimpf, professor of electrical engineering; Lloyd Massengill, professor of electrical engineering and computer engineering; Dan Fleetwood, associate dean for research and professor of electrical and computer engineering; Tim Holman, research associate professor of electrical engineering; Bob Weller, associate professor of electrical engineering and materials science and engineering; and Ken Galloway, dean and professor of electrical engineering. They are pioneering techniques to make "rad-hard" devices for use in space electronics.

"Rad-hard" techniques strengthen the resistance of integrated circuits to damage from radiation, using improved circuit designs, rearranged structural layout of the circuits, altered thickness of the materials, changed sequence of manufacturing processes, and lower temperatures during manufacturing.

This research requires in-depth understanding of both radiation and microelectronics, including semiconductors, circuit design, thin films, radiation physics and manufacturing.

Recently the radiation effects team examined materials used in current and emerging microelectronic transistors to determine their susceptibility to radiation damage. They used several different types of radiation to mimic the effects of cosmic rays and other space radiation on high-performance integrated circuits.

"This information can be used to protect microelectronic devices in space and defense applications and will enable electronics designers to work effectively with ultrathin layers of advanced materials in the future," Schrimpf says.

—Vivian Cooper-Capps

CIVIL AND ENVIRONMENTAL ENGINEERING

Xu Wins Prestigious Naval Research Award

Assistant Professor L. Roy Xu has won a prestigious Young Investigator Program award from the U.S. Office of Naval Research (ONR) for his research on hybrid interface mechanics and nano-composite materials.

Xu is one of only 26 researchers nationwide receiving grants of up to $100,000 a year for three years to support their research. The ONR Young Investigator Program supports basic research by exceptional faculty at U.S. universities who received a Ph.D. or equivalent degree within the preceding five years.

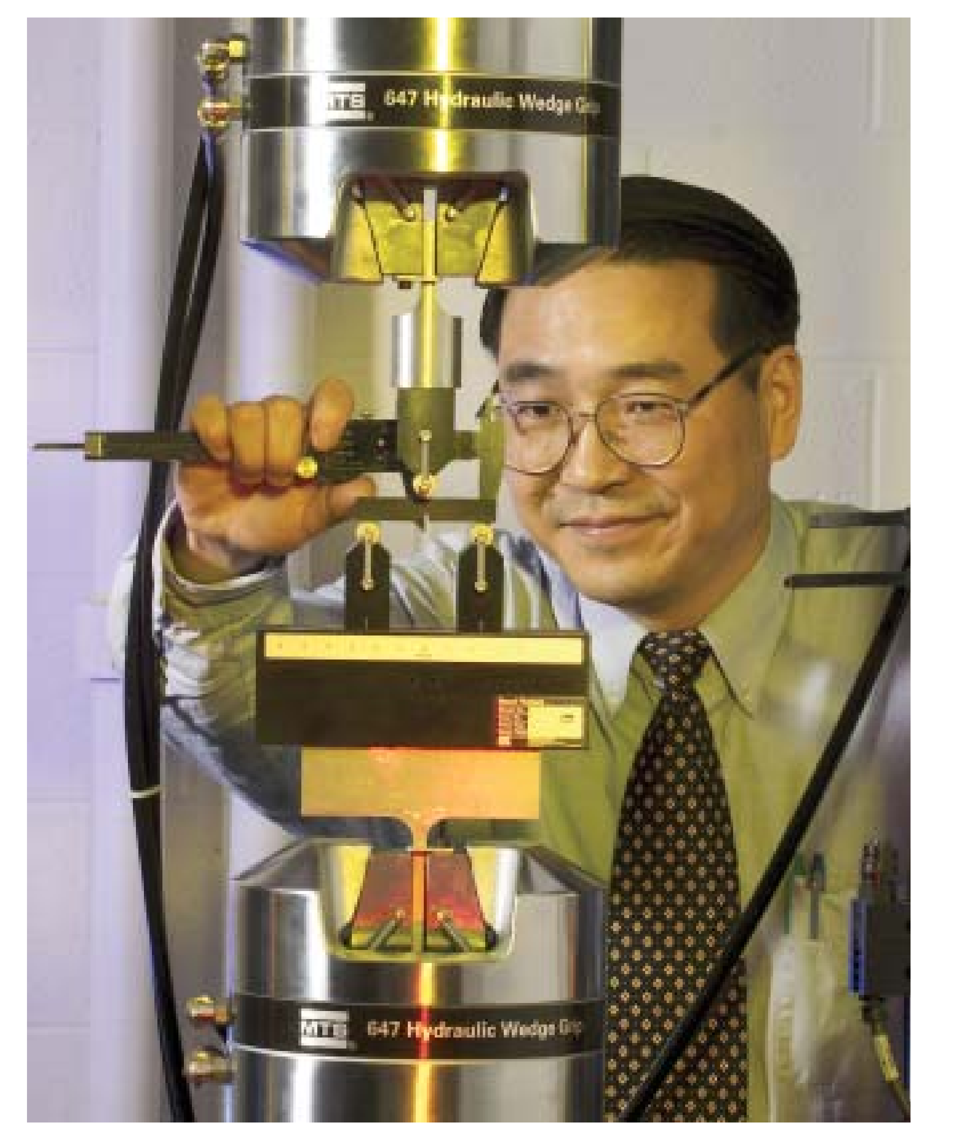
"Young Investigator awards confer honor upon the recipients beyond the research funding being provided," according to the ONR announcement. "The awards are recognition of their research achievements, potential for continued outstanding research efforts, and strong support and commitment from their respective universities."

The ONR cited Xu's work on hybrid interfaces and structures that use nano-composite materials to improve bonding. Xu studies these new materials to determine how strong and reliable they are likely to be, and how well they will perform in ships, submarines and other advanced structures.

Hybrid interfaces and joints take advantage of two kinds of dissimilar materials, such as stainless steel and composite materials. Xu's research focuses on their failure mechanics and prevention. One approach reinforces the structural adhesives using nano-fiber composite materials. The other approach Xu is examining strengthens the hybrid interfaces by developing a novel joint design that mimics the shape and mechanics of trees. Experimental activities will involve using reflective coherent gradient sensing techniques, dynamic impact in conjunction with high-speed photography, and in-situ neutron scattering.

"Professor Xu's work is an important addition to our systems reliability research and is a superb reflection of our department's expertise in this area," says Professor David S. Kosson, chair of civil and environmental engineering. Xu's research on failure analysis of advanced materials and structures provides experimental validation for structural reliability research.

"I am very glad to win this individual award," Xu says. "However, excellent support from my research group members, other faculty and staff, our department and the School of Engineering plays an important role in this achievement." Xu joined the Vanderbilt faculty in 2001 after earning his doctorate in aeronautics and materials science from the California Institute of Technology.



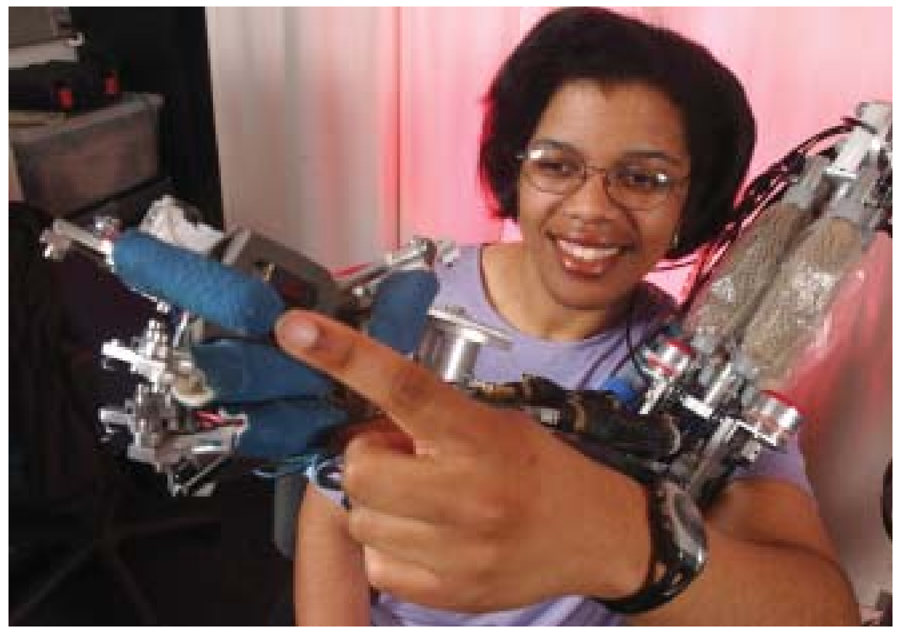
Robots at Work

Complex program involves four separate labs and two different departments

The School of Engineering is widely known for its expertise and research in robotics, but the fact that this work involves four separate robotics labs and two different engineering departments often comes as a surprise.

The difficulties inherent in creating machines that function in some ways as human beings is also surprising to many people, who have grown up watching science fiction robots capable of speaking several languages, serving high tea, and displaying humorous personal characteristics. The reality of robotics is comparatively mundane, because the complexity and volume of the computer algorithms involved in simply reaching for a doorknob coming from different directions and at different speeds is staggering. Not to mention the complexities involved in making physical pieces of equipment obey abstract commands.

These articles highlight just a few projects in two robotics labs at the school. They comprise only a small part of the intricate and painstaking work Vanderbilt engineers are pioneering in the robotics field.



Tamara Rogers, shown here with one of the robot ISAC's hands, manages the Cognitive Robotics Laboratory at Vanderbilt.

Graduate student manages one of nation's top humanoid labs

"We can leave Armstrong where he is," Tamara Rogers decides, surveying the laboratory array of "Armstrong" and his six companion computers with names like "Sally," Ninja" and "Octavia" that operate the humanoid robot at Vanderbilt. "But I want to move Musashi."

Rogers, lab manager for the Cognitive Robotics Lab, is thinking out loud about how to best rearrange the equipment once the new computers arrive. Her planning must incorporate more than logistics, since the technology upgrades will enable the lab to better integrate the robot-operating software. Having worked with the robot during most of her years at Vanderbilt while working on her doctorate, she's in an ideal position to think such strategies through.

In a way, she's surprised to be the sitting at the hub of one of the nation's most respected intelligent systems laboratories, working with the famous ISAC (for Intelligent Soft-Arm Control) humanoid robot.

"I came to Vanderbilt planning to be a biomedical engineer," she says. "I got interested in electrical engineering and mechanical engineering while I was an undergraduate, and then I decided to get my Ph.D. so I could teach." Rogers, BE'93, MS'95, was slated to receive her doctorate at Commencement ceremonies in May.

It's no small irony that much of her work involves teaching a robot.

ISAC was designed by Vanderbilt engineers to serve as a robotic aid to the physically challenged. The robot is equipped with two "soft arms" with six degrees of freedom and anthropomorphic hands which enable it to interact physically with its environment; a vision system to allow it to perceive, locate and recognize objects and people; and an auditory processing and speech system that enables it to understand spoken commands and respond.

Rogers' research focuses on developing the software that operates the robot's "Human Agent." The Human Agent is responsible for observing and monitoring the communications and actions, determining what the person wants from the robot, and communicating with the person. The Human Agent is one of two cognitive agent models ISAC uses to recognize and interact with people.

Despite cardboard cutout "eyes" that encircle its charge-coupled device and infrared motion detectors aligned in an array that looks a lot like teeth, ISAC bears little resemblance to a human being or even to the robots portrayed in movies.

"It would surprise many people to learn how much still needs to be done to endow today's service robots with the ability to do relatively simple tasks," says Professor Kazuhiko Kawamura, director of the Center for Intelligent Systems. "One of the most challenging problems is that of giving the robot an understanding of how to interact with human beings."

Rogers' work on the Human Agent software has advanced ISAC's ability to interact with people. "The robot needs to represent people so it can make decisions," she explains. "We start on the physical level, with representations of faces, hands and processing of speech. Next we represent specific tasks that people might want the robot to do."

She also worked on the robot's visual system, as part of her master's project in signal and image processing.

Her interest in robotics grew out of her work on that project with her advisor D. Mitchell Wilkes, associate professor of electrical engineering and assistant director of the Intelligent Robotics Lab. "At the time, ISAC was focused primarily on feeding the disabled," Rogers says. "I liked seeing the results of my work put to good use."

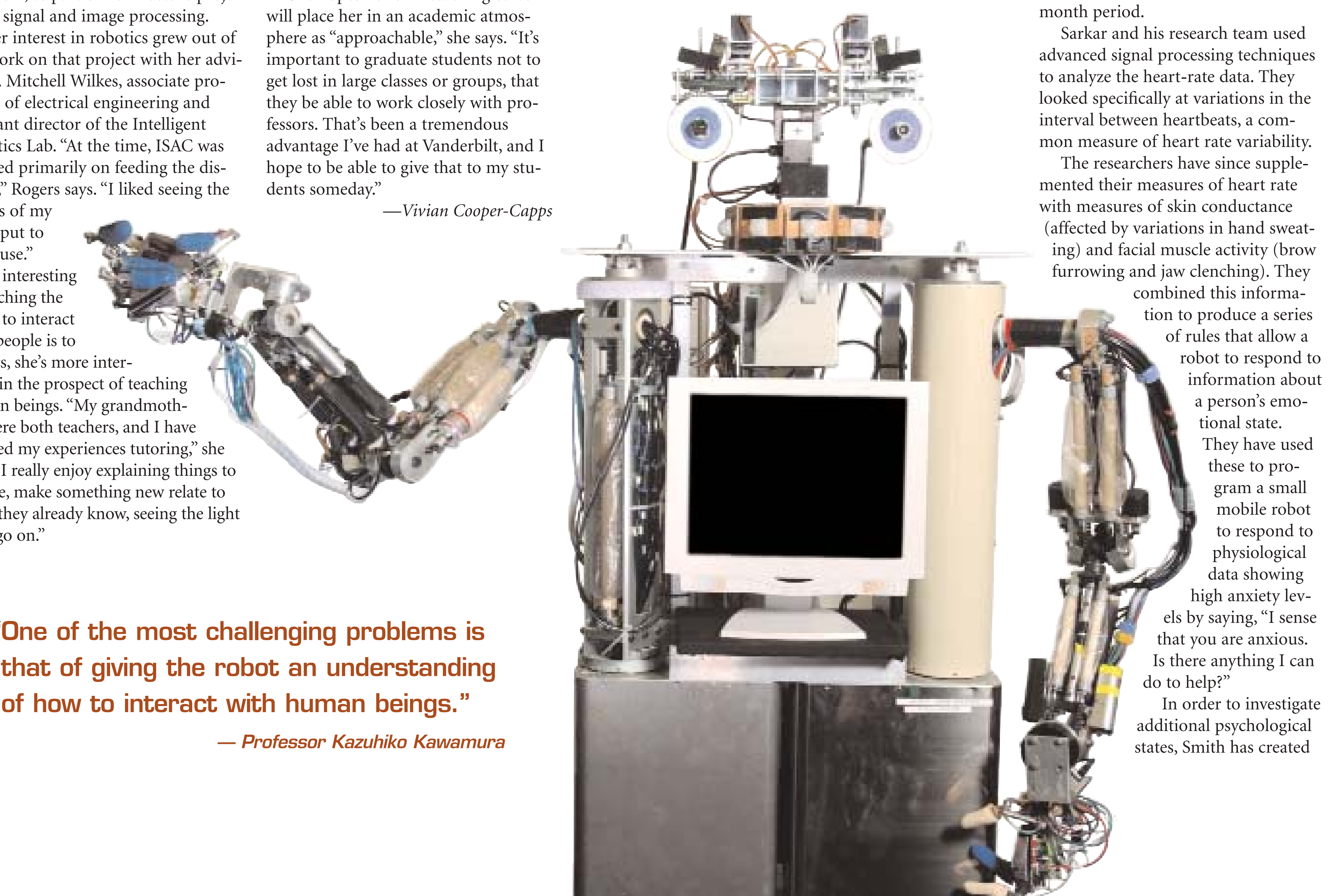
As interesting as teaching the robot to interact with people is to Rogers, she's more interested in the prospect of teaching human beings. "My grandmothers were both teachers, and I have enjoyed my experiences tutoring," she says. "I really enjoy explaining things to people, make something new relate to what they already know, seeing the light bulb go on."

She hopes to get that opportunity next academic year. "Right now I'm not thinking so much about my future plans as I am about getting this robot to work and finishing my degree requirements."

She's also clearly enjoying her last year at Vanderbilt, where she also earned her bachelor's degree. She and the other graduate students work in a relaxed, collegial atmosphere. "Vanderbilt is good at getting people to work together," she says. "In robotics you have to integrate a lot of different disciplines, methods, techniques and approaches. Faculty and students work together to achieve the goals of the system."

She hopes her own teaching career will place her in an academic atmosphere as "approachable," she says. "It's important to graduate students not to get lost in large classes or groups, that they be able to work closely with professors. That's been a tremendous advantage I've had at Vanderbilt, and I hope to be able to give that to my students someday."

—Vivian Cooper-Capps



"One of the most challenging problems is that of giving the robot an understanding of how to interact with human beings."

— Professor Kazuhiko Kawamura

Robots that can sense human emotion

Forget the robot child in the movie "AI." Vanderbilt researchers Nilanjan Sarkar and Craig Smith have a less romantic but more practical idea in mind.

"We are not trying to give a robot emotions. We are trying to make robots that are sensitive to our emotions," says Smith, associate professor of psychology and human development.

Their vision is to create a kind of "Robot Friday," a personal assistant who can accurately sense the moods of its human bosses and respond appropriately.

"Psychological research shows that a lot of our communications, human to human, are implicit," says Sarkar, assistant professor of mechanical engineering. "The better we know the other person, the better we get at understanding the psychological state of that person. So the prime motivation of our research is to determine whether a robot can sense the psychological state of a human person. Sooner or later, robots will be everywhere. As they become increasingly common, they will need to interact with humans in a more natural fashion."

When Sarkar first approached him about collaborating on the project, Smith admits that he was very skeptical. "I expected to listen and then explain to him why his ideas would never work." But the engineer surprised him on two counts: the amount he knew about the psychophysiology of emotions and his realization that any system for detecting emotions cannot be universal, but must be based on individual patterns.

The project has two basic parts, and both are ambitious. One is to develop a system that can accurately detect a person's psychological state by analyzing the output of a variety of physiological sensors.

The other is to process this information in real time and convert it into a form that a computer or robot can process.

"The hard fact is that different individuals express the same emotion rather differently," says Smith. "But I think that we have established the feasibility of the individual-specific approach that we are taking and there is a good chance that we can succeed."

The Vanderbilt researchers are using an approach similar to that adopted by voice and handwriting recognition systems. They are gathering baseline information about each person and analyzing it to identify the responses associated with different mental states.

One advantage that the researchers have is the recent advances in sensor technology. "Extremely small, 'wearable' sensors have been developed that are quite comfortable and are fast enough for real-time applications," says Sarkar.

Their first experiments concentrated on detecting high and low anxiety levels using a heart-rate monitor. "There are sophisticated medical diagnostic techniques that can detect stress in a patient," they acknowledge in a paper published in *Robotica*, but add, "All those techniques are slow, expensive and, more importantly, not suitable for a person who is moving and working."

In this case the researchers used playing video games to put subjects under pressure and induce stress. By varying the level of difficulty of the games, they were able to vary the level of stress involved. They obtained electrocardiogram data from several video-game playing subjects over a six-month period.

Sarkar and his research team used advanced signal processing techniques to analyze the heart-rate data. They looked specifically at variations in the interval between heartbeats, a common measure of heart rate variability.

The researchers have since supplemented their measures of heart rate with measures of skin conductance (affected by variations in hand sweating) and facial muscle activity (brow furrowing and jaw clenching). They combined this information to produce a series of rules that allow a robot to respond to information about a person's emotional state.

They have used these to program a small mobile robot to respond to physiological data showing high anxiety levels by saying, "I sense that you are anxious. Is there anything I can do to help?"

In order to investigate additional psychological states, Smith has created tasks designed to make the performer frustrated or bored. They will be adding additional sensors, such as electroencephalogram (EEG) brain-wave monitors and additional measures of cardiovascular activity.

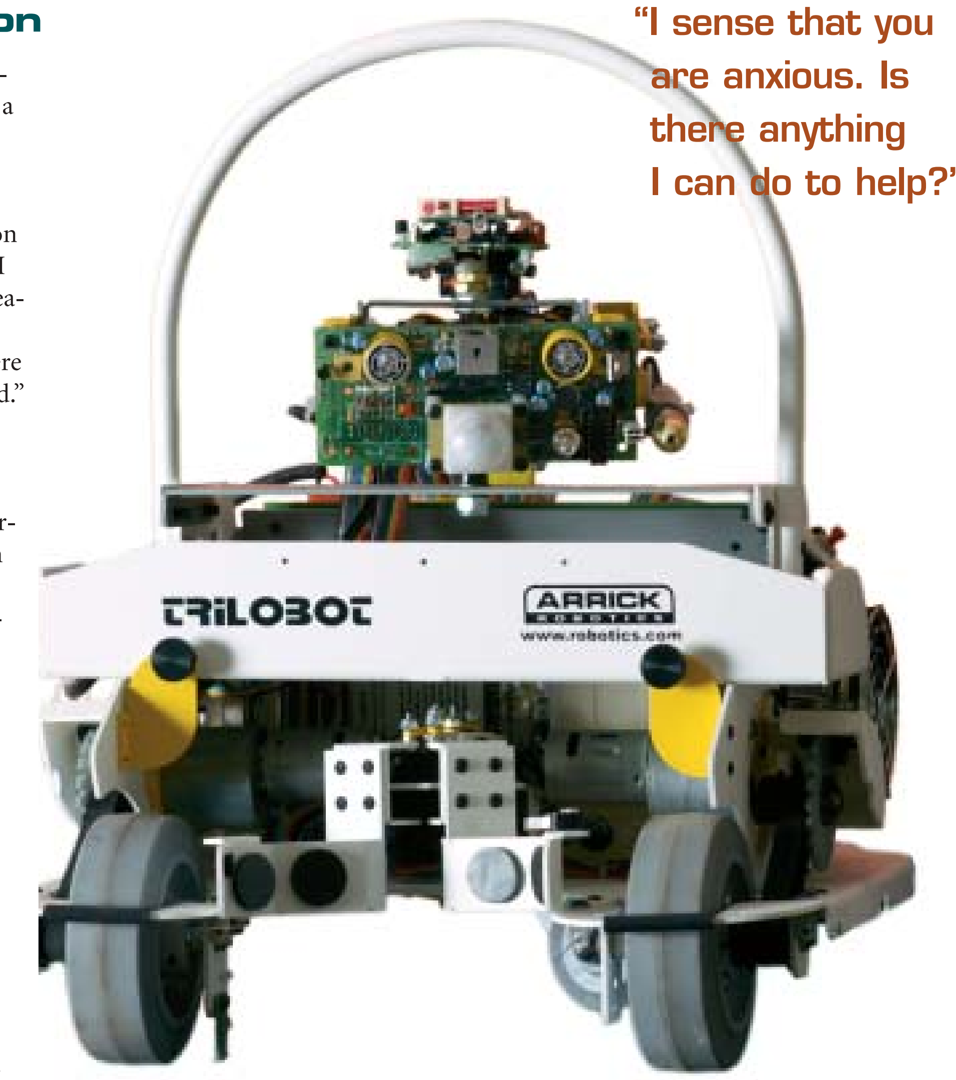
The next challenge that the researchers face is finding a way to discriminate between high levels of anxiety and engagement. These two states are accompanied by physiological responses that are much closer to each other than either of them are to low levels of anxiety or engagement. "This is the really big one," says Smith.

The research is supported by grants from the National Science Foundation, the NASA Institute for Advanced Concepts and Vanderbilt University.

For more information about this and other exciting engineering research, please visit Vanderbilt's online research journal, *Exploration*, at *http://exploration.vanderbilt.edu/news.htm*

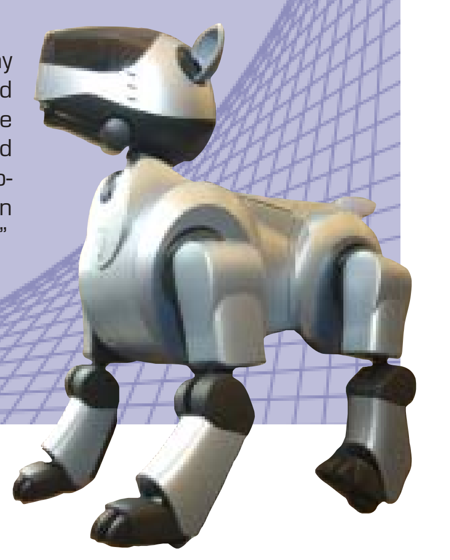
—David Salisbury

"I sense that you are anxious. Is there anything I can do to help?"



Working with Aibo

Senior electrical engineering students, Ajay Bidani, left, Karla Roncal, Will Gray, and Guillermo Lagos are programming the robotic dog, Sony Aibo, to recognize and approach objects. They are adapting Professor Alan Peters' algorithms for "action mapping using sensor-motor coordination."



BIOMEDICAL ENGINEERING

Biomedical students tapped for international scholarships

Two biomedical engineering seniors will continue their studies in England next year, thanks to receiving prestigious graduate scholarships.

David Brogan of San Antonio, Texas, will study in London on a Marshall Scholarship, and Darci J. Phillips, of Northbrook, Ill., will attend Cambridge University on a Gates Cambridge Scholarship.

Brogan, who combines his studies with cross-country competition and community involvement, is one of 40 U.S. students chosen this year to participate in the British government-financed scholarship program established in 1953 as a way of thanking the United States for its assistance after World War II. He will use the highly competitive scholarship — worth about $60,000 — to pursue a master of science in medical engineering at Kings College of London next year and a masters in international health policy at the London School of Economics the second year.

Brogan hopes eventually to become a physician and to explore combining medical imaging techniques with surgical practice to develop innovative methods of treatment.

He credits work that he has done with Professor Robert Galloway in biomedical engineering with focusing his interest on image-guided surgery. "Vanderbilt is one of the leaders in the field," he says.

After completing his studies in England, Brogan plans to return to the United States for medical school.

Darci Phillips

David Brogan

About 800 college students apply each year for the Marshall Scholarships, which are awarded on the basis of academic distinction and leadership potential. Past recipients include U.S. Supreme Court Justice Stephen Breyer; Pulitzer Prize-winning authors Tom Friedman of the *New York Times* and Dan Yergin, author of *The Prize*; and noted inventor Ray Dolby. Duke University President Nannerl Keohane, the sister of Art Overholser, senior associate dean of Vanderbilt's School of Engineering, was also a past recipient (please see related article on page 8).

Among his favorite experiences, Brogan counts his work at local elementary schools, demonstrating entertaining science experiments for fifth- and sixth-graders as part of Vanderbilt Student Volunteers for Science. He has tutored inner city school students, participated in Alternative Spring Break and Vanderbilt Kids Zone, and volunteers at Warm Springs Rehabilitation Institute.

The son of Mary and John Brogan, he attends Vanderbilt on full scholarship. He is the recipient of a Tau Beta Pi Scholarship, Robert Byrd Honor Scholarship, Harrawood Engineering Honors Scholarship and a Nashville Engineer's Association Scholarship. A National Merit Scholar and Eagle Scout, he has been on the Dean's List every semester.

Phillips is one of two Vanderbilt students and only 41 nationwide to receive the Gates Scholarship this year. Lauren Leigh Parker, a senior A&S chemistry major from LaVergne, Tenn., was also chosen as a Gates Cambridge Scholar from some 20,000 applicants. Made possible through an endowment by the Bill & Melinda Gates Foundation, it enables students of outstanding academic merit and leadership potential to pursue a second bachelor's degree, a one-year postgraduate course, or research toward a Ph.D. at the University of Cambridge.

Phillips plans to use her scholarship to pursue a master of philosophy in bioscience enterprise. She hopes to conduct research in orthopedics at Cambridge, focusing on lower-limb and knee-joint disorders.

Phillips credits her previous study at St. Andrew's University in Scotland — through the Vanderbilt study-abroad program — with exposing her to the different learning styles of her fellow classmates from around the world. Often finding herself the lone American in small research groups, Phillips was able to bring her unique perspective to the international collaborations.

"While at Cambridge, I will take advantage of the wealth of experience that both the university and the United Kingdom have to offer," she says. "I would like to thank Vanderbilt and especially the biomedical engineering department for all of their help throughout the last four years. Their support and encouragement have provided me with a foundation from which I was able to pursue these wonderful opportunities."

Phillips has conducted research at the National Institutes of Health in Washington, D.C., and ultimately hopes to become an entrepreneur in the biomedical field.

The daughter of Rhonda and Robert Phillips, she has been named to the Dean's List, served on the Student Government Association, and worked with oncology patients at Vanderbilt University Medical Center.

Among his favorite experiences, Brogan counts his work at local elementary schools, demonstrating entertaining science experiments for fifth- and sixth-graders as part of Vanderbilt Student Volunteers for Science.

Wanted: 560 thousand future engineers, scientists

Vanderbilt joins Tennessee consortium to recruit and cultivate minority engineering undergraduates

According to some predictions, the U.S. could suffer a shortfall of as many as 560,000 science and engineering professionals by 2010.

Many colleges and universities across the country are looking into ways to broaden the appeal and generate creative teaching strategies to reach and cultivate engineers, mathematicians and scientists from non-traditional demographic groups.

The Vanderbilt School of Engineering and College of Arts and Science are participating in one such program and this summer will provide research opportunities for to qualified minority undergraduates from several colleges in Tennessee. The School of Engineering will also take part in a summer bridge program for incoming freshmen engineering majors who are members of underrepresented groups. The program will acclimate them to the University and help them develop the confidence and grounding to succeed.

"Vanderbilt is extremely concerned about the needs of underrepresented groups and is quite innovative in responding to them," says Senior Associate Dean K. Arthur Overholser. "This new Alliance for Minority Participation program helps us not only better provide for our own students, but also extend the research resources to minority students in other Tennessee schools."

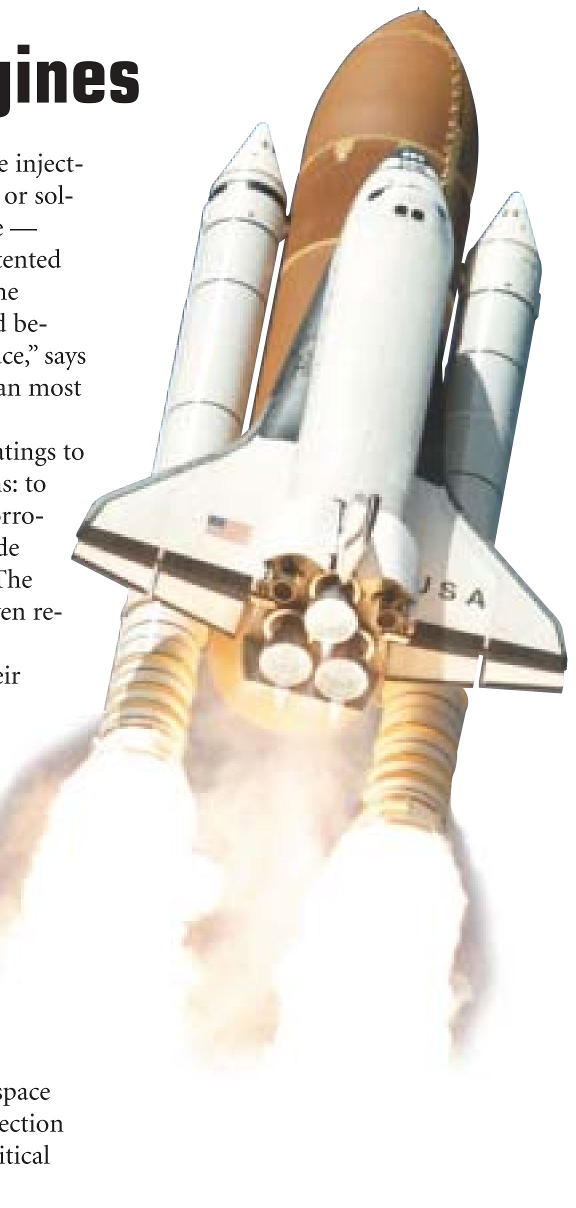
The engineering summer research program provides stipends from $3,600 - $6,000 and allows students to conduct experiments and participate in engineering research projects, much as graduate students can do.

The Tennessee Louis Stokes Alliance for Minority Participation is funded by the National Science Foundation and includes Tennessee State University, LeMoyne-Owen College, Middle Tennessee State University, University of Memphis, University of Tennessee at Knoxville and Vanderbilt. The program's goal is to double the number of Tennessee science, technology, engineering and mathematics minority students at the end of the program's initial five-year period.

Participating schools are developing new recruitment programs, student support services, summer bridge programs, undergraduate research opportunities, tutorial programs, mentoring services, collaborative learning, and preparation for graduate school.

ALUMNI

Alumnus develops coating to protect engines



Like most Americans, Timothy McKechnie was deeply distressed by the space shuttle Columbia tragedy. But as a NASA supplier, he had professional concerns about the disaster, as well.

As a Vanderbilt undergraduate and graduate student, McKechnie, BE'84, MS'85, worked in the mechanical and materials engineering labs under the direction of Professor James Wert on a project funded by GE Aircraft Engines. The company needed to protect the compressor blades of its jet engines from sand, which — if ingested into the engines — could have a profound, even catastrophic, effect on performance.

After earning his master's degree, McKechnie went to work for the Rocketdyne Division of Rockwell International, manufacturers of the space shuttle's main engines. "They have turbines similar to jet engines," he says. While working for Rocketdyne, McKechnie realized that the processes they were developing had applications that were much wider than rocketry. In 1994 with two other engineers, he formed a company called Plasma Processes, Inc., which NASA hired to develop coatings for its rocket engines, microgravity and science projects.

Plasma — the fourth state of matter — is an ionized gas superheated to 10,000 K. Coating materials are injected into the plasma as a powder or solid, accelerated through a nozzle — which Plasma Processes has patented — and applied to a surface. "The process creates a powerful bond between the coating and the surface," says McKechnie, "more powerful than most other methods of application."

Plasma Processes applies coatings to products for a variety of reasons: to prevent wear (like bearings), corrosion and oxidation, or to provide heat and electrical protection. The company can, in some cases, even rebuild damaged parts.

At the moment, NASA is their biggest customer. Using Plasma Processes's fabrication sequence, the company coats the nozzles and liners of rocket engines, places where temperatures routinely reach 5,000 to 6,000 F. And, although Plasma Processes did not supply the coating for Columbia's rockets, the recent space shuttle disaster shows that protection from heat is one of the most critical concerns of space travel.

—*Richard Daverman*

At Plasma Processes, a robot manipulates a plasma gun to deposit ceramic materials similar to those used to coat rocket engines.

ALUMNI

Father Knew Best

During the 1950s, "Father Knows Best" was a popular television situation comedy. Kelley Golden Zelickson, BS'79, learned a long time ago that her father, an electrical engineer, also knew best when he provided some sound advice that steered her into engineering.

"Like a lot of kids, I wanted to be a math teacher," Zelickson says. "Math was always my favorite subject in school. My father told me if I wanted a degree in math, that was great; but I was going to do it through the School of Engineering because it offered me versatility. It offered me many more career opportunities and the ability to make more money, while still allowing the same concentration of courses that I liked so much, which were the basic problem-solving and logic courses."

Zelickson followed her father's advice and graduated from Vanderbilt with a double major in engineering science and math in December of 1979. About three weeks later she began working for TRW, a global company engaged in the automotive, aerospace and information technology fields. The company was recently acquired by Northrop Grumman Corporation.

Zelickson moved steadily up through the ranks. She is now program director in charge of 500 people developing and testing a ground-based, mid-course defense battle management command, control and communication (GBMC3) system. It is part of a system in a "layered architecture" designed to protect the United States against a ballistic missile attack.

Despite her high-level executive position, Zelickson has maintained an active family life. She and her husband, Jeffrey, have four sons ranging in age from 14 to 21. She says time-management skills, the help of her husband, and a family-friendly company have enabled her to successfully juggle demands of job and home.

Zelickson has advice for graduating female engineers that might be every bit as valuable as that her father gave to her in the mid 1970s: "I would like for them to understand that, given some good time-management skills, it's certainly possible and likely that they can have a successful career and a successful family life. I think with good companies today that are family friendly, women can have everything they want. There are no limitations to the opportunities."

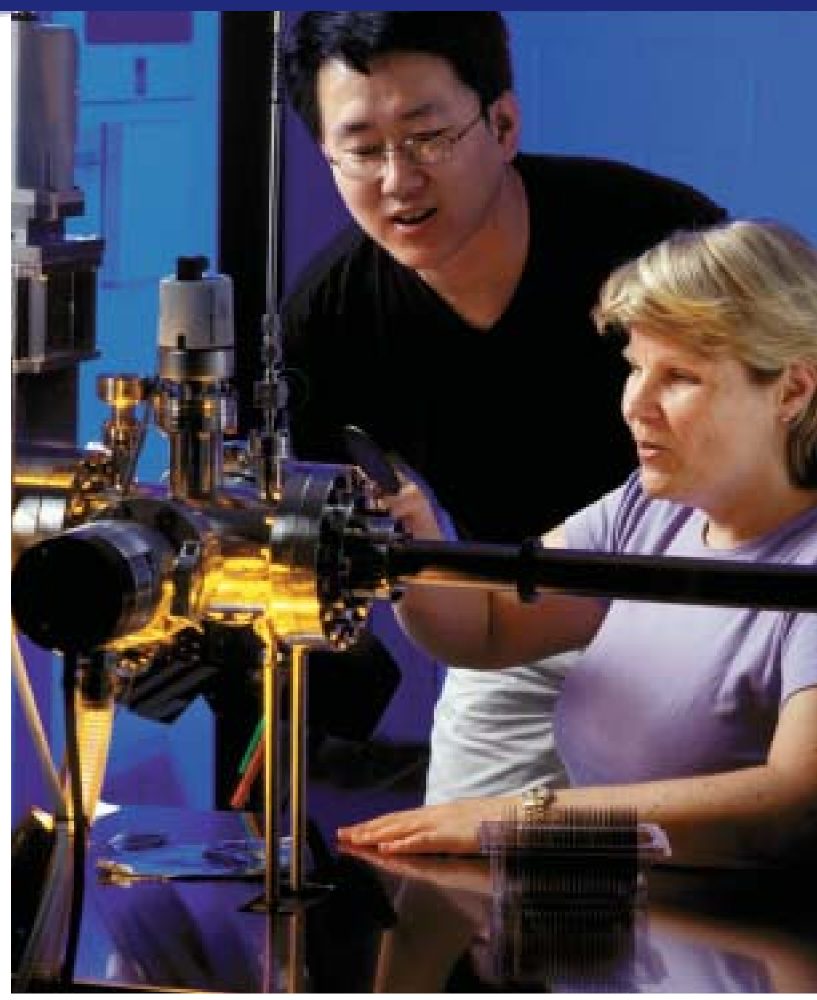
—*Lew Harris*

Students celebrate engineering challenges during E-Week

Vanderbilt students celebrated the lighter side of engineering during National Engineers Week, Feb. 17-22. Among those participating in various competitions was Adam Breed, pictured below, a junior majoring in civil engineering. He built a water tower that could support a bucket containing two 20-ounce bottles of water, using only index cards and paperclips.

Established in 1951 by the National Society of Professional Engineers, E-Week is traditionally held the week of Presidents Day, because George Washington was a military engineer and land surveyor. Vanderbilt E-Week corporate sponsors included ExxonMobil Development Company, Dell Computer Corporation, Aerostructures Corporation, Chris-More Inc., and Engineering World Health. For more information and photos about E-Week 2003, please visit http://www.vuse.vanderbilt.edu/eweek/

TOOL TIME



This ultrahigh vacuum chemical vapor deposition (UHV-CVD) reactor was custom designed by Assistant Professor of Chemical Engineering Bridget Rogers, who examines one of the silicon wafers used as substrate in her ultrathin-film research. Rogers uses the equipment — a modified Molecular Beam Epitaxy tool made by SVT Associates — to identify and characterize useful materials that might someday replace silicon dioxide in solid-state transistors and other microelectronic devices in order to make them even smaller and faster.

Creativity + Practicality = Engineering

During the week, Art Overholser wears the coat and tie of a professor of biomedical engineering and senior associate dean. On the weekends, however, he dons a helmet and leather jacket and revs up his Harley Davidson for a ride in the country. Morphing from a serious academic to a free-spirited 'hog' rider and back again, Overholser, BE'65, combines in his personality the two elements he uses to define engineering: "A combination of creativity and practicality."

"People who enjoy engineering," he says, "are creative and yet enjoy making things work, making things happen in the real world. It's a nice combination."

The holder of several teaching awards, including the university-wide Ellen Gregg Ingalls Award for Classroom Teaching, Overholser has overseen the quality of undergraduate engineering education for the past three years.

He comes from a distinguished academic family. His sister, Nan Keohane, is president of Duke University, the first woman to serve in that position. His father was a Presbyterian minister, and both parents were also college professors. But, while Art Overholser always wanted to be an engineer, he only decided on a career in higher education toward the end of graduate school at the University of Wisconsin, where he earned his M.S. and Ph.D. degrees in chemical engineering. While applying for teaching positions at other universities, he contacted Vanderbilt for letters of recommendation. The answer came back, "Why not come to Vanderbilt?" He joined the faculty in 1971.

"I enjoyed teaching and I enjoyed research," he says. "This was obviously the way to put those things together."

Overholser has completed two postdoctoral fellowships: one in engineering at the University of London in England and another in physiology at the University of California, San Francisco, where he was a visiting scientist at the Cardiovascular Research Institute.

Since becoming associate dean, one of his proudest achievements has been creating the freshman seminars in engineering three years ago. The one-hour electives, taught by senior faculty members, give students a chance to see how engineering can be applied to their particular interests, from high-fidelity sound recording, to laser eye surgery, to space flight.

"We decided to implement the freshman seminars series because it takes advantage of what's special about Vanderbilt," Overholser says. "We have some motivated students and motivated faculty, and I wanted to bring them together while the students were freshmen. It provides a way for our freshmen to come to intellectual grips with their professors — to really think together and work together."

Freshmen can take a different seminar each semester if they wish. Overholser also teaches a freshman seminar each year on "The Second Law of Thermodynamics," which states that the disorder of the universe tends to increase. Students learn how this law applies not only to engineering but also to other fields such as economics, sociology, cosmology and even theology. Last semester, his class wrote papers applying the law to topics as diverse as the stock market, the economy and vampires.

"Teaching is a service to others — and it's fun," Overholser says. "I've taught everything from freshmen to post-docs, and I like each one. To see the difference in the students is rewarding, particularly with freshmen. They make a lot of progress in one semester."

— Joanne Lamphere Beckham

> "People who enjoy engineering are creative and yet enjoy making things work, making things happen in the real world. It's a nice combination."

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LEWIS SOCIETY

Leadership Group Continues Dean's Legacy of Aid to Students

Fred Justin Lewis became dean of the School of Engineering in 1933, a position he held for 26 years until 1959. He was reputedly a man of deep conviction and intense drive who led the school to new growth in enrollment, expansion of facilities, and development of strong academic programs. He was certainly an effective administrator, but those who knew him say his greatest contribution was his ability to influence and inspire excellence in his students both professionally and personally.

Nearly three decades ago, his former students established the Fred J. Lewis Society to honor the memory of this beloved dean. Members contribute more than 65 percent of the school's annual unrestricted gifts, most of which goes to support scholarships and financial aid. According to Dean Kenneth F. Galloway, such financial help is critically needed by many Vanderbilt engineering students, who are often the first in their families to attend college.

I have witnessed firsthand our engineering students' overwhelming financial need," he says. "Forty-eight percent of our current undergraduates receive some form of financial aid. The dean's office chooses to use a significant portion of unrestricted gifts provided by Lewis Society members to increase financial aid packages and scholarships for these students. In many cases, this money is their only resource. Many students have approached our office in their sophomore or junior years unable to complete their engineering degree because of financial constraints or emergencies. The students are relieved and grateful for the assistance we can provide because of the generosity shown by the members of the Lewis Society."

Individuals may join the Lewis Society by making a five-year pledge of $5,000 or more or an annual unrestricted gift of at least $1,000. Junior alumni, who have been out of school less than 10 years, may become members by making an annual gift of $500.









The School of Engineering honored members of the Lewis Society at a gala dinner in February. Some of those who attended are featured in the photos on this page. **A** Showing off their Formula race car, which they built and will race in May, were Phil Davis, left, instructor, and students Angeline Cione, Karen Talla, Jay Bryan and David Livingston. **B** Senior David Brogan, a Marshall Scholar, addressed the gathering. **C** Graduate student Anthony Bray, right, discussed his engineering project with Terry Thomas, left, and Betsy Bibb. **D** Dean Lewis' daughter, Alice Lewis Henderson, left, attended the dinner with her husband, Dick Henderson, and sister-in-law, Bess Henderson. **E** David Bass, right, associate dean for development, with John Tipton, left, Michele Bass and Frances Tipton **F** Brent Kynoch, left, visited with Katy Anderson Sheesley, Steve Hays, and John Anderson. **G** Souby Scholarship holder Virginia Leigh Wahlig welcomed dinner guests. **H** Adams scholar Carrie Meade presented the Distinguished Alumnus Award to her benefactor Howell Adams Jr. **I** Scooter the robot served candy to David and Estelle Condra, while Joachim Schroeder, Hande Keskinpala, and Professor Mitch Wilkes looked on. **J** On hand to honor Howell Adams Sr., middle, were family members Howell Adams III, left, and his wife, Elizabeth, Madeline Reynolds Adams, and John Adams.

photos by David Crenshaw

Adams receives Distinguished Alumnus Award

Howell E. Adams Jr., retired owner and chief executive officer of The Georgia Trane Companies, received the 2003 Distinguished Alumnus Award at the Engineering School's annual Leadership Dinner in February (please see photos H and J at left).

Adams graduated in 1953 with a degree in civil engineering. After serving as an officer in the U.S. Naval Civil Engineer Corps, he worked for Westinghouse before joining The Trane Company in 1960. At Trane, a manufacturer of heating and cooling equipment, he served as sales engineer, dealer sales manager, general manager and finally Georgia franchise owner and CEO. He retired in 2000.

The Distinguished Alumnus Award recognizes distinguished achievement, significant service, excellent character, and a reputation that reflects well on the engineering profession and Vanderbilt. The honoree is chosen from nominations submitted by the Engineering Alumni Council and the faculty.

Adams' support of the school began in 1968, when he joined his brother Thomas E. Adams and sister Dabney Adams Hart in establishing the Crenshaw W. and Howell E. Adams Sr. Memorial Scholarship in memory of their parents. The scholarship is awarded to selected engineering undergraduates on the basis of merit.

An active participant in University activities ranging from chairing reunion to helping fund a Chancellor's Chair in the Department of Medicine, Adams and his wife, Madeline, were instrumental in the engineering building campaign. The new building's three-story atrium was named after the Adams family and was dedicated to the memory of Adam Gillespie Adams Jr. and his seven sons, all of whom attended Vanderbilt. Members of five generations of the Adams family have attended Vanderbilt. The 75th family member, Harris Oswalt Jr., is currently a freshman in the School of Engineering.

The son of a Vanderbilt engineer and the father of two Vanderbilt engineers (photo J), Howell Adams has served as a member of the Engineering Alumni Council and is a long-term member of the school's Lewis Society.

He and his wife, Madeline Reynolds Adams, A'56, (photo J) also donated to the Kappa Alpha Theta sorority building fund to memorialize their late daughter, Madeline, whose life was cut short by leukemia.

The Fred J. Lewis Society

The School of Engineering appreciates the generosity of the following members of the Fred J. Lewis Society

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Ms. Noel Brown Williams
Mrs. Barbara Burroughs Wilson
Mr. J. Lawrence Wilson
Mr. Lawrence A. Wilson
Mrs. Nancy Stackhouse Wilson
Mr. Samuel Fleming Wilt
Mr. Paul Walton Wojcik
Mr. Jack L. Wood
Mrs. Jean Acker Wright
Mr. Frank B. Wylie III
Mr. Charles E. Youman
Mrs. Faith A. Young
Mrs. Jane Wilkerson Yount
Mr. Thomas L. Yount Jr.

(This list is complete as of March 30, 2003)

Our brightest stars

These students, who are pictured on the back of this page, represent the many Vanderbilt engineering students who are helped by scholarships funded by Lewis Society members. They spoke to the Lewis Society Leadership dinner in February.

Carrie Meade, BE'03, (photo H), Soddy Daisy, Tenn.; computer science major; attended Vanderbilt on the Crenshaw W. & Howell E. Adams Memorial Scholarship her junior and senior years and the Engineering Scholars Scholarship her sophomore year; plans to work for TVA in Chattanooga, Tenn., as a power supply analyst:

"As a native Tennessean, I always looked at Vanderbilt with an admiration and a desire to attend this school. I wanted a well-rounded education that challenged my capabilities and Vanderbilt has been the school to make this happen. Vanderbilt has been a challenging environment, but I couldn't have done this without great support from the faculty and donors like Howell Adams."

Virginia Leigh Wahlig, BE'03, (photo G), Atlanta, Georgia; attended Vanderbilt on the A. Max and Susan Souby Scholarship in Chemical Engineering and the Lanier Scholarship; will earn a bachelor's and master's degree in chemical engineering in four years by finishing her thesis in August 2003; plans to work as a refining engineer with Marathon Ashland Petroleum, LLC, in Robinson, Ill.

"The educational and personal advantages afforded by my time at Vanderbilt have helped me to succeed in obtaining good job opportunities in a tight economy. I couldn't have done it without the assistance of my advisor, Professor Bridget Rogers. She is an excellent example of the effort that engineering faculty members make to reach out to their students."

David Micah Brogan, BE'03, (photo B), San Antonio, Texas; biomedical engineering; Marshall Scholar; attended Vanderbilt on full scholarship (please see related article on page 6).

"I'm grateful for the work that I did with Professor of Biomedical Engineering Robert Galloway that focused my interest on image-guided surgery. Vanderbilt is one of the leaders in the field. The Marshall Scholarship will afford me the opportunity to continue and enhance my research in a unique setting while receiving a great new perspective."