Mission: IMPERATIVE

Vanderbilt Projects Reduce Hazards of Space Travel

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

**Research Funding Up**

A ssociate Dean for Research Don Fawthrop 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 $14.5 million research dollars in the first half of fiscal year 2003. That figure is 47 percent more than the $8 million received at the halfway point of the previous fiscal year, which was also a record-breaker.

The total has continued into the third quarter of the year; by mid-October, the school had received more than $23.5 million. That figure eclipsed last year’s total of $13.9 million in new awards by more than $1 million. “The expansion of our research program greatly benefits our students, undergraduates, and graduate students,” Dean Fawthrop said. “Increasing research activity because it is a reality, adds more to our revenue pool, attracts better and more visible engineers, and strengthens the educational program.”

There are many reasons for the increase, he said. “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 getting noticed. Also, the School of Engineering is gaining national visibility.”

Other NASA-Sponsored Research

**Mission:** IMPETUS and main motor component of the solid rocket booster skirt. His team is studying the problem of reusable solid rocket boosters being damaged by splashdown in the ocean after separation from the booster during its ascent. He and his team are continu- ing to work on next-generation reusable launch vehicle design methods and are applying reliability and optimization techniques to integrate multiple physical factors such as structures, aerodynamics, propulsion, mass and geometry.

Rad-Hard Computers

Tiny computer circuits are especially vulnerable to the abundant radiation in space, sometimes causing critical data to be lost or even failing catastrophically. This vulnerability is miniaturized as microelec- tronic devices get smaller.

Vanderbilt’s Institute for Space and Defense Electronics, the latest in the line of its kind in the United States, is studying the performance of advanced integrated cir- cuit systems in space. The institute’s team includes John Schmếp, professor of electrical engineering, Lloyd Blasingmire, professor of computer engineering, Don Fawthrop, associate dean for research and professor of electrical and computer engineering; Tim Holman, research associate professor of electrical engineering; and Will Wallin, associate professor of electrical engineering and materials science and engineering; and Ken Galloway, dean and professor of electrical engineering. They are pion- eering techniques to make “rad-hard” devices for use in space electronics.

“Rad-hard” techniques strengthen the resistance of integrated cir- cuits to damage from radia- tion, using improved circuit designs, rearranged structural layout of the circuits, altered thickness of the materials, changed sequence of manufacturing processes, increased radiation hardness during testing, and the use of semiconductor devices that can function under more severe conditions.

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

**CIVIL AND ENVIRONMENTAL ENGINEERING**

A ssociate Professor Randy W. West was named an Institute Fellow by the Academy of Achievement for his contribution to research and national policy through leadership and innovative research on water resource systems. His work focuses on the application of economic theory to the valuation of water resource systems.

Research Funded by

**Civil and Environmental Engineering**

Dr. Justin B. Lipton, assistant professor of civil, structural and environmental engineering, has been awarded a $1.5 million grant from the National Science Foundation to study how geophysical forces such as earthquakes and tsunamis affect the safety and reliability of coastal structures.

Dr. Lipton’s research will focus on developing a new model for predicting the structural response of coastal structures to geophysical forces. The model will be validated using data from past earthquakes and tsunamis, and will be used to assess the potential for future failures of coastal structures.

This research is funded by the National Science Foundation through the Civil and Environmental Engineering Research Program (CERF) and the Civil and Mechanical Engineering Division (CMED). The project will be conducted in collaboration with the College of Engineering and the Department of Civil, Structural, and Environmental Engineering at Vanderbilt University.

Dr. Lipton’s research is expected to have significant implications for the design and construction of coastal structures, as well as for the development of new methods for assessing the safety and reliability of existing structures.

**Mechanical Engineering**

Professor Arthur L. Fleischer, chair of the Mechanical Engineering Department, has been awarded a $1.5 million grant from the National Science Foundation to study the behavior of materials under extreme conditions.

Professor Fleischer’s research will focus on developing new materials and processes for use in advanced technologies such as aerospace, energy, and medicine. The project will involve the development of new materials with enhanced properties, such as increased strength and durability, and will be conducted in collaboration with other institutions and industries.

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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 difficulty 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 teaching a robot to do something from different directions and at different speeds is tremendous. The tasks involved in making physical pieces of equipment obey abstract commands.

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

Graduate student manages one of nation’s top humanoid labs

“We can leave Armstrong where he is,” Tanama Rogers decides, surveying the laboratory array of “Armstrong” and “Octavia,” her two most respected humanoid robots. “I will want to move Mars.”

Rogers, lab manager for the Robotics Laboratory at Vanderbilt, is interrupted out loud about how to best rearrange the equipment to fit the new computer arbors. Her plan involves incorporating more robots, since the technology systems will enable her lab to best 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) robots.

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 other either of them are low levels of anxiety or engagement. “This is the really big one,” says Smith.

For more information about this and other exciting engineering research, please visit Vanderbilt’s on line research journal, Exploration, at http://exploration.vanderbilt.edu/ news/ill.
Alumnus develops coating to protect engines

Like most Americans, Timothy Mecklenburg was deeply disturbed by the Columbia space shuttle tragedy. But as a NASA supplier, he had professional concerns about the disaster, as well. As a Vanderbilt undergraduate and graduate student, Mecklenburg, MS'85, PhD'87, worked in the mechanical and materials engineering group under the direction of Professor James Watt 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, Mecklenburg went to work for the Rockwell-Collins Division of Rockwell International, manufacturers of the space shuttle’s main engines. “They have turned out to be an engine, and that is a very different perspective,” he says. While working for Rockwell-Collins, Mecklenburg realized that the processes they were developing had applications that went much wider than the space shuttle. In 1994 with two other engineers, he formed a company called Plasma Processes, Inc., which NASA hired to develop coatings for its rocket engines, military and space projects. Plasma—“the fourth state of matter—is ionized gas superheated to 10,000 K. Coating materials are injected into the plasma as a powder or solid, accelerated through a nozzle, and onto the object, which Plasma Processes has patented—and applied to a surface. “The process creates a powerful bond between the coating and the surface,” says Mecklenburg, “more powerful than any other methods of application.” Plasma Processes applies coatings to produce a variety of results: to prevent wear (like bearings), corrosion and oxidation, or to provide heat and electrical protection. The company can, in some cases, build damaged parts. At the moment, NASA is their biggest customer. Using Plasma Processes, the agency turned damaged parts for its assistance after World War II. He credits work that he has done with Professor Robert Gallion in biomedical engineering with focusing his interest on image-guided surgery.

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. The son of John and Mary Brogan, he attends Vanderbilt on full scholarship. He is the recipient of a Tau Beta Pi Scholarship, Robert Byrd Honor Scholarship, Honors 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.

Philips plans to use her scholarship to pursue a master of philosophy in business enterprise, the key to conduct research in orthopedics at Cambridge, focusing on lower-limb and knee joint disorders. Philips presents her current study at St. Andrew’s University in Scotland—through the Vanderbilt study-abroad program—efforts to bring the different learning styles of her fellow classmates from around the world. Often finding herself the lone American in small research groups, Philips was able to locate like-minded international collaborators.

“While at Cambridge,” she will take advantage of the wealth of experience that both the university and the United Kingdom have to offer, “I would like to thank Vanderbilt and international collaborations.

Despite her high-level executive position, Zelickson has maintained an active family and community life. “I would like for them to value the same opportunities that I was able to pursue as a student at Vanderbilt,” she says. “I would like for them to have the same concentration on lower-limb and knee joint disorders. I would like for them to have the same dedication to their work that I was able to bring 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 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. I offered me 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 years 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 swiftly up through the ranks. She is now program director in charge of 500 program engineers and scientists in the civil engineering division, managing design and development of advanced products like those that supported the development of the Voyager Spacecraft and those that supported the development of the Voyager Spacecraft and those that supported the development of the Voyager Spacecraft and those that supported the development of the Voyager Spacecraft.

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 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.”

—Leo Harris

Vanderbilt students targeted for international scholarships

A

ccording to some predictions, the U.S. could suffer a shortfall of as many as 500,000 engineering and science graduates by 2010. Many colleges and universities across the country are looking for ways to broaden the appeal and generate creative teaching strategies to reach and cultivate engineers, mathematicians and scientists from traditional demographics. The Vanderbilt School of Engineering and College of Arts and Science are part of a nationwide effort to recruit and retain qualified minority undergraduates from several colleges in Tennessee. The School of Engineering will also accept any part in a summer bridge program for incoming freshmen engineering majors who are members of underserved demographic groups. The program will acclimate them to Vanderbilt and help them develop the confidence and understanding to succeed.

“Vanderbilt is one of the leaders in the country in terms of minority recruitment efforts, not only in Tennessee but around the country,” says Assistant Dean John G. Warner. “Vanderbilt joins Tennessee consortium to recruit and cultivate minority engineering undergraduates

Wanted: 560 thousand future scientists, engineers

Vanderbilt joins Tennessee consortium to recruit and cultivate minority engineering undergraduates

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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 post-doctoral 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

Creativity + Practicality = Engineering

People who enjoy engineering are creative and yet enjoy making things work, making things happen in the real world. It’s a nice combination.”
Adams received Distinguished Alumnus Award

H
oover E. Adams Jr., retired owner and chief executive officer of The Georgia Company, received the 2003 Distinguished Alumnus Award at the Engineering Society’s annual Leadership Dinner in February (please see photo H and i to left).

Adams graduated in 1953 with a degree in civil engineering. After serving as an officer in the U.S. Civil Engineer Corps, he worked for Westinghouse before joining The Georgia Company in 1961. 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 2004.

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

Adams’ support of the school began in 1969, when he joined his brother Thomas E. Adams and sister Dorothy Adams in establishing the Crenshaw W. and Howel E. Adams Sr. Memorial Scholarship in memory of their parents. The scholarship provided financial aid for students in need. Adams graduated in 1946 with a degree in chemical engineering. After serving as a four-year with the U.S. Navy, he joined W.R. Grace & Co., where he first worked as a technical sales representative for chemical products. He later moved to sales management positions in chemical products and engineering services. In 1968, he joined The Georgia Company as a member of the executive committee. He retired in 2000.

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