VANDERBILT UNIVERSITY SCHOOL OF ENGINEERING

RESEARCH REPORT 2008

From Dean Kenneth F. Galloway

By nature, engineers are more interested in the present and the future, rather than taking a backward glance at the past. But the past is our definition. It shapes us. We cannot erase the past merely because it does not fit the present.

At Vanderbilt in 1874 engineering was announced to be a school within the academic department of philosophy, science, and literature. In 1879 the first professor of civil engineering was employed and classes began in drafting, surveying, applied mechanics, structures, water supply, sanitary engineering, and mechanical power. That year, we became the first private engineering school established in the South.

One year later, engineering was divided into three schools: civil, mechanical, and mining. In 1893 the first engineering course in electricity was introduced but electrical engineering was not established until 1922. Chemical engineering was created in 1903, a joint project of engineering and chemistry. It was around this time that engineering became, in fact, a School, and schools became departments. Biomedical engineering began in the mid-'60s as a research option available to chemical, electrical, and mechanical engineering graduate students. The mid-'60s also sparked a program in environmental engineering, which is now a critical element of the department of civil and environmental engineering.

From one graduate in 1880 to 431 graduates in 2008, it has been a long road. Ironically, the struggle for funds both internally and externally, and the challenges that come with growth, endure. One thing remains constant: seeking and keeping the best faculty and the brightest students.

It has been said that research keeps changing but the education system stays the same. This implies the past impedes us if we cling to it. We don't hold onto the past, but we are formed by it. With a backward glance, all the rich stories of the teachers and learners who came before us inspire agility and change. We take pride in adapting our engineering education for the present, and the future.

In the 2008 edition of *Insight Innovation Impact*, our annual research report, you will learn more about some of our young researchers and their work. You will see, once again, evidence of the extraordinary work done in the Vanderbilt University Institute of Imaging Science, one of the most highly regarded research groups in the world in the area of biomedical imaging, founded on a partnership among the School of Engineering, the College of Arts and Science, and the School of Medicine. You'll see a department name change—chemical and biomolecular engineering—to more accurately characterize the faculty's research interests and adapt to our students' growing interest in everything bio.

More and more, the efforts of our faculty and students are gaining national and international attention. It is a pleasure to give this important work more visibility in *Insight Innovation Impact*.

We take pride in adapting our engineering education for the present, and the future.

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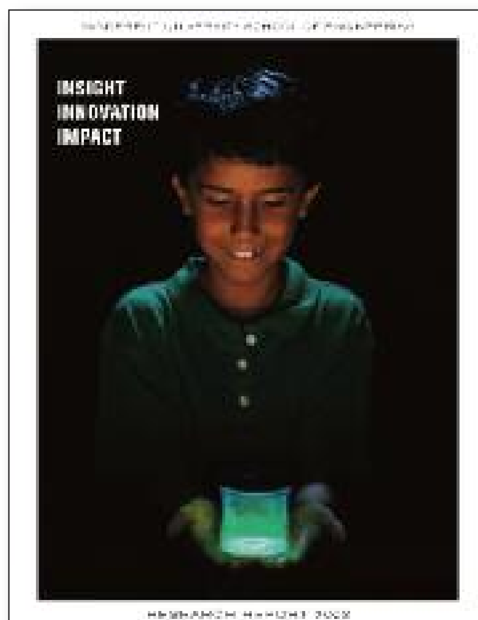


Thermographic phosphors glow under ultraviolet stimulation.

Related story on page 12

Symposium considers issues in nuclear waste management

The School of Engineering hosted in early 2008 a symposium—*Uncertainty in Long-Term Planning: Nuclear Waste Management, a Case Study*—to address, among other issues, a mandate from American courts to the federal government to ensure the safe disposal of high-level nuclear waste for one million years.

Speakers included Edward "Ward" F. Sproat III, director of the U.S. Department of Energy's Office of Civilian Radioactive Waste Management; Thomas B. Cochran, a senior scientist in the Natural Resources Defense Council's nuclear program; E. William Colglazier, executive officer of the National Academy of Sciences; Charles W. Powers, professor of environmental engineering; and David S. Kosson, chair of civil and environmental engineering and professor of civil and environmental engineering and of earth and environmental sciences, Vanderbilt School of Engineering. Other speakers included representatives from industry, public health, law and ethics, as well as international experts from Japan, Sweden, and Canada.

"The likely future reliance on nuclear materials for defense, energy, and other uses requires a forward-looking, sustainable approach," said Kosson, who proposed ongoing honest communication and public education regarding the risk of nuclear waste, as well as public/private partnerships, stable government financing, and consistent policy.

Despite the fact that the images and dangers the public associates with all things nuclear exacerbate the debate, the panel agreed the issue of nuclear waste management must be resolved, especially in light of today's escalating demand for energy.

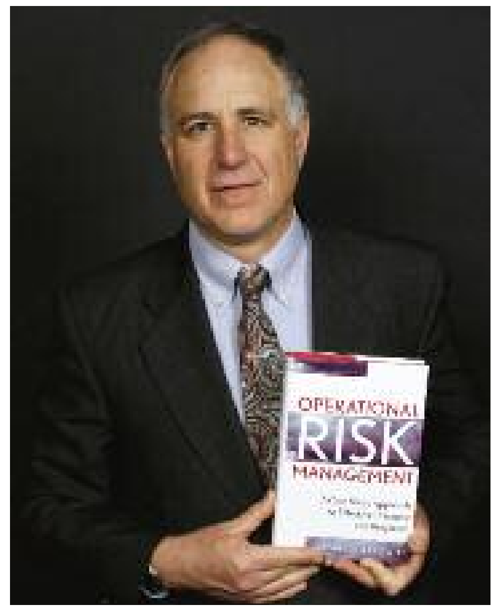
The two-day event in January honored Frank L. Parker, Distinguished Professor of Environmental and Water Resources Engineering. He has led a number of major international studies of nuclear waste issues for the U.S. National Academy of Sciences, the International Atomic Energy Agency, the Royal Swedish Academy of Sciences, and the International Institute for Applied Systems Analysis, among others. (See page 16)

Managing risk in an increasingly hazardous world

Risk managers are likely to find a new book written by Mark D. Abkowitz, professor of civil and environmental engineering, an important disaster manual to keep close at hand.

In *Operational Risk Management*, Abkowitz, a risk management expert, uses 15 case studies to examine risk from worldwide disasters from three perspectives: natural disasters, man-made accidents, and terrorist acts.

The book, published earlier this year, identifies 10 basic risk factors that underlie various catastrophes, even those as different as major oil spills and devastating tsunamis, September 11 and space shuttle accidents. It also includes two success stories where major disasters were averted through careful planning, extraordinary communication, and teamwork.



Mark D. Abkowitz

The motivation for the book came from a course on risk management Abkowitz has taught for the past six years. In class, students research and analyze specific disasters. As a result of applied hindsight, Abkowitz concludes that we can do a significantly better job of managing risk if we take an "all hazards" approach and focus on controlling the 10 risk factors he has identified.

"We have given responsibility for man-made accidents, intentional acts, and natural disasters to different organizations. Each group has its own resources and priorities with only limited coordination despite the fact that these different categories of risk share many of the same risk factors and outcomes."

There are a number of simple things we can do that would substantially increase our safety, Abkowitz said. Risks can be managed when steps are taken to prevent or mitigate them.

Faculty join group to research and fight climate change

Douglas Fisher, associate professor of computer science and computer engineering, and James Clarke, professor of civil and environmental engineering, are members of a diverse group of experts at Vanderbilt University who have created the Climate Change Research Network.

The network combines researchers from earth and environmental sciences, political science, law, engineering, business, management, economics, and nursing to investigate one of the most important and most widely overlooked sources of greenhouse gases: individual behavior.

James Clarke

The interdisciplinary team conducts research to understand the magnitude of the contribution from individuals and households. A goal is to identify the legal, economic, and social responses that can generate effective, low-cost emissions reductions by individuals and families in their everyday lives.

The network is in the early stages of creating a global network of researchers to help answer policymakers' questions.

Douglas Fisher

Faculty members receive CAREER awards

Two Vanderbilt engineering professors have received prestigious National Science Foundation Faculty Early Career Development (CAREER) Program awards, bringing the number of Vanderbilt recipients to seven in 24 months. That achievement puts the School of Engineering among the NSF's top award recipients nationally.

William Robinson

William H. Robinson, assistant professor of electrical engineering and computer engineering, and Sharon M. Weiss, assistant professor of electrical engineering and physics, each will receive $400,000 over five years to support their research.

Robinson is working on improving the reliability of integrated circuits used in avionics and space applications, as well as in enterprise servers, network routers, and control systems.

Weiss is investigating methods to achieve faster and more accurate detection of biological and chemical materials by using portable porous silicon waveguides. This work has impact in medical diagnostics, environmental monitoring, and homeland security.

Sharon Weiss

Todd D. Giorgio

New Chair, Todd Giorgio

Todd Giorgio, a professor of biomedical engineering and professor of chemical engineering, is the new chair of the Department of Biomedical Engineering. Giorgio is a Fellow of the American Institute for Medical and Biological Engineering (AIMBE) and a professional engineer. He is a researcher at the Vanderbilt-Ingram Cancer Center, where he has contributed new ideas to the treatment of cancer through his work on the disease at the cellular and molecular levels. Giorgio joined the Vanderbilt faculty in 1987. He earned his doctorate in chemical engineering from Rice University.

RESEARCH HIGHLIGHTS

Medical Imaging

Intracellular Engineering

Biomedical Optics

Biomaterials & Tissue Engineering

BIOMEDICAL

LEADERSHIP GAUGE

IEEE Fellows–Professors ***Robert L. Galloway*** and ***John P. Wikswo***

National Institutes of Health: Medical Imaging Study Section–Associate Professor ***Anita Mahadevan-Jansen***

Magnetic Resonance Imaging Journal Editor-in-chief–Professor ***John C. Gore***

National Institutes of Health: Neurotechnology Study Section–Associate Professor ***Adam Anderson***

NIH 4-year grant: The Biological Basis of Diffusion MRI of the Brain–Associate Professor ***Adam Anderson***

President-Elect, American Society for Laser Surgery and Medicine–Professor ***Duco Jansen***

2007 William Elgin Wickenden Award for an article in the *Journal of Engineering Education*–Professor ***Robert J. Roselli***

Director, National Science Foundation Engineering Research Center in Bioengineering Educational Technologies–***Thomas R. Harris***, MD, professor of biomedical engineering

Molecular imaging offers more complete assessment of cancer biomarkers' development, treatment

A priority for the Institute of Imaging Science was realized this year with the award of a five-year, $2.2 million federal grant in 2007 to apply new imaging techniques for studying cancer in small laboratory animals, said John C. Gore, biomedical engineering professor and the institute's director.

The grant, from the National Cancer Institute (NCI), establishes the South-Eastern Center for Imaging Animal Models of Cancer. Vanderbilt also will join and collaborate with 12 other centers in the NCI's Small Animal Imaging Resource Program.

Over the past three years, the National Center for Research Resources (NCRR), part of the National Institutes of Health, has provided $9.5 million to the institute for purchase of equipment. Recent NCRR grants include $2 million for a 7 Tesla scanner and $500,000 for a microSPECT system.

Small-animal imaging has been a priority of the institute since 2002, when Gore was recruited from Yale University to establish it. "We have a very active and expert group of people in the [Vanderbilt-Ingram] Cancer Center and other departments who are doing animal imaging," he said.

DANA JOHNSON

John C. Gore

Small animal models, notably genetically engineered mice, are increasingly important "discovery tools" in cancer research.

"With molecular imaging techniques you can do [studies] non-invasively and sequentially in the same animal," said Gore.

"In fact, [you can] do multiple types of measurements… It's a more comprehensive and complete assessment of biomarkers of cancer development and treatment response," Gore said.

Examples include:

• Development of novel molecular imaging agents to study spontaneously arising tumors of the colon in mice in a high-throughput and non-invasive way;

• Use of new techniques, including dynamic contrast-enhanced magnetic resonance imaging (MRI) and microbubble contrast-enhanced sonography to determine the effect of novel therapies on the formation of new tumor blood vessels; and

• Application of microCT (computed tomography), microPET (positron emission tomography) and microSPECT (single-photon emission computed tomography) to monitor breast cancer metastasis in mice.

Other centers in the NCI's Small Animal Resource Program are the University of Arizona, the University of California at Davis and at Los Angeles, Case Western Reserve University, Duke University, Johns Hopkins University, Massachusetts General Hospital, Memorial Sloan-Kettering Cancer Center, the University of Michigan, the University of Pennsylvania, Stanford University, and Washington University in St. Louis.

Small animal MRI methods

Associate Professor Mark Does is the primary investigator in a set of research projects to develop and evaluate several MRI methods on a small animal MRI system. The objective is to use MRI to look at specific characteristics of tissue, such as the cells of tumors. His current projects include the optimization of MRI pulse sequence for small animal cardiac imaging.

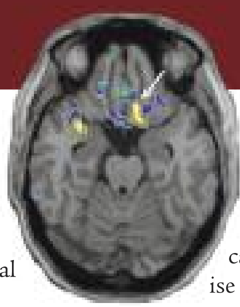
Mark Does

Nanobiotechnology and nanomedicine

Vanderbilt's Intracellular Engineering lab develops core technologies based on the unique properties of nanomaterials to significantly impact the future of medicine. With support from DOD and NIH, lab co-directors Todd Giorgio and Rick Haselton lead a team that develops and tests novel nanoparticle designs for applications such as rapid detection of virus in a clinical sample, early-stage detection of cancerous cells, identification of atherosclerotic plaques, and rapid detection of hospital pathogens.

Rick Haselton

Imaging the future



The Institute of Imaging Science—one of the most highly regarded research groups in the world in the area of biomedical imaging—is a transinstitutional initiative founded on a partnership between the School of Engineering, College of Arts and Science, and the School of Medicine.

Housed in a new 42,000-square-foot building, the institute is comprised of four floors of research, office and classroom space, three powerful magnets for conducting MRI studies in animals, and a 7 Tesla scanner—among the world's most powerful—for use in humans.

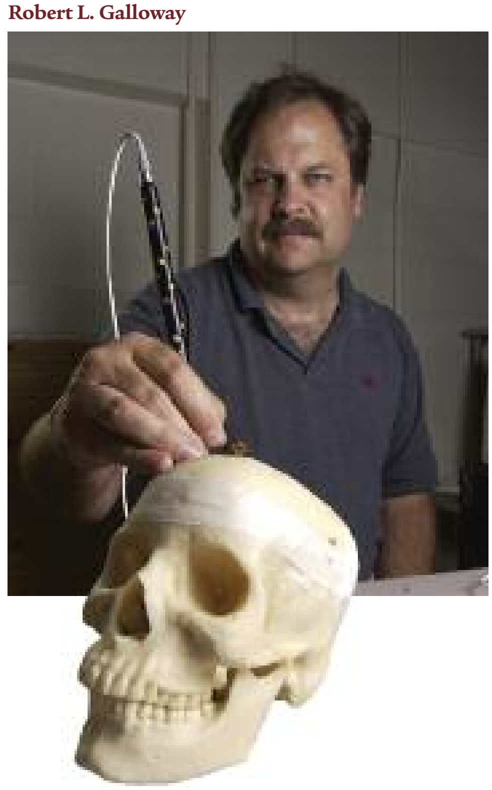
The Institute of Imaging Science conducts research using every major biomedical imaging modality (MRI, nuclear, X-ray, ultrasound, and optical imaging), and it has special expertise in the applications of imaging in the neurosciences, in cancer research, and in metabolic imaging.

For example, functional and structural magnetic resonance imaging techniques at high field strengths are used extensively to study the organization and architecture of the brain. Additional research areas include molecular and cellular imaging, cardiovascular imaging, image processing and analysis, and basic studies in the physics of imaging and spectroscopy.

Technology-Guided Therapy

Robert L. Galloway is helping surgeons more accurately pinpoint the location of tumors in tissues otherwise difficult to differentiate visually, such as in the brain and the liver. Interactive surgical guidance devices combine intraoperative tracking of surgical position and orientation with preoperative mapped scans, giving surgeons a view of where their surgical tools are within the body. These devices may be optically tracked using infrared light, magnetically tracked for non-line-of-sight application, or may be surgical robots. Galloway, a biomedical engineering professor, is director of the Center for Technology-Guided Therapy.

Robert L. Galloway



Adult stem cells aid fracture healing

In an approach that could become a new treatment for people whose broken bones fail to heal, Vanderbilt researchers have helped show that transplantation of adult stem cells can improve healing of fractures.

Cells taken from the bone marrow of mice that produce luciferase, the same molecule that allows fireflies to glow, were engineered to express a molecule called insulin-like growth factor 1 (IGF-1). IGF-1 is a potent bone regenerator necessary for bones to grow both in size and strength.

Using a computerized tomography (CT or CAT) scan, biomedical engineering researchers Michael Miga and Jared Weis showed that stem cells not only migrated to the site of the fracture, but also improved healing thereby increasing the bone and cartilage that bridged the bone gap. The bone at the fracture site in treated mice was about three times stronger than that of untreated controls.

Michael Miga

Miga and Weis are part of a team led by Dr. Anna Spagnoli, associate professor of pediatrics and biomedical engineering at the University of North Carolina School of Medicine and senior author on the study.

The study, presented June 16, 2008, at the annual Endocrine Society meeting, is the first to visualize the action of transplanted adult stem cells as they mend fractures in mice. If scientists can duplicate the results of this animal study in humans, it may lead to a new safe and effective treatment to improve bone healing.

A solar cell inspired by photosynthesis

Kane Jennings

Kane Jennings, associate professor of chemical and biomolecular engineering, and his collaborators are developing a solar cell inspired by nature's solar energy conversion process—photosynthesis.

The team extracts a key photoactive protein complex from spinach cells and assembles the 10 nanometer proteins into films on an electrode. When light strikes the film, electrons are transferred from one side of the protein to the other, and can then be captured and routed to a separate electrode to produce a current.

Unlike current expensive photovoltaics, the chief component in this solar cell literally grows on the ground, is biodegradable and non-toxic, said Jennings, who believes solar energy is the only alternative energy with the capacity to meet the world's long-term energy needs.

The research could lead to mass-produced solar cells that are economically accessible to poor countries.

RESEARCH HIGHLIGHTS

Energy and envirochemical engineering

Metabolic and molecular engineering

Biomaterials

Absorption and surface chemistry

CHEMICAL AND

LEADERSHIP GAUGE

2007 American Institute of Chemical Engineers Nanoscale Science and Engineering Forum Award—***Peter T. Cummings***, John R. Hall Professor of Chemical Engineering

Fellow, American Association for the Advancement of Science—Professor ***Peter T. Cummings***

Fellow, Royal Society of Chemistry (UK)—Associate Professor ***Clare McCabe***

Jacob Wallenberg Foundation Fellowship—Associate Professor ***Clare McCabe***

President, North American Membrane Society—Professor ***Peter Pintauro***

International Congress on Membranes and Membrane Processes 2008—Fuel Cells—Professor ***Peter Pintauro***

Director, American Vacuum Society—Associate Professor ***Bridget R. Rogers***

Program Chair, 55th AVS International Symposium (Oct. 2008)—Associate Professor ***Bridget R. Rogers***

Alternate Councillor, American Chemical Society, Division of Colloid and Surface Science—Professor ***Paul E. Laibinis***

Regenerative technology for injured military patients

An emerging biologic product has the potential to offer bone reconstructions to the heads and faces of military patients suffering from difficult blast and gunshot injuries, and speed skeletal healing.

A moldable composite of allograft bone—human bone obtained from a tissue bank—and a biodegradable polyurethane is being developed by Scott A. Guelcher, assistant professor of chemical and biomolecular engineering, in collaboration with Professor Jeffrey Hollinger of Carnegie Mellon University.

Guelcher believes these novel resorbable polyurethane/allograft materials can be used in a variety of mechanically challenging or property-critical applications.

Osteotech, Inc., a global leader in the processing of human bone and connective tissue for transplantation, is developing the technology into a commercial product as part of its Plexur composite technology platform.

"There is a compelling clinical need for a resorbable biomaterial that has the appropriate biomechanical and biological properties for fracture reduction and reconstruction, and that integrates with host bone," Guelcher says.

The research is part of a $43.5 million Department of Defense collaborative grant from the Armed Forces Institute of Regenerative Medicine (AFIRM).

Scott A. Guelcher

Name change reflects department's strength, students' interests

Last year the chemical engineering faculty proposed that the department's name be changed to Department of Chemical and Biomolecular Engineering. The dean accepted the recommendation and the name changed July 1, 2008.

The addition of *biomolecular* to the department's name more accurately characterizes the research and teaching being done by the chemical engineering faculty, where two-thirds of the professors are currently performing bio-related research. The name change also recognizes that the discipline of chemical engineering has evolved over the last few decades to include biology as a foundation science.

The department's students show a strong interest in the biomolecular sub-discipline of chemical engineering. More than half of the undergraduate class of 2005 and one-third of the 2006 graduating class completed the requirements of the department's biotechnology concentration. Approximately 80 percent of our current sophomores have indicated an interest in biotechnology. The department's undergraduate curriculum now includes required courses in molecular biology and bioprocess engineering. Half of our entering graduate students for 2008 indicated an interest in the biomolecular area for their dissertation research.

New Chair, Peter N. Pintauro

Nationally recognized for his work in the field of fuel cell membranes and electrochemical engineering, Peter N. Pintauro joins the School of Engineering as chair of the chemical and biomolecular engineering department.

Pintauro, who has won numerous awards for teaching and research, also will serve as professor of chemical engineering, teaching classes at both the undergraduate and graduate levels.

He is a member of the American Institute of Chemical Engineers, the Electrochemical Society, the American Chemical Society, and is president of the North American Membrane Society.

Pintauro earned a B.S. degree at the University of Pennsylvania and his Ph.D. in chemical engineering at the University of California, Los Angeles. After receiving his Ph.D., Pintauro served as a postdoctoral scholar and staff engineer in UCLA's chemical engineering department. From 1986 to 2002 he was a chemical engineering professor at Tulane University in New Orleans. In 2002 Pintauro joined Case Western Reserve University.

Peter N. Pintauro

BIOMOLECULAR

New faculty

Jamey Young

Jamey Young joins the department of chemical and biomolecular engineering as an assistant professor after completing postdoctoral work at MIT. Young's research focus is metabolic engineering and systems biology with applications to diabetes, obesity, metabolic disorders, and tumor metabolism.

His lab is developing methods that will use stable isotope tracers and mass spectrometry to study in vivo metabolism at fine resolution. This work involves computational analysis of isotope labeling data to quantify mammalian physiology under both normal and pathological conditions, thereby providing insight into the metabolic changes that occur in type 2 diabetes and other complex diseases. He received a Ph.D. in chemical engineering from Purdue University and a B.S. in chemical engineering from the University of Kentucky.

Students awarded NSF Graduate Research Fellowships

Senior Steven Elliot and chemical engineering alumna Shannon Capps have been awarded NSF Graduate Research Fellowships. The program provides students with three years of funding—up to $121,500—for research-focused master's and doctoral degrees in science, technology, engineering, and mathematics (STEM) fields. Capps is currently pursuing her Ph.D. in chemical engineering at Georgia Tech and Elliot is entering the chemical engineering Ph.D. program at MIT.

Simulation forecasts the spread of cancer

A multidisciplinary effort led by Vanderbilt engineers and physicians to develop a computer simulation that predicts the growth of malignant tumors offers new hope to cancer patients.

Imagine watching a dot on a computer screen grow into a mass and then sprout finger-like tendrils. This simulated image of a tumor's spread is a tool that could lead to successful, personalized treatment plans that make a real difference in outcomes for cancer patients.

"What is happening in biology is similar to trends seen in recent decades in the physical sciences," said Peter T. Cummings, John R. Hall Professor of Chemical Engineering, who is an expert in computer simulation.

"Computational models like this, in which complex behavior emerges from computer simulations grounded in understanding phenomena at a smaller scale, have been a staple of chemistry, physics, and related engineering disciplines for a long time."

In those disciplines the smaller scale is the single atom or molecule. "In the case of the cancer invasion model, the smaller scale is the single cell, for which our experimental collaborators can measure many properties—how it moves, how it responds to its environment, how it mutates," Cummings said.

Cummings and Vito Quaranta, professor of cancer biology, have developed a complex computational model—a series of mathematical equations—that suggests the microenvironment around tumor cells determines the tumor's ultimate cellular makeup and invasive potential.

Current chemotherapy approaches, which create a harsh microenvironment in the tumor, may leave behind the most aggressive and invasive tumor cells. And there is anecdotal evidence, said Quaranta, to support the idea that changes to the microenvironment result in a tumor with more or less invasive potential.

Cummings, Quaranta, and their associates at the University of Dundee in Scotland worked with a highly interactive group of cancer biologists, bioengineers, imaging scientists, computational biologists, and mathematicians to develop the model. It is sophisticated enough to begin capturing tumor behavior without being so complicated that computing power and running time for simulations become limiting.

Experimental work has begun to provide realistic values for most cellular parameters in the models. Simulations have produced novel and counterintuitive outcomes that are being tested. For example, the team is beginning to quantify how anti-cancer drugs may affect progression of specific tumors.

The project is funded by $15 million from the National Cancer Institute and the National Institutes of Health.

Peter T. Cummings

Long-life concrete

The focus of civil and environmental engineering professor Florence Sanchez's research is in the long-term durability of cement-based materials during environmental weathering.

She looks for ways to strengthen concrete (cement mixed with aggregate) by adding randomly oriented fibers ranging from nanometers—roughly the size of four atoms—to micrometers in length and made of carbon, steel, or polymers. Nanofibers made of carbon, for example, might be added to a concrete bridge, making it possible to heat the structure during winter or allowing it to monitor itself for cracks because of the fibers' ability to conduct electricity.

Florence Sanchez

Sanchez is in the second year of a four-year NSF CAREER Award grant that supports testing decalcified cement in a variety of ways—including thermal analyses, infrared spectroscopy, and electron microscopy—to analyze chemical reactions.

RESEARCH HIGHLIGHTS

Reliability analysis and engineering

Environmental engineering and risk management

Intelligent infrastructure systems

Construction project management

CIVIL AND

LEADERSHIP GAUGE

Nuclear Regulatory Commission Distinguished Service Recognition Award—Professor ***James H. Clarke***

Member, Nuclear Waste Technical Review Board (Presidential appointment)—Distinguished University Professor ***George M. Hornberger*** and Professor ***Mark D. Abkowitz***

President, Hydrology Section, American Geophysical Union, 2006–2008—Distinguished University Professor ***George M. Hornberger***

American Society of Civil Engineers Outstanding Professional Service Award—Professor ***Sankaran Mahadevan***

International Director of the Institute of Transportation Engineers, Southern District—Professor ***Robert E. Stammer Jr.***

Speaker, Eighth Annual Nanoscience and Nanotechnology Forum—Assistant Professor ***Florence Sanchez***

Member, Advisory Committees for the National Academy of Sciences/ National Research Council on the U.S. Program for Demilitarization of Chemical Weapons—Chair and Professor ***David S. Kosson***

FAA project: Uncertainty, reliability, and risk

The School of Engineering is leading a Federal Aviation Administration initiative to apply and expand aging aircraft reliability techniques to helicopters. The researchers believe much of what is learned will have a strong impact on design methods and risk management, and could be applied to other types of aircraft.

In the second year of a five-year, $1.5 million project, principal investigator Sankaran Mahadevan, professor of civil and environmental engineering, said this research differs from earlier studies on helicopter damage tolerance in that it incorporates uncertainties in geometry, material behavior, initial flaw distribution within rotorcraft components, and mission operations.

Mahadevan's team is working with subcontractor Bell Helicopter Textron Inc. of Fort Worth, Texas. Bell Helicopter—which produces a wide range of commercial and military helicopters—is contributing data about helicopter components and materials, as well as how defects grow in size. The company also will advise the engineering researchers on useful and practical demonstration problems with which to test the new analysis techniques.

"In addition to needing information about the materials, we need better understanding of how the entire structure of a helicopter functions under a variety of performance requirements," said Mahadevan.

Sankaran Mahadevan

"The margin for error in flying a helicopter, especially in rescue missions, is very slim. We want to make sure helicopter pilots don't have to deal with equipment failure, such as metal fatigue, on top of the challenges of shifting winds, unseen obstacles like power lines, and space limitations of maneuvering in tight spots."

Lighter materials can translate into fuel economies, but the industry needs more data on how these new materials will perform over time, he said. "We are helping to develop that knowledge base, which will guide recommendations on rotorcraft design as well as maintenance schedules."

The team's research will help predict the materials' behavior throughout the life of the rotorcraft using various computer models, including computer simulation and probability software.

In addition to providing a risk and reliability foundation for helicopters, the research team will refine and expand computing methods. Mahadevan's group has been successful in developing models for complex fatigue and fracture, which have shown excellent performance for a wide variety of materials, but this is the first time they are being applied to helicopter components and materials.

Mahadevan received the Outstanding Professional Service Award from the American Society of Civil Engineers in March 2008 for sustained service to the Aerospace Division over the past two decades. He has been elected to serve as General Chair of the 51st Structures, Structural Dynamics, and Materials Conference jointly organized by AIAA, ASME, and ASCE, in May 2010.

Testing contaminated soil to determine groundwater risks, treatment

Professors Andrew C. Garrabrants, Leslie Shor, and David Kosson are testing soils already treated to reduce hazardous and volatile organic chemicals like polyaromatic hydrocarbons (PAHs) to detect risks to groundwater and to determine if treatment processes are effective.

The treated soils are from former manufactured gas production (MPG) sites. The coal or petroleum used to produce nearly half the gas used by U.S. cities in the 1940s to provide lighting, heating, and cooking also produced by-products such as coal tar containing PAHs.

Waste handling policies of the MGP era have left a legacy of contaminated sites across the country. One remediation option is in-situ stabilization (ISS) where contaminated soils are mixed with cement and additives to immobilize the PAHs.

The objective of their research is to develop an approach to estimate leaching of PAHs from ISS treated soils at former MGP sites. Leaching is the release of constituents from the solid material to the water, such as groundwater.

MGP samples will be characterized under controlled laboratory conditions to develop a leaching profile of the material. Resulting estimates of leaching, which would consider changes in release as a function of time, site conditions and material, physical form and aging, will be used as a basis for determining risk to groundwater, for developing remedial objectives and assessing treatment process effectiveness.

The leaching profile is critical to the overall project as the basis for modeling of contaminant release under field conditions expected at the former MGP sites.

ENVIRONMENTAL

More projects related to uncertainty, reliability, and risk

1) U.S. Air Force—Aircraft systems health diagnosis and prognosis

The Air Force project team is developing a fast diagnosis and prognosis technique for aircraft health and capability assessment. The top-down diagnosis detects, isolates, and estimates faults or damage within subsystems and components based on system-level performance measurements. The bottom-up prognosis estimates vehicle-level health and capability based on the estimated damage. A risk-based technique is being developed to guide decisions regarding in-flight actions, allowable maneuvers by pilots, maintenance logistics, and more.

Principal Investigator SankaranMahadevan; co-PI Gautam Biswas, professor of computer science, computer engineering, and engineering management

2) NASA—Uncertainty analysis for multidisciplinary systems design

The NASA project involves developing techniques for estimating and managing many sources of uncertainty (natural variability, information uncertainty, and model errors) in space vehicle systems. These multidisciplinary, multicomponent systems require analyses at different levels of resolution, and the communication of uncertainty information between various levels. The methods include different descriptions of uncertainty (probability, fuzziness, expert opinion, etc.) and provide a meaningful basis for decision making.

Principal Investigator Sankaran Mahadevan; co-PI Mark McDonald, assistant professor of civil and environmental engineering

3) Sandia National Labs—Model validation and uncertainty quantification

The Sandia project deals with the estimation of error and uncertainty in computer model prediction. If computer models are used to make decisions for large engineering systems, then the natural question is: How reliable is the model? This project team is developing methods for validating the model, estimating the error and uncertainty, and carefully extrapolating to conditions where data are not available.

Principal Investigator Sankaran Mahadevan

4) U.S. Department of Energy—Probabilistic durability analysis of cementitious systems

The DOE project, through CRESP and a newly formed Cementitious Barriers Partnership, is concerned with long-term durability assessment of cement-based materials such as concrete. Such materials are subjected to many different

physical, chemical, and mechanical degradation processes. There are many sources of uncertainty in the durability assessment—natural variability, data uncertainty, and analysis approximations. The project involves developing methods for probabilistic durability analysis by considering the various sources of uncertainty and their evolution over time.

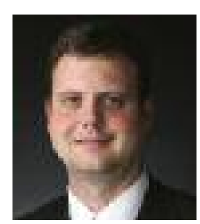
Principal Investigator David Kosson, chair and professor of civil and environmental engineering; co-PI Sankaran Mahadevan

New faculty

George Hornberger, an international leader in hydrology and environmental engineering, has joined the faculty in the Department of Civil and Environmental Engineering as a Distinguished University Professor. Hornberger uses field observation and mathematical modeling to study how hydrological and geochemical processes combine. One aspect of his current research concerns nitrate dynamics in coastal-plain streams. Hornberger is a member of the National Academy of Engineering, a presidential appointee to the Nuclear Waste Technical Review Board, and president of the American Geophysical Union Hydrology Section. He comes to Vanderbilt from the University of Virginia, where he was the Ernest H. Ern Professor of Environmental Sciences. Hornberger earned bachelor's and master's degrees in civil engineering from Drexel University and a Ph.D. from Stanford University.

George Hornberger

Mark McDonald has joined the faculty as an assistant professor. His research interests are risk and reliability analysis, structural engineering, design under uncertainty, and transportation engineering. He will teach core civil engineering courses as well as advanced-level structures and optimization courses. McDonald is a Dwight D. Eisenhower Fellow in transportation engineering and an NSF-IGERT Fellow in risk and reliability engineering. He earned his B.S. degree in civil engineering from Auburn University, an M.S. degree in civil engineering from the University of California, Berkeley, and his Ph.D. in civil engineering from Vanderbilt.



Mark McDonald

Linking U.S. troops to Global Information Grid

As part of a recent Air Force grant, a School of Engineering team led by electrical engineering and computer science professor Doug Schmidt will help develop software tools and platforms to link U.S. combatants seamlessly to the Global Information Grid, which includes all communication devices, the Internet, cell phones, land lines, and satellite communications.

Doug Schmidt

The system will allow troops to access information they need, no matter where they are or in what circumstances, and regardless of the connection device or available bandwidth.

Schmidt and his Vanderbilt team are part of a $2.8 million grant from the Air Force Research Laboratory. BBN Technologies, an advanced technology firm that was one of the original pioneers of the Internet, is the lead contractor for a team that, in addition to Vanderbilt, includes Boeing and the Institute for Human Machine Cognition.

RESEARCH HIGHLIGHTS

- **Software integrated systems**
- **Space and defense electronics**
- **Intelligent, distributed, and embedded systems**
- **Photonics and biosensing**
- **Medical image processing**
- **Computer animation/graphics**
- **Carbon and diamond-based nanoelectronics**

ELECTRICAL AND C

LEADERSHIP GAUGE

International Society for Optical Engineering (SPIE) Fellow–Professor ***J. Michael Fitzpatrick***

Distinguished Alumnus of Purdue University's School of Science–Chair and Professor ***Dan Fleetwood***

Richard F. Shea Distinguished Member Award, IEEE Nuclear and Plasma Sciences Society (NPSS)–***Kenneth F. Galloway***, Dean of the School of Engineering and Professor

Air Force Scientific Advisory Board–E. Bronson Ingram Distinguished Professor of Engineering ***Janos Sztipanovits***

Best Paper Award, Design, Automation and Test in Europe–Professors ***Janos Sztipanovits*** and ***Sandeep Neema***

National Academy of Sciences, Soldier Systems Panel; Outstanding Service Award, IEEE Systems, Man, and Cybernetics Society–Professor ***Julie A. Adams***

Women's Institute in Summer Enrichment WISE 2008 Speaker–Professor ***Yuan Xue***

2nd International Workshop on Model-Based Design of Trustworthy Health Information Systems–Co-Organizer, Professor ***Janos Sztipanovits***; Program Committee, Professor ***Akos Ledeczi***

Betty's Brain motivates learning

An animated computer program created by Vanderbilt engineers shows middle school students that self-checking their answers—a practice most resist—is an effective and enjoyable way to learn.

Teachers in Tennessee and California public school classrooms are using "Betty's Brain" to teach fifth- and sixth-grade students about river ecosystems. But Betty's Brain teaches much more than middle school science content. It also teaches students how to learn.

Supported by $2.5 million in joint funding from the National Science Foundation and the U.S. Department of Education, a team of researchers from Vanderbilt and Stanford universities—headed by Gautam Biswas, professor of electrical engineering and computer science—has demonstrated that students learn science content much better by using "Betty's Brain." Studies show students also carry over that learning into new subjects and practice monitoring themselves along the way.

Using a simplified visual representation called a concept map, the students teach a cartoon character named Betty about river-ecosystem processes, such as the food chain, photosynthesis, and the waste cycle. Then they test her to see if she has learned her lesson.

Unless the students periodically check whether Betty understands the concepts and their relations, she will refuse to take the test. In checking her, the students discover that self-monitoring is an important strategy that applies to all learning situations.

Biswas, whose field of expertise includes modeling and analysis of complex systems, describes himself as "an engineer or computer scientist who knows cognitive science." Several years ago he helped design the successful "Adventures of Jasper Woodbury" interactive videodisc series, which focused on mathematics and problem solving.

Now he and his colleagues from the fields of cognitive science and science education are working on developing software to teach reading to elementary school students and introductory computer science to college students.

Mobile pollution sensors

Vanderbilt engineers have won an award from Microsoft Corp. to develop a real-time, online, detailed and accurate picture of air quality in large metropolitan areas like Nashville.

The mobile system will make it possible to monitor air quality more accurately than the current fixed station system, by using car-mounted sensors that measure, process, and report emission levels.

Engineers will adapt Microsoft SensorMap technology for this purpose. SensorMap software is designed to integrate and publish sensor data in real time on the Internet.

According to principal investigator Akos Ledeczi, research assistant professor of electrical engineering, the system includes five prototype sensors—developed by the team—mounted on vehicles. Ledeczi's team also will develop the necessary infrastructure to measure the pollutants, process and visualize the data, and deploy the system in the Nashville area.

Xenofon Koutsoukos, assistant professor of computer science, and Peter Volgyesi, research scientist engineer, are co-principal investigators.

OMPUTER SCIENCE

Improving productivity of software developers

Continual advances in hardware and networking technologies are exceeded only by unprecedented growth in complex software-based applications.

"Today, software development and maintenance nightmares are the primary reason for a delay or cancellation of a large number of projects, which can adversely impact national and global economies," said Aniruddha Gokhale, assistant professor of electrical engineering and computer science.

These problems are mainly attributed to a lack of powerful tools and scientific techniques that can overcome the inherent challenges faced by software developers who are developing robust and high quality software quickly.

Research in hardware and networking technologies has matured to the point where strong assurances on their quality and robustness can be made, but the same cannot be said about software, Gokhale added.

Gokhale's research blends software engineering and systems research to find innovative solutions that can improve the quality of software (QoS) and improve the productivity of software developers.

Working with faculty colleagues and graduate students at Vanderbilt's Institute of Software Integrated Systems (ISIS), Gokhale is leading efforts on new model-driven software development (MDSD) tools and techniques that simultaneously address concerns related to developer productivity and software quality.

"As systems become more complex—multiple different subsystems are integrated to realize even larger systems—and the QoS requirements such as response time, real-timeliness, fault tolerance, and security needs increase, the first-generation tools and techniques start falling short."

Gokhale's new research is exploring ways in which MDSD tools can deploy systems with multiple QoS properties that often conflict with each other. The focus is on developing new techniques that can automate the trade-off decisions necessary to resolve the conflicts between different QoS properties.

His current collaborative projects fall in the context of domains as varied as insurance, conveyor belt systems, shipboard computing, and intelligent transportation.

CoSMIC suite

During his first five years at Vanderbilt, Gokhale led research on a first-generation, open source MDSD tool suite called CoSMIC (Component Synthesis with Model Integrated Computing). CoSMIC enables rapid composition and deployment of large-scale, distributed systems. The research focused on developing and deploying systems that are correct by construction.

An outcome of this research was new techniques to model systems at levels of abstraction that are intuitive to the developer, and generative technologies that automate mundane and difficult tasks that earlier were performed by developers, and that were vulnerable to errors. Lockheed Martin and Raytheon are users of CoSMIC.

Aniruddha Gokhale

Tools to meet military needs

Gabor Karsai, professor of electrical engineering and computer science, and a team of researchers have been selected by the Defense Advanced Research Projects Agency (DARPA) to create advanced software development tools and processes that meet changing military needs.

The researchers will work on adapting large-scale software systems to address emerging threats such as asymmetric warfare. (Asymmetric warfare refers to conflicts between groups with differing resources, often involving unconventional warfare strategies and tactics such as terrorism.)

Gabor Karsai

DARPA's Producible Adaptive Model-based Software (PAMS) program will develop software that enables systems to monitor their performance relative to changing conditions and adjust accordingly.

The PAMS tools and processes will be tested using flight-control and vehicle-management software and on software-defined radios, such as the Joint Tactical Radio System, to show their applicability across various software domains.

The DARPA project, led by BAE Systems, a global defense industry, also includes researchers from the Massachusetts Institute of Technology (MIT). The initial contract is valued at $3.4 million and includes a $3.4 million option for a second phase. Vanderbilt's portion of the first-phase contract is about $1 million.

Karsai is the principal investigator; co-principal investigators are engineering professors Sandeep Neema and Janos Sztipanovits. Work on the first phase of the program, which is expected to run until January 2009, will be conducted at Vanderbilt, MIT, and at BAE Systems facilities.

Gift powers new biodiesel testing facility

A new state-of-the art biodiesel testing facility, made possible by a $100,000 gift from the DENSO North America Foundation, allows students from various engineering disciplines to investigate diesel engine performance parameters and test campus-produced biodiesel fuels.

The Vanderbilt Multi-User Biodiesel Engine Test Facility will be used by mechanical, chemical, and environmental engineering seniors involved in capstone projects in biodiesel characterization and reactor design.

Engineering students and volunteers from WilSkills, an outdoor education program at Vanderbilt, are collecting used vegetable oil from campus cafeterias and recycling it into environmentally friendly biodiesel. The fuel is currently being used in the WilSkills van and in plant operations vehicles, and may soon power some Vanderbilt Medical Center shuttle buses.

Headquartered in Kariya, Japan, DENSO produces starters, alternators, instrument clusters, center displays, and an array of electronic products for major automotive companies including Toyota, Honda, Ford, GM, and DaimlerChrysler.

RESEARCH HIGHLIGHTS

Intelligent mechatronics

Laser diagnostics and combustion

Robotics and autonomous systems

Micro/nanoscale thermal-fluids

MECHANICAL

LEADERSHIP GAUGE

Fellow, American Society of Mechanical Engineers–
Professor ***Robert W. Pitz***

DARPA Young Investigator Award–
Associate Professor ***Greg Walker***

NSF Engineering Research Center Investigators–Compact and Efficient Fluid Power–
Professor ***Michael Goldfarb*** and Assistant Professor ***Eric Barth***

DARPA Four-Year Grant: Revolutionizing Prosthetics–
Professor ***Michael Goldfarb***

NIH Four-Year Grant: Powered Prosthesis for Biomimetic Locomotion in Transfemoral Amputees–
Professor ***Michael Goldfarb***

Portable Power Research Institute, Department of Defense–Army DOD–
Professor ***Alvin Strauss***

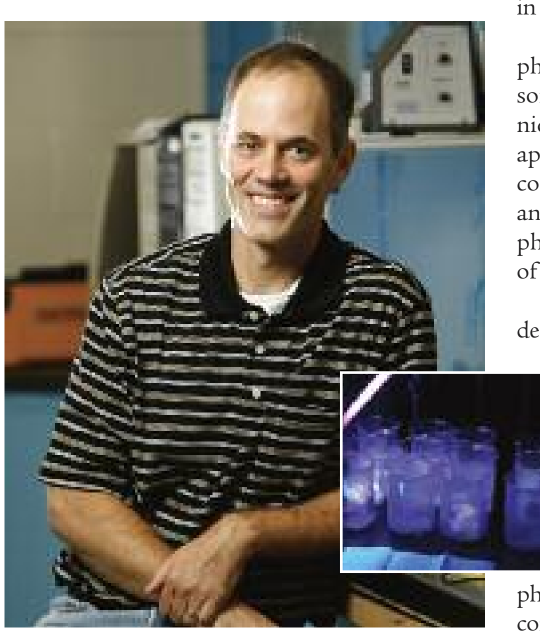
Fellow, American Association for the Advancement of Science–
Professor ***Thomas A. Cruse***

Program Co-Chair, IEEE International Symposium on Robot and Human Interactive Communication–
Associate Professor ***Nilanjan Sarkar***

When sensors glow

Using glowing phosphors as thermal sensors means the temperature response of automobile engine components or wind tunnel models can be detected remotely with optics. Any surface whose temperature needs to be studied is a candidate application for this technology, said Greg Walker, associate professor of mechanical engineering.

Thermographic phosphors used for non-contact, remote-sensing thermometry are particularly helpful where mechanical access is impossible, or in harsh environments where sensor survivability is a concern. For example, aerothermodynamic loads generated in shock tunnels are often detrimental to more traditional approaches such as thin-film gauges. And, contact technologies tend to disturb the phenomena being measured, resulting in uncertainties in the measurements.



Greg Walker

Phosphors emit light when excited by electronic energy, lasers, or radiation and are commonly found in many products. Fluorescent paint used in wristwatch hands and numbers or in children's glow-in-the-dark toys contain phosphors. Similarly, laundry detergent contains phosphors that make whites "whiter than white." Perhaps the most common uses of phosphors are in computer monitors and fluorescent lights.

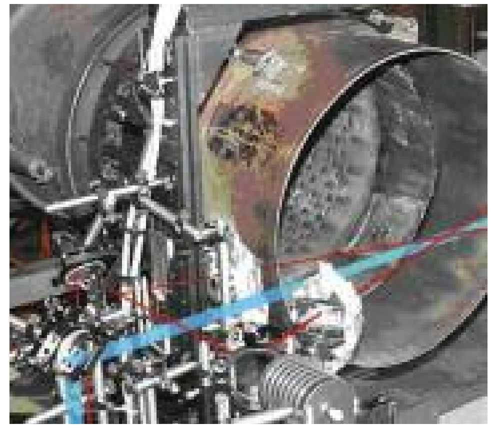
Walker's particular interest in heat-sensitive phosphors is making tunable temperature sensors using a simple combustion synthesis technique. There are two advantages to Walker's approach. Combustion synthesis is very fast compared to traditional fabrication techniques, and adjusting the size of the particles of phosphor allows Walker's team to tune the behavior of the phosphor.

"The characteristics we're interested in are decay-time of phosphorescence and quenching temperature, which is the range where phosphors are most active, or sensitive. By investigating how nanoparticles affect these properties, we can create materials with the performance metrics required by specific applications," Walker said.

Walker's experiments have shown that the emission properties of thermographic phosphors can be manipulated by adjusting the combustion parameters. His research group is currently working on quantum models to predict the performance of new materials before they are made in the lab. These models will ultimately be used in the design of custom phosphor measurement solutions.

Walker's research is funded in part by Oak Ridge National Laboratory, U.S. Air Force's Arnold Engineering Development Center, and the NSF.

Aerodynamic measurement technology

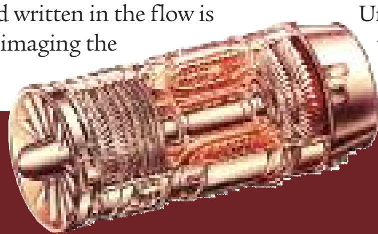


Vanderbilt University, Arnold Engineering Development Center, and the University of Tennessee Space Institute conducted the first demonstration of hydroxyl tagging velocimetry (HTV) in a gas turbine exhaust, operating a GE J85, a small single-shaft turbojet engine, from idle to full throttle.

HTV uses a laser to dissociate water vapor in the exhaust into hydroxyl (OH) and hydrogen (H) using a grid of ultraviolet pulsed laser beams. The resulting OH grid written in the flow is subsequently read by imaging the grid's OH fluorescence using another ultraviolet pulsed laser sheet.

Flow displacement measurement through grid image comparisons and knowledge of the write-read delay time provide instantaneous velocity field data. Exhaust velocities up to 500 m/sec (1,100 mph) were measured.

The J85 is one of GE's most successful and longest-in-service military jet engines. It plays a vital role in training new military jet pilots. The United States Air Force plans to continue using the J85 in aircraft through 2040.



New faculty

Robert Webster

Robert Webster has joined the ME department as an assistant professor and has established the Medical and Electromechanical Design Laboratory (MED). He is interested in engineering design, robotics, mechatronics, computer-integrated surgery, kinematics and dynamics, and his work with the MED Lab will include research in advancing the basic science of electromechanical systems through design, kinematic and dynamic modeling, control, and human-machine interaction research. Webster earned his undergraduate degree in electrical engineering from Clemson University and received his master's and Ph.D. in mechanical engineering from Johns Hopkins. He is co-holder of patents on an active cannula for bio-sensing and surgical intervention and a distal bevel-tip needle control device and algorithm.

Assistant Professor Haoxiang Luo's research focus is on theoretical and computational fluid dynamics, fluid mechanics, micro-fluidics and thermal science, applied mathematics, and scientific computing. Prior to coming to Vanderbilt, Luo conducted research at George Washington University on laryngeal aerodynamics and vocal fold modeling. Professor Luo earned his undergraduate and master's degrees in mechanical engineering from Tsinghua University in Beijing and his Ph.D. from the University of California, San Diego. He has published in the *Journal of Computational Physics*, the *Journal of Engineering Mathematics*, and the *Journal of Fluid Mechanics*, and is a member of APS/DFD, ASME, and Sigma Xi.

Haoxiang Luo

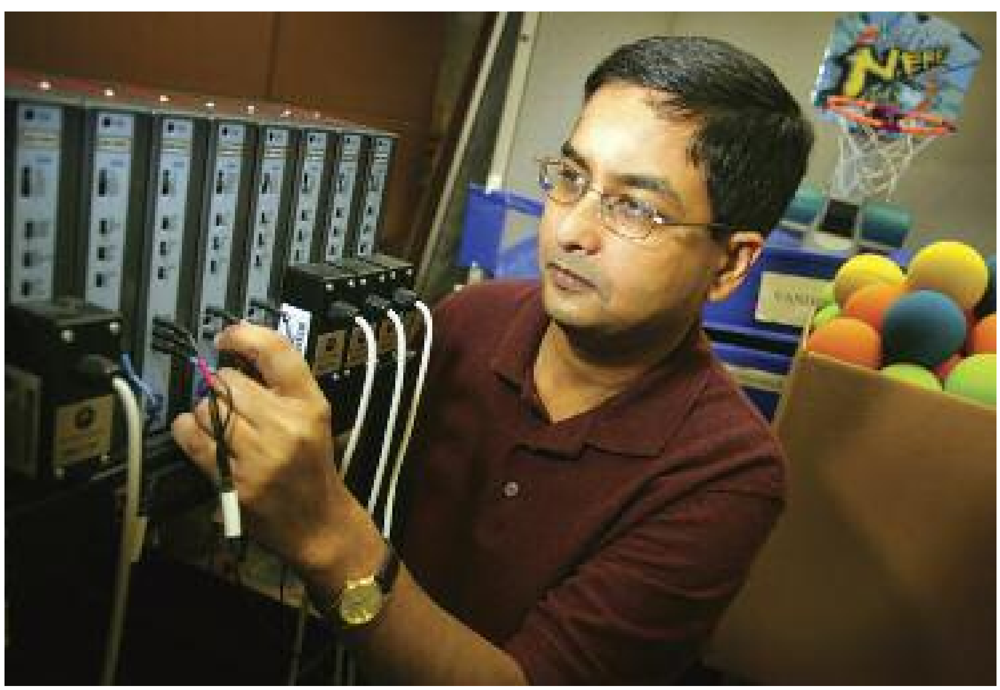
Robots and autism

Children diagnosed with an autism spectrum disorder (ASD) have a complex neuro-developmental condition whose cause isn't completely understood. What is clear, says Nilanjan Sarkar, associate professor of mechanical engineering and computer engineering, is that those with autism have difficulty communicating.

Sarkar's earlier work with a robotic system that senses and responds to physiological cues that are related to emotion, such as heart rate, grimacing, and perspiration, is at the heart of his new work. Sarkar collaborated with Wendy Stone, an investigator in the Vanderbilt Kennedy Center for Research on Human Development and director of the center's Treatment and Research Institute for Autism Spectrum Disorders.

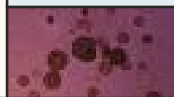
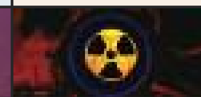
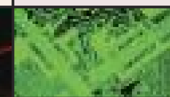
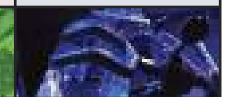
Through a grant from the Marino Autism Research Institute, Sarkar and his team developed a robot-based basketball game. The game includes a robotic arm that adjusts the difficulty of the game by moving the hoop. The calibrations are based on the mental state of children with ASD through assessment of nonverbal signals obtained from wearable physiological sensors.

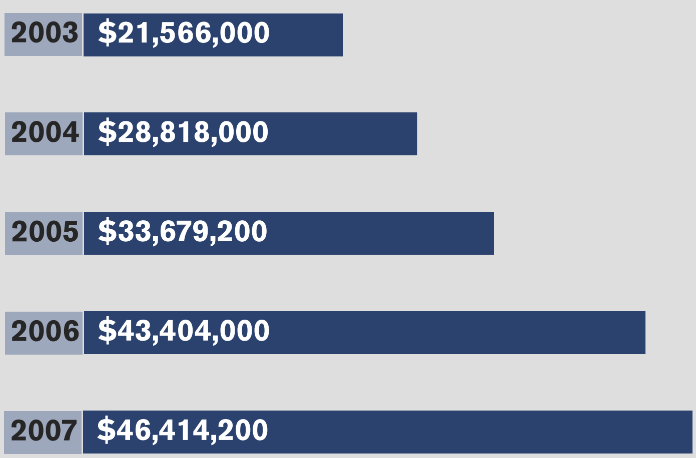
The next step is to develop an intelligent virtual reality system. The virtual reality characters will engage the child in social interactions and use the child's physiological feedback to build communication skills incrementally. Sarkar has been awarded a $120,000 biomedical research grant from Autism Speaks for this phase.



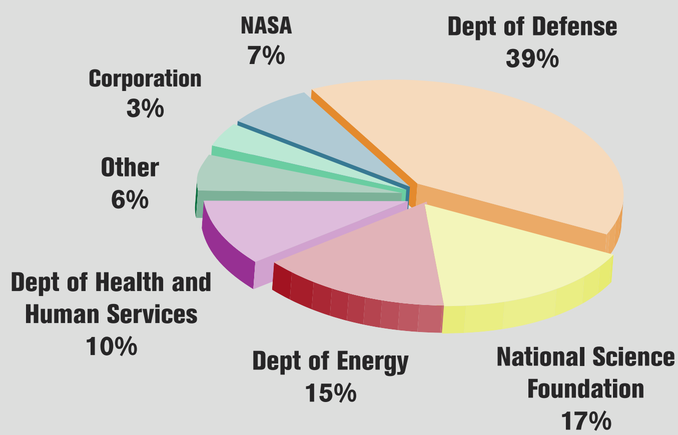
Nilanjan Sarkar

Significant Research Initiatives

Faculty and students share their expertise across multiple disciplines to address four specific engineering research initiatives that characterize the School of Engineering's commitment to help solve real-world challenges with worldwide IMPACT.	Health Care	Energy and the Environment	Information Systems	Defense and National Security
				
Department of Biomedical Engineering	●			
Department of Electrical Engineering and Computer Science	●	●	●	●
Department of Chemical and Biomolecular Engineering	●	●		●
Department of Civil and Environmental Engineering		●		●
Department of Mechanical Engineering	●	●		●
Interdisciplinary Program in Materials Science	●	●		●
Center for Intelligent Mechatronics	●	●		●
Institute for Software Integrated Systems			●	●
Vanderbilt Center for Transportation Research		●		
Vanderbilt Institute for Biosystems Research and Education	●			●
Consortium for Risk Evaluation with Stakeholder Participation		●		
Institute for Space and Defense Electronics			●	●
Vanderbilt Institute of Nanoscale Science and Engineering	●	●		●
Vanderbilt University Institute of Imaging Science	●			



Research Expenditures



Research Expenditures by Funding Source (FY 2008)

Staff Profile 2008–2009

Professors	39
Associate Professors	23
Assistant Professors	19
Adjunct and Of-the-Practice	26
Research Faculty	42
Total	149

Administrative staff	54
Research staff	51
Full-time faculty members	81

Student Profile

Undergraduate, Fall 2008

Tennessee	218 or 17%
Other U.S. states	893 or 71%
Other countries	146 or 12%
Total	1,257

Graduate, Fall 2008

U.S. citizens	262 or 64%
Foreign citizens	146 or 36%
Total	408

Student Population, Fall 2008

Graduate students	408
Undergraduates	1,257
Total	1,665

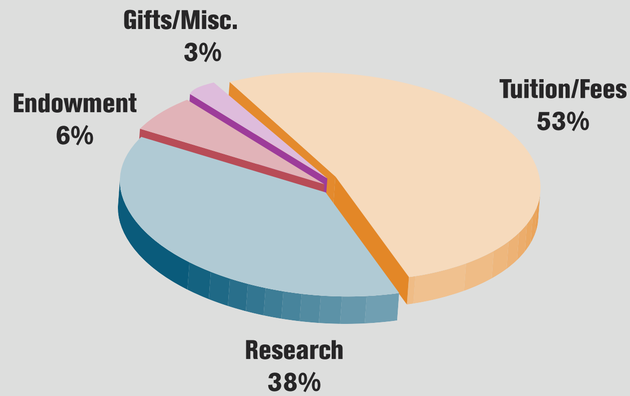
VUSE Student Diversity

Undergraduate, Fall 2008

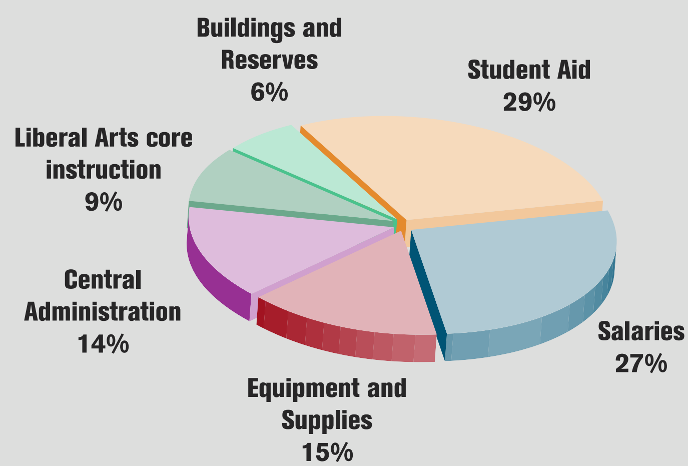
Women	30%
African American	5%
Asian-Asian American	7%
Hispanic American	4%

Graduate, Fall 2008

Women	26%
African American	5%
Asian-Asian American	3%
Hispanic American	1%



Source of Funds



Uses of Funds

Class of 2008 Degrees Conferred

Doctoral	51
Master's (ME)	17
Master's (MS)	59
Bachelor's (BE)	249
Bachelor's (BS)	55
Total	431

A long view of radioactive waste

Frank Parker

It's clear that **nuclear waste disposal** is being held to a higher standard and that it's stifling the U.S. nuclear program long term.

"We cannot ignore the problem," said Frank L. Parker, a pioneer in nuclear waste management who thinks nuclear waste management policy continues to be a major obstacle for the national and international nuclear energy renaissance.

"There is no good analogy for ultra long-term waste disposal and there's a great deal of uncertainty from a technical point of view."

"Thirty years ago we investigated 10 different options. Now we have two, geological disposal and surface storage," said Parker, reflecting on five decades of experience and research in nuclear waste management.

International consensus holds that spent nuclear fuel and high-level radioactive waste should eventually be disposed of deep underground in a geologic repository. Although geologic disposal has been national policy for many years, Parker favors contingency planning should some issue make it impossible to license a geologic repository.

Parker wrote the book on radioactive waste disposal, literally.

The National Academy of Sciences published *Rethinking High-Level Radioactive Waste Disposal: A Position Statement of the Board on Radioactive Waste Management* that Parker chaired more than 18 years ago. It still has legs. "It's interesting how many people in government, in industry, and in academia still cite this book."

Parker flips to the Recommendations section at the back of the book. "If you want to know what I think, read these." Actions are summarized into seven recommendations.

One points to reconsideration by the EPA of its detailed performance standards to be met by

Frank Parker: Pioneer in nuclear waste management

Frank Parker served in the U.S. Army in a variety of engineering positions and was among the first troops to enter Nagasaki after the atomic bomb attack in 1945. He went on to graduate from MIT and work for the U.S. Bureau of Reclamation and the Rockland Light and Power Company as a civil and water resources engineer. After graduating from Harvard, Parker worked for a consulting hydraulic engineering firm and then went to the Oak Ridge National Laboratory, where he became head of Radioactive Waste Disposal Research. He also served as head of Radioactive Waste Disposal Research for the International Atomic Energy Agency. For many years he led the Radiation Safety of the Environment program at the International Institute for Applied Systems Analysis (IIASA) in Austria. At Vanderbilt, he concentrated on thermal pollution and water resources problems for a number of years, but in recent years has concentrated on radioactive and hazardous chemical waste problems, with increasing attention to the policy questions associated with these problems.

Symposium: Uncertainty in Long-Term Planning

Six months ago, 100 invited guests attended a two-day symposium—*Uncertainty in Long-Term Planning: Nuclear Waste Management, a Case Study*—held in honor of Frank Parker, Distinguished Professor of Environmental and Water Resources Engineering and a member of the National Academy of Engineering. Ten speakers of international stature included William Colglazier, executive officer of the National Academy of Sciences; Richard Meserve, president of the Carnegie Institution of Washington and former chairman of the Nuclear Regulatory Commission; Arthur Upton, former director of the National Cancer Institute; and Roger Kasperson of the EPA's Science Advisory Board and former director of the Stockholm Environment Institute (Parker had been a senior fellow at its predecessor agency).

a repository and to consider a more realistic schedule for opening a repository.

It's clear that nuclear waste disposal is being held to a higher standard and that it's stifling the U.S. nuclear program long term, he said. The *New York Times* reported in July that "the best-case situation would result in the Yucca Mountain (Nevada) nuclear waste site opening in 2020; originally it was supposed to open in 1998."

"There is absolutely no way we can know what solution will work 1,000 years or 1,000,000 years from now." Parker believes we should make small steps—concentrate on 100 years from now—and use what some call a staged approach. "One should make continuous improvements as we learn. The Yucca Mountain site is projected to have about 100 years of operation until the repository is sealed forever."

"The accuracy of predictions is uncertain but obviously better when working in 100-year modules."

Long-term disposal is a philosophical question, he said. It polarizes; social, ethical, and economic considerations are legitimate aspects of the public policy process, and it requires better understanding of a dynamic interaction between nature, technology, and society, Parker said.

Despite our nuclear waste disposal challenges, it pales in comparison to nuclear proliferation, he said. "The consequences of a nuclear war would be devastating and we knew that more than 60 years ago."

Rocket-powered mechanical arm could revolutionize prosthetics

A prototype of this radical design has been successfully developed and tested by a team of mechanical engineers at Vanderbilt as part of a $30 million federal program to develop advanced prosthetic devices.

"Our design does not have superhuman strength or capability, but it is closer in terms of function and power to a human arm than any previous prosthetic device that is self-powered and weighs about the same as a natural arm," says Michael Goldfarb, the professor of mechanical engineering who is leading the effort.

The prototype can lift (curl) about 20 to 25 pounds—three to four times more than current commercial arms—and can do so three to four times faster. "That means it has about 10 times as much power as other arms despite the fact that the design hasn't been optimized yet for strength or power," Goldfarb says.

The mechanical arm also functions more naturally than previous models. Conventional prosthetic arms have only two joints, the elbow and the claw. By comparison, the prototype's wrist twists and bends, and its fingers and thumb open and close independently.

The Vanderbilt arm is the most unconventional of three prosthetic arms under development by a Defense Advanced Research Project Agency (DARPA) program. The other two are being designed by researchers at the Advanced Physics Laboratory at Johns Hopkins University in Baltimore, who head the program. Those arms are powered by batteries and electric motors.

Michael Goldfarb

Increasing the size of the batteries is the only way to provide additional energy for conventionally powered arms and, at some point, the weight of additional batteries becomes prohibitive.

It was the poor power-to-weight ratio of batteries that drove Goldfarb to look for alternatives in 2000 while he was working on a previous exoskeleton project for DARPA. He decided to miniaturize the monopropellant rocket motor system that is used for maneuvering in orbit by the space shuttle.

Goldfarb's power source is about the size of a pencil and contains a special catalyst that causes hydrogen peroxide to burn. When this compound burns, it produces pure steam. The steam is used to open and close a series of valves. The valves are connected to the spring-loaded joints of the prosthesis by belts made of a special monofilament used in appliance handles and aircraft parts. A small sealed canister of hydrogen peroxide that easily fits in the upper arm can provide enough energy to power the device for 18 hours of normal activity.

His adaptation impressed the Johns Hopkins researchers, so they offered him $2.7 million in research funding to apply this approach to the development of a prosthetic arm.

In the fall, DARPA's "Revolutionizing Prosthetics 2009" program will move to its second stage. Goldfarb's team has met all its research milestones and has produced a working prototype. The team hopes to meet DARPA's goal of developing a commercially available arm in two years.

Goldfarb's power source is **about the size of a pencil** and contains a special catalyst that causes hydrogen peroxide to burn.

Ensuring safety in a cyberspace domain

Janos Sztipanovits

Cyberspace is a domain characterized by the use of electronics and the **electromagnetic spectrum** to store, modify, and exchange data via networked systems and associated physical infrastructures

Securing protection by land, sea, and air requires an update. The United States Air Force now includes *cyberspace* in its defensive domains.

This summer a highly anticipated report—*Defending and Operating in a Contested Cyber Domain*—was delivered in June to the United States Air Force, which is charged with safeguarding America by dominating air, space, and cyberspace.

Janos Sztipanovits, E. Bronson Ingram Distinguished Professor of Engineering in Electrical Engineering and Computer Science, a globally recognized expert in cyber security and member of the USAF Science Advisory Board, is the study chair, heading a team of industry leaders, academics, and government officials to produce a report for the Air Force leadership.

Cyberspace has grown beyond the confines of networks and computers. Computers and networks are used to monitor and control all types of missions that increase dependence on information technology.

"In many ways, the transformational effect of information technology on defense is larger than the effect of Internet technology on society," said Sztipanovits, who is in the second year of a four-year term on the Air Force SAB.

Integrating cyber components into defense and civilian infrastructure exposes them to a host of new vulnerabilities. "Technology solutions that enable prevention, detection, and response to cyber attacks are critical to national security," said Sztipanovits, director of Vanderbilt's Institute for Software Integrated Systems (ISIS).

The 2008 study and resulting report follows on one of the Scientific Advisory Board's 2007 studies—*Implications of Cyber Warfare*—whose report made it clear that the Air Force is operating in a contested cyber environment.

Recognizing the domain's importance, the Air Force established in September 2007 a provisional Cyberspace Command to bring together the myriad existing cyber capabilities under a single commander.

A month later the study team chaired by Sztipanovits was created. The team—comprised of 22 experts, including USAF staff—spent spring 2008 fact finding, followed by a two-week retreat to pull together the report.

Part of the study's charter was to assess and characterize current Air Force operational readiness levels for rapid detection, assessment, and response, including the ability to fight through a cyber attack and to quickly reorganize networks.

The charter also included evaluating the effectiveness of technology options and providing recommendations for near-term and options for implementation.

The *Contested Cyber Domain* study is one of four major studies conducted by the SAB this year. Studies are conducted in an annual cycle and topics are selected by the Secretary of the Air Force.

Two students are Goldwater Scholars

Juniors Sesha Pinnaduwage and Arunan Skandarajah have been selected Goldwater Scholars for the 2008/2009 academic year. Each will receive a two-year scholarship worth $7,500 a year for educational expenses. Pinnaduwage is studying chemical engineering, with minors in math and biotechnology. She plans to earn a Ph.D. in chemical engineering in order to pursue a career in cancer research. Skandarajah is majoring in biomedical engineering. After earning a Ph.D. in biomedical instrumentation, he plans to work with physicians in the development of diagnostic technology.

Aerospace Club gets big lift from launch win

The School of Engineering's Aerospace Club won a prestigious altitude contest when its rocket-deployed unmanned vehicle reached a height of 5,264 feet at a launch contest held this spring. Vanderbilt's 14-foot rocket fell just 16 feet short of the one-mile goal (5,280 feet), but it soared high enough to win the "closest to altitude" prize, one of the two top prizes in the 2007/2008 NASA-sponsored University Student Launch Initiative (USLI). Two weeks earlier, the Aerospace Club claimed second place in the Team Design category at the American Institute of Aeronautics and Astronautics (AIAA) Southeastern regional competition at Cape Canaveral, Florida.

Student section of the American Nuclear Society is established

The ANS board has officially authorized full recognition of a student section at Vanderbilt's School of Engineering, and William E. Burchill, the vice president/president-elect of ANS, visited Vanderbilt to present the section with its official charter. The section is hosted by the Department of Civil and Environmental Engineering, which is widely recognized as an academic center of expertise on the subject of radioactive waste management.

Best Student Research Paper of 2008

This year two winners were named by the School of Engineering as authors of the best student research paper. Anuradha Bulusu's paper—"Quantum modeling of thermoelectric performance of strained Silicon/Germanium/Silicon superlattices using the nonequilibrium Green's function method"—was accepted by the *Journal of Applied Physics*, regarded as one of the field's top publications. Ashwath Jayagopal's paper—"Surface Engineering of Quantum Dots for In-Vivo Vascular Imaging"—appears in the journal *Bioconjugate Chemistry*. This highly ranked journal reports that Jayagopal's paper is in the top 25 of its articles viewed online in 2007.

5Q Interview: Study Abroad

Stacy Klein, associate dean for outreach, works to integrate study abroad opportunities into all School of Engineering majors, not only to increase the numbers of Vanderbilt engineering students studying abroad but also to make their education more valuable by deepening and expanding what is learned in formal studies.

Stacy Klein

Q Dean Klein, what types of experiences is the School of Engineering committed to giving its students?

A The school is focused on the overall set of experiences we offer to our engineering students. In addition to undergraduate research, we offer an increasing number of service learning opportunities and internships. This prepares our students to excel in the internationally competitive world.

Q How does the school support and encourage students in studying abroad?

A When you have a dean who makes study abroad a priority and faculty within the school who are passionate about it, then you begin to set the bar that we expect many of our students to try to do this. You then have to work to make the right opportunities available for students.

Q How does studying abroad affect the school itself?

A Study abroad heightens Vanderbilt's visibility globally, which I think is vital to our vision for the School of Engineering. With an aggressive career-focused study abroad program we can begin conversations with important partners in education and industry worldwide. As a result, we will begin to build strategic relationships.

Q How does studying abroad affect students in the job market?

A Study abroad gives students a competitive professional edge. Business recruiters note that the maturity and experience gained by those who have studied abroad make those students stand out. Similarly, students who have studied abroad have a distinct advantage academically and in the job market.

Q What do students say about their experiences studying abroad?

A Participation in a study abroad program is more than an academic adventure. There are few life experiences that are truly transformational. Living abroad is one of them. The comment I hear most often from returning students is they have gained an entirely new perspective on who they are, how others see them, and how they see the world.

In class, in Australia, independent study

This fall Gene LeBoeuf, associate professor of civil and environmental engineering, is leading students through the final semester of a year-long class that has focused on the science of sustainable development and water resource management. The class is part of the Vanderbilt Initiative for Scholarship and Global Engagement (VISAGE).

During spring semester LeBoeuf's students explored how land-use practices, social policy, economic strategies, and indigenous, national, and international cultures have influenced water-related infrastructure development in Australia.

The in-class portion at Vanderbilt was followed by a summer session at the University of Melbourne in Australia.

During their four-week session in Australia, students spent 12 to 20 hours per week with government and nongovernmental agencies. Back on campus in the fall, students will select subtopics relating to their experiences to examine in more detail through independent study.

Faculty Briefs

J. Michael Fitzpatrick, professor of electrical engineering, is among this year's 72 new Fellows of the Society honored by SPIE—The International Society for Optical Engineering. Fitzpatrick is recognized for specific achievements in image registration, which is vitally important for image-guided surgery.

Peter T. Cummings, the John R. Hall Professor of Chemical Engineering, received the 2007 American Institute of Chemical Engineers (AIChE) Nanoscale Science and Engineering Award at the institute's annual meeting, where he also delivered the guest lecture. The award honors Cummings for "outstanding research accomplishments and national leadership in computational nanoscience." Cummings also is principal scientist at the Oak Ridge National Laboratory's Center for Nanophase Materials Sciences and director of the laboratory's Nanomaterials Theory Institute.

Peter T. Cummings and **Thomas A. Cruse**, the H. Fort Flowers Professor of Mechanical Engineering, emeritus, have been elected fellows of the American Association for the Advancement of Science (AAAS), an honor bestowed upon them by their peers. They are among only 471 scientists nationwide who have been elevated to this rank.

Robert L. Galloway Jr., professor of biomedical engineering, and **John P. Wikswo**, the Gordon A. Cain University Professor and professor of biomedical engineering, have been named IEEE fellows. Elevation to IEEE Fellow is considered one of the electrical engineering society's highest honors.

Greg Walker, assistant professor of mechanical engineering, has been named the recipient of a Young Faculty Award from the Defense Advanced Research Projects Agency (DARPA), the primary research and development agency for the Department of Defense. Walker is one of only 24 promising researchers who have been recognized with an award by DARPA's Microsystems Technology Office.

James H. Clarke, professor of civil and environmental engineering, received the Distinguished Service Recognition award from the Nuclear Regulatory Commission for his service on the NRC's Advisory Committee on Nuclear Waste and Materials.

Sankaran Mahadevan, professor of civil and environmental engineering, received the Outstanding Professional Service Award from the American Society of Civil Engineers for sustained service to the Aerospace Division over the past two decades. In addition, Mahadevan has been elected to serve as General Chair of the 51st Structures, Structural Dynamics, and Materials Conference jointly organized by AIAA, ASME, and ASCE, in 2010.

Janos Sztipanovits, E. Bronson Ingram Distinguished Professor of Engineering, professor of electrical engineering, and professor of computer engineering, and Sandeep Neema, research assistant professor of electrical engineering and computer science, along with former graduate student Kai Chen, currently with Motorola Research, received a Best Paper Award at the 11th Design, Automation, and Test in Europe (DATE) conference in Munich for their paper, "Compositional Specification of Behavioral Semantics," published in the proceedings of the 2007 conference.

Vanderbilt University Institute of Imaging Science

Professor John C. Gore, **Director**

Mission

The Vanderbilt University Institute of Imaging Science (VUIIS) aims to support and integrate advances in physics, engineering, chemistry, computing, and other basic sciences for the development and application of new and enhanced imaging techniques to address problems and stimulate new research directions in biology and medicine. It houses a multidisciplinary group of faculty, trainees, and staff that is engaged in a broad range of imaging applications.

Research Areas

VUIIS faculty and trainees pursue research in developing new imaging methods and techniques, as well as in diverse applications. Some of the core areas of current interest involve the development of methods for assessing structure, function, and metabolism and for studying molecular and cellular processes. These broad areas are subdivided into:

- Cancer imaging
- Functional and structural neuroimaging
- Transgenic mouse imaging
- Metabolic imaging
- Cellular and molecular imaging
- Cardiovascular imaging
- Image processing and analysis
- Physics of imaging and spectroscopy

Institute for Space and Defense Electronics (ISDE)

Professor Ron Schrimpf, **Director**

Mission

The Institute for Space and Defense Electronics (ISDE) contributes to the design and analysis of radiation-hardened electronics, the development of test methods and plans for assuring radiation hardness, and the development of solutions to system-specific problems related to radiation effects in space and defense systems.

Status

The Radiation-Effects Group at Vanderbilt University was established in 1987 and is the largest program of its kind in the U.S. It is the only academic program actively involved in support of the U.S. Department of Defense in radiation effects for strategic applications and one of a very few programs involved in microelectronics research for space applications. In January 2003, the Radiation-Effects Group established ISDE in order to extend its capabilities to serve government and commercial customers. ISDE is composed of faculty, graduate students, and professional, nontenured staff, establishing a broad spectrum of theoretical, experimental, and industry-standard knowledge.

ISDE is developing and applying predictive, radiation-aware simulation tools in support of space and defense system design. ISDE engineers help to identify radiation-related issues at the device and circuit levels, propose design solutions, and implement test plans.

Major Programs

- Lead university in a Multidisciplinary University Research Initiative (MURI) focusing on radiation effects in emerging electronic materials and devices
- Design and test radiation-tolerant integrated circuits and semiconductor devices
- Application and development of simulation tools for analyzing the effects of radiation on integrated circuits and semiconductor devices
- Test methods and plans for predicting the survival of electronics in radiation environments

Institute for Software Integrated Systems (ISIS)

Professor Janos Sztipanovits, **Director**

Mission

The Institute for Software Integrated Systems (ISIS) is an internationally renowned research organization focused on information systems connected to the physical world. ISIS' mission is to advance the state-of-the-art in the scientific foundation and design technology of heterogeneous systems composed of networked physical and computational objects. The results of ISIS research are new methods and pioneering tools for model-based design of large-scale systems. Core application domains where ISIS tools are used include defense, aerospace, automotive, industrial automation, and medical informatics industry. The comprehensive research program at ISIS in these areas is funded by the National Science Foundation (NSF), Defense Advanced Research Projects Agency (DARPA), NASA, U.S. Air Force, U.S. Army, and a wide range of commercial companies.

Research Areas

- Theoretical foundations for embedded systems, hybrid systems
- Model-Integrated Computing
- Component middleware for distributed real-time and embedded systems
- Generative model-based programming and Model Driven Architecture
- Adaptive hardware and software systems
- Domain-specific modeling languages
- Tools for the design of embedded systems
- Semantic integration of design tools
- Synthesis and generation of software and hardware
- Wireless sensor networks and fine-grain distributed processing
- Diagnostics of complex systems
- Scheduling and planning in real-time, distributed environments
- Distributed control of unmanned air vehicles
- Wireless sensor networks
- Architecture exploration and system virtualization
- Model-based design of trustworthy information systems

Center for Intelligent Systems

Professor Kazuhiko Kawamura, **Director**

Mission

The Center for Intelligent Systems (CIS) is engaged in a diversified set of research activities in the general areas of intelligent systems. Currently, special emphasis is given to humanoid robots, cognitive robots, robot memory structures, robot skill learning, qualitative navigation, and human-robot interface.

Research Areas

- Cognitive robots
- Humanoid robots
- Personal and service robots
- Human-robot interface
- Robot memory structure
- Working memory toolkit
- Sensory EgoSphere
- Robot navigation
- Vision, image, and signal processing systems
- Biologically inspired robot control
- Affect-based robot control
- Modeling, simulation, and diagnosis
- Sensory motor coordination

Center for Intelligent Mechatronics

Professor Michael Goldfarb, **Director**

Mission

The design and control of electromechanical devices is the primary concern of this center, and research topics often involve the interface and interrelation between the two. The center is focused technically on dynamic systems and control, and the implication of such techniques toward the design of innovative devices. The primary area of application has been in the development of innovative robotics systems. Such projects have included the development of hyper-efficient piezoelectrically actuated resonant mobile robots, the development of novel compliant-mechanism-based multi-degree-of-freedom robot manipulators for scaled telemanipulation, the development of liquid-rocket-propellant-powered self-contained pneumatic robots, and most recently the development of robotic artificial limbs for both upper and lower extremity amputees.

Research Areas

- Design, modeling, and control of electromechanical devices and systems
- Nonlinear modeling and control of fluid-powered actuators
- Control of bilateral and scaled bilateral telemanipulation systems
- Design and control of high-energy-density power supply and actuation for human-scale robots
- Design and control of self-contained pneumatic actuation systems
- Robot artificial limbs

Vanderbilt Institute of Nanoscale Science and Engineering (VINSE)

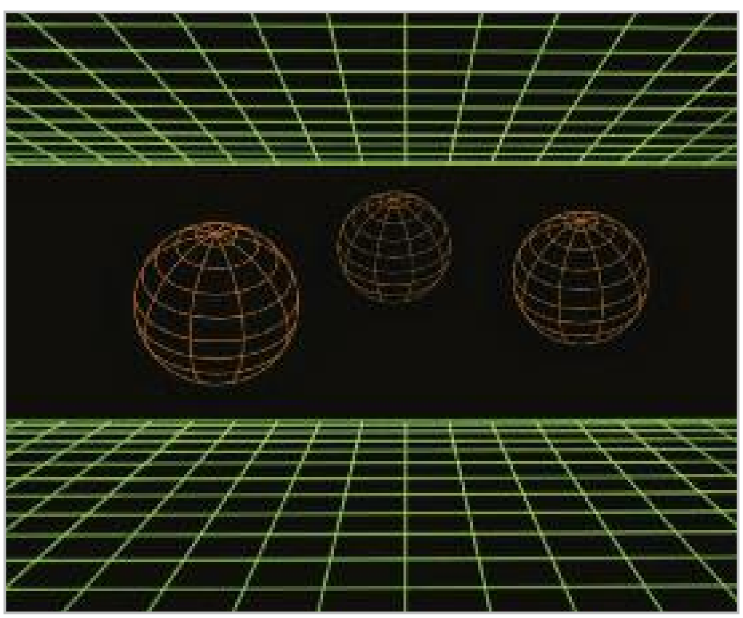
Professor Sandra J. Rosenthal, **Director**

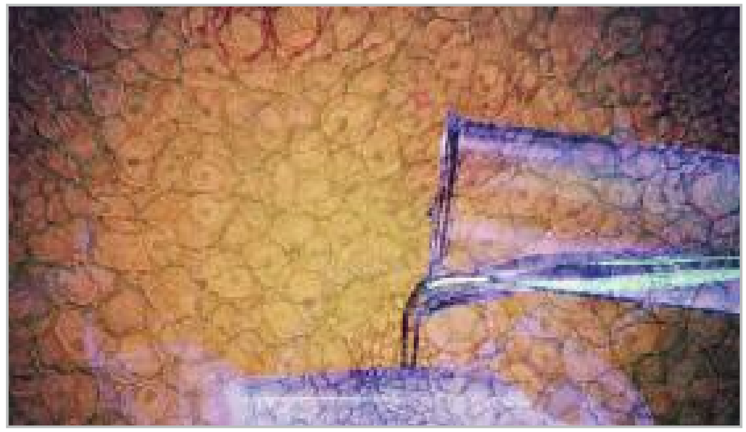
Mission

The Vanderbilt Institute of Nanoscale Science and Engineering (VINSE) is an interdisciplinary center engaged in experimental and theoretical research in science and engineering at the nanoscale. VINSE supports an extensive infrastructure of materials fabrication and analytical facilities for research in nanoscale science and engineering. Research encompasses students and faculty in various areas of nanoscience, with a special emphasis on interdisciplinary activities.

Research Areas

- Nanofluidics
- Applications of nanoscale materials in biomedical applications
- Theory and modeling of nanoscale solids
- Properties affected by nanoscale dimensions
- Atomic manipulation, coupling of properties at the nanoscale
- Controlled synthesis, fabrication, and processing at the nanoscale
- Nanoscale precursors and assembly, nanostructure arrays, fullerenes, carbon nanotubes, and organic nanostructures
- Quantum dots, quantum wires, quantum wells, superlattices
- Nanoelectronics, single-electron electronics and devices, molecular electronics, quantum computing
- Nanomechanics, nanobiological function and life sciences
- Nanoscale instrumentation and characterization
- Nano-optics, photonic crystals with nanoscale structural fidelity





Vanderbilt Institute for Integrative Biosystems Research and Education

Professor John P. Wikswo, **Director**

Mission

This interdisciplinary institute has as its mission to strengthen and broaden the existing foundation of basic research in the biophysical sciences and bioengineering; develop enabling technologies that span these disciplines; provide close articulation of the biophysical sciences and bioengineering with undergraduate, graduate, and postgraduate educational programs; and foster programs of outreach to industry, government, and other educational institutions.

VIIBRE has created on-campus collaborations in research areas such as cellular biosensors for cancer research, chemical and biological warfare defense and infectious disease detection, single- and multicellular instrumentation and control, biomedical imaging, biological applications of nanosystems, cellular/tissue bioengineering and biotechnology, and bioengineering education technologies. It has helped bring to Vanderbilt approximately $20 million of new external funding (a four-to-one return on the university's original investment) and is now totally supported by external grants and contracts.

A major thrust of VIIBRE is to develop advanced dynamic instruments for quantitative systems biology. Through the Systems Biology and Bioengineering Undergraduate Research Experience (SyBBURE), funded by a generous gift from an alumnus and launched in the summer of 2006, VIIBRE provides undergraduate students with summer and academic-year training in microfabrication and bioengineering tools and then allows them to apply these tools to research projects in systems biology and bioengineering.

Research Areas

- Instrumenting and controlling the single cell
- Instruments, measurements, and models for biotoxin discrimination
- Research into cellular dynamics in immunology, cardiology, cancer, and development
- Education in interdisciplinary biomedical sciences and engineering

Consortium for Risk Evaluation with Stakeholder Participation (CRESP)

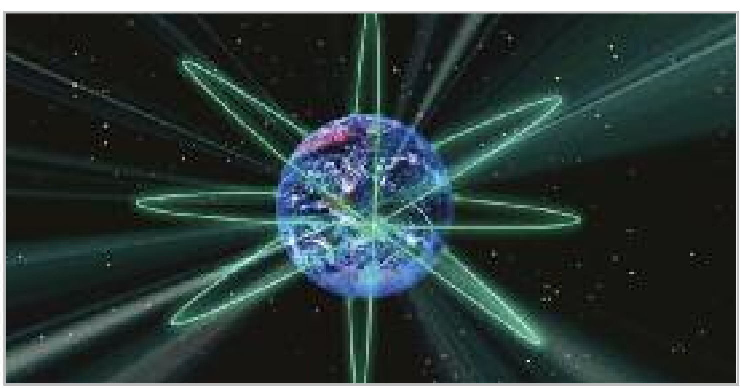
Professors David S. Kosson and Charles W. Powers, **Principal Investigators**

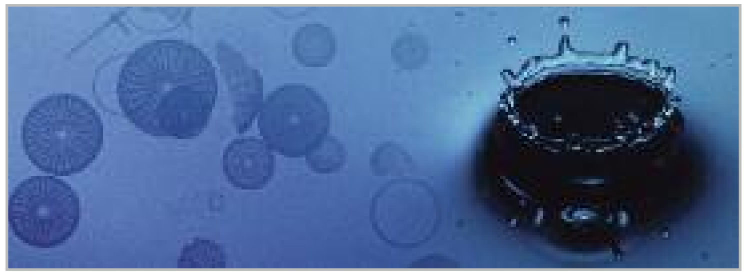
Mission

CRESP is a university consortium, supported by the Department of Energy, working to support safe, effective, publicly credible, risk-informed management of existing and future nuclear waste from government and civilian sources through independent strategic analysis, review, applied research, and education. CRESP includes senior researchers from Vanderbilt University (lead institution), Rutgers University, University of Pittsburgh, New York University, Robert Wood Johnson Medical School, Howard University, University of Arizona, and Oregon State University.

Research Areas

- Safe Containment—developing tools and techniques to assess and enhance the integrated performance of the engineered and institutional features of waste containment, land disposal systems, and isolation of residual contamination after remediation and near-surface waste disposal.
- Life Cycle Management—advancing and demonstrating appropriate use and communication of methods for comparative life-cycle risk/benefit analysis (human health and ecological resources) and cost assessment as tools for risk-informed selection among different environmental restoration and nuclear waste management options.
- Facility Siting Processes and Technology Choices—examining the potential benefits/limitations of integrated approaches to resolving nuclear waste challenges by defining/evaluating considerations for site locations (e.g., impacts on populations, natural resources, transportation) and the appropriate existing or evolving technologies needed for each type of nuclear waste management facility (e.g., interim storage, reprocessing).
- Stakeholder Involvement—assessing and demonstrating approaches to increase mutual understanding and more credibly incorporate involvement of the diverse stakeholders who can shape decisions to achieve technically sound nuclear waste management.





Vanderbilt Center for Environmental Management Studies

Professor Mark D. Abkowitz, **Director**

Mission

Vanderbilt Center for Environmental Management Studies (VCEMS) is an interdisciplinary program at Vanderbilt University under the leadership of faculty from the engineering, business, and law schools. VCEMS is at the forefront of conducting research, disseminating information, and establishing partnerships between industry, government, and academia in the emerging field of "environmental management." Environmental management (EM) is the application of strategic and operational methods and practices to achieve environmental protection and sustainability.

The vision of VCEMS is implementation of EM into the strategic planning process and core business practices within organizations so that it becomes a "business facilitator" instead of a "cost center." Although the means of achieving this goal are varied, VCEMS concentrates on two key elements of any successful EM program. These are the development of meaningful EM infrastructure in organizations and the identification and mitigation of environmental safety and security risks. The objective is to educate current and future leaders in business, government, and academia in these vital areas.

Research Areas

- Environmental safety and security risk management
- Use of information technologies to promote environmental awareness
- EM executive knowledge and awareness training
- National leadership summits that address emerging EM topics
- Making the business case for EM

Education

- Conducts executive management seminars on critical and emerging topics
- Supports interdisciplinary M.S. and Ph.D. programs in environmental management
- Promotes development and integration of environmental management curricula on campus
- Offers student fellowships and research assistantships with financial assistance from corporate sponsors and government agencies

Vanderbilt Center for Transportation Research

Professor Malcolm Baird, **Director**

Mission

VECTOR's mission is to improve the quality of life in our community, region, and nation through leadership and excellence in transportation research, education, and outreach, using all of the resources of the university and strong partnerships with government and industry.

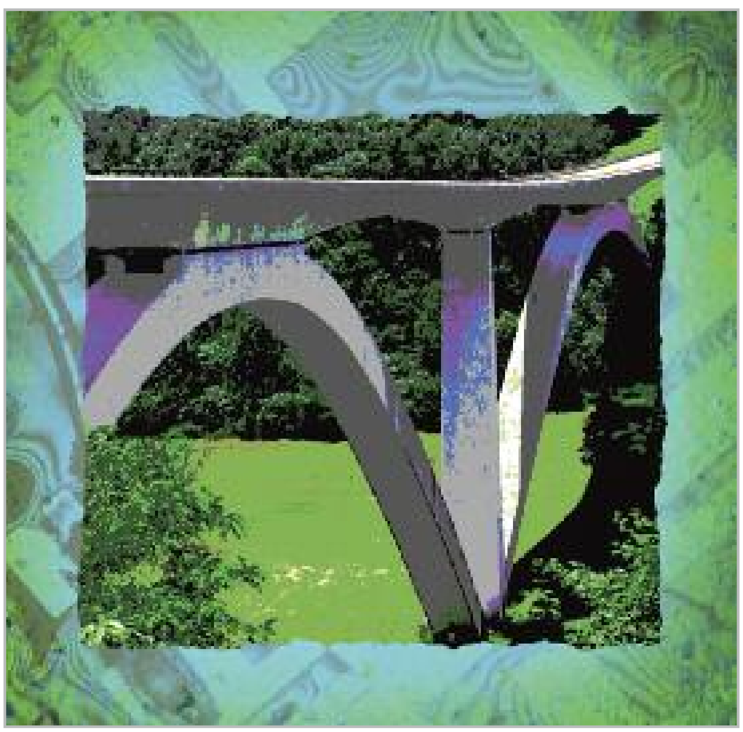
Recognizing the complexity of transportation issues at every level of government and throughout the private sector, VECTOR emphasizes the integration of transportation engineering, planning, and management.

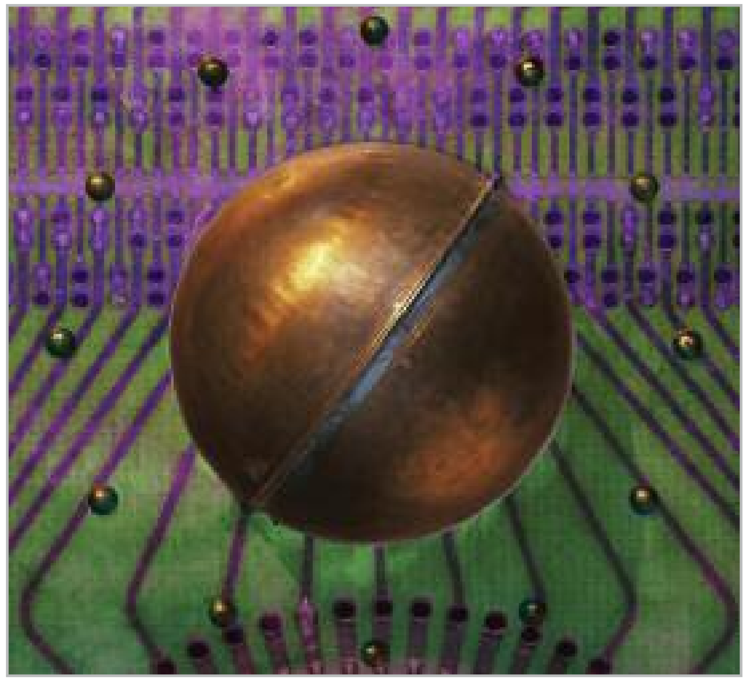
VECTOR seeks transportation solutions that are effective and efficient, use state-of-the-art technology and information systems, enhance safety and security, and incorporate environmental protection and improvement. In all its work, VECTOR emphasizes quality, objectivity, innovation, interdisciplinary approaches, timely delivery of results, and responsiveness to its stakeholders.

VECTOR has more than a decade of experience and a strong record in all three of its mission components—research, education, and outreach.

Research Areas

- Policy, management, and operations
- Advanced information systems
- Intermodal freight
- Safety, security, and risk management
- Incident management and emergency operations





Interdisciplinary Graduate Program in Materials Science

Profile

The Interdisciplinary Graduate Program in Materials Science (IGPMS) recognizes that the materials scientist requires graduate education and training represented by different departments and disciplines. This program brings together faculty from chemistry and physics from the College of Arts and Science and all the departments/programs from the School of Engineering: materials, chemical/biomolecular, electrical/computer science, biomedical, mechanical, and civil/environmental. The program is based on extensive collaboration in both teaching and research in materials science.

Research Areas

- Electronic materials
- Magnetic materials
- Materials characterization
- Materials physics
- Molecular engineering and science
- Nanostructured materials
- Organic-based devices
- Radiation effects in solid-state devices
- Science of thin films
- Solidification
- Superconducting materials
- Surface and interface science
- Surface modification
- Synthesis of materials

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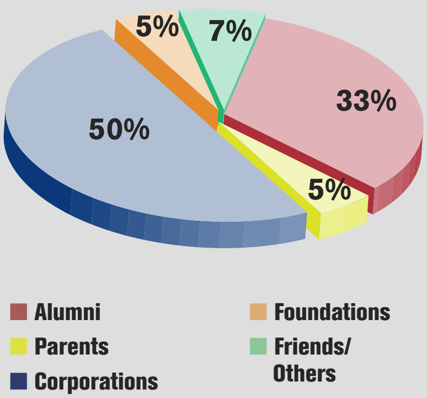
Shape the Future

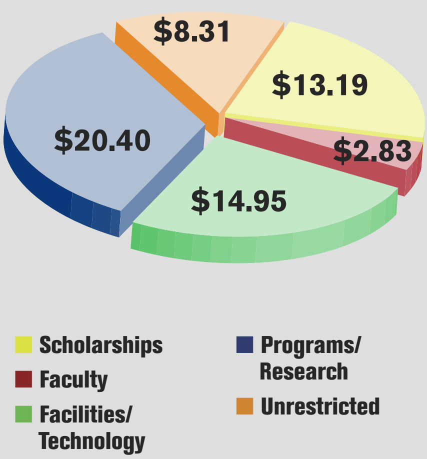
Vanderbilt University's current Shape the Future fundraising campaign exceeded its $1.25 billion goal two years ahead of schedule and set a new target of $1.75 billion by 2010.

Since July 1, 1999, to March 1, 2008, Shape the Future Campaign outright gifts and pledges to the School of Engineering have reached nearly $60 million.

Shape The Future campaign total gift amount by donor category from July 1, 2002, through July 31, 2008



Shape The Future campaign outright gifts and pledges since July 1, 1999, through July 31, 2008
Totals are in millions



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Opportunities for success

ADI AGRAWAL

Pieter Mosterman

Nothing is lost, nothing is created, all is transformed.

–Antoine-Laurent de Lavoisier (1743–1794)

Education is all "just in case," Vanderbilt Professor Art Brodersen wryly remarked, as only he could, during a free-form meeting on Total Quality Control and its principle of just-in-time manufacturing more than a decade ago. The School of Engineering's Center for Intelligent Systems held the meeting, and I, and my adviser Professor John Bourne, attended.

When I was asked recently to share some thoughts on the opportunities for success my Vanderbilt engineering education has provided me, my mind wandered back to that meeting. This led me to wonder: What is success, really? Isn't it something dynamic? That which succeeds is that which follows: an advance.

Education then truly should be a matter of preparing students to transform: always to become. Given that, as a teacher the best you can do for students is provide a broadly scoped set of anchor points of skills and knowledge to support the transition to each of their respective applications. Just in case.

In regard to engineering, Vanderbilt perfectly captures this breadth. The excellence in research at the School of Engineering, as I have come to learn over the years, operates in this manner at a supreme level. For a graduate student, this imparts a level of quality to your work that adheres to the most rigorous of standards. A testimony to this is that, after my first paper, I do not recall any of my couple of dozen peer-reviewed submissions being rejected.

The corresponding prerequisite energy and ambition of the faculty are not only contagious, but also consistently bring leading-edge research into the classroom. In true Vanderbilt spirit, even with the staggering amount of work that garners world-class recognition, faculty—such as my doctoral advisers Gautam Biswas and Janos Sztipanovits—are still committed to helping students learn and reach a similar level of achievement. Helping evaluate advanced research results establishes a process of enculturation, but it also creates an acute awareness and confidence that, yes, you can challenge the best.

Even with global accolades, the Vanderbilt community is sufficiently small to create a wonderful sense of camaraderie. It is inspiring to see how faculty collaborate on projects and thereby provide exceptional multidisciplinary research opportunities for students. This certainly contributes to developing the social skills that are essential to success as a member of a research community. Learning how to respect others earns you reciprocity and truly allows you to become an esteemed contributor to advancing a community.

By developing my ability to continuously adapt and advance, the Vanderbilt School of Engineering has given me the agility to seize opportunities as they arise and to succeed. After all, according to Antoine-Laurent Lavoisier, often called the father of modern chemistry, "nothing is lost, nothing is created, all is transformed." Just in case.

Pieter Mosterman is a senior research scientist who works on the design of core technologies for modeling, simulation, and code generation at The MathWorks, creators of MATLAB. He received a doctoral degree in engineering in 1997 from Vanderbilt University.

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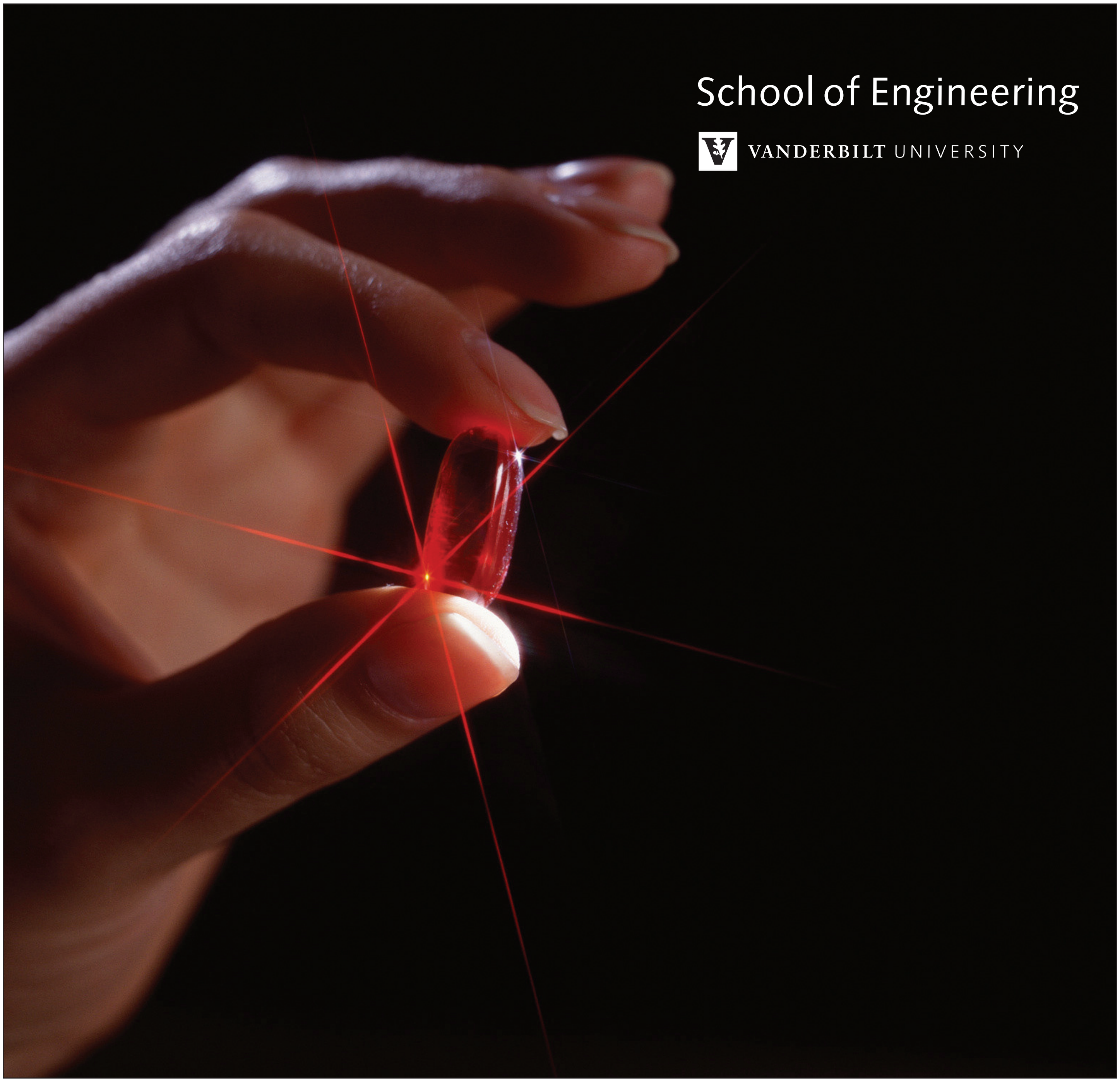

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