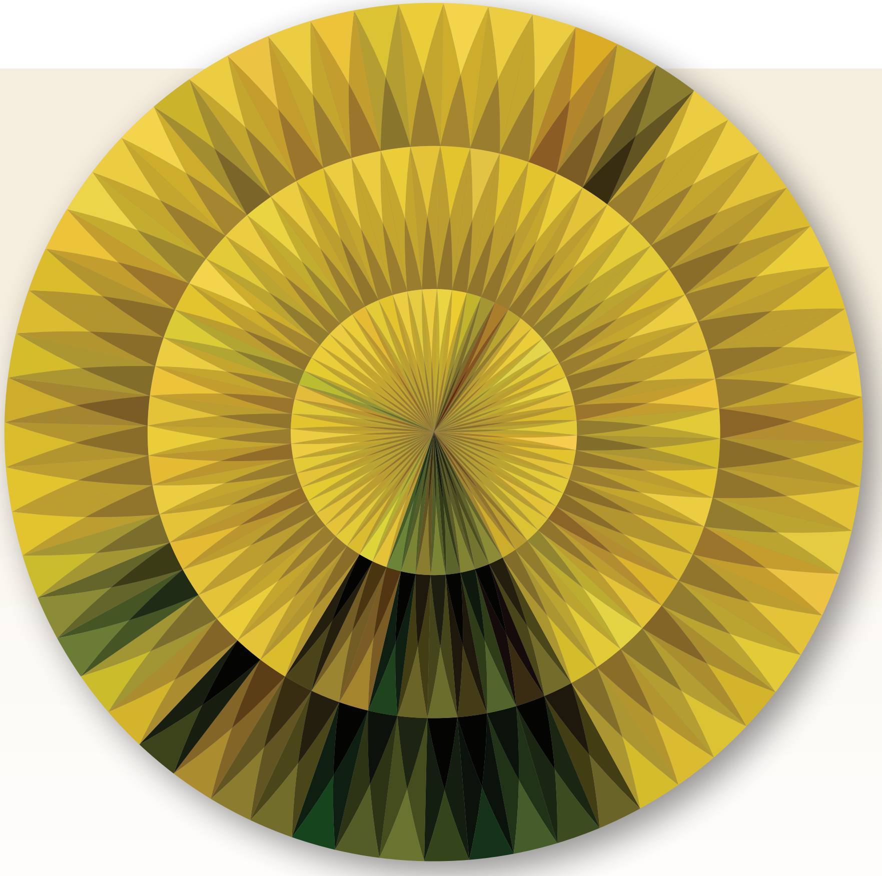
INSIGHT ◦ INNOVATION ◦ IMPACT®

SOLUTIONS 2014

Vanderbilt University School of Engineering



Opposite: Architect's rendering of the new Engineering and Science building under construction

PLANNED FEATURES OF THE **ENGINEERING AND SCIENCE BUILDING**

Fall 2014

In my two years as dean, the Vanderbilt University School of Engineering has experienced significant change. We have had unprecedented growth in entrepreneurial activity, crosscutting collaboration, and creating unique learning environments.

Our student, alumni, and faculty entrepreneurs are garnering attention and finding success commercializing innovative technologies. They have competed in and won hackathons and pitch competitions. They have incubated projects in a number of accelerators in Tennessee and beyond.

In support of this enhanced world of innovation, Vanderbilt has taken the significant step of breaking ground on a large trans-institutional facility, the Engineering and Science Building. Expected to open for the 2016-17 academic year, the building is designed to strengthen Vanderbilt's work as a major producer of intellectual leaders,

entrepreneurs, and innovators, and to provide dedicated space for students, faculty, and researchers to collaborate, innovate, and learn.

A new form of collaboration has taken root in the School of Engineering. New spaces and new challenges inspire researchers to increase collaboration across disciplines. For instance, our Multiscale Modeling and Simulation group has a new nearly 8,000-square-foot space to call home. MuMS faculty from chemical and biomolecular engineering, civil and environmental engineering, and mechanical engineering strive to understand soft and hard materials from the nanoscale up to the built environment by using tools such as molecular dynamics and advanced computational methods. These new nanomaterials can be fabricated at the Vanderbilt Institute for Nanoscale Science and Engineering and tested in real-world scale at our Laboratory for Systems Integrity and Reliability.

Atoms are not the only building blocks of today's research. The Institute for Software Integrated Systems works within the school and with outside collaborators to build future cybersecurity and cyberphysical systems. Thanks to the strong links being built among MuMS, VINSE, LASIR, and ISIS, we have the ability to scale from the nano to the macro environment, as well as link to cyber and physical systems. Additionally our Risk and Reliability group focuses on predicting when it is necessary—and how best—to intervene in a system or structure if a failure is imminent.

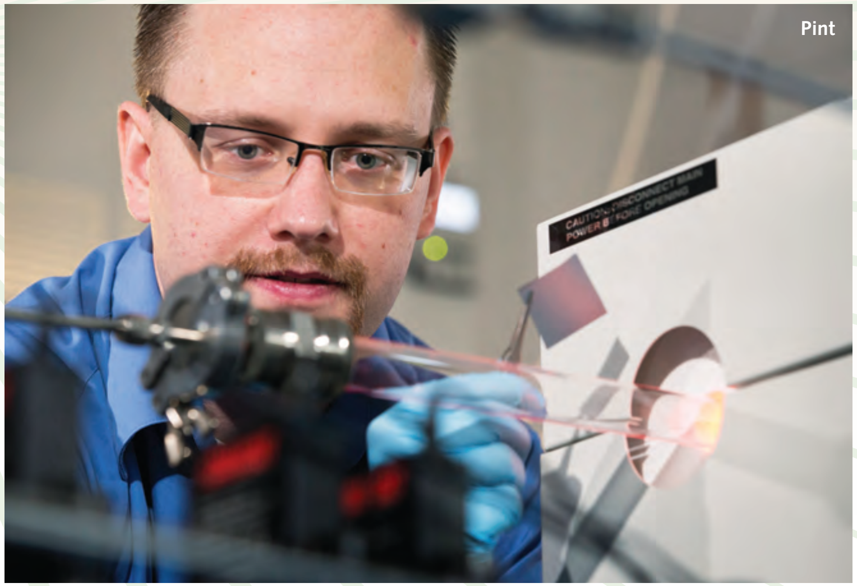
Every discipline in the School of Engineering thrives in these collaborative environments. The following pages demonstrate how our departments, centers, institutes, and research groups work across our strategic research areas of health and medicine, security, and energy and natural resources while engaging students in their work and creating learning opportunities outside the classrooms.

Best regards,

Philippe Fauchet

Cutting the **Cord**

In recent years, technological mobility has greatly impacted the way we work, shop and communicate. But that increased freedom lasts only as long as our batteries do. One solution is using supercapacitors for energy storage and power delivery instead of batteries.



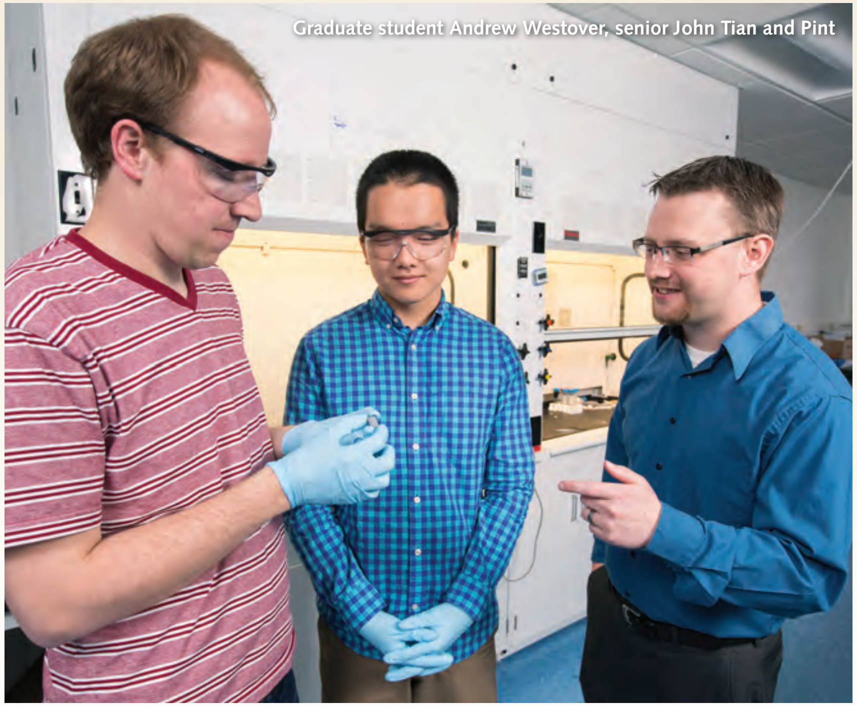
Pint

But what if that energy could be built right into system components, which could be recharged in a fraction of the time, replace the structural materials and last exponentially longer?

Thanks to the research of Assistant Professor of Mechanical Engineering Cary Pint and his team in the Nanomaterials and Energy Devices Laboratory, modern-day tethers such as batteries and power cords could be gone. They've recently designed a novel supercapacitor made out of porous silicon that can be built into a silicon chip and power onboard circuitry, or better yet, replace the structural casing of the system. Consider, for example, power built into the shell of a laptop, the chassis of an electric car or the drywall of a home to run lights and appliances.

Much of Pint's efforts have focused on using porous silicon, but his research broadly explores porous metals and carbons as well, which have equal promise across many different technologies. To activate these materials for energy storage, they are treated in such a way that nanoscale pores form. The materials are then combined with polymer films, which ooze into the pores when the electrodes are pressed together—similar to how cheese oozes into the crevices of bread in a panini. The polymer allows the charges to move back and forth and allows it to reversibly store and discharge energy.

The polymer also allows the structure to withstand pressure or

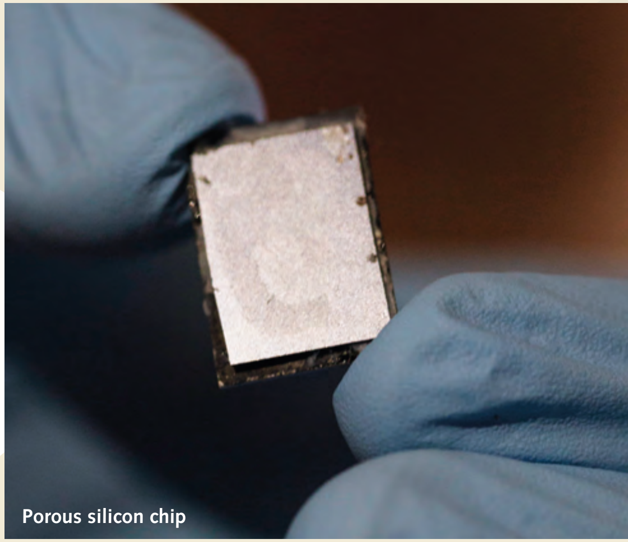

Graduate student Andrew Westover, senior John Tian and Pint

mechanical forces. Pint's group has demonstrated that these materials can maintain the charge storage behavior while subject to vibration forces more powerful than those observed in a jet engine.

Pint's supercapacitor holds several benefits over traditional batteries. By storing energy in the porous material instead of using chemical reactions like batteries do, energy can be charged and discharged in minutes instead of hours. And it will operate for millions of cycles instead of a battery's thousands. It also has the advantage of being small, unlike bulky existing supercapacitors.

Long term, the power cell technology means more energy can be stored in places where batteries don't exist today—such as integrated into technology. Devices will continue to become smaller and lighter since they will no longer need room to house a battery. Fossil fuels will be reduced as a fuel source. And since energy storage will have a longer life cycle, waste from spent batteries could be reduced.

The research was supported by National Science Foundation grants CMMI 1334269 and EPS 104083. Materials fabrication was conducted in part at the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory that is supported by the Office of Basic Energy Sciences of the U.S. Department of Energy.


Porous silicon chip

From the birth of a new center to new materials and innovations for traditional ones, School of Engineering faculty and students are tackling issues in energy and natural resources. Here are just a few highlights.

IMPACT

Preventing a Breakdown

With most waste, the faster the breakdown, the better. But when that waste is spent nuclear fuel, breakdown brings challenges—especially when it takes place in the fuel's containment system.

Florence Sanchez, associate professor of civil and environmental engineering, is exploring ways to make concrete used in storage for used nuclear fuel more durable. This concrete includes nanosized and nanostructured particles that can improve concrete's strength, durability and overall performance.

Sanchez has long explored the link between nanotechnology and concrete performance in other applications; civil infrastructure, for one, is severely affected by concrete degradation. And yes, she sees the irony in her work. Civil engineering, with its focus on massive infrastructure projects like roads and bridges, is being influenced by developments at the nano level.

Understanding how radioactive and thermal environments affect nano-engineered materials, however, is key to ensuring that nuclear material can be safely held for centuries. Sanchez currently is studying which types of nanostructured particles perform best under conditions that most simulate nuclear waste containment.

This research is supported by a grant from the U.S. Department of Energy's Nuclear Energy University Programs.

Sanchez with Catherine Stephens, MS'10, PhD'13, and current doctoral student Lesa Brown, MS'11.

Valentine

INNOVATION

Now You See It…

Technically, it still isn't possible to make an object completely invisible. But working in metamaterials—artificially fabricated resources with optical properties not found in nature—Jason Valentine is seeing new discoveries "appear."

Valentine, assistant professor of mechanical engineering, is exploring the spectrum of visibility in metamaterials. He works primarily in silicon, which offers new possibilities thanks to its higher refractive index. His use of dielectric materials—they typically absorb less light than metal counterparts—can lead to breakthroughs in high-power lasers, offer infrared concealment and create single-mode lasers.

More broadly, Valentine's research uses nanoscale structuring to engineer a material's optical properties, which may have implications in communications, imaging, solar energy conversion, photonic circuitry and products that source, control and detect light known broadly as optoelectronic devices.

Valentine joined Vanderbilt in 2010. In early 2014, he was awarded the National Science Foundation Early Career Grant to further explore ultra-compact optical elements that can improve performance of visible and infrared cameras and be used to develop free-space telecommunications and optical manipulation. This work is supported by the Office of Naval Research.

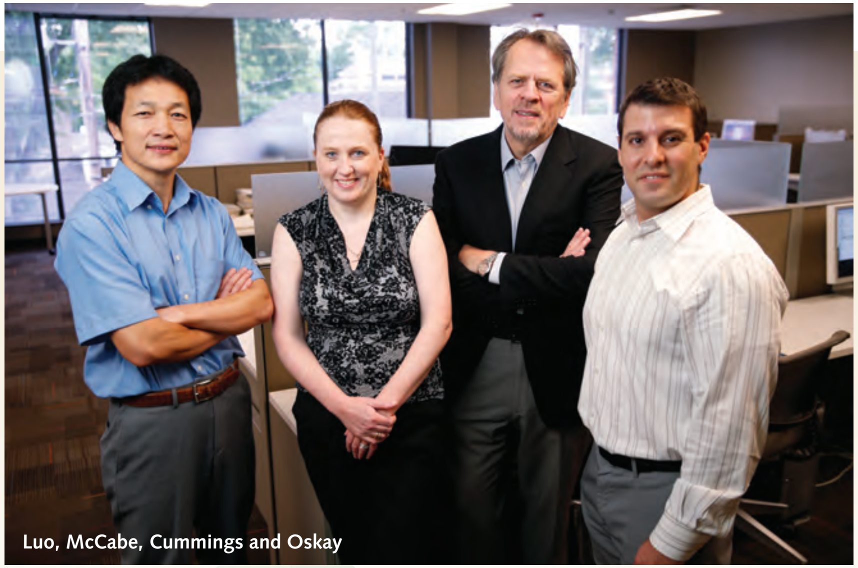
INSIGHT

Alternative Energy, Unconventional Storage

There is much promise in power from wind and solar. But what happens when the breeze doesn't blow and the sun doesn't shine? Energy storage remains a significant issue, delaying full-scale development of these renewable resources.

Peter Cummings, associate dean of research and director of the new Multiscale Modeling and Simulation facility, is exploring the use of energy storage mechanisms such as batteries and supercapacitors for alternative energy sources. Each offers electrical storage solutions—and each has unique benefits. Cummings, the John R. Hall Professor of Chemical Engineering, is developing technologies that combine the best of both, but to do so requires understanding at the molecular level.

In working on capacitors that use room-temperature ionic liquid electrolytes, Cummings has relied on the MuMS group's computer modeling strengths. The new interdisciplinary facility allows for the modeling of physical and chemical phenomena at all scales—vital since materials act differently at the nano level than they do at the micron level.

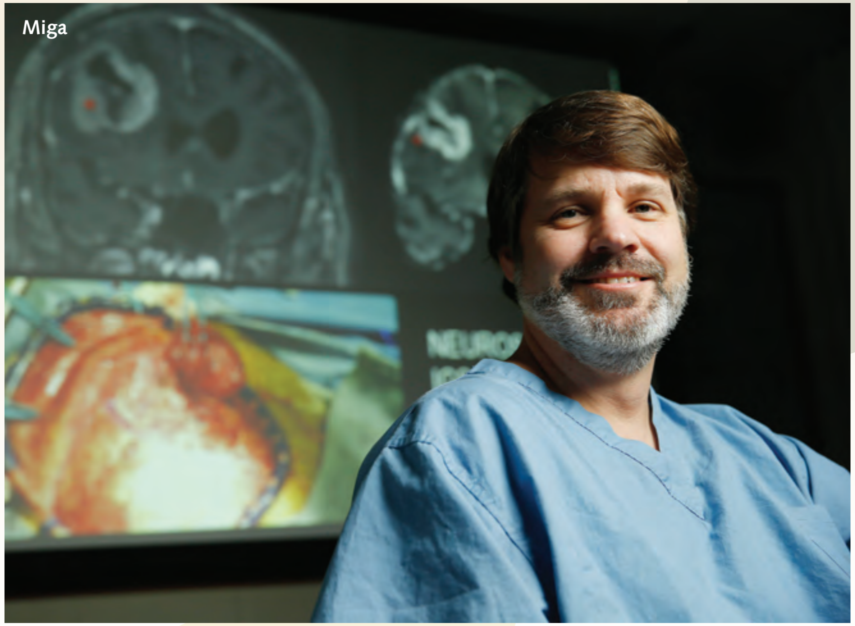


Luo, McCabe, Cummings and Oskay

Vanderbilt is the first institution to develop an entity like MuMS that can do modeling from the very large to the very small. Much of the modeling is done via computer and requires advanced software technology that must be developed in-house, which allows MuMS to collaborate with Vanderbilt's Institute for Software Integrated Systems—the world's leading expert on computer modeling. Drawing from various departments in the School of Engineering, MuMS includes Cummings, Haoxiang Luo (mechanical engineering), Clare McCabe (chemical and biomolecular engineering) and Çağlar Oskay (civil and environmental engineering).

Cummings' research is supported in part by a grant from the Fluid Interface Reactions, Structures, and Transport (FIRST) Center, funded by the U.S. Department of Energy.

It's All in the Head



When a tumor starts in the brain, even benign growth can be life changing—especially if it compresses areas that control vital body functions.

Surgery is likely the best option but there are significant risks as surgeons must navigate a thin line between removing as much of the tumor as possible and preserving neurological function—all within an ever-shifting setting.

As the skull is opened, the brain deforms or shifts, affecting the position of the subcortical structures and making targeting of a tumor more complex. Diagnostic images taken days or even hours before a scheduled surgery may not be accurate.

Being able to anticipate the changes that might occur before and during surgery, however, could help surgeons better navigate this complex environment. Michael Miga, professor of biomedical engineering, has been studying just that as part of a multi-year research project funded by the National Institutes of Health.

Miga's research centers on providing a computer model of the patient's brain before surgery to anticipate and account for potential deformations. This image-driven patient-specific modeling framework can be conducted within one day of the anticipated operation, limiting the changes between the time the images are conducted and when the surgery is scheduled—and reducing any potential for significant changes in growth or positioning.

Then, during the operation, data measuring the brain's surface is collected using a laser range scanner. Those measurements are then used with the computer model to update the pre-operative images to account for shifts that have occurred during the procedure. It updates these images rapidly, providing the surgeon with near real-time information. The technology represents a cost-effective and easily implemented hardware and software solution that is complementary to the surgeon's routine workflow during the procedure.

As part of this multi-year grant, the research is moving into another phase, testing whether the technology could offer an alternative to intraoperative magnetic resonance imaging.

If the new technology proves as—or more—effective than iMR, doors may open for improvements in care. Because iMR is a powerful solution, it is resource-intensive. If Miga's technology proves as accurate, it could represent a widely adoptable technology for any scale medical center with neurosurgical capabilities.

While this effort has been limited to neurosurgery, Miga sees potential applications in other soft-tissue environments, including abdominal and breast surgeries.

This research is supported by NIH grant R01NS049251.


Miga (seated) with graduate students Rebekah Conley, Yifei Wu, MS'14, and Jarrod Collins

On many university campuses, the disciplines of medicine and engineering are separated by more than just physical distance. But at Vanderbilt, the School of Engineering is just a few steps from the Vanderbilt University Medical Center—and rich collaborations allow engineering innovations to quickly be tested and put into practice nearby.

Impact

Better Bone Grafts

When breast cancer metastasizes, an already agonizing disease can be compounded. Bone pain, fractures and hypercalcemia—excess calcium in the blood—become as familiar as radiation, steroids and chemotherapy. Because cancer patients have compromised systems, traditional methods of healing can be challenging. To make matters worse, many bone therapies should not be used in patients with tumors.

Surgery often becomes the only option; bone grafts are used to stabilize implants and provide a scaffold on which new bone grows. Vital tissue can be taken from the patient to stimulate new growth, but that may mean another area of surgical pain at the donor site. The risk of complications increases at the site where the tissue was removed.

Scott Guelcher, associate professor of chemical and biomolecular engineering, is exploring alternatives in polymers that can serve as a scaffolding for new tissue growth. While his research is not yet in clinical trials, he currently is testing which compounds might aid in healing using minimally invasive surgery. These injectable polymers also can be augmented with antibiotics and growth factors to further increase effectiveness.

Composites also may be used to provide mechanical strength—such as when a weight-bearing bone is injured—and participate in the healing. The bone graft would then be resorbed, eliminating the need for more surgery to remove it.

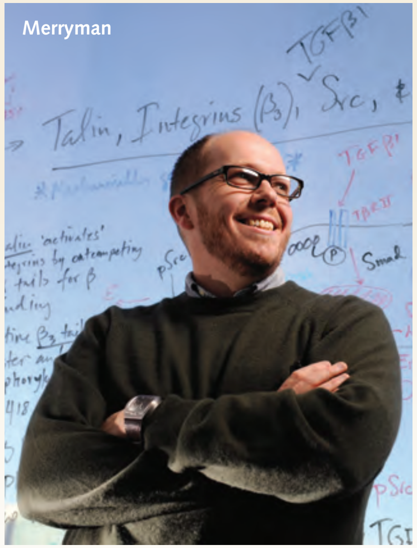
Guelcher's research is sponsored by NIH grants R01CA163499, R01AR064304 and R01AR064772.

Innovation

Hitting the Target

It's one of the cruelest ironies of medicine: Those who need invasive surgery often are so sick that the surgery is as great a risk as the underlying disorder.

That is the case with existing treatments of degenerative aortic valve disease, which affects about one-fourth of those over age 65 and eventually leads to calcific aortic valve disease (CAVD). Currently the only treatment is open-chest valve replacement—an extremely risky procedure given the age of most patients.



Merryman

W. David Merryman, who holds joint appointments as assistant professor of biomedical engineering, pharmacology, medicine and pediatrics, is exploring novel strategies to prevent and treat CAVD without the need for open-chest surgery. His most recent work is in developing serotonin-targeted drug therapies that prevent valve cells from developing into myofibroblasts, which lead to CAVD.

Merryman's approach is to create something positive out of something extremely devastating. In the 1990s, the weight-loss drug Phen-Fen caused rapid heart valve disease in previously healthy patients. His tactic is to redeem some of what was learned through Phen-Fen by targeting the same cell receptors with drugs that offer the reverse action. He believes this may prevent age-related heart valve disease altogether, which would in itself prevent the need for risky surgery for aging patients.

The research is sponsored by an NIH grant.

Graduate student Jialei Song and Luo

Insight

Finding a Voice

Complex math problems have no doubt left more than one person speechless. But what if those very math approaches could solve issues related to the voice? Haoxiang Luo, who holds dual appointments as associate professor of mechanical engineering and otolaryngology, is using complex mathematical computations to explore how air coming out of the lungs interacts with the vocal cords in producing sounds.

As Luo advances understanding of how the voice operates, new opportunities arise for treating benign lesions and scarring on the vocal fold. Luo's three-dimensional modeling is expected to yield additional treatments, diagnoses and medical research. Much of the work is conducted through the school's Multiscale Modeling and Simulation research group, of which Luo is a member.

He takes the collaborative research another step by helping train graduate and undergraduate students how to use multiphysics modeling to better understand the interaction of fluids, thermal, structures and electricity. Luo's work in vocal dynamics builds upon his computational work modeling the flow-structure of insect flight. That work earned him the National Science Foundation's Early Career Development Program award in 2010.

The research is conducted in collaboration with Purdue University and is funded by National Science Foundation grant 1066962. It is also supported by an NIH grant led by Bernard Rousseau, associate professor of otolaryngology and hearing and speech sciences in the Vanderbilt School of Medicine.

Virtually into the Wild Blue **Yonder**

Mahadevan with doctoral students in reliability and risk engineering and management

With the U.S. Air Force operating in far-flung regions of the world, a plane out of service can present challenges. Even worse: A plane that is flying but not structurally sound can be deadly.

A virtual replica of an aircraft, however, could anticipate its service needs and lifecycle, minimizing unnecessary hazards. Sankaran Mahadevan, the John R. Murray Professor of Engineering and professor of civil and environmental engineering, aims to create such airplane avatars.

Mahadevan, through his work with the National Science Foundation's Integrative Graduate Education, Research and Training Program, is directing research that will develop probabilistic models that can anticipate changes in the structural health of an aircraft's frame based on a number of factors. Since each pilot may maneuver his or her aircraft differently, and because of the vast differences in how a military aircraft is used, any probability modeling must account for significant variations.

Mahadevan's research is part of the Air Force's digital twin program, which will help virtually design and maintain each aircraft in the fleet, predicting its structural integrity and reliability at any point in its life. The digital twin will forecast future maintenance needs by using physics simulations, as well as maintenance and operational data. When fully implemented, the digital twin program is expected to ensure that the fleet is ready to fly—without sacrificing safety.

Working in conjunction with GE, Lockheed Martin Corp. and Wyle

Aerospace, Mahadevan's team is integrating various probabilistic methods—computing that accounts for variations and uncertainties—to develop new approaches for predicting airframe problems. The goal is to allow preventative maintenance to be conducted before an aircraft's structural integrity is compromised.

As this probabilistic technology is refined, it shows promise for systems such as energy storage, thermal protection and avionics.

Since joining Vanderbilt in 1988, Mahadevan has focused his research on reliability and uncertainty analysis methods, structural health monitoring, design optimization and model uncertainty in civil, mechanical and aerospace systems. His work has had broad government funding from entities such as the NSF, NASA, Federal Aviation Administration, U.S. Department of Energy, U.S. Department of Defense, several national laboratories, and corporations like General Motors, Chrysler and Union Pacific.

He is one of the country's foremost researchers into risk and reliability issues, applying his expertise to structural integrity of systems as disparate as bridges and space shuttles. In 2001,


Mahadevan

he developed the School of Engineering's multidisciplinary graduate studies in reliability and risk engineering and management, which began with a grant from IGERT, NSF's flagship interdisciplinary training program. IGERT works to educate Ph.D. scientists, engineers and educators in interdisciplinary backgrounds. This effort is now self-sustaining with government and private partners funding a myriad of research projects.

Mahadevan's research into probabilistic technology for the airframe digital twin is funded by the Air Force Research Laboratory.

In our rapidly advancing world, defense, security and the protection of data must always remain top of mind. The School of Engineering is part of the solution with defense-funded projects and creative initiatives ranging from advances in crime fighting to ensuring the structural integrity of aircraft.

Impact

Rules are Good

In its infancy, the Internet often was compared to the Wild West, since established behavior and rules were lacking. This even translated to new technologies: With everything changing rapidly, there was no guarantee devices would play nice with others.

But as the landscape has shifted into the "Internet of Things"—a vast connection of everyday devices linked to each other, and more broadly, to the world—rules are needed.

Janos Sztipanovits, director of the university's Institute for Software Integrated Systems, and other ISIS members are part of a new consortium to develop rules for such connected devices to ensure open platforms—allowing for rapid advancements—and improved integration.

The Industrial Internet Consortium includes foundations, technology giants and one academic institution: ISIS. ISIS members will play a significant role in the group, using the institute's expansive experience in developing software and tools for sharing. More broadly, much of its research will help the IIC meet its goal of advancing security issues and building confidence in new products.

In addition, Sztipanovits, the E. Bronson Ingram Distinguished Professor of Engineering, was elected to the group's steering committee, helping shape policy and determine standards.

Insight

Move Over, *Minority Report*

About a decade ago, a hit movie featured a police force that could predict crimes and swoop in before they happened. That kind of crime fighting may not be far off if a team headed by Eugene Vorobeychik, assistant professor of computer science and computer engineering, has its way. While the movie cops relied on psychics to determine potential perpetrators, Vorobeychik and his collaborators use data, computing and analysis.

The trans-institutional team of Vorobeychik, Kenneth Pence, associate professor of the practice of engineering management, and Paul Speer, professor of human and organizational development at Vanderbilt's Peabody College, uses game theory and big data to optimize policing. The researchers use crime data collected by the police and the location of officers at the time the crime occurred. They also use data from property assessors and even weather information, plus some valuable insider insight: Pence is a graduate of the FBI National Academy and a 31-year veteran of the Metropolitan Nashville Police Department.

Using game theory modeling, the researchers can gauge the effectiveness of police patrols and expert opinions of police personnel to assess solutions proposed. Then they will experiment with different techniques in the field, determining the most effective model to be adopted by police.


Speer, Pence and Vorobeychik

Innovation

Gold Standard

The world has become a more dangerous place. Lives depend on successful screening for explosives at airports, military bases and other checkpoints. But current methods are costly and cumbersome. And remote locations—which may need screening most of all—don't have the resources to implement those methods.

Sharon Weiss, associate professor of electrical engineering and physics, has developed a method that is more portable and less expensive. The process uses an ultrathin layer of white gold film that is soaked in a chemical to introduce tiny holes and then imprinted with a periodic pattern. A test sample is dropped on to the gold foil and can be measured with a portable tool. Laser light reflected from the foil contains the necessary information to identify the chemicals in the sample. Even using minute amounts of gold, the surface provides signal amplification of nearly 100 million times.

It's a far cry from the large-scale spectrometers currently in use at airports to screen baggage. The portability makes for practical application in the field, hospitals, labs or factories. Ease of use means training is simple. And in extremely dangerous situations, even robots could perform the tests, providing an added layer of safety. This work is sponsored in part by the Army Research Office grant W911NF-09-0101.

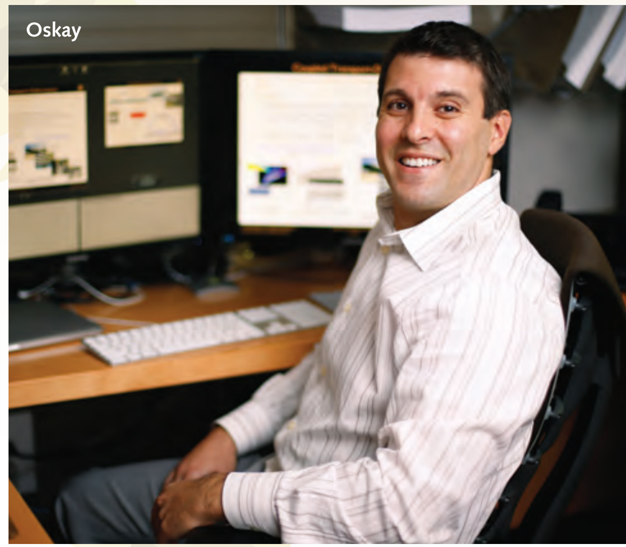
Insight

Under Pressure

When the U.S. Air Force aims high, it does so at a high rate of speed. It would like to get even higher and even faster—perhaps surpassing Mach 5. But could any plane withstand that level of pressure?

Çağlar Oskay, associate professor of civil and environmental engineering, is using computer modeling to predict structural behavior in the airplanes of the future. Computational modeling is required since the severe environments these planes will operate in can't be replicated in an experimental setting. Knowing how planes will behave at such intense pressures—and for how long—is vital to the plane's structural integrity.

Oskay, a member of the Multiscale Modeling and Simulation (MuMS) research group, is developing methods to predict whether and how these structures can survive in extreme circumstances. The work is funded by the Air Force Office of Scientific Research.



3, 2, 1...

Vanderbilt's Aerospace Club—defending champions and winning team again in 2014—in NASA national rocket competition

When it comes to national championships, Vanderbilt continues to reach great heights. This year, the engineering students in Vanderbilt's Aerospace Club again claimed first place in NASA's Student Launch program.

In the seven years the Aerospace Club has competed, it has won the award for best payload design four times. It also has earned top spots twice each for website design, educational outreach and closest-to-altitude performance. In 2011 and 2012, the club came in third overall before winning first place in 2013. In 2014, the club dominated the field, winning four of the six major category awards—project review, website design, educational engagement and closest to altitude—in addition to the top prize.

Launching a rocket and safely landing it back on Earth is no easy task. The competition is an eight-month project regularly reviewed by NASA engineers, contractors and industry experts. Teams must design unique payloads, prepare exhaustive engineering reports and flight test their evolving rocket designs and payloads—all while communicating their efforts through a website and community outreach.

It is such a difficult competition that of the 31 competitors who entered, only 16 made it to the final step: launch day at the Bonneville Salt Flats in Utah.

In the 2013-14 academic year, all schools had a new, different challenge. NASA switched the competition's focus to more intense research and required three different payloads, as well as an added focus on landing hazard detection systems.

Even with the increased intensity, Vanderbilt's Aerospace Club, advised by Professor of the Practice of Mechanical Engineering Amrutur Anilkumar, geared up to the challenge. Its STARCraft rocket undertook three experiments: a fuel delivery system that aimed to keep the fuel from sloshing in the fuel tanks under heavy deceleration, a biofuel-powered ramjet engine, and a camera-based "camjet" to detect hazards during landing.

Another challenge: The club's members were also determined to extend their education outreach activities.

For the past several years, the team has worked with Heather Johnson, assistant professor of the practice of science education at Vanderbilt's Peabody College, in developing a program to teach Nashville-area middle school students about the design, development and launch of bottle rockets. This year, they expanded their efforts by trekking several hours to rural Tennessee schools that might not otherwise have access to basic engineering curriculum.

The club members designed various experiments and Peabody educators developed a five-week curriculum in engineering design that resulted in a launch competition for the middle school students. The Vanderbilt students hope their efforts help build or increase interest for future engineers who might just be future winners of the NASA competition.

The team's winning rocket has also been popular at national events, helping promote science, technology, engineering and mathematics (STEM) careers. The rocket was an attraction at the USA Science and Engineering Festival, which drew some 325,000 people to the Washington, D.C. event.

The club is sponsored by the Tennessee Space Grant Consortium, American Institute of Aeronautics and Astronautics (Tennessee section) and Vanderbilt's Department of Mechanical Engineering.

Club members explain rocketry principles to K-8 students

Advances developed by engineers influence our everyday lives in a variety of ways, generating solutions for societal issues and providing a framework for challenges to come. Vanderbilt University's School of Engineering assures that the next generation of engineers—and the ones after that—have a solid foundation from which to start.

Innovation

Out-of-this-world Learning

From their very first class to their last, Vanderbilt electrical engineering undergraduates will have a new component in their hands-on coursework in the shape of miniature space satellites called CubeSats. The School of Engineering faculty recently added the use of CubeSats as a learning component in the official degree curriculum for electrical engineering students.

With a CubeSat, a lot is packed into a small package. At about 64 cubic inches, a CubeSat combines many elements of electrical engineering, including microprocessors, digital signal processing, radio frequency communications, power regulation and remote sensing. Add in that CubeSats are built using low-cost, off-the-shelf components, and you have a winning electrical engineering teaching tool.

CubeSat work will follow undergraduate students throughout the program. First-year engineering students will be introduced to the fundamental concepts behind satellite system design. Sophomores will be introduced to satellite circuit design techniques significantly beyond what is normally taught at that level. Junior and senior electrical engineering majors will continue to hone their skills using the CubeSats in electronics lab experiments, a satellite design elective and senior design projects. As an added plus, the curriculum is designed to encourage experimentation and personal projects.

The concept for using CubeSats as a teaching framework was presented at the 2014 American Society for Engineering Education annual conference.

Insight

Young Researchers

Students who intend to become researchers may chomp at the bit to get into the lab and begin experimenting. Thanks to Vanderbilt's participation in the National Science Foundation's Research Experience for Undergraduates, they can.

Each year, about 10 undergraduates come to Vanderbilt to work closely with faculty researchers in a true interdisciplinary research experience. In addition to working one-on-one with a Vanderbilt professor, the students participate in weekly meetings covering topics ranging from ethics and the responsible conduct of research to demystifying graduate school and the GRE examination.


McCabe

Under the direction of Clare McCabe, professor of chemical and biomolecular engineering, REU students work closely with the Vanderbilt Institute for Nanoscale Science and Engineering on nanomaterials innovation and fabrication research projects.

In addition to directing the REU program, McCabe also directs the university's overall summer research program, Vanderbilt Undergraduate

Summer Research Program, and directs graduate studies in the Department of Chemical and Biomolecular Engineering. As a member of the Multiscale Modeling and Simulation team, she focuses on molecular modeling to predict the properties of nanostructured soft materials.

The REU program is supported by the NSF's Division of Materials Research and Engineering Directorate, as well as the Department of Defense ASSURE program.

Impact

Worth More than a Mention

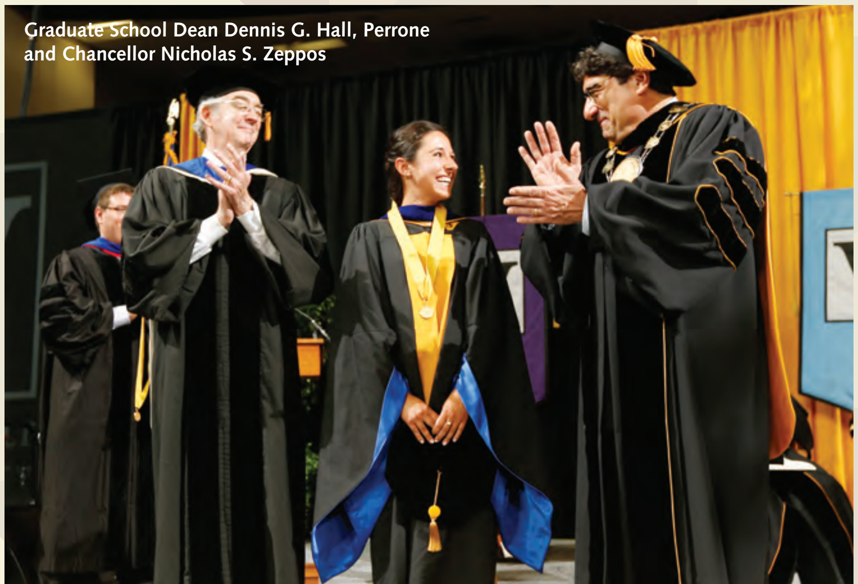
Today's research often focuses on the discoveries of tomorrow. It's equally important, however, to focus on the researchers of tomorrow. The School of Engineering does its part through educational opportunities for undergraduate and graduate students alike. A few highlights of the educational mission:

■ Engineering students and the university community at large will benefit from hearing thought-leading entrepreneurs through the Chambers Family Entrepreneurial Lectureship. The new lectureship, with an inaugural event in fall 2014, will bring entrepreneurs to campus twice a year to share expertise and inspiration with the next generation of leaders. The lectureship was endowed by alumnus Jason Chambers, BS'99, MBA'01.

■ Debra Perrone, MS'10, who received her Ph.D. in environmental engineering in May, was selected as Vanderbilt's Graduate School Founder's Medalist. The Founder's Medal is presented annually to the student graduating at the top of his or her class from each of Vanderbilt's schools. Perrone's adviser was National Academy of Engineering member George Hornberger; her research into water resources earned her an Environmental Protection Agency fellowship.

■ Metro Nashville high school students spent part of their summer interning at Vanderbilt's Institute for Software Integrated Systems. The students used software tools developed by ISIS to design LED safety lights, an LCD display screen and onboard computer for bicycles. The institute developed the software to revolutionize the manufacturing of military vehicles.

■ Undergraduate summer interns at ISIS developed applications for Google's new modular cell phone, ARA, scheduled to hit the market next year. The students demonstrated the apps, a glucose monitor and infrared remote controller, virtually for Google representatives via teleconferencing.


Graduate School Dean Dennis G. Hall, Perrone and Chancellor Nicholas S. Zeppos


LED bike safety lights

Numbers of Note

Faculty Honors

79

named fellows

VANDERBILT
School of Engineering

Recruiting

of employers ranked Vanderbilt's Engineering/IT career events as excellent or above average

Engineering Students

32% women

17.4% international students

22.5% minority students

Faculty

14:1 undergraduate students to faculty member

5:1 graduate students to faculty member

Institutes, Centers and Groups

12

Graduate Honors

NSF

15 current engineering graduate students awarded 2014 NSF graduate research fellowships

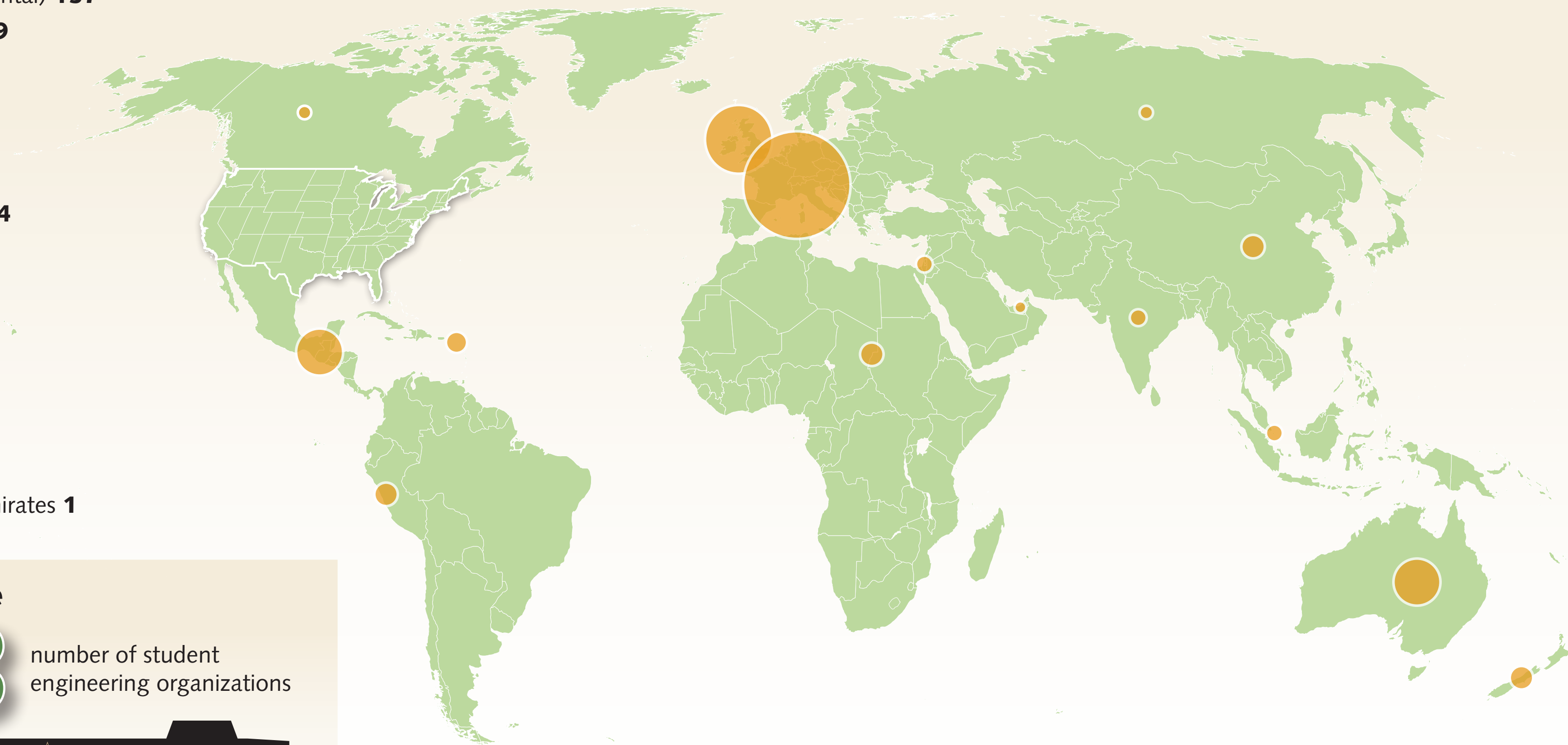
Externally Funded Research Expenditures

$71.9 million

FY2013

Students' Global Experiences*, 2010-2014

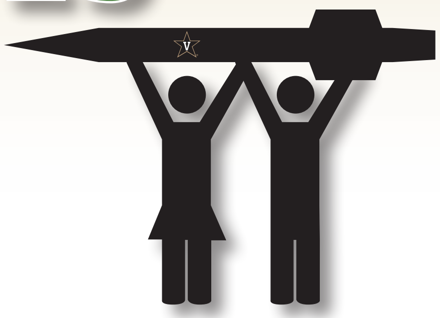
- Europe (continental) **137**
- UK & Ireland **59**
- Guatemala **41**
- Australia **38**
- China **17**
- Africa **15**
- New Zealand **14**
- Peru **13**
- Caribbean **9**
- India **5**
- Israel **5**
- Singapore **3**
- Canada **2**
- Russia **2**
- United Arab Emirates **1**



* includes study abroad, exchange and overseas service learning programs

Student Life

23 number of student engineering organizations



Undergraduate Research

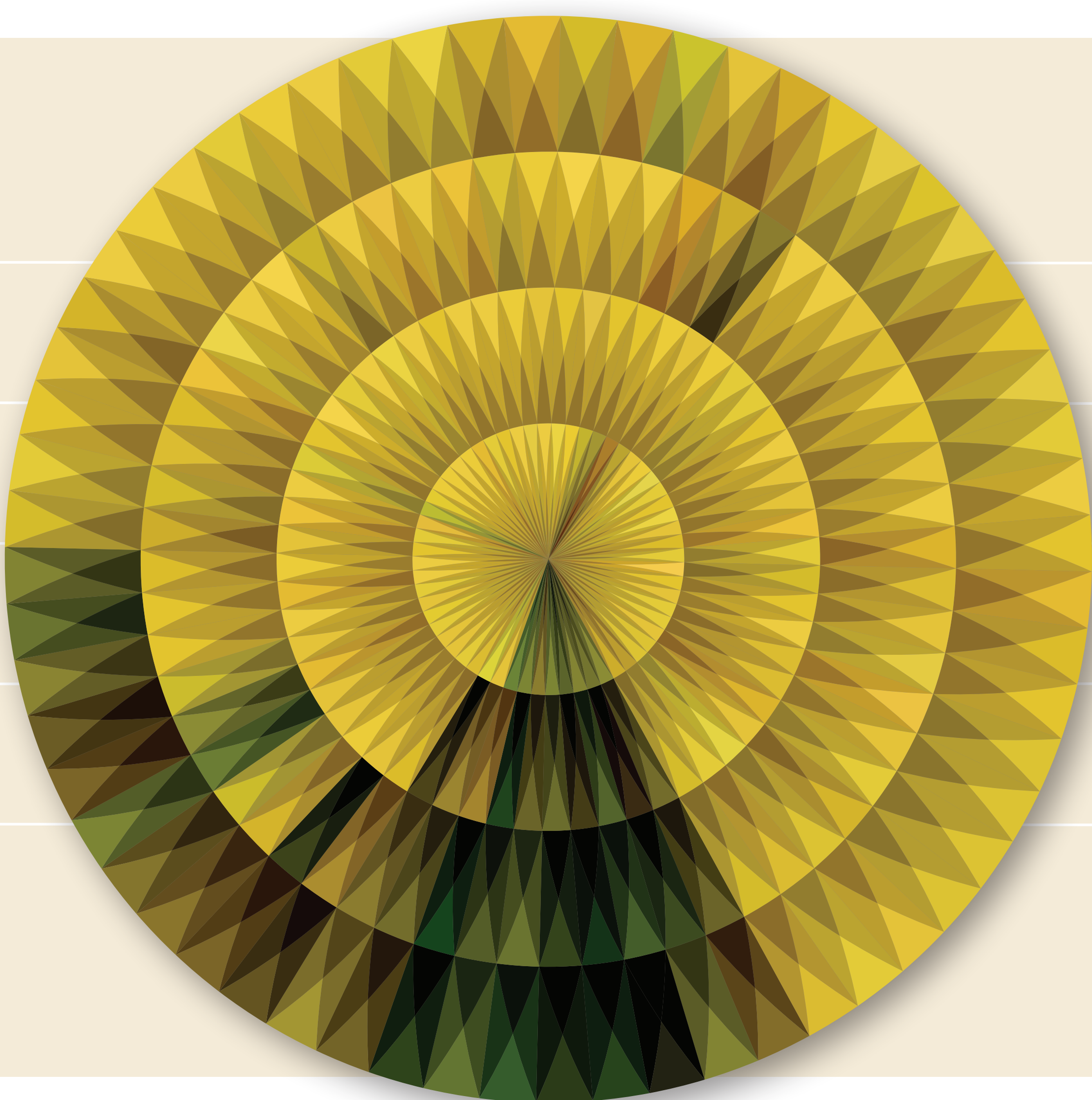
53% of all undergraduates participate in research projects outside the classroom

Selected Honors and **Leadership**

Unless otherwise noted, the following lists organizations to which Vanderbilt School of Engineering faculty have been elected as fellows (as of September 1, 2014).

American Academy of Forensic Sciences
American Association for the Advancement of Science (AAAS)
American Geophysical Union
American Heart Association
American Institute of Aeronautics and Astronautics
American Institute of Chemical Engineers
American Institute for Medical and Biological Engineering
American Physical Society
American Society of Civil Engineers (ASCE)
American Society for Engineering Education
American Society for Laser Medicine and Surgery
American Society of Mechanical Engineers
American Vacuum Society
American Welding Society
Association of Women in Science
Biomedical Engineering Society
Council on Basic Cardiovascular Sciences of the American Heart Association
Electrochemical Society
Engineering Mechanics Institute
Geological Society of America
Heart Rhythm Society
Institute of Electrical and Electronics Engineers (IEEE)
Institute of Physics (UK)
Institute of Transportation Engineers
International Society for Magnetic Resonance in Medicine
International Society for Optical Engineering (SPIE)
Materials Research Society
National Academy of Engineering, Members
National Academy of Sciences, Advisory Committees Member
National Academy of Sciences, National Associate
Optical Society of America
Royal Danish Academy of Sciences and Letters
Royal Society of Chemistry (UK)
Royal Swedish Academy of Engineering Sciences
U.S. Air Force Scientific Advisory Board, Member
U.S. Nuclear Waste Technical Review Board, Presidential Appointee

Innovation to **Commercialization**



$1.4 million
Revenue for VUSE technologies

93 **U.S. patent applications filed**

68 **New invention disclosures received**

9 **U.S. patents issued (more pending)**

8 **License agreements executed**

4 **Startups with a connection to the School of Engineering**

These figures were provided by Vanderbilt's Center for Technology Transfer and Commercialization for the fiscal year July 1, 2013, to June 30, 2014.

Expanding Engineering's Footprint

The Vanderbilt University School of Engineering, established in 1886, has grown from one building to 10. In addition to the trans-institutional Engineering and Science Building currently under construction, facilities added this year include the LASIR lab and MuMS group.

1 LASIR—MetroCenter
2 Featheringill/Jacobs Hall
3 Stevenson Center
4 W.M. Keck FEL Center
5 ISIS and ISDE—Music Row
6 MuMS—Music Row
7 VUIIS
8 Engineering and Science building (under construction)
9 Olin Hall
10 MRB IV

Research **Groups**

As the engineering arm of an internationally recognized research university, Vanderbilt University School of Engineering fosters strong partnerships inside the university and with its research peers. The combination of innovative research, commitment to education and collaboration with a distinguished medical center creates an invigorating atmosphere where students tailor their education to meet their goals and researchers join to solve complex questions affecting our health, culture and society. Vanderbilt is ranked 20th in federal research and development funding obligations among U.S. colleges and universities.

Center for Intelligent Mechatronics (CIM)

Michael Goldfarb, H. Fort Flowers Professor of Mechanical Engineering
research.vuse.vanderbilt.edu/cim

Consortium for Risk Evaluation with Stakeholder Participation (CRESP)

David Kosson, Cornelius Vanderbilt Professor of Engineering
Co-PI **Charles Powers**, Professor of Environmental Engineering
cresp.org

Institute for Software Integrated Systems (ISIS)

Janos Sztipanovits, E. Bronson Ingram Professor of Engineering
isis.vanderbilt.edu

Institute for Space and Defense Electronics (ISDE)

Ron Schrimpf, Orrin H. Ingram Professor of Engineering
isde.vanderbilt.edu

Laboratory for Systems Integrity and Reliability (LASIR)

Douglas Adams, Daniel F. Flowers Professor and Distinguished Professor of Civil and Environmental Engineering
vu.edu/lasir

Multiscale Modeling and Simulation Group (MuMS)

Peter Cummings, John R. Hall Professor of Chemical Engineering
my.vanderbilt.edu/mums

Research **Groups**

Vanderbilt Institute for Digital Learning (VIDL)
Douglas Fisher, Associate Professor of Computer Science and Computer Engineering
vu.edu/digitallearning

Vanderbilt Institute for Energy and Environment (VIEE)
George M. Hornberger, Craig E. Philip Professor of Engineering and Distinguished University Professor
vanderbilt.edu/viee

Vanderbilt Institute for Integrative Biosystems Research and Education (VIIBRE)
John Wikswo, Gordon A. Cain University Professor and Professor of Biomedical Engineering
Deputy Director **Franz Baudenbacher**, Associate Professor of Biomedical Engineering
vanderbilt.edu/viibre

Vanderbilt Institute of Nanoscale Science and Engineering (VINSE)
Sandra Rosenthal, Jack and Pamela Egan Professor of Chemistry and Professor of Chemical and Biomolecular Engineering
vanderbilt.edu/vinse

Vanderbilt Initiative in Surgery and Engineering (ViSE)
Benoit Dawant, Cornelius Vanderbilt Professor of Engineering
vanderbilt.edu/vise

Vanderbilt University Institute of Imaging Science (VUIIS)
John Gore, Hertha Ramsey Cress Professor of Medicine, University Professor of Radiology and Radiological Sciences, and Professor of Biomedical Engineering
vuiis.vanderbilt.edu

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Building Renderings

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