Solutions

INSIGHT ◦ INNOVATION ◦ IMPACT®

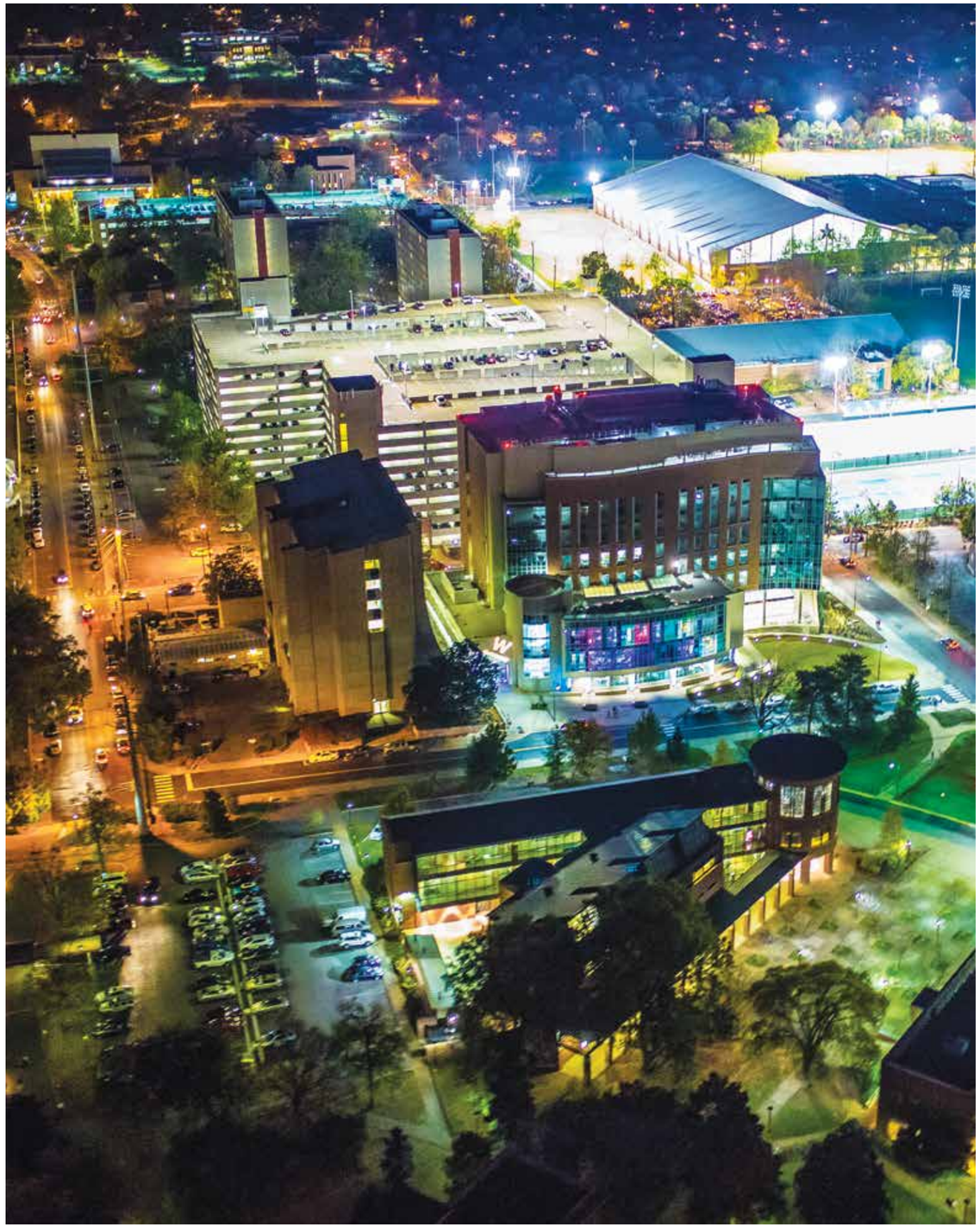
VANDERBILT SCHOOL OF ENGINEERING

2017 | 2018

Harvesting electricity from human motion

Artificial intelligence and autism

Elephant poachers beware



Dear Readers:

I hope you enjoy this redesigned version of *Solutions,* our fall publication. It provides a mix of information on the School of Engineering—ranging from classic research pieces to a message from Dean Fauchet to perspectives penned by our undergraduate and graduate students. The work we do and the education we provide our students is something to be admired and proud of. I know I am, and I believe you will be, too.

Not enough pages can capture all the great work that unfolds here at the Vanderbilt University School of Engineering. We proudly share these wonderful stories and introduce you to our faculty and students. My hope is that, once you have read through these pages, you will find yourself stimulated, encouraged and more knowledgeable about the work we do. Feel free, too, to reach out to me directly if you would like more information about a certain project or research area.

For a more regular stream of stories, please subscribe to Dean Fauchet's weekly e-newsletter at *engineering.vanderbilt.edu/news/weekly-subscribe.* We're also on Twitter *@vuengineering,* Instagram *@vanderbiltengineering* and Facebook at *facebook.com/vanderbiltengineering.*

Best regards,

Christopher Rowe
(BE'96, ME'98, EdD'08)
Professor of the Practice of Engineering Management
Communications Director

Solutions

VANDERBILT SCHOOL OF ENGINEERING
2017 | 2018

Innovations are no small feat, require federal support

by Philippe M. Fauchet, Dean, School of Engineering

Some of us remember automobiles without seat belts, navigating without GPS, and health care without CT scans or ultrasounds. These advances are so embedded in our daily lives it is easy to take them for granted, along with flu shots, LEDs, lithium-ion batteries, and yes, the internet.

These life-saving and life-changing developments were all products of research universities. Vanderbilt School of Engineering proudly continues this long and noble history. Right now, our researchers are creating "organs" on microchips that could speed drug development; using nanotechnology for stronger concrete and building materials; closing in on a nonsurgical treatment for heart valve calcification; pioneering energy-harvesting clothing; and developing exosuits and other assistive devices for the mobility of amputees as well as individuals with conditions as common as arthritis.

We work with communities to improve infrastructure resilience and accelerate disaster recovery. We work with clinicians to create less invasive procedures and advanced imaging to diagnose and treat disease more quickly.

Academic research has a "blue sky" component, but the academic spectrum contains significant translational and applied aspects. It unfolds in a setting where educating the next generation of scholars, makers, entrepreneurs, and leaders is a primary mission. Research opportunities prepare undergraduate and graduate students for important roles in industry and government as well as academia. Our alumni are CEOs of large corporations, lead successful startups, and are distinguished professors at leading universities.

This is no small endeavor. It requires community involvement, industry partnerships, and federal support. In the current era of fiscal austerity, the latter is under constant scrutiny by policymakers. Earlier this year, the new administration proposed draconian cuts to federal research agencies that would be devastating to the American academic research enterprise, one of our greatest national resources and competitive strengths.

We remain committed to providing our faculty and students with the facilities and support they need to conduct groundbreaking research and are equally committed to ensuring that federal funds are used prudently and appropriately. The costs of university research are real and significant, but when you consider the impact of the discoveries made, how can this nation not support the work our faculty and student researchers are doing?

Consider a much-cited study by the Information Technology and Innovation Foundation that looked at how collaboration among universities, the federal government, and private industry has transformed U.S. innovation.

The findings were clear: U.S. federal funding was key to nearly 90 percent of almost 100 top innovations from 1971 to 2006 identified by *R&D Magazine*. That's a powerful endorsement. And with it, we intend to keep bringing you next-generation engineering advances year after year.

Internship leads to app development, readies undergrad for real-world challenges

by Charles Colt

"What do you want to be when you grow up?"

This is the question that every college student dreads hearing at the annual family reunion. What makes it so difficult to answer is what makes everything difficult as a college student: uncertainty and indecisiveness. As a person who barely plans his dinner in advance, I find answering this question extremely difficult and found choosing the right internship challenging.

Serendipitously, I landed in the Summer Games program at Booz Allen Hamilton in Washington D.C. Along with being meaningful and productive, the work also offered me important insight on what makes summer internships valuable. Students are still maturing and developing, and internships should nurture this growth. The focus of internships should be to develop your growing skillset, establish a professional network and meaningful mentorships, and strengthen the ability to overcome failures.

The Summer Games program organizes approximately 450 interns into 78 teams that must create a solution to a problem. My team was tasked with improving government flood risk communication methods. We were given the idea of creating an app to visually communicate predictions. The project allowed me to develop my communication and leadership skills while getting real-world experience by creating a business and marketing strategy and processing large volumes of data—skills not easily learned in a few classroom scenarios.

To complete the project, our team needed to contact relevant experts throughout the company for advice and resources. This was beneficial in three different ways. First, it provided me with professional insight and feedback on our progress. Second, it required me to understand the structure of the company and all the contracts in which employees are involved. Third, it allowed me to develop personal connections with leaders in the firm who care about my career growth.

While working on my technical skills and developing an innovative solution, I experienced a flurry of failures, ranging from typos in memos to ignoring time value of money in projected profit models. While embarrassing in the moment, these failures were the most critical experiences in my internship. I learned the importance of understanding expectations set for you, taking pride in the work you complete and turning negative feedback into an opportunity to grow.

By the end of the summer, my group had developed a functioning app that utilized augmented reality and crowdsourcing techniques to effectively communicate flood risk to individuals. I had contributed significantly to building an app having only taken one introductory computer science class at Vanderbilt. I co-developed a business case for a new product with only a few engineering management classes under my belt. My internship was a success because it allowed me to explore my interests and further develop myself as an academic and professional. It was a success even though I still don't know what I want to be when I grow up.

Charles Colt is a junior pursuing a double major in engineering science and communication of science, engineering and technology and a minor in engineering management.

Support from fellowships, mentors opens doors to Ph.D. student's international opportunities

by Megan Poorman

When I decided to attend Vanderbilt for my graduate studies, I knew I was committing to a top-ranked university with stellar research and close medical collaborations. What I didn't realize was how much the university invested in the growth of its students.

In my time as a Ph.D. student at Vanderbilt, I've traveled the world to present at conferences, attended workshops to learn about new areas of my field and spent time living in another country collaborating with world-renowned researchers. These experiences have changed the course of my research career and would not have been possible without graduate fellowships and the encouragement of my mentors.

As a first-year student, I was offered an IBM fellowship through the Vanderbilt School of Engineering. This award provided me with a stipend increase and professional development funds to be used every year. Not only did this allow me to live within walking distance to campus, it also enabled me to attend multiple conferences a year to stay in touch with both of my research areas: focused ultrasound and magnetic resonance imaging.

The IBM fellowship has made a substantial impact in my day-to-day life and facilitated my interaction with researchers around the world. I am also a recipient of the Whitaker International Summer Fellowship Grant. This is an outside fellowship that funds Ph.D. students in biomedical engineering to conduct research abroad. It allowed me to live in the Netherlands for 10 weeks to work on my dissertation at one of the top research institutions in my field.

I had been keeping an eye on the Whitaker program for years but never really thought that I would be able to take time away to participate.

This all changed my second year of graduate school, when my director of graduate studies began heavily promoting the fellowship, and I decided to ask my adviser if he thought it would be a valuable experience. Much to my surprise, he didn't even question the time I would spend away from lab. Instead, he said that it sounded like an awesome experience, assured me my projects would be waiting for me when I returned and convinced me to apply. His immediate and overwhelming encouragement to pursue an individual professional development opportunity, even if it meant time away from his lab, perfectly exemplifies why Vanderbilt is such a unique place.

While the fellowships themselves provide the means to pursue enrichment opportunities, it is the unwavering support of the Vanderbilt community that makes these fellowships impactful.

Megan Poorman is a biomedical engineering Ph.D. student working in the Vanderbilt University Institute of Imaging Science. Her research focus is magnetic resonance imaging and integrating it with other imaging modalities for improved therapies and treatments.

Engineering researchers collaborate on fields from autism to materials durability

The School of Engineering is involved in 10 of 15 interdisciplinary concepts to be explored by the 2017 recipients of Vanderbilt's Trans-Institutional Programs awards. These research projects bring together more than 120 faculty members with graduate and undergraduate students from all 10 schools and colleges, creating multifaceted teams to approach complex challenges.*

Adaptive e-Books for Building Children's Language Skills

Nilanjan Sarkar, professor of mechanical and computer engineering

Developing an adaptive e-book that represents a groundbreaking approach to foster early language skills. As the child enjoys a story, an avatar will teach vocabulary and support comprehension and inferential thinking.

Addressing the Epidemic of HPV-Associated Cancers

Anita Mahadevan-Jansen, Orrin H. Ingram Professor of Biomedical Engineering

Developing educational programs for an interdisciplinary team of faculty and student researchers to lay the groundwork for a consortium focused on HPV-associated cancers: assessing the local burden of HPV-associated cancers, increasing HPV vaccination and developing methods for early detection of other cancers.

(BioMIID) at Vanderbilt Biophotonics Center

Anita Mahadevan-Jansen, Orrin H. Ingram Professor of Biomedical Engineering

Duco Jansen, professor of biomedical engineering and associate dean for graduate education

Matthew Lang, professor of chemical and biomolecular engineering

Creating a collaborative environment across three schools for biophotonics innovation and biomedical discovery, plus building microscopy systems that do not yet exist in the commercial realm and using them to answer previously unanswerable questions in biomedicine.

Center for Autism and Innovation

Maithilee Kunda, assistant professor of computer science and computer engineering

Philippe Fauchet, dean of the School of Engineering

Nilanjan Sarkar, professor of mechanical and computer engineering

Studying the unique capabilities of adults with autism, as well as how to match these capabilities to 21st-century workforce needs and how to develop managers who can leverage the "autism advantage" to fuel innovation in their organizations.

Data Science Visions

Gautam Biswas, Cornelius Vanderbilt Professor of Engineering, professor of computer science and computer engineering

Robert Bodenheimer, associate professor of computer science, computer engineering and electrical engineering

Sankaran Mahadevan, John R. Murray Sr. Professor of Engineering, professor of civil and environmental engineering

Taking the first steps to position Vanderbilt as a leader in the critical new field of data science. The initiative will identify and connect all data science activity at Vanderbilt to create a unified data science community and spark cross-campus research collaborations and educational programs.

Enhancing the Research and Educational Missions of the Vanderbilt Brain Institute

Duco Jansen, professor of biomedical engineering and associate dean for graduate education

Enabling the Vanderbilt Brain Institute to run pilot programs, invest in its training programs, establish an external advisory board and allow for VBI to continue key initiatives.

Materials Durability and Environmental Research Facilities Hub

Florence Sanchez, associate professor of civil and environmental engineering

David Kosson, Cornelius Vanderbilt Professor of Engineering, professor of civil and environmental engineering

George Hornberger, University Distinguished Professor of Civil and Environmental Engineering and Earth and Environmental Sciences, Craig E. Philip Professor of Engineering

Kane Jennings, professor and chair, Department of Chemical and Biomolecular Engineering

Shihong Lin, assistant professor of civil and environmental engineering

Scott Guelcher, professor of chemical and biomolecular engineering

Sankaran Mahadevan, John R. Murray Sr. Professor of Engineering, professor of civil and environmental engineering


Amrutur Anilkumar

Providing core facilities in support of research on the performance and durability of natural and engineered materials and systems exposed to a wide range of environmental conditions. This research includes developing advanced materials for infrastructure and a variety of other areas.

Understanding the Complexity of Life One Cell at a Time

Theodore Bapty, research associate professor of electrical engineering

Supporting a new consortium of six centers campuswide to coordinate efforts and investments in student single-cell biology in a bottom-up strategy to support and shepherd technological advances and expand access and education to the whole community.

The Vanderbilt Microbiome Initiative

Akos Ledeczi, professor of computer engineering

Providing Vanderbilt the opportunity to become the first university that unifies a major precision medicine initiative with personalized microbiome studies. The initiative will blend Vanderbilt's clinical, basic, translational and educational endeavors into a community of more than 100 microbiome scholars.

VUSAT Initiative

Amrutur Anilkumar, professor of the practice of mechanical and aerospace engineering

Robert Reed, professor of electrical engineering

Gabor Karsai, professor of electrical engineering, computer science and computer engineering

William Emfinger, adjunct assistant professor of mechanical engineering

Bringing together the advanced resources of engineering, anthropology, Earth and environmental sciences and astronomy to design and develop a space-based platform to study the evolving ecology on Earth.

*Only engineering faculty are listed here.

Opening doors for computer science majors to study around the world

Nicholas Hyman (CS, Chem, Applied Math '18)

A surge in computer science majors means they're dominating the School of Engineering's already vibrant study-abroad program, earning international experience that employers with global operations value highly.

Of the 36 engineering students who studied abroad in the spring of 2017, 17 were either majoring or minoring in computer science. The exploding interest prompted Associate Dean Cynthia Paschal and Isabelle Crist, assistant director of operations in the Vanderbilt's Global Education Office, to collaborate on ensuring a smooth transition to overseas universities.

Unlike programs at many universities, students remain enrolled at Vanderbilt while they are abroad, which means they receive full Vanderbilt credit for the courses taken abroad and receive all or most of their usual financial aid when they study for a semester or longer.

"We spent the better part of a year working on course reviews and program evaluations to expand enrollments of computer science students in direct-credit programs, which means those courses and grades factor into the Vanderbilt GPA," Paschal said.

The two also partnered with Julie Johnson, associate professor of the practice of computer science and director of undergraduate studies in computer science, to create curriculum plans to guide students' course selections at Vanderbilt and at various foreign universities.

"Adding the sample curricula helps computer science students see how they can study abroad and meet all degree requirements and still graduate on time," Paschal said.

Vanderbilt's approach means undergraduate engineers study abroad at rates nearly double the national average, Paschal said. Thirty percent of the class of 2017 studied abroad, as did 24 percent of the classes of 2016 and 2015.

Navigating those requirements was critical for Nicholas Hyman, a senior and a triple major in computer science, chemistry and applied math from Alpharetta, Georgia. He spent the spring 2017 semester at the University of Edinburgh.

"The biggest effect studying abroad had on my computer science major was working with other University of Edinburgh students and American students. It was interesting to learn about their computer science backgrounds and how they approached problems differently," said Hyman, who had never before traveled beyond the United States.

He also saw how computer science transcends language and culture barriers. "I loved traveling in Europe, and I might eventually want to live abroad. It was great to know that my CS major will provide me with universal skills."

Foundation's $15 million gift will establish engineering leaders

A visionary $15 million gift from the Clark Charitable Foundation to Vanderbilt University has established a Clark Scholars Program at the School of Engineering. The program will enable talented undergraduates to become engineering leaders.

The program emphasizes four key components—engineering excellence, business acumen, service learning and leadership.

"Time and time again, we have turned to engineers to solve great problems facing society. There's a renewed vigor at Vanderbilt for innovation and entrepreneurship," said Dean Philippe Fauchet. "The continued strength and ascent of the School of Engineering and the strategic design of this program will position Clark Scholars to facilitate great change."

A cohort of 10 students, chosen from the incoming first-year class, arrived this fall. Ten first-year students will be selected from subsequent classes.

"The Clark Scholars Program at Vanderbilt will help carry on my father's legacy," said Courtney Clark Pastrick, board chair of the A. James and Alice B. Clark Charitable Foundation. She is also a member of Vanderbilt's Board of Trust.

A. James Clark was president and CEO of Clark Construction, a Maryland-based firm with a national reach.

"He firmly believed in the power of education and how engineering leaders can change our world for the better," Pastrick said.

With a focus on underrepresented students, the goals of this program are to combine experiential learning, coursework, mentoring and summer experiences into a unique four-year undergraduate career with ability to collaborate across the School of Engineering and the university.

"Through a strategic balance of curricular, co-curricular and extracurricular opportunities, Clark Scholars will harness service, leadership and business experiences to emerge as a new kind of engineering innovator," said Christopher J. Rowe, faculty director of the program, professor of the practice of engineering management and director of the Division of General Engineering.

The students will be introduced to the university's numerous leadership programs, the engineering management minor as well as service learning experiences through the Office of Active Citizenship and Service. They will be some of the first students to complete a human-centered design boot camp that leads into structured, semester-long service learning projects through the Design as an Immersive Vanderbilt Experience program.

"The Clark Scholars Program is a first-of-its-kind opportunity to develop a cohort of engineering leaders," Rowe said. "We think it will transform the lives of these students, who will contribute to society in meaningful and significant ways."

Clark Scholars: Shyla Slater, Joey Holliday, Adrianna Johnson, Jeremiah Woldabezgi, Stephanie Schroth, Jack Mejia, Tim O'Brien, Reese Phillips, Monika Wojnowski and Yoanna Ivanova

TWO MECHANICAL ENGINEERING UNDERGRADS NAMED GOLDWATER SCHOLARS

Lauren Branscombe and **Joshua Fleck** are seniors in mechanical engineering focused on medical robotics. Both work in the Center for Rehabilitation Engineering and Assistive Technology with Karl Zelik, assistant professor of mechanical engineering. Both plan to pursue Ph.D.s in mechanical engineering, continue research and improve the lives of people with limited mobility.

But they have even more in common: Both were recognized as 2017 Goldwater Scholars.

They join 238 other scholars nationwide, selected on the basis of academic merit from a field of 1,286 in mathematics, science and engineering students nominated by colleges and universities nationwide. Each institution can select up to four students for consideration by the Barry Goldwater Scholarship and Excellence in Education Foundation.

The Barry Goldwater Scholarship and Excellence in Education Foundation was established by Congress in 1986 to honor the late Senator Barry Goldwater and increase the number of students pursuing research careers in the critical areas of the natural sciences, mathematics and engineering.

NASA weather balloon project captures eclipse data, connects radio buffs

Vanderbilt's interdisciplinary NASA Space Grant Ballooning Project team

The total solar eclipse lasted about two minutes in Nashville, but it took a team of Vanderbilt engineers months of preparation to capture video and data from that event.

Team leader Adam Jarrell, a third-year graduate student in mechanical engineering, spent a few days last summer at a workshop in Montana for about 50 schools participating in a NASA weather balloon launch program. After that, he and his team developed payload designs, bought materials, completed lab work and performed two test launches—all the maneuvering necessary to get that balloon to about 73,000 feet before 1:27 p.m. on Monday, Aug. 21.

From that height, the curvature of the Earth, the deep twilight of the eclipse and the blackness of space are visible. Striking video was streamed to a NASA website. The next day, the team declared the launch a success and began reviewing spectacular flight videos and photographs and analyzing data.

The NASA Space Grant Ballooning Project was a nationwide effort to livestream the solar eclipse. More than 50 weather balloons were released by schools from Oregon to South Carolina—along the path of totality—as a part of that project, a feat that's never been done before.

In addition to NASA, the Tennessee Space Grant Consortium, led by the School of Engineering, the National Oceanic and Atmospheric Administration and the Vanderbilt Amateur Radio Club, were project partners.

The Vanderbilt balloon was released from the rooftop of a 12-story campus parking garage. The 12-pound payload included the requisite onboard video camera to stream to the NASA website as well as a tracking system and an amateur radio repeater that the Vanderbilt Amateur Radio Club used to communicate with fellow ham radio operators across the southeastern United States.

"I cannot thank my colleagues enough for the time they volunteered to make the launch a success," Jarrell said. The DeKalb/Cannon County Amateur Radio Club quickly recovered the balloon near Watertown, Tennessee.

The payload included an atmospheric sensor package intended to measure changes in the Earth's atmosphere caused by the rapid cooling when the sun was obscured. These measurements will be used in research undertaken by Susan Stewart, adjoint assistant professor of astronomy. Stewart also has an appointment with the U.S. Naval Observatory in the astronomical applications department.

Tim Holman, Vanderbilt University's Amateur Radio Club's adviser and a research associate professor of electrical engineering and computer science, said the radio repeater was a hit. "We had contacts or reception reports from ham radio operators in Tennessee, Ohio, Illinois and Georgia," he said.

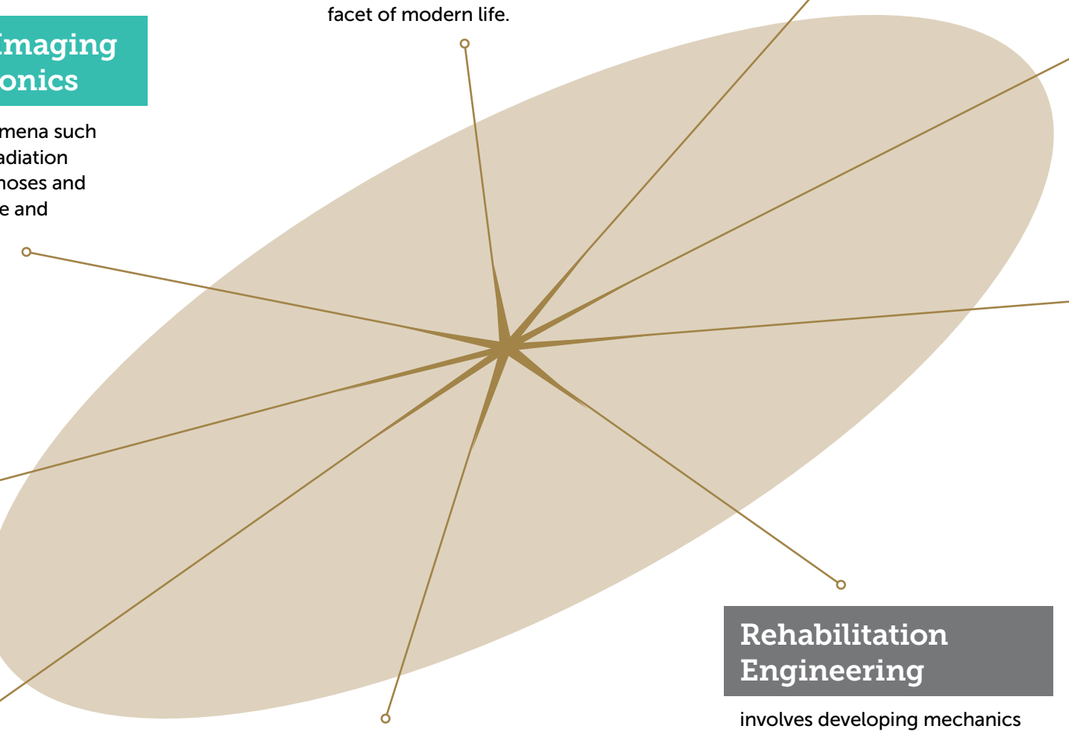
"Given that the repeater was built using a couple of inexpensive compact hand-held transceivers connected to a Raspberry Pi (a tiny, single-board computer), we got a lot of bang for the buck with the flight," Holman said.

Engineering neighborhoods

In a global world where Skyping with a colleague half a world away or reviewing medical test data via email from remote areas of Africa is commonplace, the term "neighborhood" is being redefined and revitalized. At Vanderbilt University School of Engineering, neighborhood is how we describe our distinctive culture of trans-institutionality, collaboration and cross-pollination both within and beyond the traditional walls of departments, schools, institutions and disciplines.

Vanderbilt Engineering has a long and successful tradition of collaboration with colleagues at other universities and at Vanderbilt University Medical Center, the College of Arts and Science and the other colleges and schools that make up one of the nation's top research universities.

In developing its own bottom-up strategic plan, the School of Engineering has identified nine major areas of emphasis—nine neighborhoods drawing faculty, staff, students and outside researchers together in the search for solutions. These neighborhoods are not closed nor exclusive: It's actually common for a Vanderbilt engineer's research to be part of more than one neighborhood.



Cyber-Physical Systems

technology seeks to develop processes, protocols, networking and technology needed for the seamless integration of cyber (software) and physical (hardware, networks and users) systems. It impacts almost every facet of modern life.

Energy and Natural Resources

targets transformative research that will enable sustainable resource and energy conservation, production and recovery.

Biomedical Imaging and Biophotonics

uses physical phenomena such as magnetic fields, radiation and light to aid diagnoses and treatments of disease and dysfunction.

Nanoscience and Nanoengineering

concerns the discovery and application of how materials and processes behave on the nanoscale in diverse areas of engineering, science and health care.

Big Data Science and Engineering

aims to develop tools and processes to harvest and use knowledge from collections of large data sets. The goal is to accelerate progress in health care, science and engineering research and innovation.

Regenerative Medicine

works to replace, engineer and heal damaged tissues and organs. Biomedical, chemical and biomolecular engineering research may involve tissue engineering, drug delivery, drug efficacy and molecular biology.

Surgery and Engineering

concentrates on the collaborative efforts of engineers and surgical experts to create, develop, implement and evaluate technology, methods and tools that improve patients' outcomes and experiences.

Risk, Reliability and Resilience

focuses on improving risk assessment and predictability, as well as increasing reliability of systems, infrastructure and materials. It includes the creation of technology with increased resilience.

Rehabilitation Engineering

involves developing mechanics and robotics to help restore lost physical and cognitive functions.

Using autism to inform AI research could lead to more effective educational tools

Big Data Science and Engineering

aims to develop tools and processes to harvest and use knowledge from collections of large data sets. The goal is to accelerate progress in health care, science and engineering research and innovation.

There's a computer on the third floor of Vanderbilt's Featheringill Hall that scans patterns of geometric shapes, deciding which missing shapes are most likely to fit in.

It chooses about as well as a human 17-year-old would, and it's only getting smarter, thanks to a study of the way certain people on the autism spectrum see the world.

Inspired by the writings of Temple Grandin, perhaps the most famous person on the spectrum, Assistant Professor of Computer Science Maithilee Kunda figured out how to write code that emulates the kinds of image-based thinking that Grandin used to design complicated livestock equipment. The result is a form of artificial intelligence that allows researchers to study a model of human cognition, determine how it problem-solves and then tweak it to perform better.

"Most of us think in a combination of lots of different things. We think in words, we think in pictures, we think in smells and feelings," Kunda said. "What we see in some people with autism is that they're very much on the visual side. Temple Grandin talks about how she thinks really strongly with images, and certain kinds of language-based thinking are a little more difficult for her."

Kunda works with Isabelle Soulières, a neuropsychologist at the University of Quebec at Montreal who studies visual cognition in autism. At Vanderbilt, computer science students in Kunda's lab are working to turn that system of thinking into code. The lab's computers are programmed to solve many different types of human cognitive tests, such as the Raven's Progressive Matrices, an intelligence test developed in 1936 that asks subjects to look at a series of patterns and determine what the missing one would be.

The benefits to this research run both ways, Kunda points out. AI is improved by looking at intelligence that isn't neurotypical. It can draw from a richness of variety in human intelligence, making it more creative and effective. At the same time, researchers can use the AI to develop specific educational tools for people with autism.

"One of the big mysteries we have right now is there is so much variability among different people on the spectrum and how they think," Kunda said. "By trying to pin down these visual reasoning processes more carefully, we're hoping we can start to divide up that spectrum into people who reason in particular ways and support them more effectively."

This research is partially funded by National Science Foundation grant No. 1730044.

Maithilee Kunda, with autism nonprofit leaders Billy and Jennifer Frist

Researchers unlock fMRI's potential as predictor of epilepsy surgery outcomes

Biomedical Imaging and Biophotonics
uses physical phenomena such as magnetic fields, radiation and light to aid diagnoses and treatments of disease and dysfunction.

A common brain scanning technique can map electrical activity under the skull as precisely as more invasive methods that rely on probes or electrodes, according to an interdisciplinary team of Vanderbilt researchers.

The 2017 study "validates the use of high-field, high-resolution functional magnetic resonance imaging as a mapping tool to tell where things are happening," said senior author John Gore, University Professor, Hertha Ramsey Cress Chair in Medicine and professor of biomedical engineering.

The technique is a version of fMRI, and the findings have important implications for diagnosing and monitoring treatment of brain injuries, tumors and conditions ranging from epilepsy to psychiatric disorders.

This imaging method detects signal changes related to oxygen levels in the blood. Such changes had been considered indirect measures of neuron activity, but they indicate far more.

The Vanderbilt study found that fMRI "actually does reflect directly electrical activity—not only where it is but how strong it is," said Gore, director of the Vanderbilt University Institute of Imaging Science. "It clarifies one of the uncertainties in the fMRI field."

In an animal study, the team found fMRI can accurately map functional connectivity when the brain is at a resting state and when it is actively engaged.

Mapping blood oxygenation level-dependent signal changes and connectivity is at the heart of another 2017 Vanderbilt study, which shows fMRI at lower, clinical levels can identify the best surgical candidates with temporal lobe epilepsy.

For such patients, treatment choices are anti-seizure drugs or surgery to remove the focus of the seizures in the hippocampus. Among those who have surgery, 60 to 70 percent remain seizure-free after three years. Predicting which patients will benefit from the operation has been difficult.

Led by Victoria Morgan, associate professor of radiology, radiological sciences and biomedical engineering, the team mapped connectivity in 22 patients before and after surgery. The group also includes Bennett Landman, associate professor electrical engineering, computer science and biomedical engineering. They successfully identified a presurgical, connectivity-based biomarker that can predict which patients will continue to experience seizures a year after the procedure.

This research was partially supported by National Institutes of Health grants NS078680 and NS069909.

Pai-Feng Yang, Feng Wang, Ruiqi Wu, Zhaoyue Shi, Limin Chen, and John Gore

New shockwave sensor to turn elephant poachers' guns against them

Cyber-Physical Systems technology seeks to develop processes, protocols, networking and technology needed for the seamless integration of cyber (software) and physical (hardware, networks and users) systems. It impacts almost every facet of modern life.

An African elephant wearing a tracking collar

It takes a big gun to take down an elephant, but a small sensor under development will give anti-poaching authorities a powerful new weapon of their own.

The sensor, to be integrated with existing commercial tracking collars, will detect ballistic shockwaves and send an immediate alert with GPS coordinates to authorities.

Dubbed WIPER, the project is a joint effort between Vanderbilt computer engineering faculty and Colorado State University, which has used GPS in tracking collars for years to study and protect elephants slaughtered by the thousands for their ivory tusks.

Professor of Computer Engineering Akos Ledeczi is leading the effort with longtime elephant scientist George Wittemyer of CSU, who also is chairman of the scientific board of Save the Elephants.

Ledeczi's expertise is in acoustic shooter detection, localization and classification. He and his team have received major grants from the Defense Advanced Research Projects Agency and built multiple wireless sensor nodes to detect and locate the source of gunfire.

"Our aim is to create an open-source technology freely available to all collar manufacturers so that it can become a common feature in all wildlife tracking devices," Ledeczi said.

Elephant poachers routinely muzzle

Akos Ledeczi

their high-powered weapons, but the blast also produces an acoustic shockwave, which cannot be suppressed. WIPER—Wireless Anti-Poaching Technology for Elephants and Rhinos—will detect a bullet that passes within 50 meters of a protected animal.

The 50-meter range means that only a few sensor collars per herd are needed, and every sensor expands the area monitored to include more noncollared elephants. With a $200,000 grant from the Vodafone Americas Foundation, Ledeczi is developing a prototype to field test for shot-detection accuracy and power requirements. A 12-month battery life is the goal.

Authorities and wildlife protection groups already use planes and drones to identify poacher blinds, herd hotspots and animal carcasses, but these existing systems have limitations. Lower-cost drones have limited fly time and cannot cover large areas. Fixed-wing UAVs with sophisticated cameras can remain airborne longer but are expensive to buy and operate. Animal-borne sensors that track movement speed, or accelerometry, are prone to false positive alerts and delayed response times.

The next step will be integrating the sensor with commercial GPS collars manufactured by partner Savannah Tracking of Kenya. Field studies with collared elephants in northern Kenya will follow. The team hopes to collar 100 elephants with the shockwave detectors each year.

NEW CPS MASTER'S DEGREE FILLS ESCALATING WORKFORCE DEMAND

A new School of Engineering master's degree is preparing students to meet the dramatic rise in workforce needs in the Internet of Things, the security of cyberdomains, the smart grid and defense.

The Cyber-Physical Systems professional master's degree is a 12-month, 30-hour interdisciplinary program. It puts graduates on the fast track for careers in industries critical to U.S. innovation and competitiveness. The first cohort enrolled in fall 2017.

Students tailor the program to their interests by selecting foundational computer science courses and courses in biomedical, civil and mechanical engineering—all fields profoundly impacted by IoT. Their capstone project will be with institutes and laboratories that conduct research in CPS, such as the Vanderbilt Institute for Software Integrated Systems, which hosts the national hub and portal for CPS research; Vanderbilt Institute for Surgery and Engineering; and the Laboratory for Systems Integrity and Reliability.

"This program is ideally suited for both STEM professionals already working in industry who want to accelerate their careers and students with a baccalaureate degree in engineering, math or physical sciences," said Xenofon Koutsoukos, faculty director of the CPS master's program and professor of computer science, computer engineering and electrical engineering.

CPS technologies employ sensors, processors and actuators to enable computers to perform dynamically in the physical world. Vanderbilt already is a global leader in CPS research, receiving substantial funding from the National Science Foundation, the Department of Defense and the National Institutes of Health, among others, for significant research projects in energy, transportation, health care and defense.

Novel nanotube tech lands PhD student at prestigious ORNL accelerator

Energy and Natural Resources
targets transformative research that will enable sustainable resource and energy conservation, production and recovery.

Anna Douglas

An interdisciplinary materials science graduate student is spending two years at an entrepreneurship program to scale and commercialize a revolutionary method of carbon nanotube production.

Anna Douglas was one of five entrepreneurs who earned a coveted spot in the inaugural cohort of the Department of Energy Innovation Crossroads program at Oak Ridge National Laboratory.

"This is an once-in-a-lifetime opportunity," Douglas said. "The facilities and expertise are unmatched, and the proximity to Vanderbilt can't be beat. Having the opportunity to spend two years at a national lab during the course of my Ph.D. studies is phenomenal—but getting to do so while working on a startup company is a truly unique experience."

Douglas is CEO of SkyNano LLC, a company she founded with Cary Pint, assistant professor of mechanical engineering and CTO of the company. SkyNano aims to develop and use nanostructures in energy-related applications.

Its goal is shared by researchers worldwide—to greatly reduce the cost of manufacturing single-walled carbon nanotubes. The tiny structures are widely viewed as a promising material for applications ranging from next-generation electronic devices to lighter composites with better durability.

Single-walled carbon nanotubes, or nanotubes with 0.7-3 nanometer diameter and only a single rolled-up sheet of carbon atoms, are a high-value product. They also are the most difficult to synthesize compared to larger diameter carbon nanotubes with more carbon walls.

The materials can cost upward of $900 a gram in some cases. Scaled up, SkyNano's approach could produce the material at costs well below $1 a gram, according to Douglas and Pint.

"This could transform the production of single-walled carbon nanotubes," Pint said.

The new process simultaneously removes carbon in the atmosphere, in the form of carbon dioxide, and repurposes it into a stable carbon nanotube. SkyNano's big breakthrough is in its catalyst materials, which can tune the carbon nanotubes to very small diameters. Already, Vanderbilt has filed two provisional patent applications on the technology.

Innovation Crossroads supports entrepreneurs in transforming their early-stage, potential game-changing ideas into clean energy companies. The accelerator program includes $350,000 in seed funding, two years of salary, unlimited access to ORNL resources and access to experts in participants fields. Douglas also will receive business support for developing strategies, conducting market research and seeking investment and commercial partners.

TOP DOE OFFICIAL AND VANDERBILT ENGINEERING ALUM TO DESIGN NUCLEAR CLEANUP CURRICULUM

A national environmental management expert is establishing a new nuclear environmental engineering curriculum at Vanderbilt's School of Engineering and an internship program that will place engineering students with the U.S. Department of Energy.

Sue Cange (BE'82, MS'83), former head of the federal government's cleanup program in Oak Ridge, has begun a two-year appointment as a visiting scholar in the Department of Civil and Environmental Engineering. She has three decades of experience in federal leadership positions and developed the EPA policies that govern cleanup of Superfund sites. Most recently, she was principal deputy assistant secretary and acting assistant secretary for DOE's Office of Environmental Management.

Cange, who remains a DOE employee, is known as a master team builder with an impressive history of public speaking, community outreach and mentoring.

At the School of Engineering, Cange will set up a curriculum to train the next generation of workers in the nuclear cleanup industry as well as through internships at DOE headquarters and DOE sites. Additionally, she will develop and deliver undergraduate seminars on career opportunities in government service and environmental cleanup of federal facilities.

The Vanderbilt community and students will benefit greatly from her "tremendous professional and expertise," said David S. Kosson, Cornelius Vanderbilt Professor of Engineering and professor of civil and environmental engineering.

Ultrathin device harvests electricity from human motion

Nanoscience and Nanoengineering
concerns the discovery and application of how materials and processes behave on the nanoscale in diverse areas of engineering, science and health care.

Imagine slipping into a jacket, shirt or skirt that powers your cell phone, fitness tracker and other personal electronic devices as you walk, wave and even when you are sitting down.

A new, ultrathin energy-harvesting system developed at Vanderbilt University's Nanomaterials and Energy Devices Laboratory has the potential to do just that. Based on battery technology and made from layers of black phosphorus that are only a few atoms thick, the new device generates small amounts of electricity when it is bent or pressed even at the extremely low frequencies characteristic of human motion.

Doctoral students Nitin Muralidharan and Mengya Lico, working in the lab of Cary Pint, assistant professor of mechanical engineering, led the effort to make and test the devices. "When you look at Usain Bolt, you see the fastest man on Earth. When I look at him, I see a machine working at 5 hertz," said Muralidharan.

The Vanderbilt lab's ultrathin energy harvester is based on the group's research on advanced battery systems. Over the past 3 years, the team has explored the fundamental response of battery materials to bending and stretching. They were the first to demonstrate experimentally that the operating voltage changes when battery materials are placed under stress. Under tension, the voltage rises and under compression, it drops.

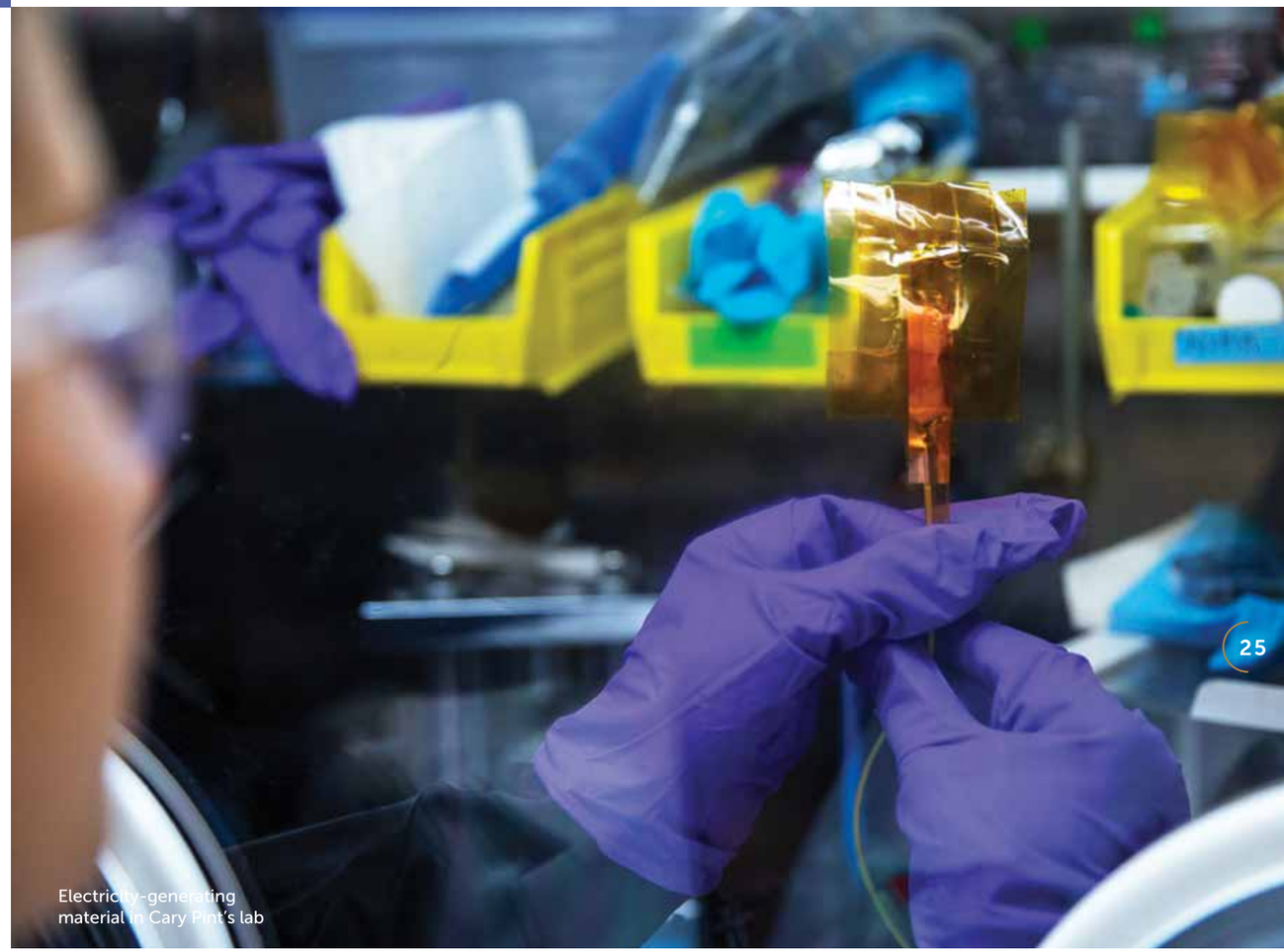
Because the basic building blocks of the harvester are about 1/5000th the thickness of a human hair, the engineers can make their devices as thin or as thick as needed for specific applications. They have found that bending their prototype devices produces as much as 40 microwatts per square foot and can sustain current generation over the full duration of movements as slow as 0.01 hertz, one cycle every 100 seconds.

The researchers acknowledge that one of the challenges they face is the relatively low voltage that their device produces. It's in the millivolt range. However, they are applying their fundamental insights of the process to step up the voltage.

One of the more futuristic applications of this technology might be electrified clothing. It could power clothes impregnated with liquid crystal displays that allow wearers to change colors and patterns with a swipe on their smartphone.

"We are already measuring performance within the ballpark for the power requirement for a medium-sized, low-power LCD display when scaling the performance to thickness and areas of the clothes we wear." Pint said.

This research is partially supported by National Science Foundation grant CMMI 1400424 and Vanderbilt University's Discovery Grant program.



Electricity-generating material in Cary Pint's lab

Cotton candy capillaries lead to circuit boards that dissolve when cooled

Nanoscience and Nanoengineering
concerns the discovery and application of how materials and processes behave on the nanoscale in diverse areas of engineering, science and health care.

Building transient electronics is usually about doing something to make them stop working: blast them with light, soak them with acid, dunk them in water.

Professor Leon Bellan's idea is to dissolve them with neglect: Stop applying heat, and they come apart.

Using silver nanowires embedded in a polymer that dissolves in water below 32 degrees Celsius—between body and room temperature—Bellan and mechanical engineering graduate student Xin Zhang made a simple circuit board that, so far, just turns on an LED light. Its potential applications are far more promising.

"Let's say you use this technology to make an RFID wireless tag," said Bellan, assistant professor of mechanical and biomedical engineering at Vanderbilt University. "You could implant important information in a person, and body temperature would keep it intact. If the tag were removed or the bearer died, it would dissolve. You could use it for implanted medical devices as well—to cause them to disintegrate, it would only require applying ice to the skin."

In the lab, his tiny circuit boards stay operational in water warmed by a hot plate. Turn off the hot plate, and they start dissolving in minutes.

The unusual circuit board represents an application of technology Bellan developed last year. Using a special polymer and a cotton candy machine purchased from a department store, he spun networks of threads comparable in size, density and complexity to capillaries—the tiny conduits that deliver oxygen and nutrients to cells.

Bellan's cotton candy-like fiber networks can be embedded in materials that mimic the extracellular matrix and then be triggered to dissolve away, potentially producing capillary systems for artificial organs. He's using the same triggering system to produce transient electronics.

In this system, the silver nanowires are held together in the polymer so that they touch, and as long as the polymer doesn't dissolve, the nanowires will form a path to conduct electricity similar to the traces on a circuit board. Trigger the polymer to dissolve by lowering the temperature, and the nanowire network disintegrates, destroying the conductive path.

"Transient electronics are cool, and once you start coupling that to a stimulus-responsive material, you start coming up with really sci-fi ideas," Bellan said. "You could have any cascade of events that results in a very unique stimulus that causes it to degrade or prevent it from falling apart. Temperature is just the beginning."


Leon Bellan and Xin Zhang

CLEANROOM WITH A VIEW—NEW FACILITY BOOSTS NANOSCALE RESEARCH ABILITIES

When Sandra Rosenthal, director of the Vanderbilt Institute of Nanoscale Science and Engineering, looks at the new 10,000-square-foot, commercial-grade cleanroom, she sees opportunity.

The VINSE Cleanroom in the Engineering and Science Building more than triples the space researchers have used in the Stevenson Center since 2003 and long since outgrown.

"The opportunity is tremendous," said Rosenthal, the Jack and Pamela Egan Chair of Chemistry and professor of chemical and biomolecular engineering. "It makes us competitive with anybody."

Every department in the School of Engineering plus faculty, researchers and graduate students in chemistry and physics use the space. The design placed the main walkway along a two-story glass wall that faces the ESB's atrium, making it visible to passersby and more likely to spark undergraduate interest.

The room speaks to Vanderbilt's growing investment and expertise in nanoscale engineering.

A five-person team worked with Abbie Gregg Inc., a consulting firm that specializes in academic cleanrooms, on design and equipment needs.

The space is half-filled, which leaves room to accommodate newly recruited professors with specialized equipment needs.

But the state-of-the-art facility will do far more than help recruit top faculty and graduate students—it already hosts an undergraduate class in nanoscale semiconductor processing and fabrication and, in the spring, another undergraduate course in graphene transistors.

Additionally, a team of 10 undergraduates is tasked with maintaining the space and its equipment in what resembles an industry internship, Rosenthal said.

Hijacking human proteins to better deliver anti-cancer drugs

Regenerative Medicine
works to replace, engineer and heal damaged tissues and organs. Biomedical, chemical and biomolecular engineering research may involve tissue engineering, drug delivery, drug efficacy and molecular biology.

Graduate student Thomas Werfel and Craig Duvall

Powerful molecules can hitch rides on a plentiful human protein and signal tumors to self-destruct, a team of Vanderbilt University engineers found.

Their research gives oncologists a better shot at overcoming the problems of drug resistance, toxicity to patients and a host of other barriers to consistently achieving successful gene therapy for cancer. It is particularly promising for patients with triple-negative breast cancer, an aggressive type that makes up about 15-20 percent of cases.

Craig Duvall, associate professor of biomedical engineering, put the effectiveness of a specialized ribonucleic acid hitchhiking on the human protein albumin up against jetPEI nanoparticles, the mostly widely used synthetic carrier for the task of tumor gene silencing.

Ribonucleic acids can control the behavior of cancer cells, but they require a carrier to get them to the target. Duvall's team made a simple modification to a small-interfering ribonucleic acid molecule, called siRNA-L2, allowing it to rapidly load into an albumin pocket typically reserved to ferry fatty acids around the body.

They found that the siRNA-L2, using albumin as its carrier, has no apparent dose-limiting toxicity, a significant problem for synthetic nanoparticles. That means a higher dose of the anti-cancer drug can be delivered to the tumor without potentially harming the patient.

"We used albumin because it's the highest-concentrated protein in your blood," Duvall said. "Our molecule, siRNA-L2, binds into the fatty acid pocket of albumin. Albumin circulates in the body for days, making the siRNA-L2 molecules more available for delivery into tumors."

Because cancer cells show higher metabolic activity, the albumin that's carrying siRNA-L2 travels to tumors and gets to work quickly. The molecule's smaller size allows it to penetrate tumors at a higher rate—with 100 percent of tumor cells testing positive for siRNA-L2 as opposed to only 60 percent when the molecule was carried by jetPEI. Once there, Duvall's molecule silences a gene crucial to the tumor's growth and survival.

To make sure their results were translatable to human therapy, the team tested siRNA-L2 in human breast tumor tissue removed from a donor. The Vanderbilt molecule remained more effective, with siRNA-L2 more than three times as present in the tumor than siRNA delivered with synthetic nanoparticles.

This research is partially supported by the National Institutes of Health grant R01EB019409 and the National Science Foundation CAREER BMAT 1349604.

ALEX'S LEMONADE STAND GRANT ALLOWS ENGINEERING GRAD STUDENT TO JOIN NEUROBLASTOMA FIGHT

A $5,000 training grant from cancer research nonprofit Alex's Lemonade Stand Foundation allowed a Vanderbilt grad student to join the fight against pediatric neuroblastoma.

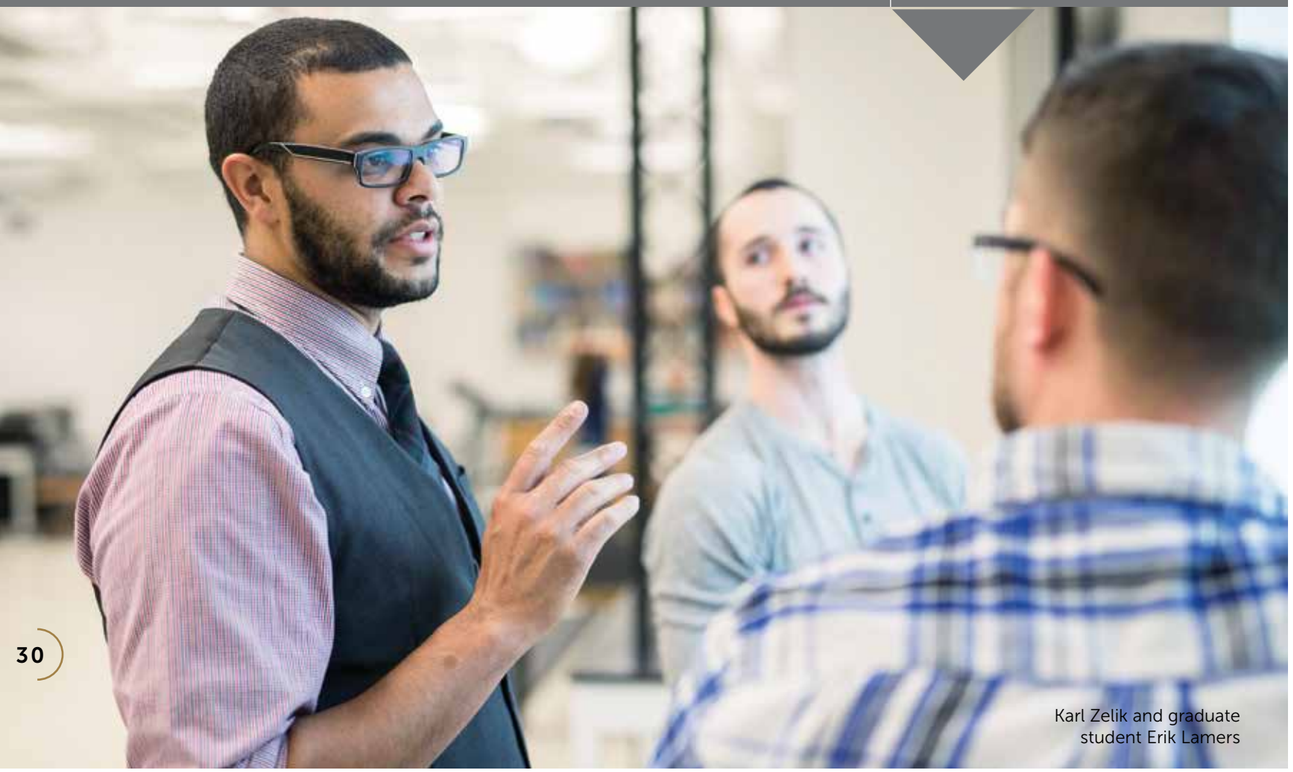
Chemical and biomolecular engineering doctoral student **Kyle Garland** spent much of the past summer on a project titled "Immunotherapeutic Targeting of the STING Pathway to Combat Neuroblastoma" supported by a Pediatric Oncology Student Training Grant. He's working with John Wilson, assistant professor of chemical and biomolecular engineering, who last year won a $450,000 'A' Award from the foundation for developing a new class of therapeutic to retrain the immune system against neuroblastoma.

Garland's research is similar but involves a different method of beating the disease: using the stimulator of interferon gene (STING) pathway that has demonstrated initial success prompting immunity against acute myeloid leukemia and various adult solid tumors. Now, he's trying it with neuroblastoma.

"We could develop a therapeutic cancer vaccine that incorporates a STING enhancer," he said. "I'm also looking at including a neuroblastoma antigen that's specific to that disease in hopes that the specificity would prompt a strong immune response. One of the most promising things about this kind of immunotherapy is the potential for memory—you'd not only remove the disease, you'd keep it from coming back."

Proven smart underwear prevents back stress with just a tap

Rehabilitation Engineering
involves developing mechanics and robotics to help restore lost physical and cognitive functions.



Karl Zelik and graduate student Erik Lamers

TV infomercials offer a world of potential solutions for back pain, but most of them have at least one of three problems—they're unproven, unworkable or just plain unattractive.

A team of Vanderbilt University engineers is changing that with a design that combines the science of biomechanics and advances in wearable tech to create a smart, mechanized undergarment.

Well over half of all adults will experience low back pain in their lifetimes, and the condition is estimated to cost $30 billion in medical expenses and more than $100 billion in lost productivity in the U.S. annually. Karl Zelik, assistant professor of mechanical engineering and the principal investigator on the project, experienced back pain himself repeatedly lifting his toddler son, which he said got him thinking about wearable tech solutions.

"I'm sick of Tony Stark and Bruce Wayne being the only ones with performance-boosting supersuits. We, the masses, want our own," Zelik said. "The difference is that I'm not fighting crime. I'm fighting the odds that I'll strain my back this week trying to lift my 2-year-old."

The device consists of two fabric sections, made of nylon canvas, Lycra, polyester and other materials, for the chest and legs. The sections are connected by sturdy straps across the middle back, with natural rubber pieces at the lower back and glutes.

The device is designed so that users engage it only when they need it. A simple double tap to the shirt engages the straps. When the task is done, another double tap releases the straps so the user can sit down, and the device feels and behaves like normal clothes. The device also can be controlled by an app that the team created—users tap their phones to engage the smart clothing wirelessly via Bluetooth.

Eight subjects tested the device leaning forward and lifting 25-pound and 55-pound weights while holding their position at 30, 60 and 90 degrees. Using motion capture, force plates and electromyography, Zelik's team demonstrated that the device reduced activity in the lower back extensor muscles by an average of 15 to 45 percent for each task.

"The next idea is: Can we use sensors embedded in the clothing to monitor stress on the low back, and if it gets too high, can we automatically engage this smart clothing?" Zelik said.

This research is partially supported by a Vanderbilt University Discovery Grant, a National Science Foundation Graduate Research Fellowship and a National Institutes of Health Career Development Award K12HD073945.

HIGH-PROFILE INNOVATION IN BIOMECHANICS, EXOSKELETONS, PROSTHETIC DEVICES EMBODIED IN NEW CENTER

The new Center for Rehabilitation Engineering and Assistive Technology reflects the School of Engineering's growing profile as an international innovator in biomechanics and neuromechanics.

CREATE combines prominent labs under of Michael Goldfarb, H. Fort Flowers Professor of Mechanical Engineering, and Karl Zelik, assistant professor of mechanical engineering. Both are co-directors of CREATE.

The focus is restoring health, mobility, independence and societal participation to individuals with disabilities. Current projects include a prosthetic arm, a powered exoskeleton for people who have suffered spinal-cord injuries or strokes and upper limb orthotics for people who experience paralysis after a stroke.

A new smart clothing device that can reduce low back stress during lifting and leaning tasks received international media attention in August. Ongoing work includes innovative ways to attach prosthetic limbs to improve force and power transmission and development of soft ankle exoskeletons to aid individuals with injuries, arthritis and other conditions.

Goldfarb, who also is a professor of electrical engineering and physical and medical rehabilitation, has been director of the Center for Intelligent Mechatronics, which focuses on the design and control of electromechanical devices, especially as applied to the field of rehabilitation robotics.

Zelik, also an assistant professor of biomedical engineering and physical medicine and rehabilitation, has overseen the Biomechanics & Assistive Technology Laboratory.

The center, in the Engineering and Science Building, consists of a 3,000-square-foot motion analysis lab for working with human subjects plus another 3,000 square feet of engineering and fabrication space.

Web-based tool will help officials realistically plan for climate change

Risk, Reliability and Resilience
focuses on improving risk assessment and predictability, as well as increasing reliability of systems, infrastructure and materials. It includes the creation of technology with increased resilience.

Life beside the Mississippi River always came with some uncertainty about the safety of homes, crops and city streets. Residents looked at flood maps based on historical data and chose their sites, built their levies and bridge footings and kept a wary eye on the river stages.

That's not enough anymore, a team of Vanderbilt University engineers contend, because climate change is rendering the old ways obsolete. They've earned a number of research grants to study how commerce and flood control on inland waterways and the residents along them must change.

With U.S. Department of Housing and Urban Development funding, Professor Mark Abkowitz, director of Vanderbilt's Center for Environmental Management Studies, and Janey Camp, research associate professor of civil and environmental engineering, are deploying web-based tools to map West Tennessee flood vulnerabilities under future climate scenarios. The tools will have applications nationwide.

"What our parents called a 100-year flood could be today's 50-year flood," said Camp, former president of the Tennessee Society of Professional Engineers. "We're going to use localized climate models to examine the impact of global warming and let governments and community planners know what infrastructure is vulnerable."

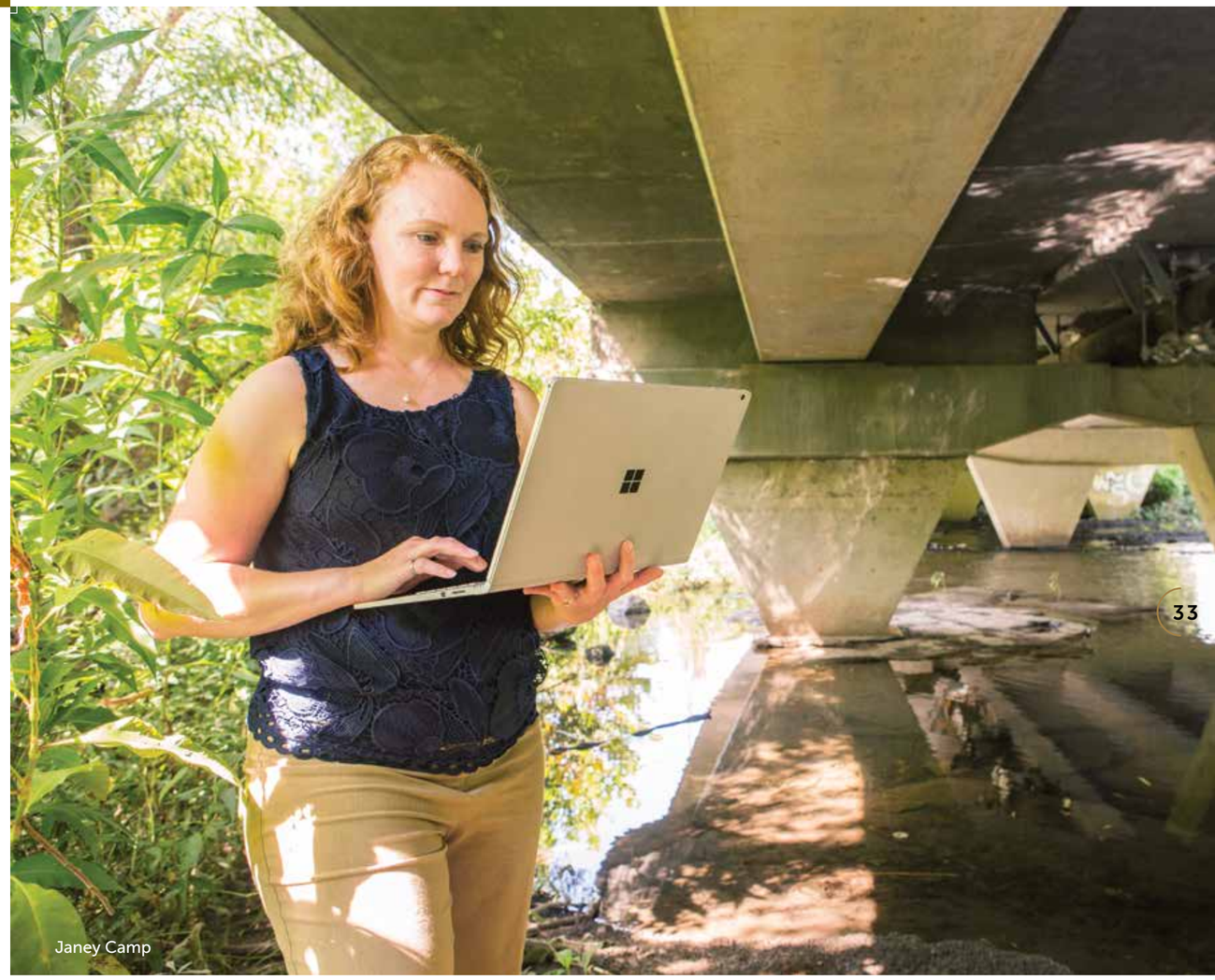
Localized climate models take national level models, which typically include just a few areas per state, and reduce them to the county level or smaller so the results can be applicable to local decision-makers.

Moving forward, the team is seeking funding to study how to be realistic about disaster mitigation in a nation now routinely affected by climate change.

"We're often raising roadways, bridges and flood walls to try and hold back Mother Nature instead of asking, 'What if that investment wasn't put into infrastructure and instead was used to relocate people to somewhere safer?'" Camp said. "Being an engineer, I took an oath to protect people, but that's not always going to be through infrastructure."

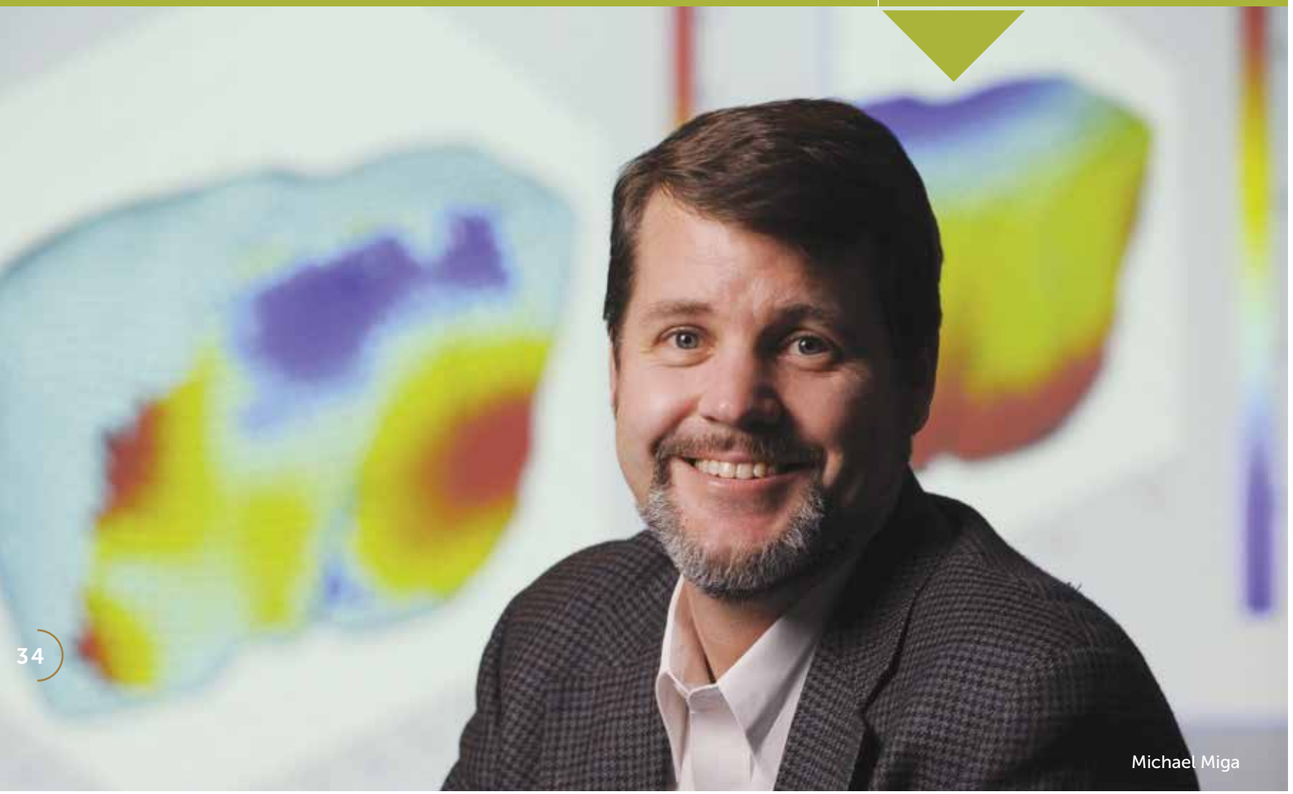
Professor Craig Philip, who directs Vanderbilt's Center for Transportation and Operational Resilience, is examining how inland waterway stakeholders—including freight shippers and carriers and the U.S. Army Corps of Engineers—can communicate to ensure there are plans in place to maintain safe navigation even in the face of more frequent, more devastating events.

"Extreme events are becoming more common," he said. "What we used to think was episodic has become chronic, and that affects everything."


Janey Camp

New tools help surgeons find liver tumors, not nick blood vessels

Surgery and Engineering
concentrates on the collaborative efforts of engineers and surgical experts to create, develop, implement and evaluate technology, methods and tools that improve patients' outcomes and experiences.



Michael Miga

The liver is a particularly squishy, slippery organ, prone to shifting both deadly tumors and life-preserving blood vessels by inches between the time they're discovered on a CT scan and when the patient is lying on an operating room table.

Surgeons can swab the exposed liver lightly on the surface with a special stylus, capturing the shape of the organ during surgery, and a computer can match that image with the CT scan on a screen. This GPS-like ability is far better than guessing where the tumor and vessels are by feeling for them, but even this road map can be off by centimeters and leaves surgeons guessing.

Vanderbilt University's Michael Miga, Harvie Branscomb Professor and professor of biomedical engineering, and his team found the potential solution: surgery-tested software that better marries the CT scan's image with the tracked tool's. It's an advance that stands to help more than a half-million liver cancer patients worldwide each year.

"Deformation happens," said Miga, who developed the Pathfinder stylus system for abdominal surgeries.

"The way the liver is configured in the body at the time of diagnostic imaging and the way it's presented for surgery are very different," he said. "If you're trying to get to a tumor the size of a dime and avoid a blood vessel, you need to avoid errors."

The trick to fixing that error without investing in additional expensive equipment is software that makes a computer model out of the original image of the liver and simulates the forces being applied during surgery—such as packed gauze lifting the liver upward. The computer adjusts the CT-derived GPS map to better match the exposed organ shape in the operating room.

Used in a blind, randomized 20-patient bystander study over the past two years at Memorial Sloan Kettering Cancer Center in New York, surgeons said the new technology improved the registration in more than 70 percent of cases.

This research was partially supported by National Institutes of Health grant R01-CA162477.

COFFEE GROUND CAP IMPROVES IMAGE GUIDANCE FOR NOSE, THROAT SURGERY

Inspired by experiments that used coffee grounds to help robots grip irregularly shaped objects, Vanderbilt University engineers have created a more accurate tracking system to guide surgeons in delicate nose and throat procedures.

Coffee grounds form a thin layer inside a stretchy silicone headpiece, which resembles a black latex swim cap decorated with reflective dots. A vacuum pump removes air from the cap once it is in place, forming a rigid layer that conforms closely to the patient's head.

Pre-surgery, a scanner maps the dots relative to key features. During surgery, an overhead camera uses the dots to track the head as the surgeon repositions it. Combined with a CT scan, the tracking data provides a detailed 3-D view of bone, soft tissue and surgical instruments in use in real time.

"These are very delicate operations. A sophisticated image guidance system has been developed to help the surgeons, but they don't trust the system because sometimes it is spot on and other times it is off the mark," said Robert Webster, associate professor of mechanical engineering and otolaryngology. "We began wondering what was causing these errors and decided to investigate."

Graduate student Patrick Wellborn and Robert Webster

Previous research found that when everything went well, the guidance system produced targeting errors of about 2 millimeters but, in about one operation out of seven, the target error was much larger, forcing surgeons to remap reference points.

The culprit? Markers attached to the patient's head with an elastic band and double-backed tape often shifted from skin movement and accidental bumps, at times producing large tracking errors.

Using a cap rather than a headband also allows many more markers, which enhances the guidance system, too. Across multiple tests, the granular cap outperformed the traditional headband. In one, after an experienced surgeon repositioned test subjects' heads several times, the cap had 66 percent lower error rates than the headband.

"It's a very clever way—that doesn't involve drilling holes in patients' skulls—to greatly improve the accuracy of the guidance system when we are operating in the middle of a person's skull: a zone where the accuracy of the current system is inadequate," said Associate Professor of Otolaryngology Paul Russell, who is collaborating with the engineers on the project.

The research was partially supported by National Institutes of Health grant R01 EB017467 and National Science Foundation Graduate Research Fellowship grant 144519.

Numbers of note

5:1
graduate:faculty ratio

15:1
undergraduate:faculty ratio

31.2%
undergraduate women students

11.8%
undergraduate international students

21.4%
undergraduate minority students

53%
of undergrads participate in research projects outside the classroom

82%
of graduates have job offers before graduation*

32
student engineering organizations

95
faculty honors from 33 societies

12
institutes, centers and groups

#10
most innovative universities in the world**

#16
best undergraduate engineering program among private research universities***

*U.S. citizens and permanent residents (Class of 2017)

***Reuters,* Sept. 2017

****US News and World Report,* Sept. 2017

32%
of the Class of 2017 studied or interned abroad for at least a month*

*includes study abroad, exchange and overseas service learning programs

Innovation to Commercialization

$1,442,967 Revenue generated from VUSE technologies

93 U.S. patent applications filed

55 Invention disclosures received

17 U.S. patents issued

20 License agreements executed

5 Startups with a connection to the School of Engineering

These figures were provided by Vanderbilt's Center for Technology Transfer and Commercialization for the most recent fiscal year (July 1, 2016, through June 30, 2017).

Selected Honors and Leadership

Unless otherwise noted, the following lists organizations to which Vanderbilt School of Engineering faculty have been elected to as fellows (as of Sept. 1, 2017).

American Academy of Environmental Engineers and Scientists

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

Heart Rhythm Society

Geological Society of America

Institute of Electrical and Electronics Engineers (IEEE)

Institute of Physics (U.K.)

Institute of Transportation Engineers

International Society for Magnetic Resonance in Medicine

International Society for Optical Engineering (SPIE)

Materials Research Society

Microscopy Society of America

National Academy of Engineering, Members

National Academy of Inventors

National Academy of Sciences, Advisory Committee Members

National Academy of Sciences, National Associate

Optical Society of America

Prognostics and Health Management Society

Royal Danish Academy of Sciences and Letters

Royal Society of Chemistry (U.K.)

Royal Swedish Academy of Engineering Sciences

U.S. Air Force Scientific Advisory Board, Member

U.S. Nuclear Waste Technical Review Board, Presidential Appointee

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.

Biophotonics Center at Vanderbilt
Anita Mahadevan-Jansen, Orrin H. Ingram Professor of Biomedical Engineering
vanderbilt.edu/vbc

Center for Rehabilitation Engineering and Assistive Technology
Michael Goldfarb, H. Fort Flowers Professor of Mechanical Engineering
Karl Zelik, Assistant Professor of Mechanical Engineering
engineering.vanderbilt.edu/create

Consortium for Risk Evaluation with Stakeholder Participation
David Kosson, Cornelius Vanderbilt Professor of Engineering, Professor of Civil and Environmental Engineering
cresp.org

Institute for Software Integrated Systems
Janos Sztipanovits, E. Bronson Ingram Professor of Engineering
isis.vanderbilt.edu

Institute for Space and Defense Electronics
Ron Schrimpf, Orrin H. Ingram Professor of Engineering
isde.vanderbilt.edu

Laboratory for Systems Integrity and Reliability
Douglas Adams, Daniel F. Flowers Professor, Distinguished Professor of Civil and Environmental Engineering
vu.edu/lasir

Multiscale Modeling and Simulation Group
Peter Cummings, John R. Hall Professor of Chemical Engineering
my.vanderbilt.edu/mums

Vanderbilt Center for Environmental Management Studies
Mark Abkowitz, Professor of Civil and Environmental Engineering, Professor of Engineering Management

Vanderbilt Center for Transportation and Operational Resilliency
Craig Philip, Research Professor of Civil and Environmental Engineering
vanderbilt.edu/vector

Vanderbilt Institute for Energy and Environment
George M. Hornberger, Craig E. Philip Professor of Engineering, University Distinguished Professor of Civil and Environmental Engineering and Earth and Environmental Science
vanderbilt.edu/viee

Vanderbilt Institute for Integrative Biosystems Research and Education
John Wikswo, Cain University Professor, Professor of Biomedical Engineering
vanderbilt.edu/viibre

Vanderbilt Institute of Nanoscale Science and Engineering
Sandra Rosenthal, Jack and Pamela Egan Professor of Chemistry, Professor of Chemical and Biomolecular Engineering
Sharon Weiss, Deputy Director, Cornelius Vanderbilt Professor of Engineering, Professor of Electrical Engineering
vanderbilt.edu/vinse

Vanderbilt Institute for Surgery and Engineering
Benoit Dawant, Cornelius Vanderbilt Professor of Engineering
vanderbilt.edu/vise

Vanderbilt University Institute of Imaging Science
John Gore, Hertha Ramsey Cress Professor of Medicine, University Professor of Radiology and Radiological Sciences, Professor of Biomedical Engineering
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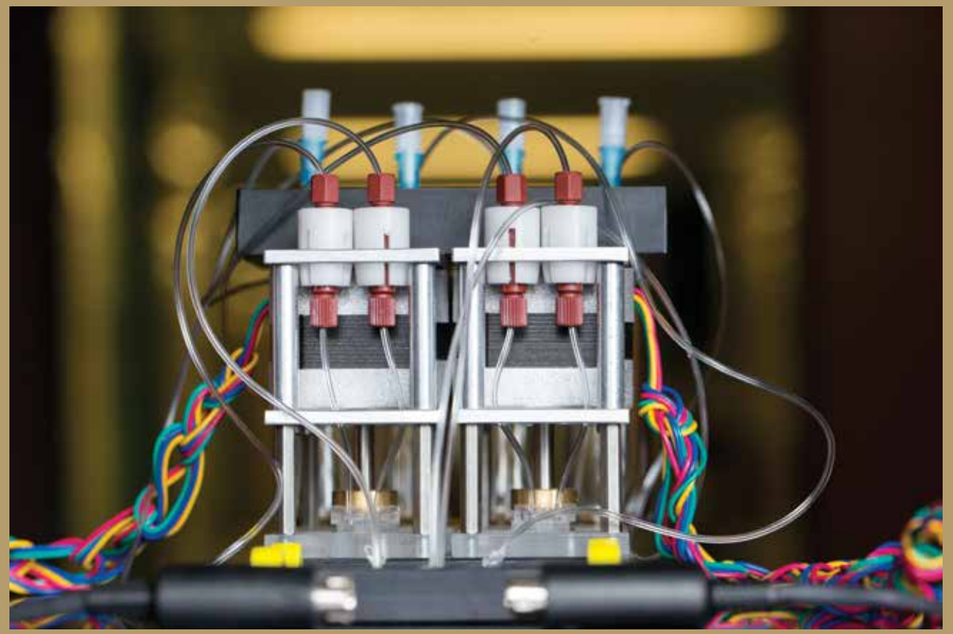

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