NC STATE Engineering

FALL/WINTER **2018**

A BRIGHT IDEA

NSF FREEDM Center marks 10 years of innovation

MASNARI LED COLLEGE'S GROWTH IN SIZE, PRESTIGE

Dr. Nino A. Masnari, distinguished professor of electrical and computer engineering and dean emeritus of the College of Engineering, passed away on May 19, 2018.

Masnari received his bachelor's, master's and doctoral degrees, all in electrical engineering, from the University of Michigan in Ann Arbor in 1958, 1959 and 1964, respectively. His research interests were in the areas of silicon processing technologies and solid-state electronic devices.

He joined NC State in 1979 as the head of the Department of Electrical Engineering. In 1988, after nine years of leading the department, he was awarded leadership of a prestigious NSF Engineering Research Center (ERC) and became the founding director of the NSF ERC on Advanced Electronic Materials Processing and the SEMATECH Center of Excellence on Advanced Single Wafer Processing, both at NC State.

In 1996, Masnari was appointed dean of the College of Engineering, a position he held from August 1996 through June 2006.

During his tenure as dean, the College experienced a new era of growth and accomplishment. In 1997, the College held the grand opening for the Engineering Graduate Research Center, now the Monteith Research Center, and established the Women in Engineering Program. With the passage of a bond referendum in November 2000, the College began its move to NC State's Centennial Campus. Masnari oversaw the construction of the first two academic engineering buildings to be constructed at NC State since 1964. Engineering Buildings I and II opened in 2004 and 2005, respectively. Funding was also procured and design began on Engineering Building III under Masnari's leadership.

With Masnari at the helm, the College grew into the third largest producer of engineering and computer science degrees in the nation and research expenditures in the College nearly doubled to more than $90 million annually. Scholarship funding more than quadrupled, with total endowments growing to more than $51 million. The College received its largest gift from a single individual, a $10 million endowment in support of industrial engineering. As a result, the Edward P. Fitts Department of Industrial and Systems Engineering became the first named academic department in the history of the University. In addition, the College established the joint Department of Biomedical Engineering with the University of North Carolina at Chapel Hill and added a bachelor's degree in paper science and engineering. The College also became a leader in distance education, ranking as one of the best online degree programs in the nation and adding 2+2 programs that serve students across the state.

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OFFICE OF THE DEAN

College of Engineering
Campus Box 7901, NC State University
Raleigh, NC 27695-7901
919.515.2311
www.engr.ncsu.edu

NC STATE ENGINEERING FOUNDATION, INC.

Campus Box 7901, NC State University
Raleigh, NC 27695-7901
919.515.7458
www.engr.ncsu.edu/alumni-and-giving/ncsef

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Q&A

QUESTIONS FOR **MADISON MALONEY**

Madison Maloney is a senior aerospace engineering major from Greenville, NC, and a 2018 Goldwater Scholar. Chosen twice as an Astronaut Scholar, Maloney is pursuing her passion for space exploration and hopes to follow in the footsteps of a fellow female NC State engineer with her eyes on the stars.

When did you become interested in space exploration?

In middle school. Initially, I kept my dream to myself, as I thought my goals would seem crazy to my peers, given that there is no space industry in Eastern North Carolina and I did not know a single engineer. All the while, I studied documentaries on the history of NASA, woke up in the middle of the night to watch launches on my computer and read as many astronaut biographies as I could. In 2013, the dream transitioned into a goal that I have been passionately pursuing since, when fellow Eastern North Carolinian and NC State alumna Christina Koch was chosen as an astronaut candidate. Her selection meant the world to me.

Why did you choose to attend NC State?

NC State has felt like home since the first time I toured as a high school student, and the Park Scholarship sealed the deal for me. Our university has what I once heard summed up as "small school feel, big school opportunities." Students can choose to make NC State feel more like a small school environment by becoming involved in various student organizations, connecting with faculty members for mentorship or collaboration and finding their niche within the community. Simultaneously, they have the ability to access an extremely large alumni network, make use of world-class facilities and experience the thrill of ACC athletics.

What kind of undergraduate research have you participated in during your time at NC State?

My research has revolved around two main categories: system evolvability and advanced materials with aerospace applications. Through my work with system evolvability in the System Design Optimization Lab, I have focused on systems such as the International Space Station, CubeSats (a type of miniature satellite), dart guns and space suits. My work relating to advanced materials at NASA Langley Research Center focused on guided wave cure monitoring for composite materials.

You plan to pursue a Ph.D. in astronautics and aeronautics. What are your career plans after graduation?

After earning a Ph.D., I hope to work at NASA as a researcher focused on the human-technology interactions enabling deep space exploration. Unmanned exploration of planets such as Mars has been going on for decades, but adding humans to the equation is a game changer. As we look to Mars and beyond, utilizing the strengths of humans and robotic technology, while also ensuring effective integration, is going to be imperative.

Do those plans include a trip to outer space or engineering work on the ground?

Hopefully both. My ultimate dream is to become an astronaut, as I believe it is one of the most exciting and dynamic jobs in (and out) of this world. It is truly an exciting time in the realm of space exploration, and I hope to push the field forward in whatever role allows me to contribute the most. ▪

FROM THE DEAN

LOUIS A. MARTIN-VEGA

The beginning of fall semester is an exciting time, as we welcome our first-year students as well as our returning students and faculty. In addition to assisting our new students with their adjustment to the rigors of university classes and life away from home, one of our jobs is to introduce them to the many opportunities the College provides to enhance their education beyond their classroom experiences.

One of the most important is our Research Experiences for Undergraduates program, where our undergraduates are involved in cutting-edge research projects together with our graduate students and world-class faculty researchers. We have expanded this program significantly over the last few years, and together with our co-op and internship, entrepreneurship, immersive study abroad and other experiences, enhance their communication and leadership skills in addition to the critical thinking and technical rigor provided by an engineering degree. The goal is to provide them with an advantage over their peers when they enter the workforce or go on to graduate or professional programs. .

All of these efforts benefit from our outstanding research program. Over the last decade, we have made significant investments in faculty and research infrastructure that have resulted in successful nationally competitive research center awards funded by the National Science Foundation, the Department of Energy, the Department of Defense and others. These investments have led to some amazing results.

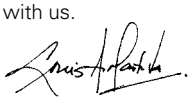
This year, for the first time, ASEE data shows that our College has cracked the **top 10 nationally** in research expenditures among colleges of engineering. We are now **eighth in the nation** overall, and **sixth** among public colleges of engineering, with **more than $206 million** in research expenditures trailing only MIT, Texas A&M, Michigan, Purdue, Illinois, Berkeley, and Stanford. This accomplishment, of which we are very proud, clearly places our College in very elite and preeminent company nationwide.

In addition to many examples of our outstanding research, in this issue you will also read about our new Rural NC Internship Program, where we place students in summer internships in areas of our state with great need for economic development.

Our annual College homecoming will be held on Friday, Nov. 2, in the Hunt Library on Centennial Campus. I encourage you to take advantage of this opportunity to visit campus, connect with former classmates and learn more about what's happening in your College.

While you are here, check out the progress being made on Fitts-Woolard Hall, our newest building on Centennial Campus. This issue provides an update on fundraising efforts to support the new building and why they are so important to the College's upward trajectory.

Finally, my thanks always for your great support. I trust our efforts and accomplishments are making you prouder every day of being a graduate of our College and invite you to stay in touch with us.



Louis A. Martin-Vega, Ph.D.
Dean

BRENNER ROTHERMEL

Department heads named in Materials Science, Computer Science

The College has named new department heads in the Department of Computer Science (CSC) and the Department of Materials Science and Engineering (MSE).

Dr. Donald Brenner, Kobe Steel Distinguished Professor in MSE, had served as interim head since fall 2017. He succeeds Dr. Justin Schwartz, who left NC State to become dean of engineering at Penn State University.

Brenner joined the NC State faculty in 1994 as an associate professor in MSE after holding a position as a research chemist in the Theoretical Chemistry section of the Naval Research Laboratory in Washington, DC.

Dr. Gregg Rothermel is joining NC State from the University of Nebraska-Lincoln on Nov. 1. He will succeed Dr. Mladen Vouk, who left his position as department head to serve as associate vice chancellor for research development and research administration. Dr. Laurie Williams has served as interim head of the department for the last two years.

Rothermel has most recently served as a professor and Jensen Chair of Software Engineering at the University of Nebraska-Lincoln.

He is a co-founder of the ESQuaReD (Empirically-Based Software Quality Research and Development) Laboratory and the EUSES (End-Users Shaping Effective Software) Consortium, a group of researchers who, with National Science Foundation support, have led end-user software engineering research. ▪

NC STATE NAMED FIRST UNIVERSITY-BASED IBM Q HUB IN NORTH AMERICA

NC STATE WILL BE THE FIRST UNIVERSITY in North America to establish an IBM Q Hub as part of the global IBM Q Network, a collaboration between tech powerhouse IBM and top Fortune 500 companies, national research labs and leading universities to advance quantum computing.

The network provides early access to IBM's quantum computing systems, with the goal of exploring practical applications important to business and science.

Starting this fall, NC State will have access to IBM Q commercial quantum computing devices, including the most advanced and scalable universal systems available. The current 20-qubit IBM Q system will be followed by a 50-qubit prototype in the next generation.

WHAT IS QUANTUM COMPUTING?

While the field is still in its infancy, quantum holds the promise of solving problems far beyond the capabilities of ordinary computers. Instead of relying on conventional bits (binary digits, ones and zeroes) to store information, quantum computers use "qubits," which can represent multiple states at once — a phenomenon known as superposition. They can work on problems in parallel and potentially find solutions to problems too complex for any classical machine to compute.

Quantum computing could prove momentous for complex optimization, molecular modeling, machine learning, physics, materials science, chemical simulations and data discovery. By better understanding molecular interactions, quantum computing could:

- Help researchers create new medicines or materials
- Deliver a product across the globe with the least amount of fuel
- Manage risk in constantly fluctuating financial markets
- Train artificial intelligence

THE LATEST IN A LONG PARTNERSHIP

For three decades, IBM and NC State have worked together across research, education and advanced technology development, yielding breakthroughs in cloud computing, advanced analytics, cybersecurity, renewable energy, advanced networking and healthcare IT. In 2016, IBM opened its Education Innovation Center on Centennial Campus, a collaboration space for NC State students and faculty members and IBM employees to uncover solutions.

In this latest partnership, NC State joins three established IBM university-based quantum computing hubs worldwide: the University of Oxford, Keio University and the University of Melbourne. Hubs within IBM's network are critical for accelerated learning, skills development and the global rollout of quantum computing. ▪

RESEARCHERS PROPOSE A BLOCKCHAIN DATA NETWORK TO BOOST MANUFACTURING

RESEARCHERS IN INDUSTRIAL AND SYSTEMS ENGINEERING are proposing the creation of a public, open-source network that uses blockchains — the technology behind cryptocurrencies — to share verifiable manufacturing data. The system could be used as a peer-to-peer network that allows companies to find small- and medium-sized manufacturers that are capable of producing specific components on a reliable basis.

"Small- and medium-scale manufacturers often lack the resources and network reach necessary to make all of their potential clients aware of their manufacturing capabilities," says Dr. Binil Starly, corresponding author of a paper on the work and head of NC State's Data Intensive Manufacturing Environment Lab.

"A public network like the one we're proposing would help potential clients find manufacturers with relevant expertise and equipment in an efficient way," says Starly, who is an associate professor in the Edward P. Fitts Department of Industrial & Systems Engineering.

> "So clients can find the right manufacturers, and manufacturers can find new clients, without relying solely on claims made in marketing materials."
>
> **ATIN ANGRISH**

"Our approach, called FabRec, would allow companies to automatically report about their manufacturing activities: which machines are being used, what materials they are working with, raw material inventory levels, whether the work is being completed on time, and so on," says Atin Angrish, a Ph.D. student in Starly's lab and first author of the paper.

"Because these updates are automated, users can be fairly certain that the information is accurate," Angrish says. "And because it's being done through the blockchain, which allows event logs to be traced to their source, there is accountability. So clients can find the right manufacturers, and manufacturers can find new clients, without relying solely on claims made in marketing materials."

To demonstrate the viability of the concept, the researchers created FabRec — a publicly accessible, prototype network that currently accepts input from a handful of machines.

The paper was co-authored by undergraduate student Benjamin Craver and Ph.D. student Mahmud Hasan, both members of Starly's lab. ▪

PACK POINTS

NEW TECH MAY MAKE PROSTHETIC HANDS EASIER FOR PATIENTS TO USE

> "This is not only more intuitive for users, it is also more reliable and practical."
>
> **DR. HELEN HUANG**

RESEARCHERS HAVE DEVELOPED NEW TECHNOLOGY for decoding neuromuscular signals to control powered, prosthetic wrists and hands. The work relies on computer models that closely mimic the behavior of the natural structures in the forearm, wrist and hand. The technology could also be used to develop new computer interface devices for applications such as gaming and computer-aided design (CAD).

The technology, which has worked well in early testing but has not yet entered clinical trials, is being led by researchers in the UNC/NC State Joint Department of Biomedical Engineering (BME).

Current state-of-the-art prosthetics rely on machine learning to create a "pattern recognition" approach to prosthesis control. This new approach requires users to "teach" the device to recognize specific patterns of muscle activity and translate them into commands — such as opening or closing a prosthetic hand.

"Pattern recognition control requires patients to go through a lengthy process of training their prosthesis," says Dr. He (Helen) Huang, a professor in BME and director of the Closed-Loop Engineering for Advanced Rehabilitation (CLEAR) core. "This process can be both tedious and time-consuming.

"We wanted to focus on what we already know about the human body," says Huang, who is senior author of a paper on the work. "This is not only more intuitive for users, it is also more reliable and practical.

"That's because every time you change your posture, your neuromuscular signals for generating the same hand/wrist motion change. So relying solely on machine learning means teaching the device to do the same thing multiple times; once for each different posture, once for when you are sweaty versus when you are not, and so on. Our approach bypasses most of that."

Instead, the researchers developed a user-generic, musculoskeletal model. The researchers placed electromyography sensors on the forearms of six able-bodied volunteers, tracking exactly which neuromuscular signals were sent when they performed various actions with their wrists and hands. This data was then used to create the generic model, which translated those neuromuscular signals into commands that manipulate a powered prosthetic.

"When someone loses a hand, their brain is networked as if the hand is still there," Huang says. "So, if someone wants to pick up a glass of water, the brain still sends those signals to the forearm. We use sensors to pick up those signals and then convey that data to a computer, where it is fed into a virtual musculoskeletal model. The model takes the place of the muscles, joints and bones, calculating the movements that would take place if the hand and wrist were still whole. It then conveys that data to the prosthetic wrist and hand, which perform the relevant movements in a coordinated way and in real time — more closely resembling fluid, natural motion."

Lead author of the paper is Dr. Lizhi Pan, a postdoctoral researcher in Huang's lab. ▪

NATIONAL SECURITY AGENCY RENEWS SCIENCE OF SECURITY LABLET AT NC STATE

NC STATE HAS AGAIN BEEN AWARDED a Science of Security Lablet by the National Security Agency (NSA) to continue its work in developing the cybersecurity and privacy breakthroughs needed to safeguard cyberspace.

The Science of Security Lablet at NC State was established in 2012. NSA this spring announced that NC State would again host a Lablet for an additional five years under a new contract, with $2.5 million in funding.

Science of Security Lablets are multi-disciplinary labs at leading U.S. research institutions that are part of NSA's Science of Security and Privacy (SoS) Initiative. SoS promotes security and privacy science as a recognized field of research and encourages rigorous research methodologies.

Under the latest contract, the University of Kansas, Vanderbilt University and the International Computer Science Institute will join three of the original SoS Lablets established in 2012: Carnegie-Mellon University, University of Illinois Urbana-Champaign and NC State.

The NC State Lablet was tasked with working on five "hard problems" when it was established:

Scalability and Composability: The challenge of this problem is to develop methods enabling the construction of secure systems with known security properties.

Policy-Governed Secure Collaboration: Projects addressing this hard problem seek to develop methods to express and enforce normative requirements and policies for handling data with differing usage needs and among users in different authority domains.

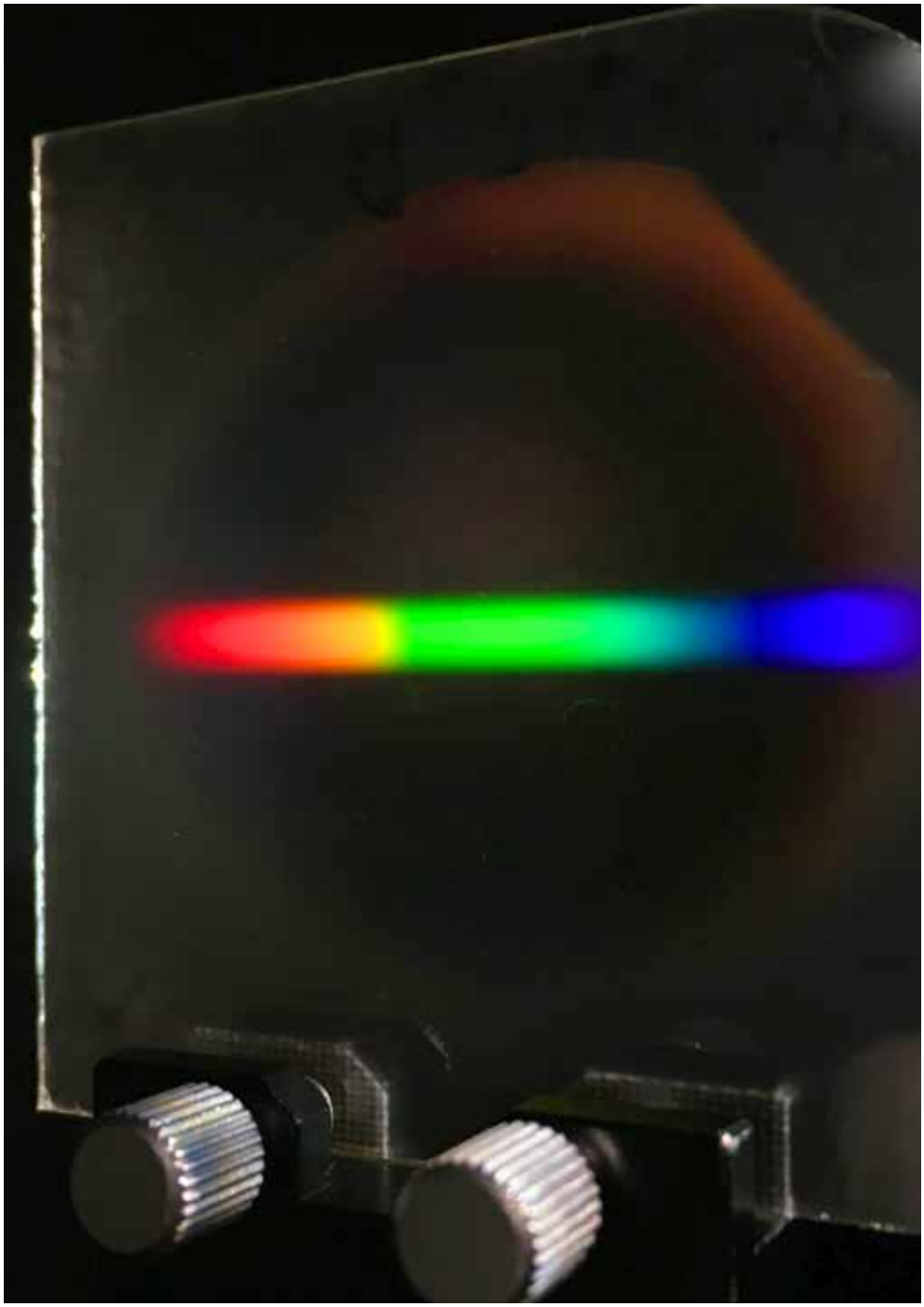
Predictive Security Metrics: The challenge of this problem is to develop security metrics and models capable of predicting whether or confirming that a given cyber system preserves a given set of security properties (deterministically or probabilistically), in a given context.

Resilient Architectures: The challenge of developing the means to design and analyze system architectures that deliver required service in the face of compromised components.

Human Behavior: Modeling human behavior is a daunting task, and projects addressing this hard problem seek to develop models of human behavior (of both users and adversaries) that enable the design, modeling and analysis of systems with specified security properties.

Those same problems will continue as the focus for the next five years, said Dr. Laurie Williams, Distinguished Professor in the Department of Computer Science and principal investigator of the NC State Lablet. ▪

TECH BENDS LIGHT MORE EFFICIENTLY, OFFERS WIDER ANGLES FOR LIGHT INPUT



ENGINEERING AND PHYSICS RESEARCHERS at NC State have developed a new technology for steering light that allows for more light input and greater efficiency — a development that holds promise for creating more immersive augmented-reality display systems.

At issue are diffraction gratings, which are used to manipulate light in everything from electronic displays to fiber-optic communication technologies.

"Until now, state-of-the-art diffraction gratings configured to steer visible light to large angles have had an angular acceptance range, or bandwidth, of about 20 degrees, meaning that the light source has to be directed into the grating within an arc of 20 degrees," says Dr. Michael Escuti, a professor in the Department of Electrical and Computer Engineering (ECE) and corresponding author of a paper on the work. "We've developed a new grating that expands that window to 40 degrees, allowing light to enter the grating from a wider range of input angles.

"The practical effect of this — in augmented-reality displays, for example — would be that users would have a greater field of view; the experience would be more immersive," Escuti said.

The new grating is also significantly more efficient.

"In previous gratings in a comparable configuration, an average of 30 percent of the light input is being diffracted in the desired direction," says Xiao Xiang, a Ph.D. student in Escuti's lab and lead author of the paper. "Our new grating diffracts about 75 percent of the light in the desired direction."

This advance could also make fiber-optic networks more energy efficient, the researchers say.

The new grating achieves the advance in angular bandwidth by integrating two layers, which are superimposed in a way that allows their optical responses to work together. One layer contains molecules that are arranged at a "slant" that allows it to capture 20 degrees of angular bandwidth. The second layer is arranged at a different slant, which captures an adjacent 20 degrees of angular bandwidth.

The paper was co-authored by Dr. Jihwan Kim, a research assistant professor in ECE ▪

NEW TECHNIQUE ALLOWS PRINTING OF FLEXIBLE, STRETCHABLE SILVER NANOWIRE CIRCUITS

SILVER NANOWIRES HAVE DRAWN significant interest in recent years for use in many applications, ranging from prosthetic devices to wearable health sensors, due to their flexibility, stretchability and conductive properties. While proof-of-concept experiments have been promising, there have been significant challenges to printing highly integrated circuits using silver nanowires.

Silver nanoparticles can be used to print circuits, but the nanoparticles produce circuits that are more brittle and less conductive than silver nanowires. But conventional techniques for printing circuits don't work well with silver nanowires; the nanowires often clog the printing nozzles.

"Our approach uses electrohydrodynamic printing, which relies on electrostatic force to eject the ink from the nozzle and draw it to the appropriate site on the substrate," says Dr. Jingyan Dong, co-corresponding author of a paper on the work and an associate professor in the Edward P. Fitts Department of Industrial and Systems Engineering. "This approach allows us to use a very wide nozzle — which prevents clogging — while retaining very fine printing resolution."

"And because our 'ink' consists of a solvent containing silver nanowires that are typically more than 20 micrometers long, the resulting circuits have the desired conductivity, flexibility and stretchability," says Dr. Yong Zhu, a professor in the Department of Mechanical and Aerospace Engineering and co-corresponding author of the paper.

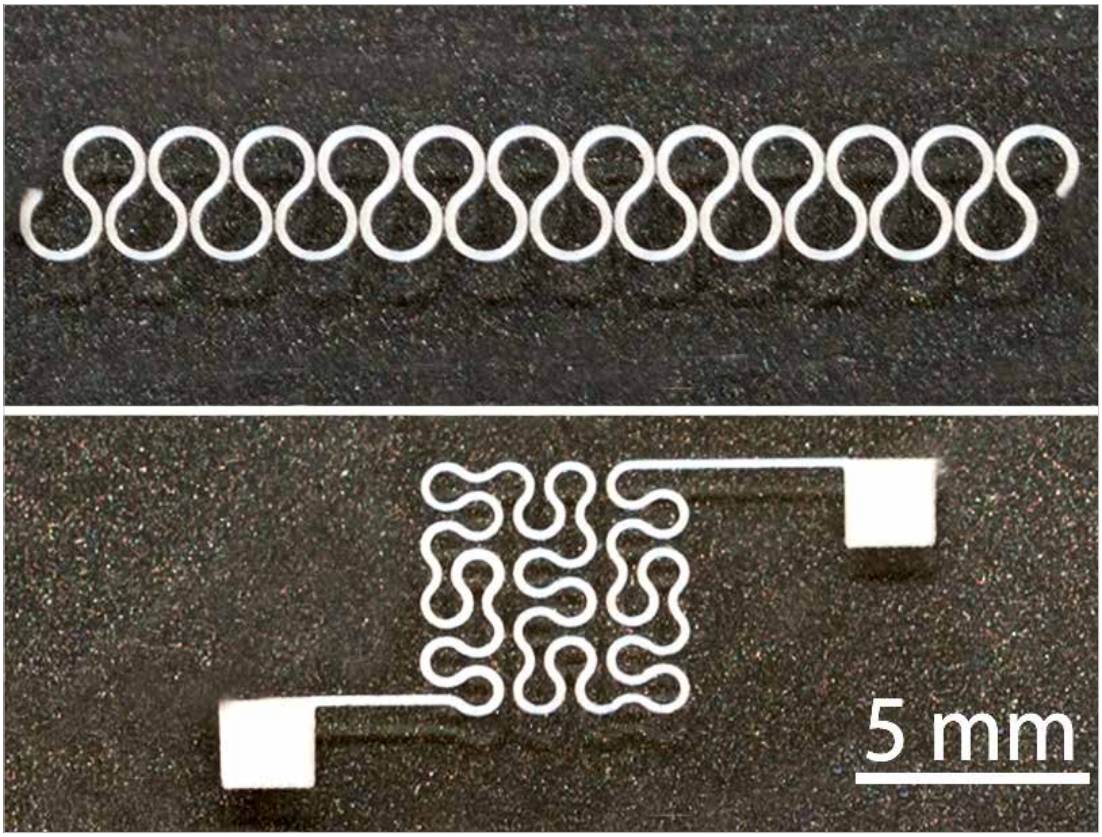
"In addition, the solvent we use is both nontoxic and water-soluble," says Zheng Cui, a Ph.D. student in Zhu's lab and lead author of the paper. "Once the circuit is printed, the solvent can simply be washed off."

What's more, the size of the printing area is limited only by the size of the printer, meaning the technique could be easily scaled up.

The researchers have used the new technique to create prototypes that make use of the silver nanowire circuits, including a glove with an internal heater and a wearable electrode for use in electrocardiography. NC State has filed a provisional patent on the technique.

"Given the technique's efficiency, direct writing capability and scalability, we're optimistic that this can be used to advance the development of flexible, stretchable electronics using silver nanowires — making these devices practical from a manufacturing perspective," Zhu says.

The paper was co-authored by Yiwei Han, a Ph.D. student in Dong's research group, and Dr. Qijin Huang, a former postdoctoral researcher at NC State. ▪



COMMON BRICKS CAN BE USED TO DETECT PAST PRESENCE OF URANIUM, PLUTONIUM

NUCLEAR ENGINEERING RESEARCHERS have demonstrated a technique that can determine whether bricks — the common building material that is omnipresent on the NC State campus — have ever been near a radiological source and identify the specific type of source, such as high enriched uranium or plutonium. The technique is possible when there are no chemical residues left behind and has security and nuclear nonproliferation applications.

Dr. Robert Hayes, an associate professor in the Department of Nuclear Engineering and co-author of a paper on this work, previously used simulations to demonstrate the concept that building materials could be used to characterize nuclear material — even after it was no longer there.

But the NC State team has now validated that the technique works for characterizing transuranic radioactive materials and fine-tuned the technique so that it can be done in days instead of weeks.

"The technique laid out in our paper can take brick samples the size of a thimble and use them to identify whether a radiological source was plutonium, uranium, and so on, even if the source has been removed," says Ryan O'Mara, a Ph.D. student in Hayes' lab and first author of the paper.

"That has clear nonproliferation applications. For example, if a facility says that it has not been making high-enriched uranium — the kind used in weapons — you could take a sample from the building itself and determine whether there had been high-enriched uranium on site."

Researchers envision a variety of future applications as well.

The researchers think the technique may also be used to determine whether nuclear facilities are shipping out as many spent "low burnup" fuel rods as they say they are. This is significant because some facilities have secretly diverted a percentage of their low burnup fuel rods for use as feedstock that can be used to create weapons-grade plutonium. ▪

RESEARCH IMPROVES FOOD BANK EFFECTIVENESS, EQUITY

RESEARCHERS IN INDUSTRIAL AND SYSTEMS ENGINEERING have developed new computer models to improve the ability of food banks to feed as many people as possible, as equitably as possible, while reducing food waste.

Food banks serve as networks, collecting food from many different sources and distributing it to local agencies that then share it with people in need. The researchers, who launched this project eight years ago, quickly realized that there is a great deal of uncertainty in food bank operations. Supply and demand both fluctuate — which researchers anticipated.

"But we found that capacity — the ability of local agencies to collect, transport, store and distribute food — was also variable," says Dr. Julie Ivy, a professor in the Edward P. Fitts Department of Industrial and Systems Engineering (ISE) and co-author of a paper on the work. "These agencies are often small and rely heavily on volunteers.

"Our goal was to develop models that account for uncertainty in a food bank network's capacity and can help food banks distribute food efficiently and equitably — ensuring all of the regions served by the food bank are treated fairly — while minimizing food waste."

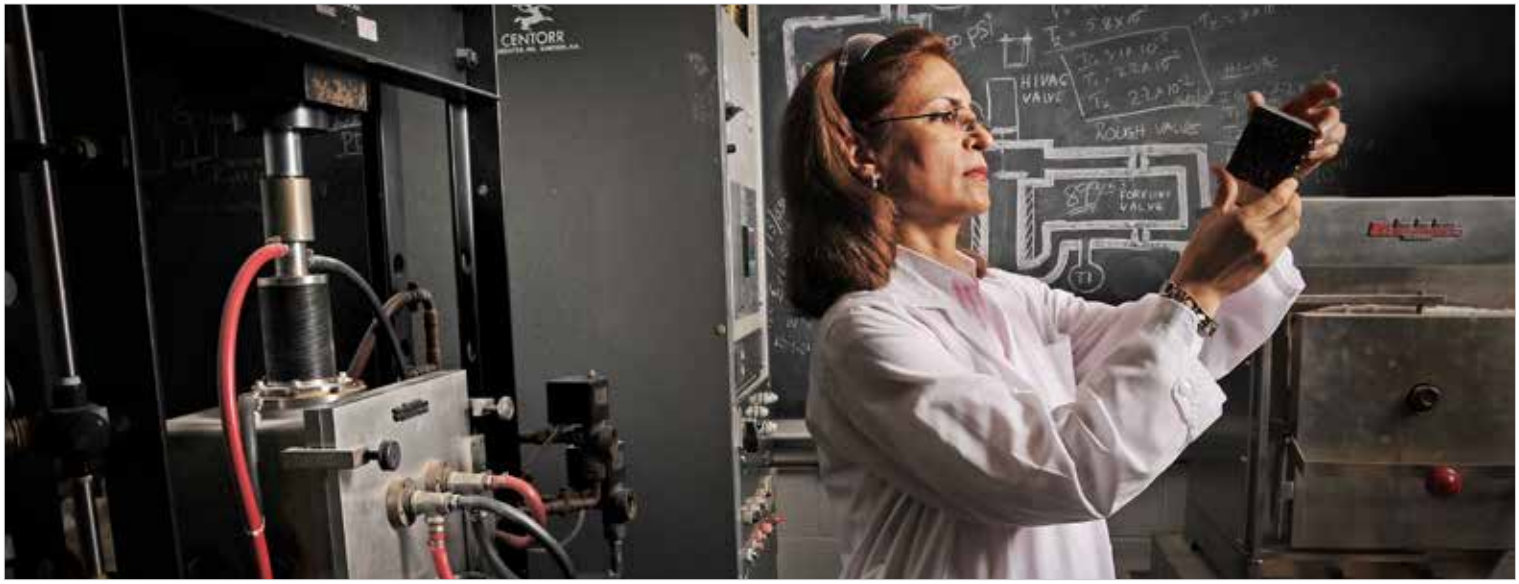
"Our work here was conducted with the Food Bank of Central and Eastern North Carolina, but these are challenges that are common to most, if not all, food banks, as well as for national food collection and distribution networks, such as Feeding America," says Dr. Irem Sengul Orgut, a former Ph.D. student at NC State and lead author of the paper. Orgut now works for Lenovo.

For this project, the researchers developed two models, which can be used in conjunction with each other. The first model uses historical data to establish ranges of how much capacity each county has. The model then uses those ranges, in conjunction with each county's needs, to determine how food supplies should be distributed.

The second model takes into account each county's need and capacity — or ability to distribute food in a timely way across counties before the food goes bad.

"Some counties have agencies with more volunteers, more refrigerated storage, or better transportation resources, allowing them to distribute more food before it goes bad," says Dr. Reha Uzsoy, a co-author of the paper and Clifton A. Anderson Distinguished Professor in ISE. "But if those counties get all the food, it wouldn't be equitable — other counties would suffer. The second model aims to find the best possible balance of those two factors." ▪

> "Our goal was to develop models that account for uncertainty in a food bank network's capacity and can help food banks distribute food efficiently and equitably."
>
> **DR. JULIE IVY**



LIGHTWEIGHT METAL FOAM BLOCKS BLASTWAVE, DEBRIS FROM HIGH-EXPLOSIVE ROUNDS

NEW RESEARCH FROM THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING (MAE) and the U.S. Army's Aviation Applied Technology Directorate shows that stainless steel composite metal foam (CMF) can block blast pressure and fragmentation at 5,000 feet per second from high explosive incendiary (HEI) rounds that detonate only 18 inches away.

"In short, we found that steel-CMF offers much more protection than all other existing armor materials while lowering the weight remarkably," says Dr. Afsaneh Rabiei, senior author of a paper on the work and a professor in MAE. "We can provide as much protection as existing steel armor at a fraction of the weight — or provide much more protection at the same weight.

"Many military vehicles use armor made of rolled homogeneous steel, which weighs three times as much as our steel-CMF," Rabiei says. "Based on tests like these, we believe we can replace that rolled steel with steel-CMF without sacrificing safety, better blocking not only the fragments but also the blast waves that are responsible for trauma such as major brain injuries. That would reduce vehicle weight significantly, improving fuel mileage and vehicle performance."

For this study, researchers fired a 23×152 millimeter (mm) HEI round — often used in anti-aircraft weapons — into an aluminum strikeplate that was 2.3 mm thick. Ten-inch by 10-inch steel-CMF plates — either 9.5 mm or 16.75 mm thick — were placed 18 inches from the aluminum strikeplate. The researchers assessed that the steel-CMF held up against the wave of blast pressure and against the copper and steel fragments created by the exploding round, as well as aluminum from the strikeplate.

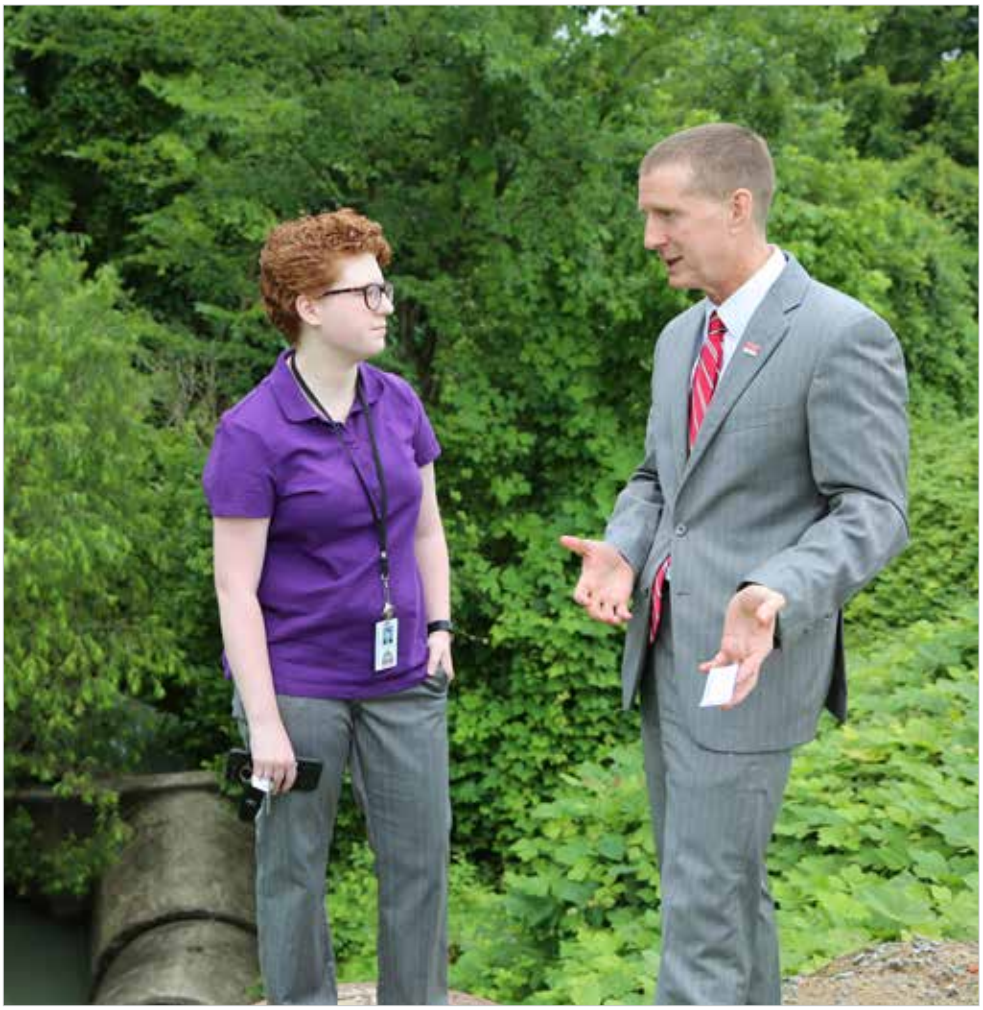
"Both thicknesses of steel-CMF stopped the blastwave, and the 16.75 -mm steel-CMF stopped all of the fragments from 15-mm^2 to over 150-mm^2 sizes," Rabiei says. "The 9.5-mm steel-CMF stopped most, but not all, of the fragments. Based on the results, a 10-mm steel-CMF plate would have stopped all of the frag sizes."

The researchers also developed computer models of how the steel-CMF plate would perform. When compared to the experimental results, the model matched very closely. The researchers then used the model to predict how aluminum 5083 armor — a type of armor already on the market that has a similar weight and thickness to the 16.75-mm steel-CMF — would perform against HEI rounds.

The model showed that, while aluminum armor of similar weight to the steel-CMF panels would stop all of the frags, the aluminum armor would buckle and allow fragments to penetrate much deeper. The steel-CMF, on the other hand, absorbs the energy of the blast wave and flying fragments through local deformation of hollow spheres, leaving the steel-CMF armor under considerably less stress — offering more protection against fragments and blast waves.

Lead author of the study is Jacob Marx, a Ph.D. student working in Rabiei's research group. ▪

PROGRAM PLACES STUDENTS IN INTERNSHIPS ACROSS RURAL NORTH CAROLINA



KRISTEN MANCHETTE IS A SENIOR from Charlotte, NC, studying materials science and engineering. This summer, though, she learned the ins and outs of storm water best management practices.

Manchette was placed in a summer engineering internship with the city of Kinston, NC, Public Services Department through Rural Works!, an NC State program that matches talented students with internship opportunities across North Carolina.

Her first duty upon arrival in the county seat of Lenoir County in eastern North Carolina? Taking a look at a storm pipe pulling runoff from 133 acres of impervious drainage area in downtown Kinston and putting it into the Neuse River. The city identified a problem with trash and oil being carried with the storm water into the Neuse and asked Manchette to work on it.

"It's not doing its job, so we're going to fix it," she said while showing off the design she created using AutoCAD design software in her office. Manchette designed a pair of walls that storm water will have to pass over and then under, catching trash and debris, and separating oils, as it goes. As the summer went on, she designed an access road that will allow city workers to clean out the trap and worked on the construction and environmental permits that will be needed to kick the project off.

Created by a partnership between the Division of Academic and Student Affairs, the Office of Outreach and Engagement and NC State Cooperative Extension, Rural Works! supports NC State's commitment to social, economic and technological development across North Carolina by offering an engaging internship experience for high-caliber students in rural Tier 1 counties — areas identified by the state as needing assistance to reach their full economic potential. The program also requires students to participate in local service programs — to learn about local needs and challenges.

John Siddiqui, a junior from northern Wake County, NC, who is studying both mechanical engineering and foreign languages and literature as a Benjamin Franklin Scholar, spent the summer getting to know every nook and cranny of Kinston.

One of Siddiqui's jobs with the city is to help identify Kinston's roughly 12,000 electric meters. The information will be entered into a digital mapping program that will give Kinston officials a better way to track and prevent outages and other problems, and allow the city to move to smart-meter technologies.

In its first year, the College of Engineering placed four students through the program — two with the city of Kinston and two with Timberline, a packaging and materials handling company in Vance County. The College provides participating students with a stipend from the Engineering Enhancement Fee, which is used to add and enhance educational opportunities.

"There is a real commitment on the University's part to Tier 1 counties," said Dr. Jerome Lavelle, associate dean of academic affairs in the College. ▪

Ducoste receives **Blessis Outstanding Undergraduate Advisor Award**

Dr. Joel Ducoste, professor in the Department of Civil, Construction, and Environmental Engineering (CCEE), received the 2018 George H. Blessis Outstanding Undergraduate Advisor Award. He is a recognized expert in modeling water and wastewater treatment processes using Computational Fluid Dynamics.

The award recognizes faculty members who consistently and willingly give their time and effort to advising, counseling and mentoring students and assisting student groups. Ducoste has served as a faculty member at NC State for 20 years. He is known for not only being supportive, but also for being a mentor in and out of the classroom, and a highly knowledgeable instructor. ▪

DR. JOEL DUCOSTE

Chi, Haugh receive **Alcoa Foundation Engineering Research Awards**

DR. MIN CHI

DR. JASON HAUGH

The 2018 Alcoa Foundation Engineering Research Awards were presented to **Dr. Min Chi**, assistant professor in the Department of Computer Science, and **Dr. Jason Haugh**, professor in the Department of Chemical and Biomolecular Engineering.

Chi was awarded the Alcoa Foundation Engineering Research Achievement Award, which recognizes young faculty members who have accomplished outstanding research achievements during the preceding three years.

Chi's research has helped pioneer the use of techniques from Reinforcement Learning to improving the decision making of Intelligent Tutoring systems. Her research addresses both how we should induce effective pedagogical strategies and how to empirically evaluate the resulting policies to improve educational outcomes.

Haugh received the Alcoa Foundation Distinguished Engineering Research Award, made to a senior faculty member for research achievements over a period of at least five years.

During his time at NC State, Haugh has quickly risen to the rank of professor and is well known as a talented educator and leader. He has broken new ground by bringing quantitative fluorescence microscopy and computational image analysis as a central approach in his lab. ▪

Carbonell receives **highest UNC System honor**

Dr. Ruben Carbonell, Frank Hawkins Kenan Distinguished Professor of Chemical Engineering, has been honored with the O. Max Gardner Award, the most significant university wide honor given to faculty members by the University of North Carolina System, for his contributions in engineering, health care, education and public policy.

Carbonell and colleagues published two landmark papers reporting for the very first time the removal of the infectious prion protein responsible for the transmission of mad cow disease in humans from whole blood.

As director of NC State's Kenan Institute, Carbonell established the Kenan Fellows Program for Teacher Leadership, an innovative program to nurture teacher-leaders through a yearlong mentorship with university faculty and industry partners aimed at developing novel curriculum tools to bring groundbreaking research to K-12 students.

Additionally, Carbonell was a co-principal investigator in the proposal that led to the March 2017 launch of the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL). ▪

DR. RUBEN CARBONELL

Three receive **NSF CAREER awards**

DR. KATHRYN STOLEE

DR. LANDON GRACE

DR. FERNANDO GARCIA MENENDEZ

Three young faculty members in the College have been chosen to receive Faculty Early Career Development (CAREER) awards from the National Science Foundation (NSF).

The NSF CAREER award is one of the most prestigious awards in support of junior faculty members who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research. Each award provides more than $500,000 in funding over five years.

Dr. Kathryn Stolee, assistant professor in the Department of Computer Science, for her project, "On the Foundations of Semantic Code Search."

Dr. Landon Grace, assistant professor in the Department of Mechanical and Aerospace Engineering, for his project, "Exploiting the Dynamic Dielectric Behavior of Water to Understand and Predict Polymer Composite Damage Progression."

Dr. Fernando Garcia Menendez, assistant professor in the Department of Civil, Construction, and Environmental Engineering, for his research project "A Modeling and Educational Framework to Support Air Quality Management in a Smoky Atmosphere." ▪

Bryant, de los Reyes, and Dietrich receive **Outstanding Teaching Award**

DR. MATTHEW BRYANT

DR. FRANCIS DE LOS REYES

DR. CASEY DIETRICH

Three faculty members in the College received Outstanding Teacher Awards for 2017-18: **Dr. Matthew Bryant**, an assistant professor in the Department of Mechanical and Aerospace Engineering; **Dr. Francis de los Reyes**, a professor in the Department of Civil, Construction, and Environmental Engineering (CCEE); and **Dr. Casey Dietrich**, an assistant professor in CCEE.

The award recognizes excellence in teaching at all levels and is a prerequisite for being considered for the Board of Governors Award for Excellence in Teaching and the Alumni Distinguished Professor Award.

Bryant's research seeks novel solutions and new devices that contribute to the advancement of emerging technologies in areas including ambient energy harvesting, fluid-structure interaction, and robot actuation and mobility.

De los Reyes' research interests are in the areas of environmental engineering; water and wastewater treatment; environmental biotechnology; and water, sanitation, and hygiene.

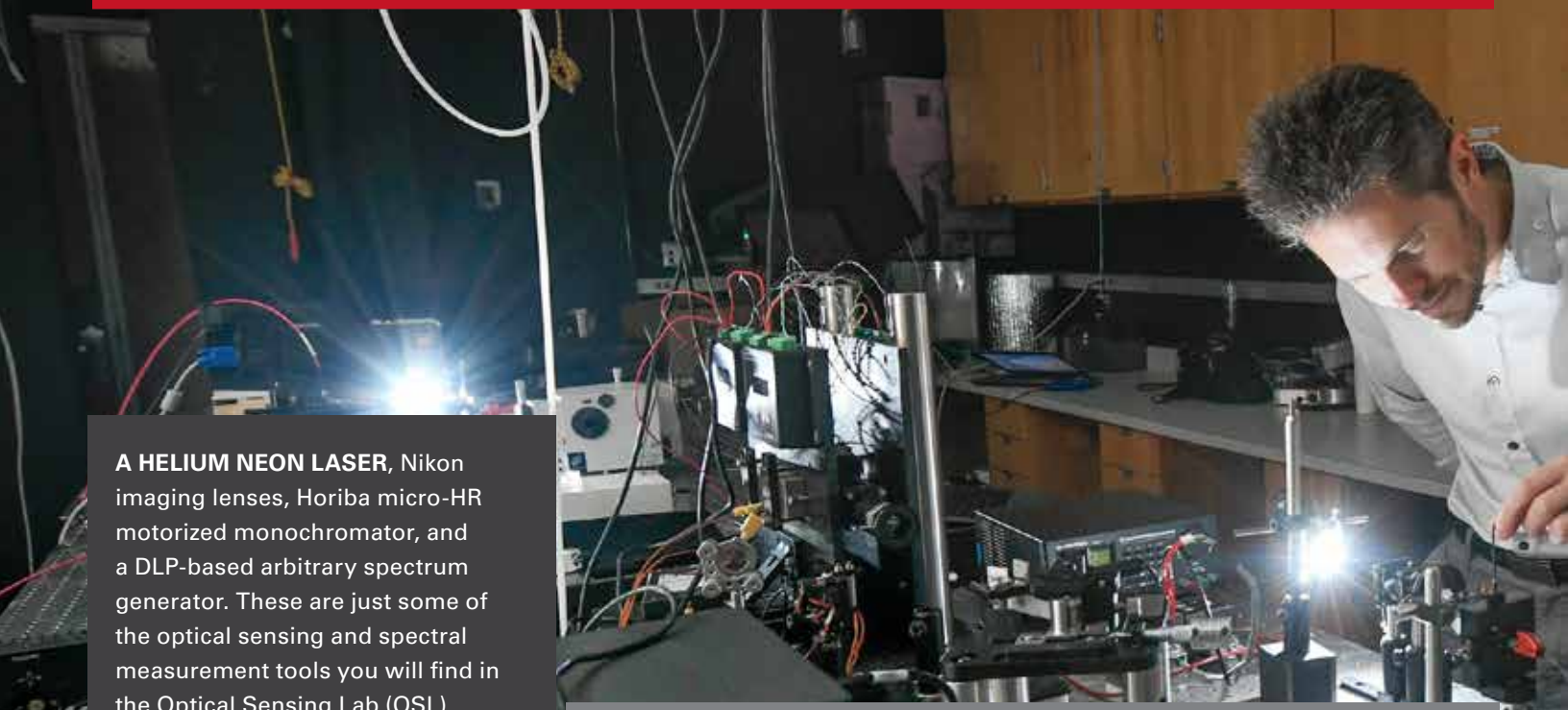
Dietrich develops computational models for wind waves and coastal circulation and then applies these models to high-resolution simulations of ocean behavior. ▪

IN OUR LABS

THESE ARE THE SPACES THAT ENABLE
GROUNDBREAKING RESEARCH

OPTICAL SENSING LABORATORY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING



A HELIUM NEON LASER, Nikon imaging lenses, Horiba micro-HR motorized monochromator, and a DLP-based arbitrary spectrum generator. These are just some of the optical sensing and spectral measurement tools you will find in the Optical Sensing Lab (OSL).

With a background in optics, Dr. Michael Kudenov started the OSL to explore the cross-field's capabilities to implement emerging technologies and see how we can use them to make optical systems smaller, faster and more capable.

"Primarily, what we focus on is optical instrumentation. So, our primary goals are to develop smaller sensors that are more capable or developing sensors that exploit new capabilities. Also, implementing emerging technologies into optical systems," said Kudenov, an associate professor in the Department of Electrical and Computer Engineering (ECE).

LOCATED IN THE MONTEITH RESEARCH CENTER on NC State's Centennial Campus, the lab's major research area is in spectral and polarimetric imaging as it applies to both remote sensing and biomedical imaging applications. Through incorporating novel Polarization Grating (PG) technologies into spectral and polarimetric sensors, the researchers in OSL are increasing the sensor's spatial, spectral or radiometric performance, or reducing the sensor's overall size or cost. Dr. Michael Escuti, professor in ECE, is a collaborator on the work.

Additionally, emphasis is given on the development of ultra-compact sensors with novel capabilities. An example is the ability to passively measure velocity at higher signal-to-noise ratios than were before possible.

From a remote sensing perspective, it can be used to quantify chemicals in the environment, perform quality control in industrial and commercial manufacturing processes, assess water quality and vegetation health, identify targets, and for mineral mapping. Meanwhile, polarimetric sensing can be used to enhance a target's contrast in cluttered backgrounds, measure surface roughness and quantify aerosols in the atmosphere.

THE LAB'S CAPABILITIES also expand into biomedical imaging. Kudenov has worked with UNC Chapel Hill researcher Dr. Spencer Smith and assisted in his high-speed femtosecond microscopy. OSL researchers helped optimize objective lenses for brain imaging in mice. In this process, glass slides were placed on the brains of test mice. Once under the microscope, the mice were given visual stimuli. The lenses were then used to examine how the neuron firing pattern in the visual cortex correlates to other regions of the brain in response to different visual stimuli.

Ongoing projects for the lab branch into multiple fields and areas, including remote detection and identification of projectiles, retinal spectroscopy and polarimetry for glaucoma detection, satellite tracking and orbital prediction, hypersonic wind tunnel testing and imaging, and real-time monitoring of thermal spray processes.

And the applications do not stop there.

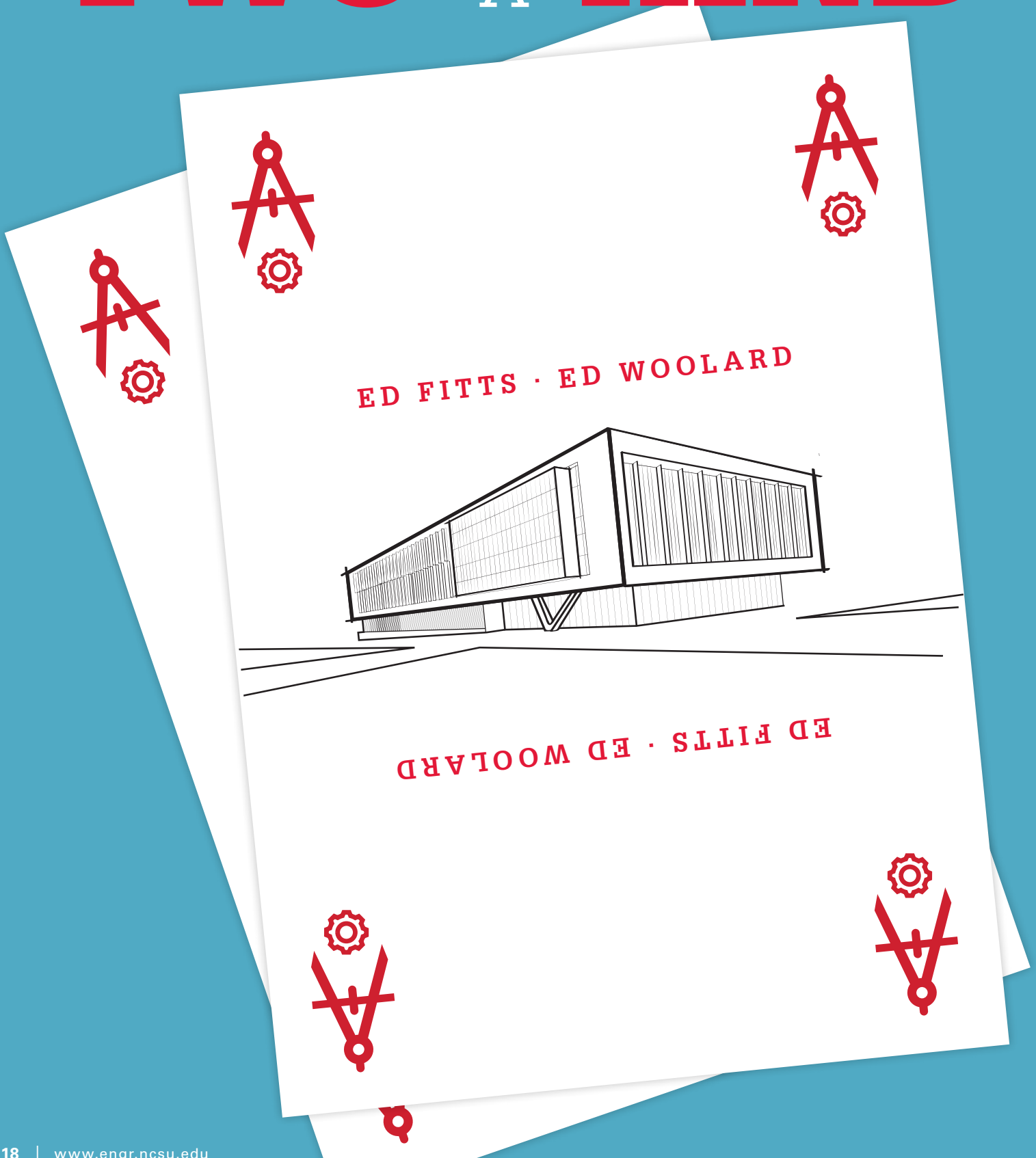
"We're also looking into farming," said Kudenov. "Imagine being able to take these very small, very lightweight unmanned aerial vehicles and equipping them with a disposable miniaturized hyperspectral imaging camera and being able to identify which plants have disease, what kinds of diseases those plants have, while you can still do something about it from a management perspective."

Kudenov has been working with collaborators in the College of Agriculture and Life Sciences to study these types of applications.

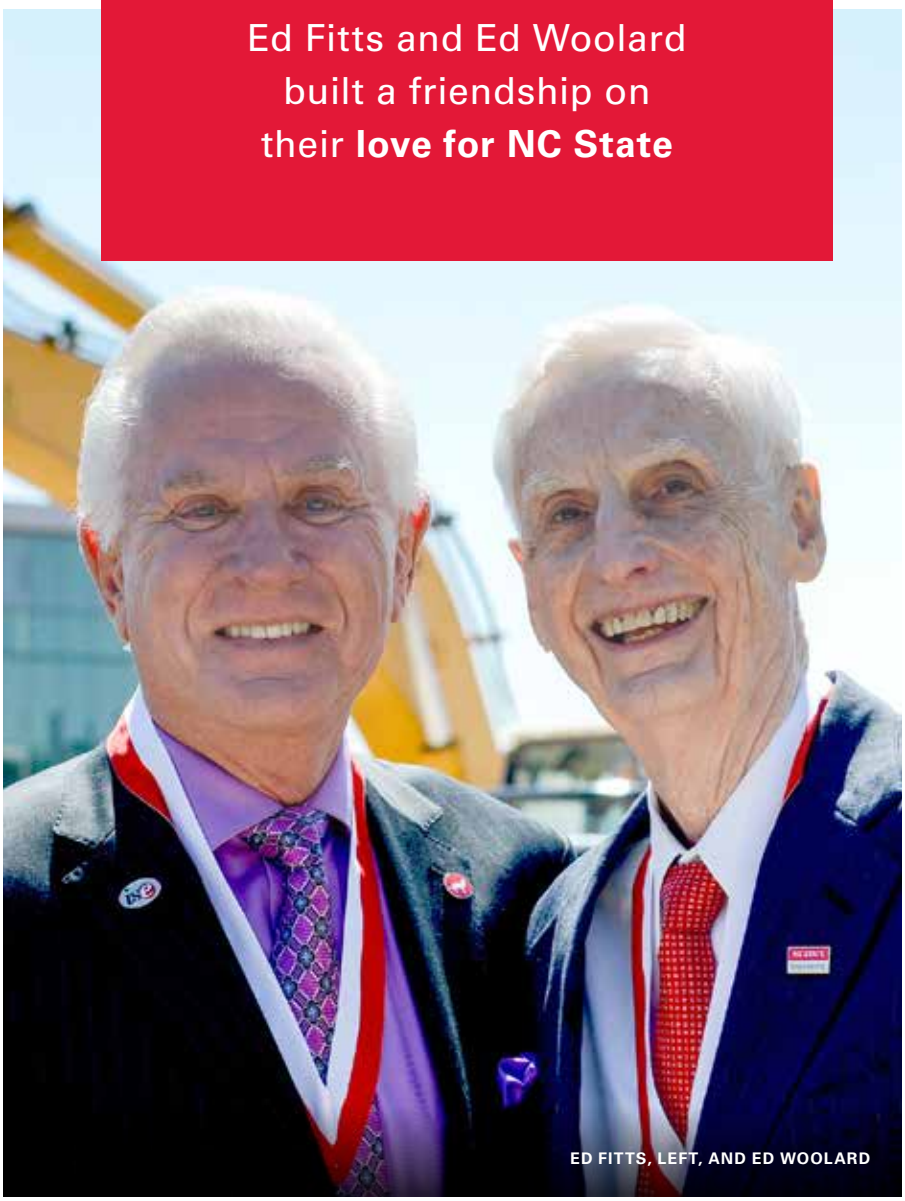
IN THE FUTURE, Kudenov would like to see more research in the areas of ultra-spectral imaging and advanced camera imaging array technologies.

"Moving from 2D to 3D imaging camera arrays may open a new paradigm for measuring information," Kudenov shared. Beyond conventional 2D silicon array detector technology, as is found in all cell phone cameras, he and Dr. Brendan O'Connor, associate professor in the Department of Mechanical and Aerospace Engineering, are creating new devices that could enable this vision. Based on organic light detectors, they offer similar architectures to retinas found in biology — specifically, the Mantis shrimp. In these biological systems, light sensing cells (detectors) are cascaded in more complex 3D structures, thereby enabling enhanced color and/or polarimetric vision sensing. ▪

TWO OF A KIND



Ed Fitts and Ed Woolard built a friendship on their **love for NC State**



ED FITTS, LEFT, AND ED WOOLARD

BOTH INDUSTRIAL ENGINEERS from NC State. Both from small North Carolina towns. Both highly successful businessmen.

Both Eds.

Edward P. Fitts, Jr. and Edgar S. Woolard, Jr. began a friendship based on their mutual love for NC State, their appreciation of the paths that their engineering degrees started them down and a common goal: to make the University, the College and the department where they studied the best that they can be.

"I've always wanted NC State to be number one in everything that we do," Ed Fitts said.

Their work for NC State took different but equally important paths. Ed Woolard began his contributions in the early 1980s, working as an advisor to NC State chancellors, serving on the University's Board of Trustees and helping lead two University capital campaigns. Fitts "burst on the scene" — as Woolard puts it — with a vision to make the Department of Industrial and Systems Engineering one of the top five industrial engineering departments in the country. In 2005, he made a $10 million transformational gift that named the department, and he has been instrumental in the fundraising efforts for the College's newest building on Centennial Campus.

The two Eds returned to campus in April 2018, when the University named that building Fitts-Woolard Hall. Their $25 million gift to help fund construction is the largest gift given to a campus building naming in NC State's history.

The future home of the Edward P. Fitts Department of Industrial and Systems Engineering; the Department of Civil, Construction, and Environmental Engineering; and the dean's administrative offices will further the College's move to Centennial Campus. It will also leverage the power of convergence across disciplines, forming one of the world's most dynamic research and education environments.

For Fitts and Woolard, it was a move that had to be made. The College has committed to raising $60 million in private donations to help fund the $154 million project.

"The key in my mind from day one was that we make certain that we raise the money that we need to meet our commitments," Fitts said.

The $25 million gift has taken the College a long way toward reaching its fundraising goal. But the work is not complete, and Fitts and Woolard hope that more alumni will follow their example and provide support so that the College will not have to borrow to complete construction.

"We still need to raise another $12.8 million to meet our commitment to the state, and that's very important to us as well," Fitts continued.

The commitment to seeing this building project through is par for the course for two alumni who have given tirelessly of their time, resources and leadership to NC State Engineering. Their

"It's a tale of two people participating in the university we love, and we give it great credit for what we learned about how to succeed as engineers and businessmen."

EDGAR S. WOOLARD, JR.

friendship, which started with a breakfast meeting in Jupiter, Fla., 13 years ago, has been very beneficial to the College, their home department and to them.

"It's a tale of two people participating in the university we love, and we give it great credit for what we learned about how to succeed as engineers and businessmen," Woolard said.

SOMETHING BIGGER

Fitts knew what he wanted to do, he just wasn't sure how to do it. So, he called on someone who could help.

A native of Littleton, NC, Fitts earned his B.S. in industrial engineering in 1961. After graduation, he went to work with Sonoco Products Company, rising to the position of vice president of paperboard packaging. In 1979, he purchased Sonoco's folding carton operation, renamed the business unit Dopaco Inc. and turned it into the number-one fast-food packaging company in the world.

Fitts endowed his first scholarship in industrial engineering in 1999 and his first professorship in the department in 2002. But he had plans for something bigger.

He wanted to make a sizable donation to support industrial engineering and tie it to a business plan that would help transform it into one of the top five such departments in the United States. Having just reconnected to the University, he wasn't sure how to implement such an audacious plan in an academic setting. So, he called on Ed Woolard.

After graduation with a bachelor's degree in industrial engineering in 1956, Woolard began a career with DuPont that would see him rise to president, CEO and chairman of the board. Then, as chairman of the board at Apple, the Washington, NC, native famously brought the company back from the brink when he convinced Steve Jobs to return in 1997.

As he rose to the top echelons of DuPont, Woolard worked as a close advisor to Chancellors Larry Monteith and Marye-Anne Fox, who asked him to co-chair the University's Achieve! campaign. That campaign, NC State's first to raise $1 billion, was an important turning point, Woolard said.

"So many of our alumni just thought that the government took care of everything at NC State," he said. "We had to explain to them that those days are over."

The two had never met in school or in business, but both had homes in Jupiter, Fla. Fitts asked Woolard to meet him for breakfast to discuss his plans to donate $10 million to their home department. Woolard agreed to be part of a committee that included a couple of Fitts' business associates and an engineering faculty member from Georgia Tech.

In developing a plan for how the donation would help transform the department, the group looked at its strengths and weaknesses. They examined where the field is headed in the coming decades, from healthcare and medical logistics to the Internet of Things.

In 2005, the Edward P. Fitts Department of Industrial and Systems Engineering became the first named academic department in NC State's history. Thanks to Fitts' $10 million donation, which became a $12 million gift to the department with matching funds from the state of North Carolina, the department has risen in national rankings and has nearly doubled in size in the last decade.

BRICKS AND MORTAR

The committee knew that a new home for the department would be part of the plan. But the first investment was in scholarships, fellowships and named professorships.

"It became very apparent to me that the first thing we needed to do was build up our faculty, attracting the best and brightest," Fitts said. "If you don't have something like a chaired position to offer a top professor from Purdue or Michigan, they're not coming."

With a new department head and talented new faculty members in place and more scholarship and fellowship opportunities for top students, a new home to replace aging Daniels Hall would bring it all together and help the department achieve its full potential. Fitts-Woolard Hall will not only give faculty members and students the best facilities, it will put them in a cross-disciplinary collaborative environment on Centennial Campus with other engineering departments and some of the world's top companies.

"I personally had been looking forward to this event for over 10 years," Fitts said of the April dedication of Fitts-Woolard Hall. "Of course, at that time, never knowing that I would be part of it."

More than 300 alumni and friends have made commitments to support the building. Fitts and Woolard hope that many more alumni will sign on to help raise the additional $12.8 million, people who, like them, know the importance of an NC State engineering or computer science degree and appreciate all it has done for them.

"We cannot remain a top engineering college without financial support and aid from our alumni," Fitts said. "Our alumni have to really understand that they have to support their alma mater." ▪

"I've always wanted NC State to be number one in everything that we do."

EDWARD P. FITTS, JR.

TAKE A CLOSER LOOK INTO

Fitts-Woolard Hall

OUTSIDE ADVANCED MANUFACTURING LAB

Industrial and systems engineering researchers and students will collaborate inside the Advanced Manufacturing lab and work on the development of new materials and the instrumentation and testing of new methods for additive processes.

ADVANCED MANUFACTURING LAB

Looking out from inside the Advanced Manufacturing Lab, this point of view shows the Oval and the EB buildings to the north.

To learn more about how you can support Fitts-Woolard Hall and the naming opportunities available, contact **Lora Bremer**, executive director of major gifts and campaign planning for the NC State Engineering Foundation, at ***lora_bremer@ncsu.edu*** or ***919.513.0983***.

ROOF DECK

The roof terrace, located at the south end of the building, looks into the loose seating area around the open stair and atrium.

LOBBY

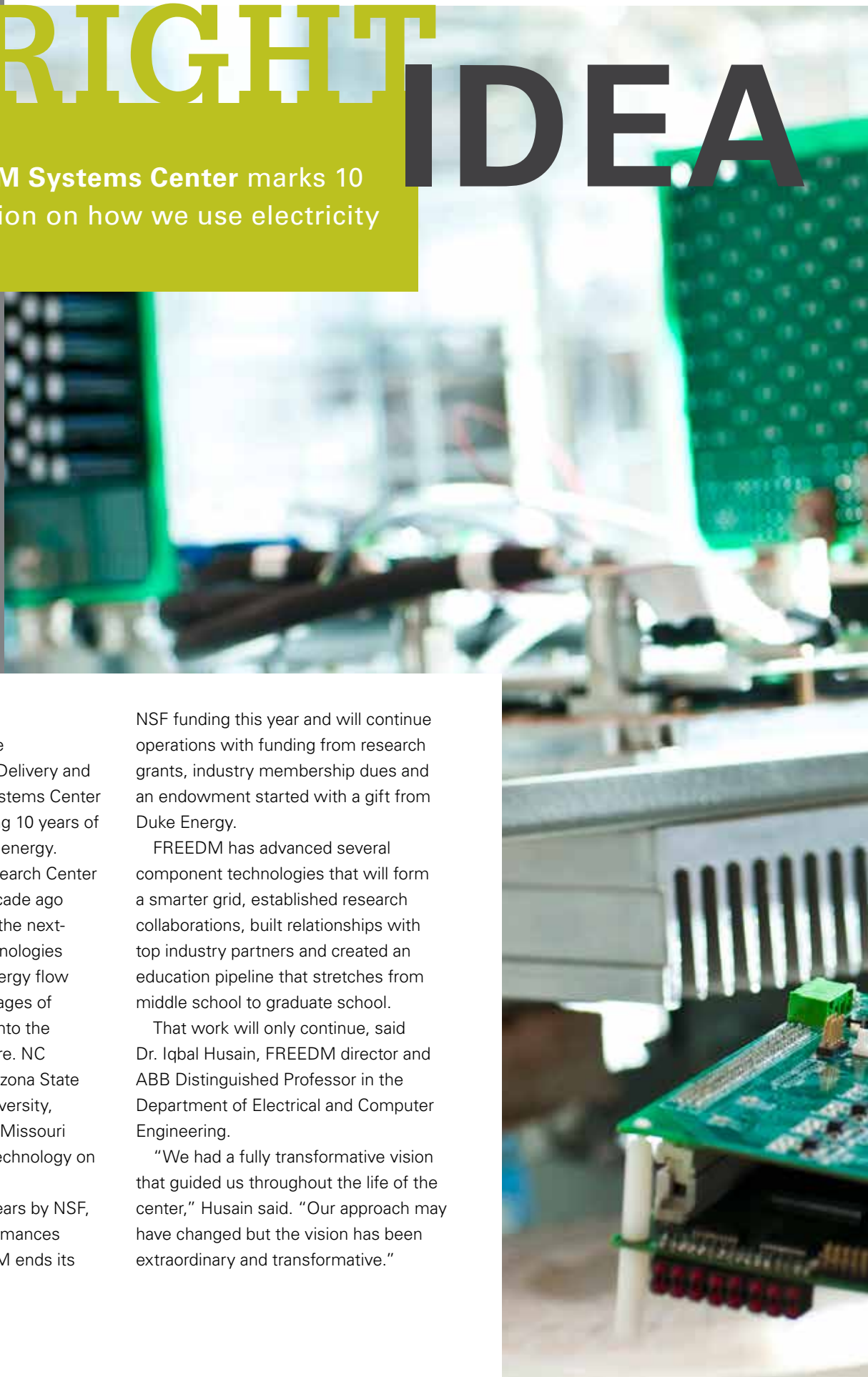
This view from the lower level lobby highlights the Student Projects Lab, as seen in the background, that will bring together undergraduate and graduate students in the College.

ENTRY

From the Partners Way Entry Plaza, you can see the Structural Testing Lab (left) where civil, construction and environmental engineering students will work to develop new methods and designs for resilient structures.

A BRIGHT IDEA

The **NSF FREEDM Systems Center** marks 10 years of innovation on how we use electricity



THE NATIONAL SCIENCE FOUNDATION (NSF) Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center led by NC State is celebrating 10 years of work changing how we use energy.

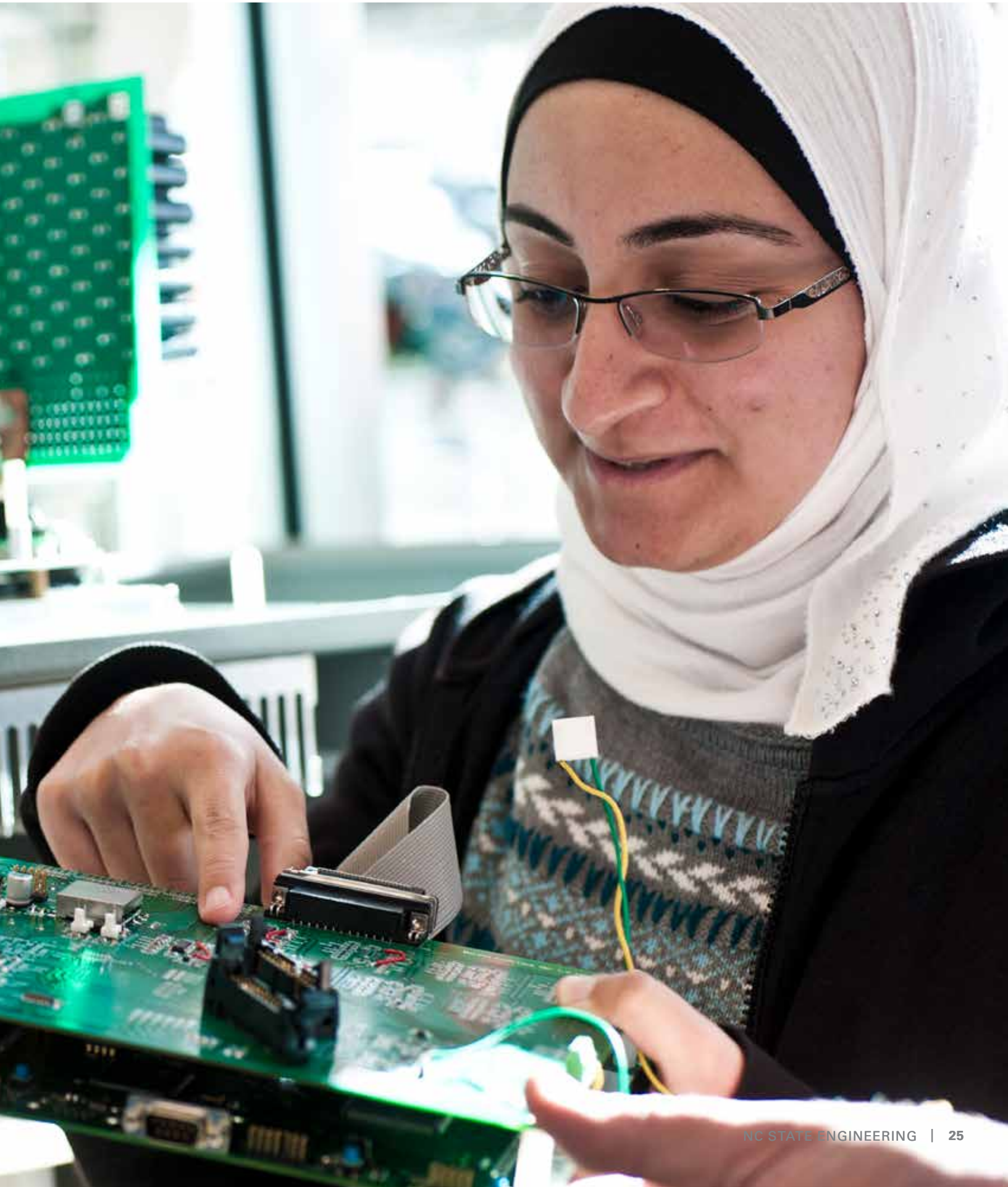
The NSF Engineering Research Center (ERC) was established a decade ago with the goal of developing the next-generation electric grid technologies that enable bi-directional energy flow and integrate larger percentages of renewable energy sources into the national electric infrastructure. NC State has partnered with Arizona State University, Florida A&M University, Florida State University and Missouri University of Science and Technology on the center.

ERCs are funded for 10 years by NSF, based on satisfactory performances at annual site visits. FREEDM ends its NSF funding this year and will continue operations with funding from research grants, industry membership dues and an endowment started with a gift from Duke Energy.

FREEDM has advanced several component technologies that will form a smarter grid, established research collaborations, built relationships with top industry partners and created an education pipeline that stretches from middle school to graduate school.

That work will only continue, said Dr. Iqbal Husain, FREEDM director and ABB Distinguished Professor in the Department of Electrical and Computer Engineering.

"We had a fully transformative vision that guided us throughout the life of the center," Husain said. "Our approach may have changed but the vision has been extraordinary and transformative."



> "Our approach may have changed but the vision has been extraordinary and transformative."
>
> **DR. IQBAL HUSAIN**

AN INTERNET OF ENERGY

The FREEDM vision, outlined in a proposal to NSF submitted by a team led by Dr. Alex Huang, then a Distinguished Professor of Electrical and Computer Engineering at NC State, imagined a new kind of smart grid. This Internet of Energy would let users generate their own energy from renewable sources and allow excess power to be stored or sold back to a utility. It would tackle the resiliency issues inherent to a system based on centralized generation, enabling generation close to the loads. It envisioned a distributed control system that is responsive to price signals, customer preferences and situational considerations.

The technology would help reduce dependence on fossil fuels and lower carbon emissions by making it possible for renewable sources like wind and solar to be fully integrated into the existing electric infrastructure.

NSF believed in that vision, giving one of five ERC grants awarded nationwide in 2008 to NC State and its partner schools. In 2012, NSF established the Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) at NC State to guide work on wearable health-monitoring systems that are powered by the human body. With that, NC State became one of only two engineering schools in the country to lead two ERCs at once and one of only two schools to ever be awarded the lead role in three.

The FREEDM Systems Center has spent the last decade developing a working FREEDM system and the technologies that underpin it: a solid-state transformer (SST) that allows bi-directional power flow and takes away the need to convert DC current to AC for home use, a more efficient fault-isolation device, and the controllers and algorithms that allow them to work together. Whether deployed as a complete system or as independent components, these technologies are having a modernizing impact on the national electric grid.

"The research at FREEDM led to fundamental changes in how the industry thinks about grid modernization," Husain said.

While the idea of using an SST to connect renewable resources was a novel idea 10 years ago, today academic institutions (including some new ERCs) and companies are following FREEDM's lead. The Department of Energy has established a Solid State Power Station Roadmapping group to study how SSTs will be integrated into the grid.

As these components are worked into the existing legacy grid, utility companies will soon realize that the entire system will have to change. That's when a true FREEDM system will be implemented, said Ken Dulaney, FREEDM's director of industry and innovation.

"Eventually, we're going to need to move to a system like FREEDM that enables us to manage the massive distributed resources that are on our grid," Dulaney said.

A PROCESS THAT WORKS

Just as FREEDM researchers had a vision for changing the grid, NSF has a specific vision for ERCs.

A successful ERC starts with a plan to create new technology that has the potential to transform national healthcare, energy, security or infrastructure.

FREEDM developed novel ideas to advance the SST, and a startup company called GridBridge licensed that intellectual property from NC State. GridBridge commercialized a low-voltage SST that can be purchased today. Recently, the company was acquired by a traditional transformer manufacturer.

"The NSF process works," Dulaney said. "Ideas move from research to product development to commercialization."

FREEDM has initiated 10 startup companies, has more than 50 patents and has established a strong industry consortium.

But building the technology is not the only goal. NSF wants to develop innovative, inclusive cultures that further engineering education and work collaboratively with industry partners.

Over 10 years, FREEDM has built just such a culture.

The center's education efforts include summer camps for K-12 students and research experiences for undergraduates. FREEDM has produced more than 140 Ph.D. graduates and more than 200 master's graduates who were attracted to the center's faculty, facilities and research opportunities.

Renewable energy education programs are now established at both graduate and undergraduate levels in all partner institutions.

Niloofar Ghanbari chose FREEDM for a Ph.D. in power electronics research after completing bachelor's and master's degrees in her native Iran.

"FREEDM is so related to what I wanted to study," Ghanbari said. "It has a very great and facilitated laboratory that we can use to test our theory and thinking. It gives me very good insight into what I am doing in my Ph.D."

At the same time, the center is working to increase participation in STEM fields by women and members of traditionally underrepresented groups at all levels.

FREEDM's industry partners include major utilities like Duke Energy and equipment and systems leaders like ABB and Eaton, but also Toyota, Hitachi, Toshiba and SAS Institute.

As the center continues, FREEDM research will expand further into other research areas, including electric transportation technologies such as new inverters, novel motor topologies and high-power electric vehicle charging.

At the same time, FREEDM will continue to drive development of the Internet of Energy, the basis of that vision that came together 10 years ago.

As Husain says, it's a "much, much longer-term vision." ▪

FIRST DECADE

100+ INVENTIONS

$1.5M ENDOWMENT

$12M RESEARCH FUNDING PER YEAR

20+ INDUSTRY PARTNERS

200+ PAPERS AND CONFERENCE PROCEEDINGS

24 FACULTY IEEE FELLOWS

10 STARTUP COMPANIES

50+ PATENTS

140 PH.D. GRADUATES
200 MASTER'S GRADUATES

A SHARED EXPERIENCE

Research Experiences for Teachers program builds on teamwork

A TEAM OF UNDERGRADUATE students and North Carolina educators came together for six weeks on NC State's campus this summer to form a research team.

Their subject? Rats. Specifically, rats with injuries to the brachial plexus, a network of nerves extending from the cervical spinal cord to the shoulder. By studying those rats and how they grow and move after injury, they hoped to draw conclusions about how similar injuries in infants affect their bone and muscle growth and overall shoulder function.

Their larger goal, though, is to help enhance how engineering and computer science is taught across the nation, from middle school classrooms to university laboratories, as part of a program sponsored by the National Science Foundation (NSF).

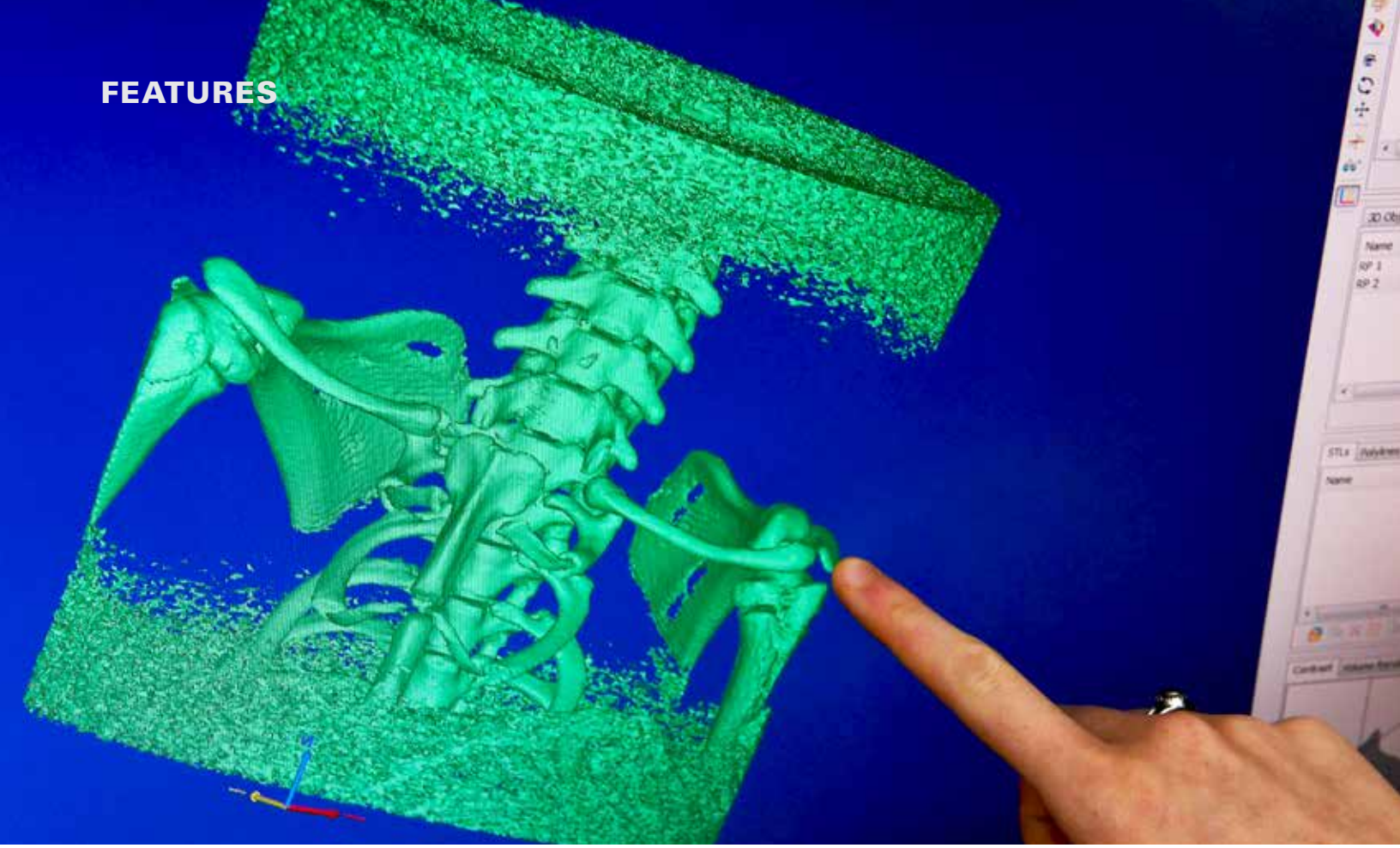
The Research Experiences for Teachers (RET) in Engineering and Computer Science program awarded the College of Engineering at NC State with a research site in order to strengthen STEM subject knowledge curriculum at all levels of the educational system and increase awareness of the Grand Challenges for Engineering in the 21st century identified by the National Academy of Engineering.

Multidisciplinary teams that include a K-12 teacher, a STEM-field community college professor and undergraduate students in engineering and education, are assigned to one of four engineering or computer science faculty members' laboratories at UNC Charlotte and NC State.

They work as paid employees for the faculty members, seeing firsthand how engineering and computer science research is done in the lab and gaining knowledge they can take back to their classrooms to enhance STEM education. For the engineering students, the program offers a great opportunity for undergraduate research.

"They actually get into real research pretty fast," said Dr. Katherine Saul, an associate professor in the Department of Mechanical and Aerospace Engineering at NC State. Saul is one of four faculty members, three from the College of Engineering at NC State and one from the William States Lee College of Engineering at UNC Charlotte, who worked with an RET team over the summer as part of the program.

At the same time, the teams develop curriculum plans that can be used in K-12 and community college classrooms. Along with implementing the plans in those team members' classrooms, teachers also share the plans through TeachEngineering, a peer-reviewed digital library collection with standards-based engineering curricula for use by educators.



IN THE LAB

Lauren Boop is branching out this year.

Trained as a history teacher, Boop also has a love for engineering. This fall, she will combine her passion for history, engineering and science into two courses at STEM-focused Hilburn Academy in Raleigh. In her sixth-grade class, students will examine how the Mayans created a calendar, the methods the Romans used to engineer aqueducts and the origins of gunpowder in China. In her seventh-grade class, students will study biomedical engineering.

The RET program was a natural fit for Boop, who was also part of NC State's Kenan Fellows STEM-focused teacher leadership program. She was assigned to Saul's Movement Biomechanics Laboratory on a team that also included Erin Doughney, a biology instructor at Wake Technical Community College in Raleigh; Emily Keller and Megan Haase, undergraduate students in the UNC / NC State Joint Department of Biomedical Engineering (BME); and Jessie Taylor, an undergraduate student in NC State's College of Education.

The brachial plexus birth injury that the team studied affects approximately four of every thousand births each year. It occurs when an infant's shoulders and head become stretched in opposite directions during a difficult delivery.

A rat's shoulder structure is similar enough to a human's to make the animal a good comparison subject. The team examined CT scans of rats with brachial plexus injuries to determine differences in bone formation. They watched videos of the animals walking on treadmills to record data on stride length and other measurements.

Keller used a program called OpenSim to develop a model of the shoulder and arm bones based on CT scans. Then muscles were put onto the bones. The model includes markers that link to data compiled by Boop and Taylor to determine how the muscles stretch and what loads are put on each of them. Muscles can also be turned off to mimic the brachial plexus injury to determine how the body reacts.

Doughney also worked in the lab of Dr. Jacqueline Cole, an assistant professor in BME, using a laser to study the length of the sarcomere tissues from injured rats so they could be compared to tissues from healthy rats.

The experience will help inform how Boop, Doughney and, later, Taylor teach STEM subjects in the classroom. For Haase and Keller, it's valuable early experience working in an engineering lab.

"It's not always lab coats, goggles and chemicals," Haase said of the hours spent recording measurements in the lab.

"It's a whole lot of data," Doughney added.

As Boop worked on the curriculum plan that she will use with her 7th graders, Keller mentioned an idea for a lesson on prosthetic hands she saw on Instagram, the photo-sharing social media app. The team worked together to create movable hands using cardboard, drinking straws and string. Boop's students will do the same thing as part of a seventh-grade lesson on human body systems.

Doughney, who teaches biology for students who aren't majoring in biology, is translating the research into a lesson plan that will touch on how nerve cells interact with muscle cells and what happens when a damaged nerve no longer works. She will have her students come up with ideas for a treatment plan.

MAKING A MATCH

Saul is in her third year working with RET and says she thinks that her field of biomechanics, which applies mechanical principles to the human body in order to understand movement and the structure and function of different tissues, is very accessible and translates well to young students. She also enjoys outreach.

Along with the brachial plexus injury work, Saul has had previous RET teams study and take measurements from the wrists and arms of a high-speed guitarist to gain insight into how the muscles work.

Other faculty members involved in RET are Dr. Tiffany Barnes, professor in the Department of Computer Science, and Dr. Brendan O'Connor, associate professor in the Department of Mechanical and Aerospace Engineering, both from NC State; and Dr. Chris Vermillion, formerly an assistant professor in the Department of Mechanical Engineering and Engineering Science at UNC Charlotte and now a new faculty member in the College of Engineering at NC State.

This summer, O'Connor's RET team worked on selecting optimal light wavelengths for hydroponic plant growth, Vermillion's students studied how energy can be drawn from wind and tides and Barnes' team examined personalized learning and how students use online learning tools.

Along with their work in the lab and developing curriculum plans, the participants attend brown bag lunch presentations on topics in STEM education. Some teams have also gone on industry visits; Durham LED-light manufacturer Cree, Inc. and heavy equipment maker Caterpillar are two companies that have participated.

At the end of the six weeks on campus, the four teams presented during a research symposium in the James B. Hunt Jr. Library on Centennial Campus.

The program has been successful in recruiting North Carolina educators. Many are from schools that are already placing an emphasis on STEM education, said Dr. Amber Kendall, coordinator of STEM partnership development in the College and director of the RET program.

RET tries to match educators with a research area that lends itself well to what they are doing with students.

"So, some piece of what they experienced doing engineering research will be taken back to their classroom," Kendall said.

> "It's not always lab coats, goggles and chemicals."
>
> **MEGAN HAASE**

NC State's site is in the third year of a three-year RET program and there are plans to apply for another three-year grant from NSF.

Thanks to funding from NSF, the College will host a first-ever conference in October that will bring together participants from other RET sites around the country to share their experiences and build an action plan to make the program even better. ▪

BUILDING A LEGACY

ENGINEERING STUDENTS RETURNING to NC State's Centennial Campus for the fall 2018 semester are seeing quite a different landscape than the one they left in May.

Though heavy equipment was on site at the future home of Fitts-Woolard Hall and grading work had begun when the spring semester ended, the foundation of the College's newest building is now in place, and the walls that will form a hub for research and teaching collaboration and innovation are rising skyward.

The future home of the Department of Civil, Construction, and Environmental Engineering (CCEE); the Edward P. Fitts Department of Industrial and Systems Engineering (ISE); and the dean's administrative offices is scheduled to open in June 2020.

Thanks to the generosity of more than 300 donors and a transformational naming gift from industrial engineering alumni Edward P. Fitts and Edgar R. Woolard (see more on **page 18**), the College has raised more than $47 million of the $60 million in private donations pledged to help fund the construction of Fitts-Woolard Hall.

With $12.8 million left to raise, though, there is more work to be done. Alumni and friends have a chance to make a gift that will have a lasting impact on thousands of future students who will benefit from all that this iconic building has to offer.

Over the last decade, the College has made significant strides in its national rankings, research expenditures, graduate student enrollment and faculty diversity. At the same time, a long-envisioned plan to move the entire College to Centennial Campus has advanced, giving students and faculty members world-class facilities and a unique collaborative environment. Fitts-Woolard Hall is the next step in that move.

Meeting the $60 million fundraising goal is vital to ensure the College is not constrained with debt as it continues this forward momentum.

"Fitts-Woolard Hall is a crucial component of our plan for the College of Engineering to reach its full potential. We have received tremendous support from the state of North Carolina and our alumni and partners," said Dr. Louis A.

GET INVOLVED

Learn how you can support the College's work on Fitts-Woolard Hall by contacting Lora Bremer, executive director of major gifts and campaign planning with the NC State Engineering Foundation, at **lora_bremer@ncsu.edu** or **919.515.0983**.

Martin-Vega, dean of the College. "We still have a way to go, and it's crucial that we reach our fundraising goal and meet the commitment we made to fund construction."

OPPORTUNITY COST

Fitts-Woolard Hall represents a first-of-its-kind infrastructure project for NC State, using a public-private partnership to fund the construction of an academic building.

The $154 million project received $75 million from the people of North Carolina through a 2016 bond referendum. The NC Legislature provided $2 million, and the University will provide $17 million, with the College pledging to provide the remaining $60 million from private commitments. The College is short of its private commitment goal and will need to meet this goal to avoid having to borrow to fund construction, at a time when interest rates are rising.

This is what happened in 2004 when the College had to borrow $8 million to help fund construction of Engineering Building II, which opened on Centennial Campus in 2006. This 20-year loan has cost the College $600,000 annually to service the debt. The more than $12 million the College has paid could have been invested in student scholarships and educational programs, faculty hiring, research infrastructure or additional things that make the College great.

Having to borrow $12.8 million would represent an even larger opportunity cost since the College would then be facing more than $1.2 million per year in debt service payments for the next 20 years. Just investing this amount in hiring 10 new faculty members could bring in well over $100 million in new research funding to the College and NC State over these same 20 years. These research expenditures directly impact the education of students in the College, providing opportunities to work alongside some of the top researchers in the nation. With fully funded construction, the College could hire those faculty members rather than paying out more than $20 million on a $12.8 million loan.

That's the power of private philanthropy and the generational impact it can have.

A BENEFIT TO ALL

Fitts-Woolard Hall will allow the College to move completely out of Mann and Page halls, and allow ISE to move out of its current space in Daniels Hall.

Both buildings are more than 50 years old. It will also become the administrative home of the College housing the dean's office and the majority of the administrative and development functions that benefit all of the College's departments and programs. This is why alumni support from all of the College's departments and programs is crucial.

Once Fitts-Woolard Hall is complete, eight of the nine academic departments and more than 90 percent of the faculty, students and staff will have moved to Centennial Campus, taking the College much closer to its goal of unification on this unique campus. Centennial Campus is a national and international model for how academia, government and private enterprise can collaborate and innovate in a shared space and is a living classroom for students to learn and work in such an environment.

Donors can leave a legacy through several available naming opportunities within Fitts-Woolard Hall. Additionally, alumni of the College's other seven academic departments can make a naming gift that will benefit Fitts-Woolard Hall but will be recognized in their home department.

As Dean Martin-Vega leads the effort to make the College the top public college of engineering in the country and one of the preeminent colleges of engineering in the world, unification on Centennial will mark a true turning point.

Those who have benefited from an NC State engineering or computer science degree or who know firsthand the impact of its work have a chance to make an impact that will last for generations.

"We need you now more than ever," Martin-Vega said. "And you can help make that difference." ▪

Alumni and friends have a chance to make a lasting impact for the College

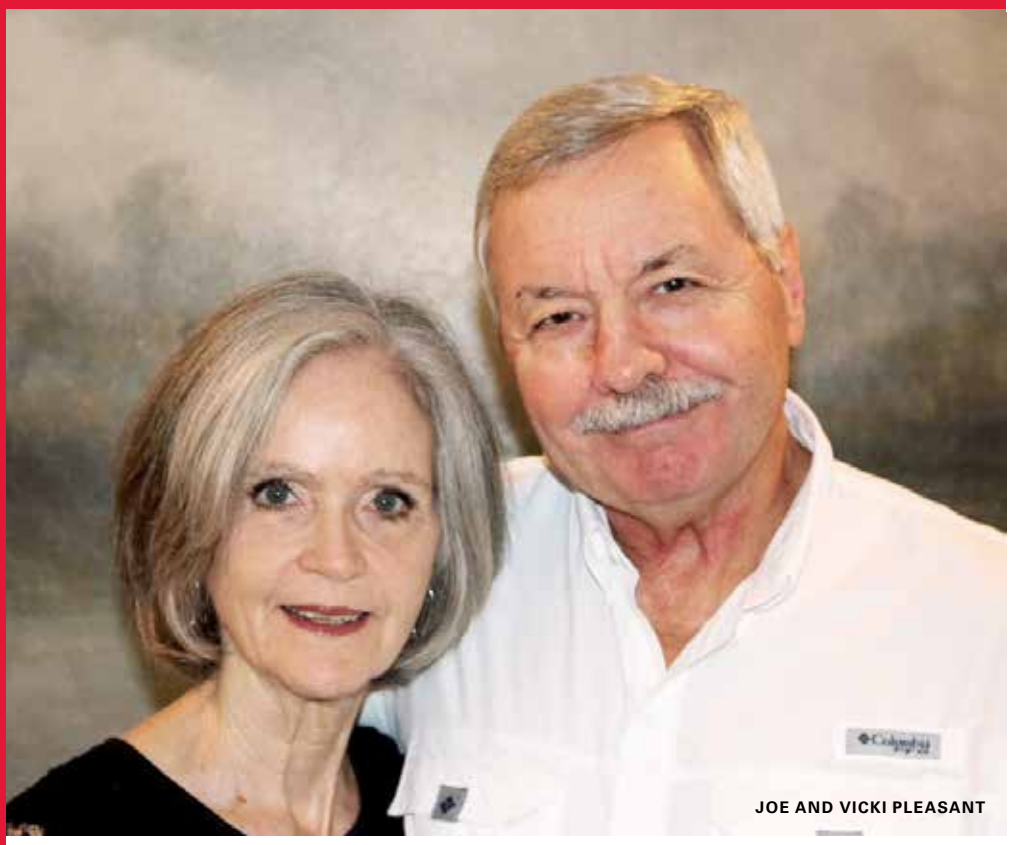
KEEP TRACK OF OUR PROGRESS

You can watch work being done at the Fitts-Woolard Hall site by checking out our webcam at go.ncsu.edu/fwh-camera

TOM AND MIMI CUNNINGHAM

ON FRIDAY, APRIL 20, 2018, the University broke ground on Fitts-Woolard Hall, the crucial next step in the College's move to Centennial Campus. The new building will bring together innovators from the Department of Civil, Construction, and Environmental Engineering and the Edward P. Fitts Department of Industrial and Systems Engineering (ISE). Meet two alumni who have supported the project and are helping continue the College's excellence in engineering.

Support of Fitts-Woolard Hall offers unique opportunities to current and future students



JOE AND VICKI PLEASANT

THOMAS (TOM) AND MIMI CUNNINGHAM

Growing up, Tom Cunningham's father always told him he'd be an engineer. "NC State University is the only place to go become an engineer," said Cunningham, who graduated with his bachelor's and master's degrees in materials science and engineering.

But, he did not have the usual path to completing his degrees. "I found I was lacking focus and direction. So, I decided the military would help."

Cunningham took a break during his undergraduate years and joined the U.S. Army. It was here that he became an officer, stationed at Fort Jackson, South Carolina, in 1967. He left for Vietnam in 1968 as a first lieutenant, moving up in the ranks to captain when he returned to Fort Jackson. In May 1970, he returned to NC State to complete his degree after

four years in the service. He graduated in December 1971.

With the GI Bill and a NASA fellowship, Cunningham decided to continue his education and worked toward his master's degree, graduating in 1974.

"I always look back with fond memories of my time as a student because of faculty like Chuck Manning and Abdel Fahmy who guided me — there were so many caring people in the engineering departments."

Post-graduation, Cunningham joined GE as a process engineer and worked his way up to engineering management over a 32-year career, retiring in 2006.

"Without my engineering degrees, I wouldn't be able to do the things I have in my life," said Cunningham. "I have been given the opportunity to travel, taking my family from not having two pennies to rub together to making substantial gifts to the University. The military gave me leadership skills and my education gave me the tools to know how to learn."

Cunningham and his wife, Mimi, a University of South Carolina alumna who retired from UNC Wilmington's university relations office, have a long history of university giving. They have established an endowment to support the Park Scholarships Program, a planned gift in the College and the Tom and Mimi Cunningham Academic Leadership Endowment — a scholarship that supports their mission of empowering undergraduate students through higher education. The Cunninghams have most recently donated toward Fitts-Woolard Hall.

"We saw (Fitts-Woolard Hall) was truly a need and we are glad to contribute," said Mimi Cunningham. "Any time you get a first-class building like that, it helps to recruit the best faculty, staff and students."

"Over the years, we have seen the importance of giving to the University and the difference being made bit by bit," said Tom Cunningham. "This new building is going to give the College an opportunity to offer new teaching experiences and help students be more involved, making a difference for years to come."

JOE AND VICKI PLEASANT

Joe Pleasant has deep roots to NC State.

"I grew up on a farm in Angier, NC, down the road from NC State and my dad was a 1947 agriculture education graduate," said Pleasant, a 1972 graduate with a bachelor's degree in industrial engineering.

After graduation, Pleasant had an interest in patent law and after an internship in a patent office, he interviewed with a manufacturing firm. He then went on to work with a small healthcare engineering and systems improvement consulting firm in Charlotte, NC. It was here that Pleasant conducted engineering consulting at hospitals, where he was part of a small team of fewer than 10 at Carolinas Hospital and Health Services, later to become Premier, Inc. After 42 years at Premier, he retired as chief information officer after helping grow the company nationwide and expand shared services for healthcare organizations to include biomedical engineering, data services, information systems, benchmarking and group purchasing.

Reflecting on his industrial and systems engineering degree, Pleasant shared that it provided a great base for how to analyze problems and develop creative solutions. "My engineering background gave me the ability to solve problems as they came about in my career, and the technical systems approach served me well in leading the information technology portion of the company," said Pleasant, who earned his MBA at UNC Charlotte in 1977.

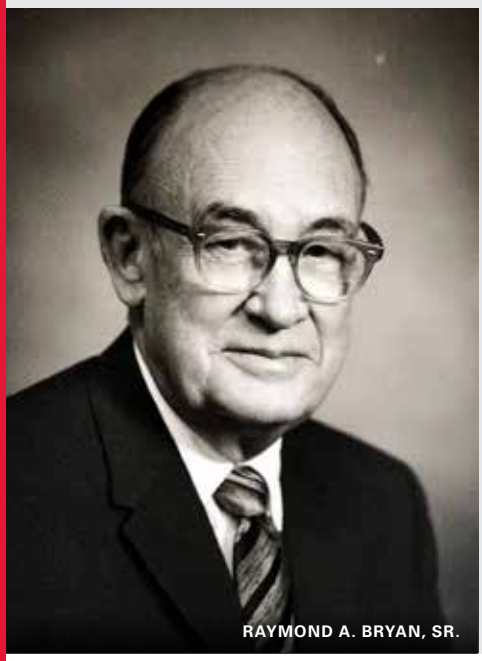
Pleasant's connection to NC State has continued throughout the years, as two of his three sons are NC State graduates, as well as two of his brothers. "Our whole family appreciates the great foundation you get from being an NC State graduate and how it helps you grow in your career."

Pleasant and his wife, Vicki, wanted to give back to the school that enriched so many in their lives. They have donated toward the ISE enhancement fund, the College Leadership Fund and the Clarence Smith Endowment in the ISE department, and established the Joseph M. Pleasant Family Department Head Endowment in ISE. Most recently, they have donated toward Fitts-Woolard Hall.

"Centennial Campus provides NC State the opportunity to expand and provides an opportunity to students, alumni, faculty and business partners to learn, develop, teach and network," said Pleasant. "This unique opportunity for students to work with companies integrates the practice of academics with real-life companies. It is allowing the University to offer something to engineering students most other universities do not, putting the College at the top." ▪


STEPHEN C. BRYAN


RAYMOND A. BRYAN, JR.


RAYMOND A. BRYAN, SR.

R. A. Bryan Foundation has a tradition of multigenerational giving

SOME OF THE MOST GENEROUS supporters of NC State University and the College of Engineering come from multiple generations of family members who have attended NC State. The Bryans are one such family.

According to Stephen C. Bryan, vice chairman of T. A. Loving Company headquartered in Goldsboro, NC, family commitment to the University began with his grandfather, **RAYMOND A. BRYAN, SR.**, who attended NC State for engineering as part of the class of 1922, and continued with his father, **RAYMOND A. BRYAN, JR.**, who graduated from NC State in 1953 with a degree in construction engineering. **STEVE BRYAN**, who received his B.S. degree in engineering operations with a construction option at NC State in 1982, sustains that commitment.

The family's generous service and philanthropy are tied to their business success and their desire to give back to their alma mater and community.

Bryan Sr. joined T. A. Loving Company in 1931 and became president of the company in 1947 and later served as chairman of the board. Bryan Jr. took over as president from his father in 1969, and then served as chairman of the board from 1988 until he passed away in 2016.

The construction company is a well-respected, award-winning building, utility and bridge contractor. Its numerous construction projects include many on NC State's campus such as the North Carolina State University Alumni Center built in 2006.

His success at T. A. Loving and with other business ventures led Bryan Sr. to form the R. A. Bryan Foundation in the late 1950s, a private family foundation, which through the years has made generous contributions to NC State University, Campbell University and Vidant Medical Center in Greenville, N.C., among others.

"I don't know why the (foundation) was started," Steve Bryan said, "but you know, my granddad was a modest fellow, and he made helping others a priority."

For his service to NC State, Bryan Sr. received the Watauga Medal in 1977.

Bryan Jr. inherited his father's modesty, business acumen, civic responsibility and philanthropy. Like his father, he was dedicated to NC State University. He was a past president of the Wolfpack Club, a former director of the NC State Engineering Foundation Board, a Peele Lifetime Giving Society member, a 2007 recipient of the Distinguished Engineering Alumnus Award and a 2013 recipient of the Godwin Red Torch Award for furthering the mission of the NC State University Foundation.

At his impetus, the family foundation established several endowments in the College, including the R. A. Bryan Foundation Scholarship Endowment in 1996 and the R. A. Bryan Foundation Construction Engineering and Management Endowment in 2008.

More recently, the family made a significant donation to the Fitts-Woolard Hall project. Their $2 million pledge to the building project was among the first.

Since his father's passing in 2016, Steve Bryan manages the R. A. Bryan Foundation and has participated in alumni meetings to encourage others to donate to Fitts-Woolard Hall.

The Bryan family service to NC State continues into a third generation. ▪

GLENN AND PHYLLIS FUTRELL

Alumnus' ties to **NC State inspired endowments**

IF YOU ASK GLENN FUTRELL what drew him to NC State, he will share about growing up on a farm in Wayne County, NC, and speak of his father's best friend Mr. Raymond Bryan, BSCE '53, president and part owner of T.A. Loving Construction Company. "I wanted to become an NC State engineer because of Mr. Bryan. He was my role model and was my inspiration," shared Futrell, who graduated with bachelor's and master's degrees in civil engineering in 1963 and 1965, respectively.

Futrell does not have one favorite memory of being at NC State, but rather one important moment. "The most important decision I ever made was my decision to go to graduate school and specialize in soil mechanics and engineering."

Initially, he intended to study structures or transportation, but as luck would have it, there were no open research positions in those fields. Then, he learned there was a spot open with Dr. Harvey Wahls in soils and geotechnical engineering. "That field fit me well and I did well," said Futrell. "That decision was paramount in my decision to go into business and one of the most important in my whole life."

After graduate school, Futrell worked at Law Engineering and Testing Company in Charlotte, then founded Soil & Materials Engineers (S&ME). In 1973, S&ME started with five employees. By 1986, it was the fifth-largest geotechnical engineering firm in the U.S., boasting 1,000 employees in 35 branches throughout the Southeast. The company was sold in 1987 to Westinghouse. Futrell moved into the real estate development business and began work on Pirates Cove — a residential community of 600 homes and a 200-slip marina in Manteo, NC, which was finished in the early 2000s.

Currently, Futrell is working on three projects in Zebulon, Cary and Chapel Hill, developing more than 1,000 single-family homes.

As an NC State Engineering alumnus, Futrell believes in giving back to the University that helped him so much. "There is no way I could totally repay what NC State has done for me, my success in life and business, but I know I've always felt the need to give back any way I can."

His generosity has led to the establishment of a scholarship in the Department of Civil, Construction, and Environmental Engineering (CCEE), two endowed professorships in CCEE and donations toward the new Fitts-Woolard Hall.

"When the new building was brought to my attention, I felt a need to participate. It's gratifying to help the College in its next steps to moving completely on Centennial Campus," shared Futrell. "This new building will enable students and graduate CCEE students to be part of the partnerships with private industries on Centennial Campus. The amount of benefits for current and future students is endless."

Futrell believes that an education is essential as a foundation for success, but that there are other critical characteristics that a student must also have. To elaborate, he shared one of his favorite quotes, from the 30th president of the United States, Calvin Coolidge:

"Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan 'Press On' has solved and will always solve the problems of the human race." ▪

NC STATE Engineering

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Alumni meet before **the highest court**


JONATHAN ELLIS

IN WESTERNGECO LLC V. ION Geophysical Corporation, the Supreme Court of the United States considered whether a U.S. patent owner was entitled to foreign lost profits when components of the patented invention were assembled and used outside of the United States.

It's subject matter that only an attorney could love. And in this case, three of the attorneys involved in the proceedings hold undergraduate degrees from the College of Engineering.

JOHN O'QUINN represented the patent owner, WesternGeco LLC. **JONATHAN ELLIS** represented the federal government, drafting a brief for his employer, the Office of the Solicitor General, on whether the Supreme Court should take the case. **TIM HOLBROOK**, Asa Griggs Candler Professor of Law and vice provost for faculty affairs at Emory University, wrote about the case and filed an amicus brief.

O'Quinn and Holbrook earned undergraduate degrees in chemical engineering, and Ellis earned a B.S. in computer science from NC State.

"So you had three NC State grads in a single Supreme Court case, which is probably unheard of," said O'Quinn, a partner at the firm Kirkland & Ellis, LLP in Washington, DC.

Earning an undergraduate degree in engineering or computer science and later earning a law degree is not unusual, and O'Quinn and Ellis both say the training they received at NC State prepared them well. What makes O'Quinn and Ellis stand out is that they both clerked for Supreme Court justices, O'Quinn for the late Antonin Scalia and Ellis for John Roberts.

The two had corresponded by email and met for the first time at an NC State Engineering Foundation event in Washington a couple of years ago before being part of the same Supreme Court case.

> "So you had three NC State grads in a single Supreme Court case, which is probably unheard of."
>
> **JOHN O'QUINN**

O'Quinn, originally of Fuquay-Varina, NC, studied both chemical engineering and multidisciplinary studies as part of the Benjamin Franklin Scholars program. He was valedictorian at NC State and served as student body president from 1995-96, before receiving graduate degrees from Oxford on a Fulbright Scholarship and MIT, but always had his eyes on law school.

O'Quinn graduated first in his class at Harvard Law. The year before, he said, the student who finished first in his class had also studied chemical engineering as an undergraduate. He doesn't think that was an accident.

"The practice of law is fundamentally about problem solving," O'Quinn said. "And that's what engineering teaches you."

Ellis grew up in Cary, NC, and worked for IBM for several years before attending law school at the University of Pennsylvania. Ellis, who also finished first in his class at Penn, decided to be a "dedicated generalist" and found an interest in appellate law.

He worked for a firm for four years after graduation before taking a position with the Solicitor General on a staff of 21 attorneys who represent the federal government before the Supreme Court. The job includes regular opportunities to present oral arguments before the Court.

"It's an amazing honor and has been a fantastic experience," he said.

Ellis drew parallels between his time at NC State learning to write code and his current work building appellate arguments.

"It's a lot like putting together a program, at least in my head anyway." ▪


JOHN O'QUINN

DAVID SIMPSON

David Simpson's parents worked hard so that he and his brother could focus on their engineering courses at NC State and wouldn't have to work jobs on the side. Simpson, a 1981 civil engineering graduate and owner of Simpson Engineers & Associates, P.C., in Cary, NC, carries on that generous spirit in taking care of the employees in his firm and endowed a scholarship in the College of Engineering.

Natives of Reidsville, NC, David and Michael Simpson both earned civil engineering degrees and own engineering firms. Michael Simpson graduated a year after his brother and started his own firm five years earlier than his brother, in Greenville, S.C. "I'm the horizontal guy; I design bridges," David Simpson said. "He's the vertical guy; he designs buildings."

After working in the Structure Design Unit for the North Carolina Department of Transportation and two private engineering firms for more than 23 years, David Simpson started his own business in January 2004. Simpson Engineers & Associates has 45 employees (including 13 NC State graduates) and specializes in transportation structure design, in-service bridge inspections and transportation planning services. "I love my job. I consider it a privilege and an honor to be the owner of this firm. It's not just me, it's the families of the employees who are part of this firm," Simpson said.

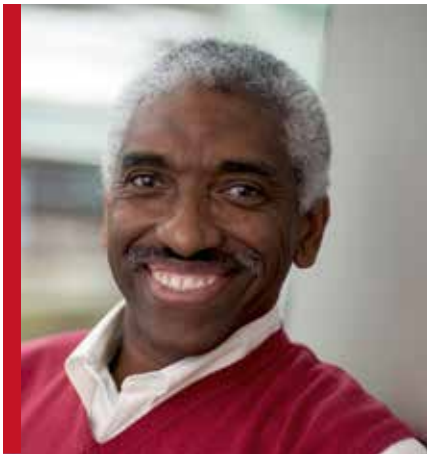
Simpson is a regular contributor to the Civil, Construction, and Environmental Engineering Enhancement Fund, serves on the department's industry advisory board and was a commencement speaker in May 2015 for the departmental graduation. The brothers endowed the David B. and Annie P. Simpson Scholarship to honor their parents' sacrifice and to give a deserving engineering student the same opportunities their parents' hard work provided for them. "NC State is very near and dear to my heart," Simpson said.

RACHEL AND DAVID MORRISON

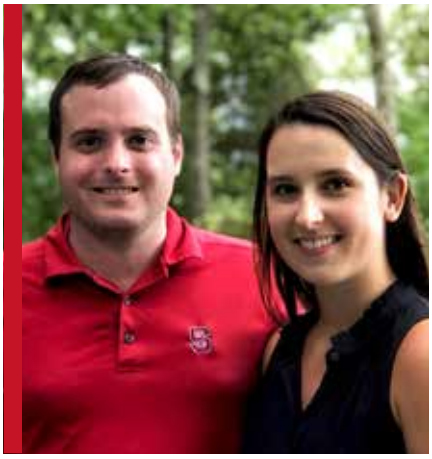
Rachel and David Morrison loved NC State when they were students on campus. And they think it's just gotten better since then.

The couple met during freshman orientation and lived on the same hall as part of the University Honors Program. Both graduated in 2012, David with a degree in electrical and computer engineering and Rachel with a degree in civil engineering.

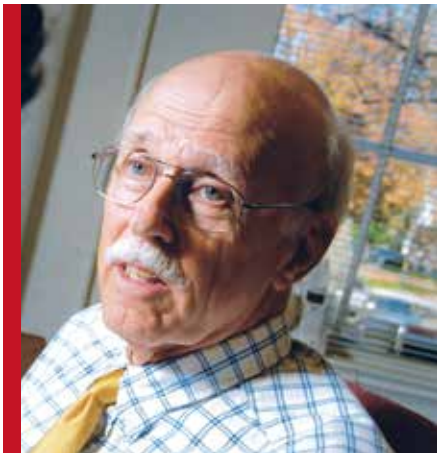
Rachel's father is a general contractor in the Triangle and she has plenty of family connections to the University.



DAVID SIMPSON



RACHEL AND DAVID MORRISON



DR. THOM HODGSON

Meet the DEAN'S CIRCLE

NC State and the Department of Civil, Construction, and Environmental Engineering felt like a good fit. David, who grew up in Charlotte, was sold on an engineering degree, and NC State offered a very competitive program that, for an in-state North Carolina student, was a bargain. He came to campus undecided but became interested in electrical and computer engineering during E-101, a first-semester course all first-year students in the College are required to take that introduces the many possibilities an engineering degree affords them.

Rachel participated in the Engineers Council, including a term as vice-president, and was an active volunteer for the Engineering Career Fair. David did three co-op rotations and internships and served as a co-op ambassador, along with being a big Wolfpack sports fan.

The Morrisons settled in Raleigh, where David is an IP network engineer with Bandwidth, a communications technology services firm located on NC State's Centennial Campus, and Rachel works in operation management for Raleigh-based custom home builder Homes by Dickerson.

The Morrisons have watched with pride as the James B. Hunt Jr. Library and renovated Talley Student Union have opened their doors. They hold season football tickets and have attended some of the College's networking events for young alumni.

Supporting the College through annual donations to the Dean's Circle was an easy choice.

"We love seeing NC State succeed," David Morrison said. "We both got a great education here and it really jump-started our careers."

DR. THOM HODGSON

Dr. Thom Hodgson has served the Edward P. Fitts Department of Industrial and Systems Engineering (ISE), the College of Engineering and the National Science Foundation (NSF) in several leadership positions since coming to NC State.

He was recruited from the University of Florida in 1983 to be the head of the ISE Department and during his seven years of service in this position the department made significant strides both in terms of faculty and student quality and national reputation.

Together with Dr. Carl Zorowski, he also co-founded and directed the Integrated Manufacturing Systems Engineering institute (IMSEII), and later served as co-director of the interdisciplinary Operations Research Program and director of Graduate Programs for Engineering Online. His service at NSF included holding the position of director of the Division of Design and Manufacturing in the Engineering Directorate from 1990-1992.

He is a Distinguished University Professor, an Alumni Distinguished Research Professor and the department's James T. Ryan Chair.

On July 1, 2018, he added another title: Professor Emeritus.

Hodgson, a member of the National Academy of Engineering, says he woke up one morning this spring and knew that it was time to retire.

"I had said 'I'll know when it's time,' and that's exactly what happened," he said.

Hodgson wanted to be an automotive engineer from a young age and went to work for Ford Motor Company after earning a bachelor's degree in engineering and an MBA, both from the University of Michigan. He later earned a Ph.D. in industrial engineering from Michigan, recognizing that "I needed to continue learning."

He and his wife, Grace, have endowed a fund to support IMSEI and have made a donation to support the construction of Fitts-Woolard Hall, the newest engineering building on Centennial Campus and the future home of ISE.

Hodgson said that when you tie the academic resources in ISE together with the industry and military partners he's been able to work with, there is an environment in Raleigh that is worth supporting. It's an environment he has enjoyed being a part of for 35 years.

"If you're in a university, you've essentially dedicated yourself to lifelong learning," he said. "Research in itself means you don't know how to do it."▪

MEMBERS OF THE DEAN'S CIRCLE, the College's signature annual giving fund, provide the consistent support that has fueled NC State Engineering's growth and improvement.

Gifts help fund scholarships and fellowships, which are used to attract and retain top students, and support innovative programs in the College's academic departments.

The Dean's Circle donors you'll meet above come from different backgrounds and have taken varying paths. But they share a philanthropic mindset and a love for the College and NC State.

Engineering Foundation creates **Young Alumni Advisory Board**

FROM LEFT, JACOB BOWES, SAM WURST, JOSEPH SILVERS AND LAURA GEARY.

IN AN EFFORT TO HELP ENGAGE younger NC State Engineering alumni in their relationship with their alma mater and provide an opportunity for them to connect with each other, the NC State Engineering Foundation has created the Young Alumni Advisory Board (YAAB). This board, made of 18 young professionals, represents various engineering disciplines from NC State classes of 2003 and later.

The YAAB strives to increase involvement with the College by helping cultivate and foster a community of young NC State engineers while also promoting and encouraging opportunities for those alumni to give back to the College. The board is made up of four committees, each with a chair: Events — **LAURA GEARY** '17 industrial and systems engineering, Communications — **JOSEPH SILVERS** '12 electrical engineering, College Relations — **SAM WURST** '15 industrial and systems engineering, and Development — **JACOB BOWES** '16 civil engineering.

"Expanding the communication channels between the College and young alumni, hosting networking and informational events, increasing interactions between young alumni and current NC State Engineering students, and growing the number of young alumni who give back to the College, these are some of the board's goals," shared Silvers.

Looking to long-term goals, Silvers said it could be summed up in one word: sustain. "We want young alumni to sustain their involvement with NC State and to sustain their support of the College throughout their professional careers and their lives."

The board made its first steps in connecting with young alumni with a networking event held on May 22 to help establish the first annual young alumni and new graduate celebration. A total of 75 alumni attended, coming together over appetizers and drinks on NC State's Centennial Campus to hear a panel of six expert engineering graduates talk about the different career paths they took, highlighting the multitude of options available to someone with an engineering degree from NC State.

"The event in May was a huge success. We had a full house at the Lonnie Poole club house, and there was a lot of great interaction and discussion among all attendees," said Silvers. "The high event registration numbers indicate that there are young alumni in Raleigh and the surrounding areas who want to engage with the college and other alumni, and we look forward to carrying that interest and excitement forward as a board."

The YAAB is currently planning a special event for young alumni during the College's homecoming celebration the weekend of Nov. 2-4, 2018. To learn more about this event and the Young Alumni Advisory Board, please contact Erica Fuller, assistant director of development and alumni engagement with the Engineering Foundation, at eacinder@ncsu.edu. ▪

DR. WILLIAM WURTH KRIEGEL

GERALD KRIEGEL

Family honors longtime ceramic **engineering department head** with naming

ROOM 3010 IN ENGINEERING BUILDING I on NC State's Centennial Campus is occupied by the head of the Department of Materials Science and Engineering (MSE).

Dr. Donald Brenner, Kobe Steel Distinguished Professor and MSE department head, is the current occupant. **GERALD KRIEGEL** hopes that whomever sits in that office adopts an open-door policy for students. After all, that's what his father did.

DR. WILLIAM WURTH KRIEGEL spent 32 years at NC State as an instructor, professor and then department head in the Department of Ceramic Engineering, which grew into today's MSE.

"It was largely in that one room, supporting students," Gerald Kriegel said of his late father's office, and the career he made occupying it.

Wurth Kriegel always made students a priority and always wanted them to feel comfortable visiting him in his office. So, in making a donation to support MSE and put his father's name on the department head's office, Gerald Kriegel hopes that its occupant will do the same.

Wurth Kriegel enjoyed teaching, primarily graduate students, his son said. But he also enjoyed the research and the administrative duties that went along with the department head position.

Ceramic engineering was not as large a department on campus in those days as the departments of civil, mechanical and nuclear engineering.

Today, it's still one of the College of Engineering's smaller departments but in the last few years has seen a marked increase in research expenditures, faculty hiring, enrollment and national rankings.

"It's in a smaller arena. They're excellent in that smaller arena," Gerald Kriegel said in describing his motivations for supporting the department.

A native of Seattle, Wash., Wurth Kriegel earned bachelor's degrees from the University of Washington and a master's degree from the Montana School of Mines before earning a Ph.D. in ceramic engineering from the Technische Hochschule in Hanover, Germany.

After returning to the United States, he served as an instructor at Montana School of Mines. In 1939, he and his wife, Evelyn, moved to Raleigh, where he took a position as an instructor at North Carolina State College. Duty called in 1941, though, and Kriegel served as a first lieutenant and later lieutenant colonel in the Army Artillery during World War II. He returned to campus after the war and was named head of the Department of Ceramic Engineering in 1946.

An authority on the mechanical properties of ceramic materials, Wurth Kriegel was a charter member of Keramos, the professional ceramic engineering fraternity, and a Fellow in the American Ceramic Society. He helped found the University Conference on Ceramic Science and served as a consultant to several private companies and governmental agencies, including the Atomic Energy Commission's Oak Ridge National Laboratory and the U.S. Army's Office of Ordnance Research. Kriegel retired from the NC State faculty in 1971 and died in Seattle in May 1980.

Gerald Kriegel grew up in Raleigh's Hayes Barton neighborhood and earned a degree in civil engineering from NC State as an ROTC student and commissioned second lieutenant. After graduation, he worked for DuPont at facilities in South Carolina and Tennessee before entering the Army as an artillery officer.

After his service, Gerald Kriegel worked in the construction industry as an area designer. In 1969, he and his wife, Penny, moved to Massachusetts, where he started two companies: Concrete Structures, Inc., specializing in the erection of precast prestressed concrete structures throughout the Northeast, and Newspan, specializing in bridge work.

Kriegel retired in 2015 and the couple now live in Plymouth, Mass.

Gerald Kriegel remembers his father as a man of integrity who was tenacious in his efforts to make sure that things were done the right way.

"I owe him a lot," Gerald Kriegel said. ▪

FOUNDATIONS

NC STATE ENGINEERING FOUNDATION, INC.

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Foundation **Year in Review**

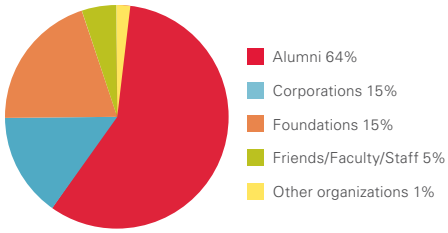
Fueled by strong and early support for Fitts-Woolard Hall, **THE NC STATE ENGINEERING FOUNDATION** had another record-setting fundraising year with giving totals to the College at $39,287,344. Fiscal Year 2018 ended on June 30, 2018.

Endowments to the College generally fall into one of three categories: scholarships, named professorships and fellowships. There are now 301 permanently endowed scholarships in the College and 52 permanently endowed named professorships. Total endowments benefiting the College are $3,300,815 with total economic support from all fundraising sources being $10,794,968

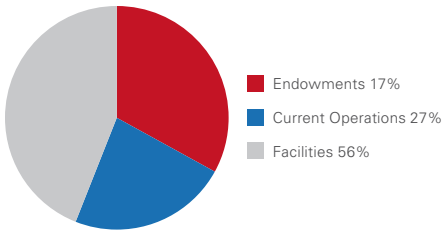
The annual giving program for the College of Engineering raised a total of $1,539,977 for the College of Engineering Leadership Fund and all nine department enhancement funds. This represents a 3-percent increase from the previous year. The Dean's Circle, the College's leadership annual giving society, grew by 33 members, bringing our total membership to 487 alumni and friend donors.

The Think and Do the Extraordinary Campaign began in 2013 and concludes in 2021. The College of Engineering goal is $230 million and thus far has raised $160,828,448.

GIFTS AND NEW COMMITMENTS BY GIFT SOURCE, FISCAL YEAR 2017-18



GIFTS AND NEW COMMITMENTS BY GIFT USE, FISCAL YEAR 2017-18



The NC State Engineering Foundation, Inc., established in 1944, is the fundraising arm of the College of Engineering. For more information on the Foundation, including financial statements, audits and tax identification number, please visit: **foundationsaccounting.ofa.ncsu.edu/foundations/nc-state-engineering-foundation-inc**. ▪

BRIAN E. CAMPBELL
Assistant Dean for Development and College Relations and Executive Director of the NC State Engineering Foundation Inc.
brian_campbell@ncsu.edu | 919.515.9956

LORA F. BREMER
Executive Director of Major Gifts and Campaign Planning
lora_bremer@ncsu.edu | 919.513.0983

ANGELA S. MARTIN
Associate Director of Annual Giving and Prospect Development
angela_stallings@ncsu.edu | 919.513.1714

BEN H. HUGHES
Special Development Advisor
hughes@ncsu.edu | 919.515.9974

KYLE KREMER
Director of Development
Department of Materials Science and Engineering and Department of Computer Science
klkremer@ncsu.edu | 919.515.9417

LINDSAY SMITH
Director of Development
Department of Civil, Construction, and Environmental Engineering
lksmith4@ncsu.edu | 919.515.7738

MICHAEL WALSH
Senior Director of Development
Department of Mechanical and Aerospace Engineering and Edward P. Fitts Department of Industrial and Systems Engineering
mpwalsh2@ncsu.edu | 919.515.7237

KENNETH M. TATE
Department of Computer Science
tate@csc.ncsu.edu | 919.513.4292

RUSS O'DELL
Department of Chemical and Biomolecular Engineering
russ_odell@ncsu.edu | 919.513.2071

LIGHT IT **RED**

THE MEMORIAL BELLTOWER, completed in 1937 as a monument to honor NC State alumni killed in World War I, serves as a campus landmark and rallying point for the University community to celebrate NC State's successes.

Though the cornerstone was placed in 1921 with 10-foot sections added in 1924, 1925 and 1926, work was delayed by the Great Depression and then again by World War II. Stonework was finished in 1937 thanks to the federal Works Progress Administration. Student honor societies and the class of 1938 donated the clock, and the class of 1939 purchased a set of floodlights.

Finishing touches, including the chimes, shrine room and memorial plaque, were completed in the late 1940s and a formal dedication was held on Nov. 11, 1949.

The Belltower is lit red for holidays that honor our veterans, such as Memorial Day and Veterans' Day, and to celebrate NC State's proudest occasions and achievements. The list of occasions eligible for a lighting include honorable awards and achievements for faculty and staff members and students, athletics victories and campus events such as spring and winter commencements and the Celebration of Faculty Excellence. ▪

THE COLLEGE OF ENGINEERING had several of its achievements recognized with Belltower lightings during the 2017-18 academic year:

MAY 8, 2018
Election of Dr. Donald Bitzer, Distinguished University Research Professor in the Department of Computer Science, to the National Academy of Inventors.

MAY 4, 2018
Awarding of the Goldwater Scholarship to aerospace engineering student Madison Maloney.

APRIL 20, 2018
The College breaks ground on Fitts-Woolard Hall, its newest building on Centennial Campus.

APRIL 14, 2018
Awarding of the Marshall Scholarship to chemical and biomolecular engineering student Kobi Felton.

NOVEMBER 8, 2017
Election of Dr. Paul Turinsky, professor in the Department of Nuclear Engineering, to the National Academy of Engineering.

OCTOBER 12, 2017
Election of Dr. Jay Narayan, John C. C. Fan Distinguished Professor in the Department of Materials Science and Engineering, to the National Academy of Engineering.

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NC STATE Engineering

NC State University
College of Engineering
Campus Box 7901
Raleigh, NC 27695-7901

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NC State Engineering Alumni

www.engr.ncsu.edu

NOVEMBER 2, 2018

NC STATE CENTENNIAL CAMPUS

Visit **go.ncsu.edu/homecoming** to find out more.

- Hear from Dean Louis Martin Vega and alumnus Jeff Garwood about the College's impact and the construction of the new Fitts-Woolard Hall.
- Join fellow alumni for a BBQ lunch on the Engineering Oval.