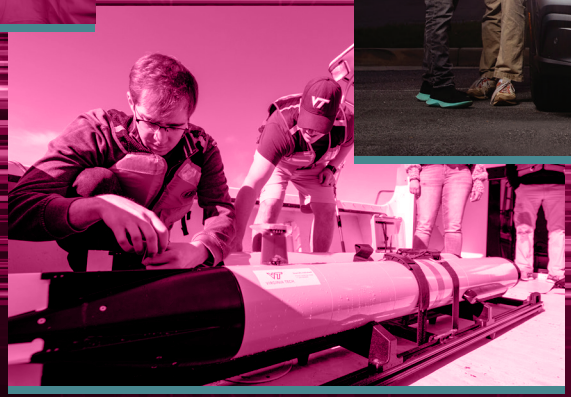
MOVING DREAMS TO DONE

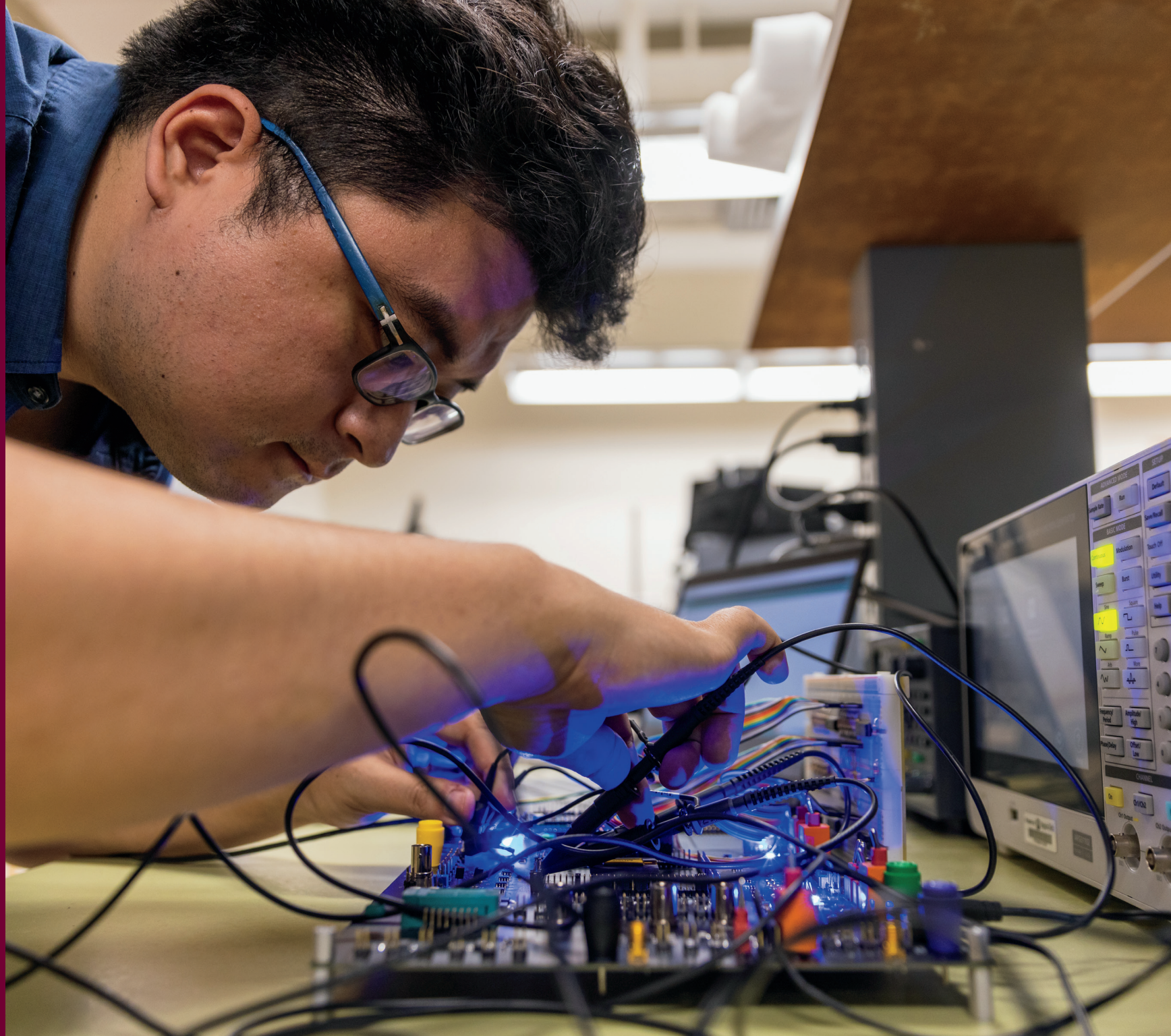


2023 Annual Report

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

This report was produced with funds from

The Harry Lynde Bradley Endowment



MOVING DREAMS TO DONE

#4 In the U.S. for producing most undergrads in computer engineering

TOP 10 Institution for undergrad degrees awarded to women in engineering

120+ ECE interdisciplinary faculty & researchers

4th Largest ECE department in the United States

From the ECE Department Head

The last year has been one of major milestones, celebrations, and achievements for The Bradley Department of Electrical and Computer Engineering (ECE) at Virginia Tech. Several of our faculty members have joined the inaugural group of Innovation Campus faculty and will play a vital role in shaping the new campus by helping to establish key research themes, enhancing the project-based curriculum, and developing the campus governance. In addition, our Northern Virginia-based faculty continue to work diligently with our Master's of Engineering students as they work toward obtaining a professional degree to supplement their industry expertise and prior knowledge of the computer engineering field.

One of those Northern Virginia faculty members, Saifur Rahman, is currently serving as President of IEEE for 2023 and we could not be more proud. His extensive service to our technical profession and department over the last 40+ years is certainly something to be celebrated.

The celebrations don't stop there. Recently, the *U.S. News and World Report* ranked our department as No. 4 in the category of "Best Global Universities for Electrical and Electronic Engineering in the United States" tied with University of California, Berkeley. This significant top-five ranking is a testament to the cutting-edge research and advancements our faculty and students are doing, and for that, I cannot thank you enough.

We have worked closely with our ECE Advisory Board with the goal of recognizing and engaging our alumni in the future pathways of the department. In 2022, we honored seven outstanding alumni (after a 23-

year hiatus) for their outstanding achievements in the engineering profession and/or for their dedication to ECE. I am proud to announce that we are continuing that induction ceremony during this year's annual Bradley Banquet. This year's inductees of the ECE Distinguished Academy of Alumni will be honored in one of four award categories: meritorious service, exemplary giving, extraordinary impact, or career achievement.

Another Advisory Board objective that has recently come to fruition is the formation of our departmental communications and advancement team. Under the direction of our Associate Department Head and Chief of Operations Scott Dunning, our department now has support for communications, digital, and alumni relations strategies. We are looking forward to connecting further with our alumni and telling the stories of the department through digital and written content that captures our audiences' hearts and minds.

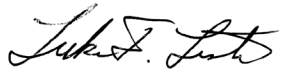
Over the course of the last year, ECE has also been leading the charge on the semiconductor technology research and development focus with support from the recent CHIPS Act as well as discussion and planning with government officials like U.S. Senator Mark Warner. Our graduates are stepping up to fill the tech talent pipeline by way of our Chips-Scale Integration program, which was a direct result of the NSF RED Grant curriculum overhaul. In addition to the new curriculum, many of our faculty are doing revolutionary research that will allow the Commonwealth and the United States to once again become a CHIPS powerhouse. This initiative was even highlighted by the *Washington Post*!

Our departmental priorities and strengths continue to align with university initiatives like Virginia Tech's Research Frontiers. These include the Artificial Intelligence Frontier, the Health Frontier, the Security Frontier, and the Quantum Frontier.

We've made great strides over the last year in all four of these research areas by:

- helping develop and provide leadership support to Virginia Tech's two new quantum research centers;
- pushing the envelope in terms of artificial intelligence with cutting-edge research from several faculty and students who are studying machine learning, digital twins, autonomous vehicles, and more;
- advocating and advancing security in terms of wireless and radio communication as well as electrical grid and smart grid cybersecurity;
- and creating new technologies to detect and prevent diseases.

Last year, nearly 450 students earned either a B.S., M.S., M(Eng), or a Ph.D. from the department. We ranked no.4 for producing the most undergraduates in computer engineering and continue to make up more than 10 percent of the university's total research expenditures, clocking in at more than $56 million. As we look forward to even more advancements in the year to come, I want to extend my most sincere thank you to all who have supported and continue to support the Bradley Department of Electrical and Computer Engineering. Your generosity, mentorship, dedication, and hard work are what have made this department the powerhouse it is today. Cheers to yet another year of advancement and forward thinking.



Luke Lester
Roanoke Electric Power Professor
ECE Department Head

From the Chair of the Advisory Board

The ECE Advisory Board continues to be highly engaged with the department, and it has had the opportunity to meet in person twice this past year in Blacksburg – a welcome change from previous years of virtual activities in response to the COVID-19 pandemic.

With a goal to provide advice and support on ECE educational and academic programs and other activities, the Advisory Board thoughtfully selects internal projects to undertake that help guide strategies in the planning of departmental objectives.

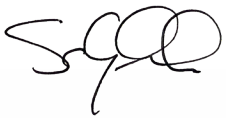
Recently, we've focused our efforts on providing recommendations to increase domestic graduate students and undergraduate female students with the goal of diversifying the department's student population. The Commonwealth of Virginia and corporate partners are investing more than $2 billion to expand Virginia's tech talent pipeline. This includes doubling the number of graduates each year in ECE-related fields. With thought leaders from industry, government, and academia, the board is generating ideas to increase the number of students while creating diverse, industry-ready graduates ready to make a difference in the tech sector.

We are also focused on providing feedback and suggestions for the ongoing NSF Revolutionizing Engineering Departments (RED) mission. We have been actively involved with the curriculum design process since the initial RED grant in 2016. This process has led to a transformation in the ECE curriculum that emphasizes design and encourages innovation, while offering students a variety of pathways to a degree in a program with disciplinary depth and a range of learning experiences. Observations regarding student performance are emerging and advisors believe the curriculum is enabling students to think "outside of the box." Faculty, staff, and industry mentors are finding a stronger grasp of electrical engineering tasks and concepts when compared to students in the past who did not experience as much hands-on, project-based learning. This year, the board has started to look at the outcome of the implemented curriculum changes further to recommend continuous improvement ideas.

In addition to the board's strategic role, we have also had several opportunities to meet with students, review their Major Design Experience projects, and witness firsthand their technical expertise, communication skills, and ability to work within interdisciplinary teams. These skills are instrumental after graduation and help prepare the students to contribute value to their employers and peers almost immediately. These interactions with the students provide us confidence that the changes in curriculum are indeed creating the competencies required to be successful.

Technology continues to evolve, and the ECE department is well positioned to develop future technology, strategy, and business leaders in rapidly emerging technologies such as Quantum Engineering, Artificial Intelligence, Data Science, and Chip-Scale Integration. The need for leadership in these areas has never been more important to the United States and the world.

As an advisory board, we must look toward the future and ensure that our own membership is comprised of leaders that represent the changing tech landscape. This involves understanding the convergence between emerging technologies, industry needs, and academic programs, and using that understanding to select individuals that will provide unique insights to the department. Our members take heart in the guiding principle "That I may serve," better known in the Hokie domain as Ut Prosim. We are excited to be a continuing part of shaping the future of ECE!



Sam Yakulis
President, Yakulis Labs
Chair, ECE Advisory Board

31 IEEE Fellows, 22 NSF Career Awardees, 4 DOD YIP Awardees

TOP 10 Research enterprise with over $56M/year in expenditures

~450 ECE degrees conferred annually

#4 In Best Global University for Electrical and Electronic Engineering in the U.S.

The Bradley Department of Electrical & Computer Engineering

1872 Virginia Agricultural and Mechanical College established as Virginia's land grant school

1892 Department of Physics and Electrical Engineering formed

1892-1935 Samuel Pritchard, Department Head

1898 Department of Electrical Engineering separated from Physics Department

1907 Graduate department established

1909 EE graduate program started

1935 1935-56 W. A. Murray, Department Head

1944 Name changed to "Virginia Polytechnic Institute"

1956 1956-58 B. M. Widener, Department Head

1958 1958-64 George Powley, Department Head

1962 EE Ph.D. program started

1964 1964-66 Ralph Wright, Acting Head

1966 $45,000 in research expenditures

1966-81 William A. Blackwell, Department Head

1970 Named changed to "VPI & SU"

1980 $1.9 million in research expenditures

1981 1981-89 Daniel B. Hodge, Department Head

1987 Department endowed and named Harry Lynde Bradley Department of Electrical Engineering

1989 1989-90 Hugh F. VanLandingham, Acting Head

1990 1990-94 F. William Stephenson, Department Head

1994 1994-95 Ira Jacobs, Interim Head

1995 1995-2000 Leonard A. Ferrari, Department Head

1997 Department renamed to The Bradley Department of Electrical and Computer Engineering

1998 CPES was a National Science Foundation Engineering Research Center (NSF ERC)

1999 $20 million in research expenditures

2000 2000-01 Warren L. Stutzman, Interim Head

2001 2001-02 Robert J. Trew, Department Head

$25 million in research expenditures

2003 2003-04 Warren L. Stutzman, Interim Head

2004 2004-09 James Thorpe, Department Head

2007 Wireless@VT is founded

2008 Space@VT is founded

James Thorpe and Arun Phadke received the Benjamin Franklin Medal

2009 2009-12 Scott Midkiff, Department Head

2011 Virginia Tech Research Center in Arlington, VA opens its doors

2012 2012-13 Paul Plassmann, Department Head

2013 2013-Current Luke Lester Department Head

2014 Major Design Experience (MDE) Senior capstone course is created

2015 $50 million in research expenditures

2016 NSF Revolutionizing Engineering Departments (RED) Grant is awarded with the goal of transforming ECE's curriculum

2019 CPES expands to the greater Washington D.C. Metro area

2020 8th in the US for Research Expenditures by NSF HERD 2020 survey ($62.3M)

2021 Master's of Engineering in Computer Engineering degree is launched

2022 Quantum engineering labs in Blacksburg and Arlington are up and running & Virginia Tech Celebrates 150 years

2023 ECE ranks #4 by *U.S. News & World Report*

Celebrating 150 Years of Impact Since Our Founding in 1872

We are honoring our past and celebrating our present. Our Sesquicentennial Celebration is an opportunity to propel us into the future, charting a course toward greater engagement and positive impact.

Our Vision for the Future

The sesquicentennial will advance our Beyond Boundaries vision. Three themes illustrate the vision: showing what we do, how we do it, and why. They reflect the land-grant mission of the university.

Solve Problems | We respond to current problems and conduct research to discover answers to emerging questions. Our faculty, students, and professionals collaborate with communities to identify and address problems that affect the human condition.

Expand Knowledge | Teaching and learning are integral to our land-grant identity. We develop and share knowledge using a variety of methods. Some are tried and true. Others are at the leading edge of experiential learning approaches.

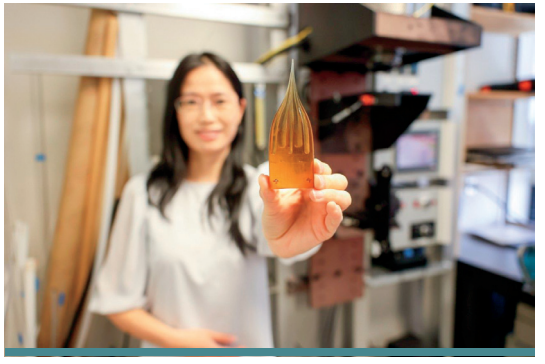
Create & Engage Communities | The Hokie nation is broad and diverse. It includes students, faculty and staff, alumni, and the university's donors, partners, and friends. The Cooperative Extension network and other researchers serve citizens of the Commonwealth and offer assistance across the U.S. and around the world.

ECE SOARS TO #4 in Latest U.S. News Rankings | U.S. News & World Report

The Bradley Department of Electrical and Computer Engineering (ECE) has generated an electrifying climb all the way to the No. 4 spot in *U.S. News & World Report's* rankings for best global universities for electrical and electronic engineering in the United States.

This latest top-five ranking focuses on electrical engineering programs in the United States specifically and puts Virginia Tech just behind Princeton, Georgia Tech, and the Massachusetts Institute of Technology. Tied at No. 4 with the University of California, Berkeley, Virginia Tech has established itself as a heavy hitter in electrical engineering research and innovation.

Luke Lester, Roanoke Electric Steel Professor and head of the department, noted the significance of the latest ranking as well as the program's forward momentum. "With the rise of objective rankings and our department's passion for outstanding scholarship, we are now seeing the impact of our exceptional research efforts over the last decade," said Lester. "This important recognition is not just because we have grown to be one of the largest departments in the country, but also because we have many acknowledged experts in our respective fields, including power electronics, power systems, cybersecurity, wireless communications and networks, and software systems."



The department's research expenditures account for more than 10 percent of the university's $600 million total, with projects covering both ever-evolving fundamentals and cutting-edge concepts. Industry partnerships and government collaborations also have opened new opportunities for project-based learning at both the undergraduate and graduate levels.

Some of the most exciting and recent success for ECE has been the focus on the semiconductor chip-scale integration major for undergraduate students. Paired with cutting-edge research from several faculty members, the department is doing its part to ensure that students are ready to enter the workforce and move the needle on semiconductor development in the Commonwealth and beyond.

Beyond work stemming from the CHIPS Act are the university's strategically focused Research Frontiers, which have helped drive the department's acceleration. In partnership with industry, government, and foundations, these focus areas "address emerging challenges and opportunities that seek to improve the human condition and create a better world for all," according to Virginia Tech's Office of Research and Innovation.

ECE has faculty and students contributing to innovative advancements in all four of the frontiers: Quantum, Artificial Intelligence, Health, and Security.

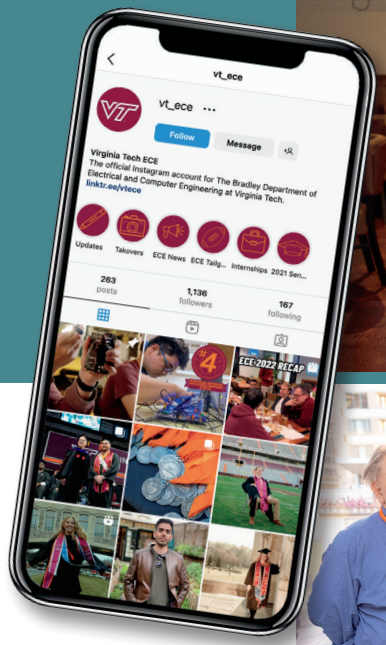
With several industry partnerships, government support, and high-caliber faculty and students, Virginia Tech ECE isn't planning on stopping the momentum any time soon.

"This accolade is just the beginning of many big things for ECE," said Lester. "With the collaborations of our faculty, staff and students, the sky's the limit. I'm especially looking forward to seeing how our presence at the VT Innovation Campus and the addition of use-inspired research to our portfolio will further elevate our reputation."

A Strategic Mission

Virginia Tech's Advancement Division was created in 2015 and is responsible for the university's fundraising, communications, marketing, and alumni engagement efforts. Since then, the university has seen record-breaking giving for several years including in fiscal year 2019-20, when more than $185.4 million in new gifts and commitments were made despite the impacts of a global pandemic.

The Virginia Tech Bradley Department of Electrical and Computer Engineering understands the value of this strategic approach and has developed its own rockstar team to tackle these opportunities for growth head-on.



Scott Dunning

Associate Department Head and Chief of Operations

"As part of my role with the department, I lead our ECE advancement team efforts. Having the opportunity to connect with our alumni and cultivate relationships with Virginia Tech ECE grads that are making waves in their respective fields is such an honor. Our goal is to keep our alums updated on what's happening in the department and to connect them with current students so the next generation of engineers can see what's possible."

Chelsea Seeber

Communications Manager

"Telling the stories of our department through written content and photography is something that never gets old. Every day it seems like there is a new research finding or award to celebrate. It's easy to market something when you have a great product and that's exactly what we have here at ECE."

Diana Maher

Digital Content Projects Coordinator

"I am thankful for my role on the ECE advancement team because of how creative I get to be every day. From managing our social media accounts, to graphic design, and even updating the website, I always get the chance to create eye-catching work."

Scott Dunning and ECE board member Christine Whiteside mingle at the ECE Board Meeting Social in Fall 2022.

Middle & Bottom | *Graduating students take the "Oath of the Engineer" and receive their medals as members of the ECE Heta Lambda Beta Society.*

New Faculty Members

Jordan Budhu

Assistant Professor

Ph.D. University of California, Los Angeles, 2018
M.S. California State University, Northridge, 2010

Areas of Interest

Electromagnetics, Antennas, Computational Electromagnetics Algorithms, Metasurfaces & Metamaterials, Electromagnetic Cloaking/Illusions/Camouflage, Infrared/Optical Metasurfaces

What's Your Favorite Thing About Being a Professor/Faculty Member?

I like that I am able to be a positive influence for my students. I remember the faculty that made an impact on me during my career development, and how monumental they were to the path I took. I also love that I'm free to pursue my research interests (whatever crazy ideas that they may be) and that feeling that I may be onto something new and potentially impactful – or even revolutionary.

Zin Lin

Assistant Professor

Ph.D. Applied Physics, Harvard University, 2018
BA Physics and Math, Wesleyan University, 2012

Areas of Interest

Numerical Methods & Optimization, Computational Modeling & Design, Quantum Photonics and Engineering, Electromagnetics & Nanophotonics, Scientific Machine Learning

What Advice do You Have for Students Looking to Join the Electrical and Computer Engineering Field?

Try to develop a passion for it; if you have the passion, then everything you do becomes quite enjoyable. And if you think you might like research, start early. Approach professors boldly — most of us are always hungry for great students.

Academy of Distinguished Alumni

Whether in research and development, leadership, or service, ECE alumni are changing the world. To recognize their contributions, ECE has inducted seven of these alumni into the department's Academy of Distinguished Alumni.

"We have many incredible alumni, who are making significant impacts to their fields—either in their career or by giving back to the department," says Department Head Luke Lester. "We want to honor their achievements and inspire our students."

The department has four award categories to recognize different forms of alumni excellence:

- The Career Achievement Award in recognition of significant contributions to the field over the course of a career.
- The Extraordinary Impact Award in recognition of extraordinary accomplishments that improve people's lives.
- The Exemplary Giving Award for outstanding philanthropic service to ECE.
- The Meritorious Service Awards for outstanding volunteer service to ECE.

Each award recipient receives a trophy and will be recognized in hallway displays on the Virginia Tech campus for members of the Academy of Distinguished Alumni.

Nominations

In 2022, the department resurrected the Academy of Distinguished Alumni Awards after a 23-year hiatus. The seven inductees from 2022 joined a group of 12 alumni who were inducted in 1998 and 1999. ECE faculty and staff are committed to continuing this tradition moving forward as a way to cultivate relationships and recognize excellence among our alumni.

The Honorifics Committee recently revamped the nominations and selection process for ECE's Academy of Distinguished Alumni awards in 2022, and continues to work with the Industrial Advisory Board to streamline the review and selection processes.

An alum must be nominated by another person. Nominations may be submitted year-round through the ECE website and should include basic information on the individual's achievements such as a bio or CV. Submissions are then verified before going to a selection committee made up of faculty, staff, Industrial Advisory Board members, alumni, and past award recipients.

In addition to the alumni awards, the Honorifics Committee supports ECE students and faculty through the application process for departmental, university, and national awards.

Do you know an ECE alum that is deserving of one of these awards?

Scan to submit your nomination.

2022 Inductees

The Career Achievement Award
David W. Roop | BSEE '76

The Extraordinary Impact Award
Gregory E. Bottomley | BSEE '83, MSEE '88
Noel Nunnally Schulz | BSEE '88, MSEE '90

The Exemplary Giving Award
Sean M. Kelley | BSEE '90, MSEE '94
Dan Sable | MSEE '85, Ph.D. '91
Dan Talbert | BSEE '65

The Meritorious Service Award
Kenneth R. Schulz | MSEE '94

Scan to read more about the 2022 inductees.

1998 Inductees

Gilbert L. Faison | BSEE '47
Former president and chairman of Roache Mercer & Faison

Robert B. Fetter | BSEE '47
Former professor of Health Care Management at Yale University

Horace G. Fralin | BSEE '48
Former president of Fralin & Waldron

James K. George | BSEE '64
Retired corporate vice president of Motorola

Thomas L. Leivesley, Jr. | BSEE '49
Former vice president and director of Davis H. Elliott, Co.

Harold L. Martin | Ph.D. EE '80
Chancellor at North Carolina A&T

C. Hyde Tucker | BSEE '56
Retired president and CEO of Bell Atlantic International

William B. Webber | BSEE '34
Former vice president of Tektronix

1999 Inductees

Joseph R. Loring | BSEE '47
Former chairman & CEO of Joseph R. Loring & Associates

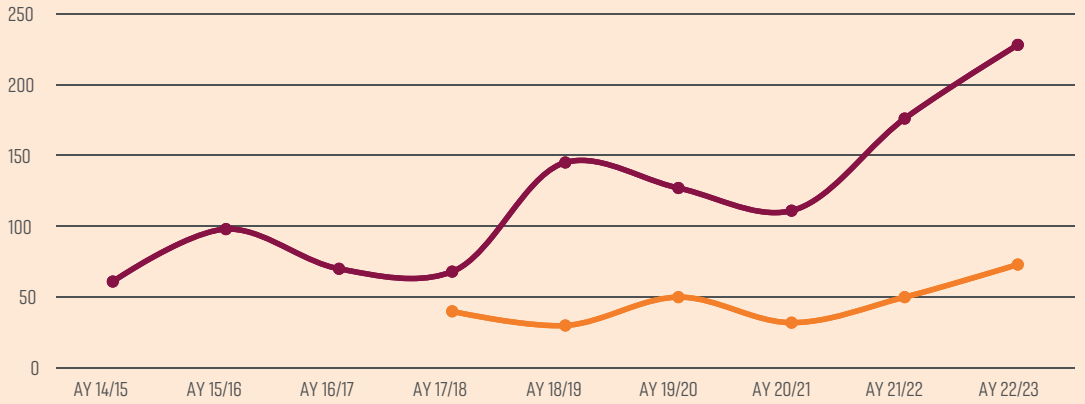
Joe T. May | BSEE '62
Founder of Electronic Instrumentation Technology, Inc and former member of the Virginia House of Delegates

Thomas L. Phillips | BSEE '47, MSEE '47
Former chairman, CEO, and director of Raytheon

Major Design Experience

Since its inception in 2014, the Major Design Experience has provided ECE undergraduate students with an "industry-like" experience that includes technical, business, and professional skill development. This realistic engineering team experience provides hands-on learning at-scale and in context while in a safe environment to learn, grow, and thrive.

MDE Students Over the Years



Fall Semester Start

MDE students that start in the fall semester of school year.

Spring Semester Start

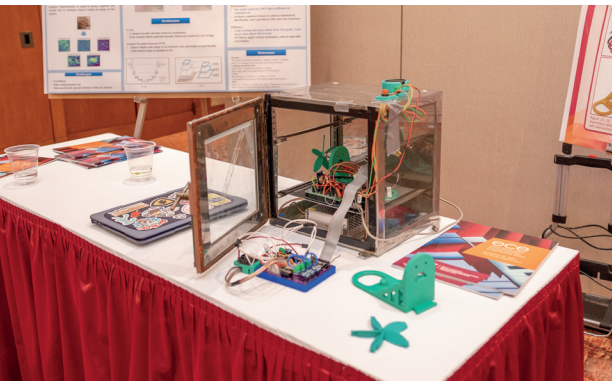
MDE students that start in the spring semester of school year.

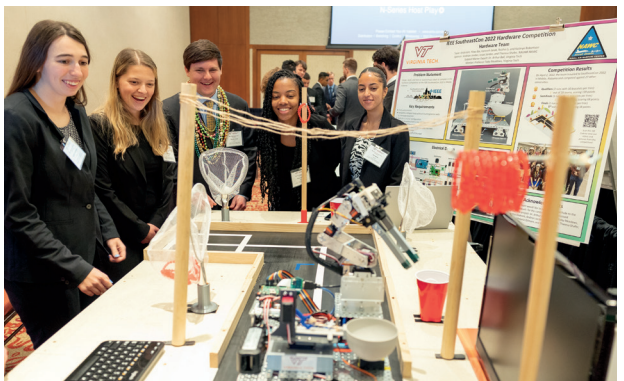
"This course is designed to teach students engineering by experiencing it. Mistakes made in MDE provide opportunities to learn and as a result, may be avoided in careers. These students are truly building their futures with hands-on experiences that a textbook-only approach can't teach."

Scot Ransbottom
Director of Design Projects and Collegiate Associate Professor

Each semester, students are paired with an industry partner that sponsors their group's particular project. These projects are proposed by companies like Collins Aerospace, General Dynamics, NASA, Lockheed Martin, Mitre, General Motors, and many others in hopes of finding real solutions to a particular problem while training the emerging generation of engineers.

Students celebrate their success and key deliverables at the Major Design Experience Expo where they present project results and solutions to their industry partners, faculty, and other sponsors of MDE. Top performers in each presentation track and overall are recognized at the end of the event after judging is complete.





Project-Based Learning for the Next Generation of Engineers

In April 2022, twelve highly accomplished Virginia Tech faculty experts in computer science and computer engineering formally joined the Virginia Tech Innovation Campus in Alexandria. Seven of the twelve faculty members are ECE professors and will play a vital role in shaping the new campus by helping to establish key research themes, enhancing the project-based curriculum, and developing the campus governance structure.

Project-based learning, the ethos of the Innovation Campus, provides new and innovative approaches to teaching and learning. In contrast to most master of engineering degree programs in the country, Virginia Tech's master of engineering from the Innovation Campus will be primarily based on completion of a collaborative, externally sponsored project. Students will be divided into teams, each of which is paired with a faculty mentor and personnel from the sponsoring organization.

The seven ECE faculty members that will help facilitate this hands-on learning approach are listed and pictured below.

- Paul K. Ampadu *(a)*
- Walid Saad *(d)*
- Yang "Cindy" Yi *(g)*
- Vassilios Kovanis *(b)*
- Angelos Stavrou *(e)*
- Lingjia Liu *(c)*
- Yaling Yang *(f)*

Among the affiliate appointments are designations for several "lead" positions within the Innovation Campus. Ampadu will serve as diversity lead, Stavrou as entrepreneurship lead, and Walid Saad as Next G lead.

The Innovation Campus's first building, an 11-story, 300,000-square-foot structure, is on track to open to students in 2024. Innovation Campus students currently take classes based at Virginia Tech's Falls Church location. By 2030, the campus expects to enroll 750 master's degree candidates.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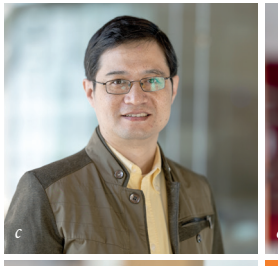
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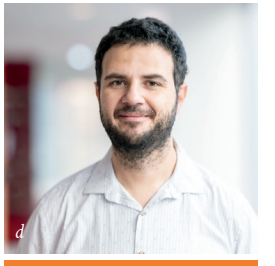
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g

The M(eng) Journey

John Robie is a recent graduate of the Master's of Engineering program and one of the first to experience the benefits of project-based learning. As a full-time naval research scientist, going back to school was something that he had contemplated for a long time. The real-world application of the curriculum at Virginia Tech coupled with the faculty research expertise are what led him to eventually choose the program.

"The collaboration between cutting-edge research and industry experience from the professors in this program has been really exciting to see," said Robie.

Robie's faculty mentor and advisor was Angelos Stavrou. Stavrou is not only an ECE professor, but also a successful entrepreneur. His company, Quokka, specializes in mobile security and code analysis.

Although earning a Ph.D. is in Robie's future, he's still undecided about wanting to teach. The Fredericksburg native mentioned that learning from a professor with a background in industry and academia inspired him to one day do the same.

"I definitely see myself in the entrepreneurial space. Specifically in defense and cyber security," said Robie.

"A lot of professors teach while starting up a business of their own. I'd love to build a team of students and create something that is useful to federal customers in the D.C. area–especially as it relates to hot topics like defense and machine learning."

Diversifying the Quantum Workforce

By Kelly Izlar

Quantum technology may be key to unlocking new opportunities, not only in scientific disciplines, but also in the effort to increase diversity in the STEM workforce.

With an overarching goal of diversifying the quantum workforce, faculty members from Virginia Tech partnered with HBCUs for a five-day quantum workshop in August 2022 at the Virginia Tech Research Center in Arlington.

With support from the Commonwealth Cyber Initiative in Southwest Virginia, the workshop was the result of a joint effort between Virginia Tech, Virginia State University (VSU), Prairie View A&M University (PVAMU), and Texas Southern University to address the stagnation of diverse representation in the STEM workforce, particularly among Black and Latinx workers.

"When you look at the diversity in STEM data, you can see that there hasn't been significant progress in 30 years," said Wayne Scales, the J. Byron Maupin Professor of Engineering. "Diversity and inclusivity programs for students are critical, but the next step has to more aggressively involve faculty members."

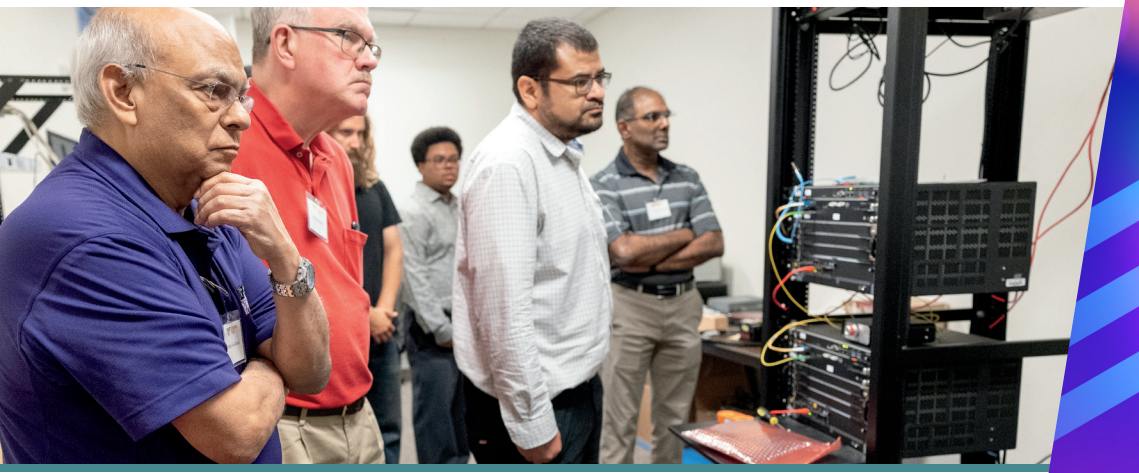
Scales and his colleagues developed a new strategy: provide faculty members with the tools they need to teach their students about the emerging field of quantum information sciences and engineering and provide infrastructure for advancing a research agenda in the field.

Scales and his collaborators mustered a small, talented group of faculty members from minority-serving institutions for an intensive five-day boot camp to familiarize them with quantum information science and engineering with linkages to cybersecurity.

Scan to see what Quantum Boot Camp is all about.

Collegiate Assistant Professor Ravi Raghunathan walked the participants through the new Quantum Key Distribution test bed at the Virginia Tech Research Center in Arlington, which uses quantum properties to ensure secure communication between two parties. The participants also toured the Commonwealth Cyber Initiative xG testbed architecture for research on secure and intelligent wireless network communications.

In addition, Scales and a team of graduate student researchers demoed the quantum experiential learning laboratory infrastructure, which they transported up from its home base on the Virginia Tech Blacksburg campus. Thanks to Virginia Tech Engineering Online, future students will be able to access this hands-on lab virtually — a feature that can be incorporated into the creation of an HBCU quantum research and learning community.



Scales and his collaborators have several additional proposals in the works to replicate the Virginia Tech laboratories, testbeds, and long-term infrastructure at VSU and PVAMU, with access for a greater network of HBCUs and minority-serving institutions.

"A lot of people see quantum as the next great challenge in higher education because it's so interdisciplinary," said Scales. "But we see it as a tremendous opportunity, and we're going to make some great headway."

Scales is also the associate vice provost of research and diversity for the Office of Diversity and Inclusion and is a member of the ECE Diversity and Inclusion Committee.

To learn more about the department's D&I committee visit:
ece.vt.edu/about/ece-diversity-inclusion

The Next National Shortage?

Skilled Semiconductor Chip Labor.

By Brandy Salmon, Virginia Tech Associate Vice President of Innovation and Partnerships

As seen in The Washington Post

How One University is Powering the Talent Pipeline With Work-Ready Engineers.

As companies around the world launch plans to onshore semiconductor chip production, a new challenge is quickly being revealed—a shortage of labor skilled in semiconductor technology. In the United States alone, companies will face a shortfall of 300,000 engineers and nearly 90,000 skilled technicians by 2030.

ECE is stepping up to fill the pipeline by preparing students through a pioneering new Chips-Scale Integration program, infusing industry-inspired learning in the classroom and propelling use-inspired research. This comes just in time, with the passing of the historic CHIPS and Science Act of 2022.

In a recent visit to Virginia Tech, U.S. Senator Mark Warner, chair of the Senate Intelligence Committee and a longtime advocate of investing in domestic semiconductor manufacturing, praised the university for its work to unite the public and private sectors through its research and industry partnerships.

"Our nation must maintain international leadership in advancing technology. The CHIPS and Science Act is a huge step forward," said U.S. Senator Warner. "Virginia Tech is doing groundbreaking work in this area, and it's exciting to learn more about opportunities to collaborate."

Pioneering a New Approach

Ranked No. 4 in the nation for producing the most undergraduates in computer engineering, VT's computer engineering program is known for providing hands-on opportunities for students via internships, a legacy of world-class research, and its team-based, multidisciplinary approach.

"Through our long-standing tradition of research excellence and industry partnerships, we understand the importance of empowering the next generation of engineers who know how to design and manufacture chips. That's what ECE's Chip-Scale

Integration curriculum has been doing since 2016," said Luke Lester, ECE Department Head.

The Chip-Scale Integration major is one of 14 specialized majors that resulted from the National Science Foundation's ambitious Revolutionizing Engineering Departments grant.

The NSF-supported curriculum aims to transform the traditional engineering education curriculum model and emphasizes design and innovation approaches. Students in the Chips-Scale major are able to "tailor their choice of courses to their own career goals by drilling into more depth in transistor manufacturing or computer-aided design tools, or by connecting it to application areas such as cybersecurity and entertainment," said Tom Martin, VT ECE Professor & Bradley Faculty Fellow of Education.

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Top left | *A Virginia Tech student testing electrical components in the semiconductor fabrication lab.* **Top right** | *Virginia Tech researchers observing patterned and fabricated devices in a desiccator.* **Right** | *A Virginia Tech graduate student sets up a fabricated sample under a microscope for observation. Photos: Luke Hayes*

continued from page 21

Scaling up Investment

While the national semiconductor labor shortage may quickly become a constraint, the Commonwealth of Virginia and Virginia Tech have been long aware of the need for academic institutions to scale up quickly.

It's a major impetus behind the Commonwealth's tech-talent initiative, in which Virginia Tech has made an intentional commitment to substantially increase undergraduate and graduate degree production while developing new accelerated masters-level degree programs. Since 2018, Virginia Tech's undergraduate enrollment in computer engineering and computer science has increased by 53 percent and master's degree enrollment in both disciplines has more than doubled.

Additionally, Virginia Tech has partnered with other universities to increase access to future high-demand, high-paying jobs through a 4+1 accelerated undergraduate and master's degree program. In addition, the Master of Engineering degrees allow students to gain hands-on experience by tackling industry-sponsored, project-based learning so that they are ready to contribute to their future employers on day one.

With a growing presence in the greater Washington, D.C. metro area, Virginia Tech is combining a tradition of research and talent development with new pioneering programs at both the undergraduate and graduate level.

Front & Center Research Focus

ECE's semiconductor-related research is a prime example of the importance of semiconductor chips in our everyday lives, as well as the steps being taken to address the ongoing shortage.

For example, Virginia Microelectronics Consortium Professor Masoud Agah is developing a skin sensor that can detect volatile organic compounds being emitted from human skin for biomarker discovery and disease diagnoses.

Additionally, four ECE faculty members were recently awarded a $1.5 million National Science Foundation grant with a focus on future semiconductor technologies. The team of ECE researchers has proposed optically-driven, ultra-wide-bandgap power semiconductor and packaging technologies for power electronics for the power grid.

In terms of long-standing research in this area, the Center for Power Electronics Systems (CPES) has made contributions resulting in technologies that are incorporated in virtually every device including voltage regulators in microprocessors that are in high-end graphics processors, memory devices, telecommunication networks, and all forms of mobile electronics.

"Power semiconductor devices are at the heart of power electronics converters, which are essential for electric vehicles, integration of renewable energy and energy storage, data centers, and all of our electronic devices," said Christina DiMarino, assistant professor and CPES researcher.

DiMarino, is creating more effective solutions to improve power grid sustainability through innovative approaches to power conversion and related technologies, like semiconductors.

The packaging of these semiconductor devices is also critical to their performance. Virginia Tech's new semiconductor packaging lab in Arlington, VA, is researching advanced packaging technologies for emerging semiconductor devices that will enable faster switching, higher efficiency, greater power, and improved reliability.

Right | *Virginia Tech Assistant Professor Christina DiMarino at the Center for Power Electronics Lab in Arlington, VA. Photo: Anthony Wright.*

Reducing Greenhouse Gas Emissions With a New Semiconductor Technology

At the intersection of future semiconductor technologies and the reduction of greenhouse gases emitted by the U.S. power grid is research from four electrical and computer engineers at Virginia Tech.

Principal investigator and Assistant Professor Yuhao Zhang along with Assistant Professors Dong Dong, Christina DiMarino, and Associate Professor Xiaoting Jia from the Bradley Department of Electrical and Computer Engineering have been awarded a $1.5 million grant from the National Science Foundation's Electrical, Communications, and Cyber Systems flagship program, ASCENT.

Otherwise known as Addressing Systems Challenges through Engineering Teams, ASCENT is focused on future semiconductor technologies. Zhang and his team are proposing a first-of-its-kind semiconductor technology that is optically driven for use in grid power electronics.

Key collaborators in this project include faculty from the Center for Power Electronics Systems (CPES) in Arlington and Blacksburg and the Center for Photonics Technology (CPT). Both of these research centers are world leaders in their areas of focus.

Zhang is an expert in the areas of power electronics, micro/nano-electronic devices, and advanced semiconductor materials. Dong is a Center for Power Electronics Systems faculty member with research expertise in power electronics and power conversion systems. DiMarino is also a member of that center's faculty and has expertise in power electronics packaging. Jia is a Center for Photonics Technology faculty member with a background in fiber-based neural interfaces, nano-bio interfaces, and fiber sensors and devices.

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The current U.S. power grid relies primarily on coal and natural gas to produce electricity. Furthermore, electricity generation is responsible for about 25 percent of greenhouse gas emissions. In an effort to reduce this environmental impact, the team will leverage the unique electronic and optical properties of ultra-wide-bandgap semiconductors, materials that can withstand a very high electric field.

Semiconductor devices within the power grid can be thought of as "switches" that turn on and off. When a switch is turned on, it allows power to flow. When it is off, it blocks the power current. These on and off "switches" are important for the power grid because they dictate when power flow should and should not occur.

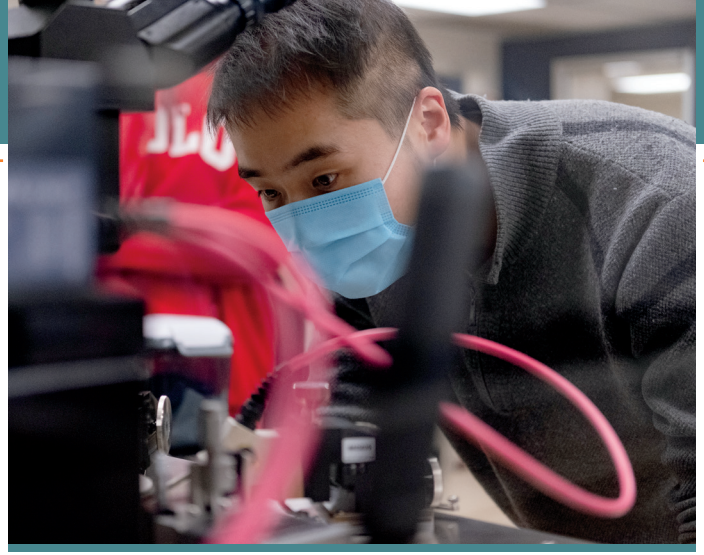
Most of today's power switches are electrically driven, meaning they rely on the base drive current or the gate-drive voltage to turn the device on and off. As more renewable energies and higher power levels have been introduced into the grid structure, the high switching frequency needed has increased the risk of "noise." In addition, stacking hundreds of devices to enhance power means it is difficult for them to be driven synchronously.

Innovation in power semiconductors is a driver for energy savings in data centers, electric vehicles, and the electric grid.

DiMarino explained the current setbacks of semiconductors and the potential for optically driven devices. She said advanced devices can transition on and off very quickly, which generates noise that can cause the devices to turn on when they should be off, also known as false triggering. This can cause problems such as short circuits. Further, when multiple devices are operated together, nonsynchronous driving can occur, resulting in some devices turning on before others and therefore being over-stressed. Optically driven devices can significantly reduce and potentially eliminate these challenges, enabling simpler and smaller converters that can be used in the grid.

Optically driven semiconductors operate on the principle of photo-generation, using a light source from a laser fiber to turn the switch on and off. This approach provides more noise immunity because photons, or light, are being used instead of electrons. The fast speed of light allows for an ideal synchronization for driving hundreds of devices, and the number of required electrical components can be reduced.

Implementing these devices into the semiconductor power grid would drastically simplify the complexity of grid scale power, resulting in greatly improved scalability, efficiency, interactivity, and resiliency.



"The power semiconductor market has reached $40 billion and is forecasted to more than double that amount by the year 2030," said Zhang. "Innovation in power semiconductors is a driver for energy savings in data centers, electric vehicles, and the electric grid. Therefore, it holds the key for realizing the unprecedented cuts in carbon dioxide for a greener and more sustainable environment."

Zhang noted the strength of VT ECE and the quality of researchers available for innovative projects like this one.

"Our department is very diverse and transdisciplinary," said Zhang. "One unique thing about the department is that we are not just collaborating with individuals but also collaborating with different centers — in this case, CPES and CPT. These research centers add another opportunity to strengthen the bond."

Each team member will contribute to different areas of the project at different stages throughout the four-year timeline. As part of the ASCENT grant, the team will provide educational opportunities to train future engineers in the areas of semiconductor technologies, optical systems, power electronics, and microelectronics.

Zhang is hopeful for the future of the grid based on the research being done, the technology being developed, and the training being provided to students — all focused in the area of semiconductors.

"The advancements we are going to develop are for the next generation of power electronics," said Zhang. "If successful, the hope is that in 10 to 20 years, we can have these devices built into the system."

Left | *Virginia Tech Assistant Professor Christina DiMarino at the Center for Power Electronics Lab in Arlington, VA. Photo: Anthony Wright.* **Top right |** *One of Yuhao Zhang's students measures semiconductor devices that were fabricated in the clean room. Photo: Brian Freer.* **Bottom right |** *Yuhao Zhang works in a clean room on semiconductor technologies. Photo: Uncork-it.*

Beauty is Only Skin Deep.

As it Turns Out, so is Disease Detection.

Human skin is the body's largest organ. It also protects internal living tissue and other organs, regulates body temperature, and even metabolizes vitamin D. Studies suggest that skin diseases modify the molecular and microbial composition of human skin, making it a rich source of information about our physical health.

Masoud Agah, Virginia Microelectronics Consortium Professor and founding director of the Virginia Nanotechnology Networked Infrastructure, has been awarded a nearly $400,000 grant from the National Science Foundation (NSF) that aims to develop a novel skin scent sampler. Agah will collaborate with researchers from Ireland to develop this new biomedical device.

The proposed skin scent sampler, named SenSorp, will have the ability to monitor the amount of volatile organic compounds (VOCs) collected in real time. Skin VOCs, found on the skin's surface, are derived from gland secretions and their interactions with external microorganisms. They can give insight into the health of an individual and offer a noninvasive route to probe the body's biochemistry. Testing of skin gland secretions has detected more than 500 compounds, including aldehydes (often used as insecticides for plants and vegetables), carboxylic acids, alcohols, ketones, and derivatives of ammonia or amines.

Recent research has highlighted the link between skin volatiles and the potential passage of compounds from blood vessels, dietary influences, and age-related metabolic activity. In addition, research has shown that dogs have the olfactory ability to detect the presence of COVID-19 from the volatile emission of the body. Therefore, researchers have identified the skin and VOCs as importance resources when it comes to identifying health issues and detecting certain diseases.

The SenSorp skin scent sampler, along with its Smart Key, which measures the collected VOCs in real time, informs the user via mobile app when the skin odor collection is complete. This communication is achieved through the device's embedded electronic circuitry.

The ultimate goal of this new skin sensor parallels that of an at-home COVID test. Consumers have come to expect minimally invasive, affordable, and convenient options for health care needs. Devices like SenSorp meet this need and are beneficial in reducing the burden on health care providers and hospital systems.

SenSorp allows caregivers, parents of sick children, and nursing home clinicians, among others, to administer the test and send the test kit to a lab for analysis.

Skin VOCs... can give insight into the health of an individual and offer a noninvasive route to probe the body's biochemistry.

Agah has more than 20 years of experience applying electrical and computer engineering concepts to biomedical engineering research projects. For this project, the Micro Electro-Mechanical Systems faculty lead will contribute to the design and fabrication of these new devices. Specifically, Agah will develop the SenSorp unique 3D-printed package with rotatory lock-in mechanism as well as the SenSorp Auto Injector Module, which will release the collected sample in the form of a sharp plug into gas chromatography systems. After these two pieces of equipment are fabricated, Agah will send them to the other team members.

This collaborative research project includes the expertise of two academic researchers from Ireland. Co-principal investigator Hamza Shakeel is an assistant professor at the School of Electronics, Electrical Engineering and Computer Science at Queen's University in Belfast. He is well-versed in Micro Electro-Mechanical Systems gas sensors and will help evaluate the VOCs emitted from the skin and absorbed by SenSorp.

Shakeel, a former doctoral student of Agah's, graduated from Virginia Tech's electrical and computer engineering department in 2015. Agah said he was excited about the opportunity to work with Shakeel in a new capacity.

Aoife Morrin, co-principal investigator, is an associate professor of analytical chemistry at the School of Chemical Sciences at Dublin City University. She is an expert within the field of chemical sensors and materials chemistry for biomedical and environmental applications, specifically epidermal sensors and will validate the SenSorp technology as a reliable skin odor sampler to differentiate between human odors through gas chromatography–mass spectrometry analysis. Several graduate students in ECE also are involved with the project and have enjoyed gaining hands-on experience throughout the research process.

In future years, Agah and his team hope to use this same technology to tap into the wearable medical devices market, which is expected to reach $196 billion by 2030. The goal is to eventually develop a wearable semiconductor chip that collects the odor of our skin for a period of time. The collected odor can then be analyzed using sophisticated laboratory equipment or low-cost sensors to detect changes for signs of possible physical or mental disease.

Agah envisions a day in the future when shoppers can use one of these semiconductor skin patches at their local pharmacy or grocery store.

"Imagine — while you do your shopping, it collects your skin odor, and then you can insert it into a micro gas chromatograph to do an instant analysis," he said. "The COVID-19 pandemic has shown us that we need to have access to novel technologies that we can scale up rapidly, deploy in mass, and then use those technologies to monitor our individual health and prevent disease spreading. This research is a direct call to those challenges."

Left | *SenSorp test kit storyboard instructions show the process of sample collection, use of the device, and instructions for mailing and collecting results. Graphic courtesy of Masoud Agah.*

Top | *Masoud Agah (at left) and graduate student Nipun Thamatam discuss improvements for the next version of the SenSorp prototype.*

Bottom | *Masoud Agah stands outside Whittemore Hall.*

IEEE From Student to Member to Fellow. And Even–President.

The Institute of Electrical and Electronics Engineers (IEEE) has roots that date back to 1884 when electricity began to become a major influence in society. The organization dedicated to advancing innovation and technological excellence for the benefit of humanity is the world's largest technical professional society. It is designed to serve professionals involved in all aspects of the electrical, electronic, and computing fields and related areas of science and technology that underlie modern civilization.

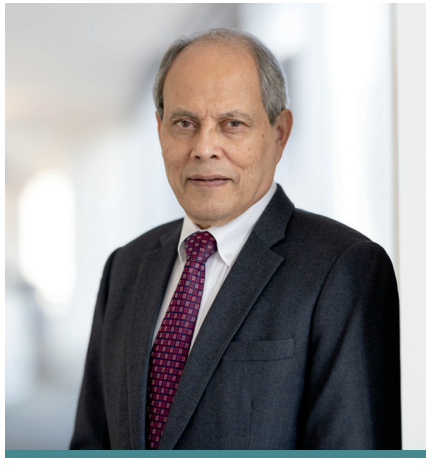
31 IEEE Fellows

1949 IEEE Student Branch Formed | Predates the formation of IEEE which happened in 1963 when American Institute of Electrical Engineers (AIEE) and Institute of Radio Engineers (IRE) merged to form IEEE.

1st IEEE President From Virginia Tech | Saifur Rahman

Harpreet S. Dhillon | *IEEE Fellow*

"I still remember the day when I received the acceptance of my first IEEE journal paper during graduate school. That is a special day for every ECE student and I was no different," said Dhillon. "As a researcher at heart, I enjoy the whole process of identifying meaningful problems and coming up with new solutions for them. I am honored that my research contributions have been deemed worthy of my elevation to the grade of IEEE Fellow. I am so grateful to my family, mentors, colleagues, collaborators, and students for putting me on this path and to Virginia Tech for providing an intellectually stimulating environment."



Saifur Rahman | *IEEE President*

"I have engaged with academics, young professionals, mid-career engineers in both industry and government, as well as corporate executives, including women and other underrepresented minorities," said Rahman. "These interactions with members and volunteers, both globally and at the grassroots level, have provided me with better insight into understanding community needs and thinking about what kinds of programs IEEE should develop to help them advance their careers."

Madalyn Killian | *IEEE Student Organization President*

For Madalyn Killian, IEEE served as a sense of community – even when she was more than 1,000 miles from home. The Texas native spent the majority of her first few years as an undergraduate searching for a sense of community. After changing her major from computer science to computer engineering, her calling to find community support became more of a mission.

"I didn't know anyone. All my friends were graduating, and I was basically starting over," said Killian. "I knew I needed to make friends and find a network of people to help me with the transition to this new major."

Killian saw a flier for an IEEE information session and decided to attend to learn more. "I thought it would be a great way to meet other computer engineering majors and at least connect with some of my classmates."

After attending the information session, Killian felt instantly welcomed. The rest is history. She went on to become president of the organization and even landed her first internship with Lockheed Martin because of the networking opportunities IEEE@VT provided her. The life-changing experience in Grand Prairie, Texas, inspired her to give back to other IEEE members.

"If it weren't for the connections and the networking and the community that IEEE gave me, I would never have gotten that internship," said Killian. "My goal was to give the same opportunities to other students in the organization."

During her time as IEEE@VT president, Killian grew the organization to more than 450 members. She also hosted more than 30 events – both social and professional – during her term and increased the social media presence to an audience of more than 700 followers.

Killian was nominated for the Outstanding Undergraduate Student Leader Award at Virginia Tech in Spring 2022 and was honored with an award for outstanding service from the electrical and computer engineering department. IEEE@VT was also nominated for Virginia Tech's Student Organization Leadership Award's Outstanding Organization of the Year. Killian's leadership even earned her the IEEE Larry K. Wilson Award, a regional recognition for the student member most responsible for an extraordinary accomplishment associated with student activities. Virginia Tech is part of Region 3, which spans from Virginia to Florida and includes several other states.

Killian graduated in December 2022 and now works as a software engineer at MITRE. "There is no doubt in my mind that the education I received at Virginia Tech and my experiences in IEEE have prepared me for what's next."

Above | *Madalyn Killian, BSCPE '22 | 2022 IEEE Student Organization President. Photo by Peter Means.*

Underwater Subs Get Their Day at the Lake

There's a fascinating place where electrical engineering, ocean engineering, and autonomous underwater robotics collide. It's called the Center for Marine Autonomy and Robotics, or CMAR.

Professor Dan Stilwell and Professor Stefano Brizzolara of the Kevin T. Crofton Department of Aerospace and Ocean Engineering (AOE) are the principal investigators of several research projects at CMAR.

The underwater vehicles developed at CMAR can be used for many applications, including sonar mapping, detecting biochemical properties of a body of water, and even finding underwater objects, such as a sea mine or lost scuba gear. The overarching goal is to develop new robots and to make those robots smart.

Stilwell described the role of his students and Brizzolara's students, and the way those pieces come together.

"My students contribute to autonomy and control, with emphasis on multi-vehicle collaboration," said Stilwell. "We are currently developing new approaches to distributed interference and distributed control that allow our teams of vehicles to develop a joint understanding of the environment around them, and to make joint decisions, and to do so with very limited communication."

Meanwhile, Professor Brizzolara and his team work on hydrodynamics, dynamic models, and propulsion, among other areas. His team has developed state-of-the-art dynamic models of AUVs that are used to predict performance and support design decisions and control design.

Just thirty minutes south of Virginia Tech's campus sits Claytor Lake State Park. Stilwell and his team of students frequent the lake with its picturesque trails and sandy beaches to test their AUVs in a "true to life" environment.

Benjamin Biggs described the conditions at Claytor Lake as quite calm, making it easier to launch and recover the subs.

"Claytor Lake is an excellent testing ground for our AUVs because it's large enough and deep enough that we can perform meaningful tests," said Biggs, an ECE Ph.D. candidate.

Stilwell is a big fan of testing these vehicles in outdoor conditions.

"One of my favorite parts about this research is that we get to take these vehicles out into the field for testing. After working hard in the lab, spending a day outside on the boat is hard to beat," said Stilwell. "Our students all come from different backgrounds but contribute to the same challenging problem, and then they get to see it work out here in the field – very exciting stuff."

The use of AUVs has generally been a very niche field, but it continues to grow. There's increasing demand for AUVs in many applications, including search and rescue, mapping, and environmental monitoring.

Stephen Krauss, an ECE Ph.D. student in Stilwell's research group, commented on both the current technology and the future of AUVs.

"Some of the biggest advancements in the field, which much of our research contributes to, come in the form of algorithms that improve the ability of AUVs to cooperate in teams," said Krauss. "In the future, I believe that swarms of AUVs cooperatively mapping and monitoring the environment will be pivotal to furthering our understanding of the Earth's oceans."

As seen in *Virginia Tech Engineer*, Spring 2022.

Scan to check it out!

Photos: Peter Means

Cybersecurity & the Grid

Supercharged Research Boosts Cybersecurity

If you drive an electric vehicle, your future trips to the charging station may be quicker thanks to up-and-coming charging technologies, but could also result in an uninvited stowaway: a computer virus.

While most EV owners charge their batteries overnight in a garage, longer journeys require "filling up" at a public station. Those public stations, while convenient and necessary, pose a different set of problems – time being one of them. Taking your battery electric vehicle from empty to full at a public station can take nearly 12 hours.

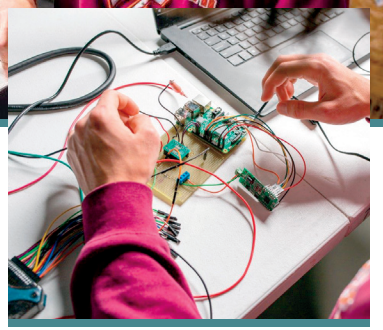
The slow-charging dilemma has inspired researchers to create a quicker solution: extremely fast charging (XFC). A recent article from New Atlas reports that scientists in China have created XFC technology that can get a lithium-ion battery to 60 percent charge in under six minutes. Implementing this fast charging technology may seem like a no-brainer, but this improved feature could come with risks.

Ryan Gerdes, associate professor and a team of student and faculty researchers are curious to learn more about the vulnerabilities of these public charging stations, the risks of XFC, and the fallout for EV drivers if they are exposed to cyberattacks.

Having more alternative vehicles on the road increases demand for charging stations. However, having more stations gives hackers the opportunity to compromise these technologies on a larger scale.

To combat these threats, Gerdes has been awarded $2.5 million by the DOE to analyze the risks of XFC and cyberattacks. In addition, Ford has provided two Mustang Mach-Es, the company's newest electric vehicle model, to put EV cybersecurity to the test.

The Ted and Karyn Hume Center for National Security and Technology, is the student-focused research and learning center within the Virginia Tech National



Security Institute, and home of this cutting-edge EV work. For traditional research projects or student design teams in which vehicles are involved, you might expect to see twisting wrenches and oil-soaked hands; however, the work completed in this garage looks quite different. Students are building circuits, writing code, interfacing with modems, and tackling much of the project from a laptop.

Senior ECE student Eric Wilson feels ready for life post-graduation thanks to his own problem-solving skills and self-guided work on the project.

"Unlike classwork, this stuff has never been done before. We can't always rely on internet tutorials and documentation, which forces us to apply different problem-solving skills," said Wilson.

By simulating attacks on the Mach-E and working to implement more secure systems that address vulnerabilities, Gerdes' team is gaining an understanding of EV security from both ends of the spectrum. Creating a safe charging environment could result in an electrifying win for consumers and manufacturers.

"Currently, there are several questions regarding the security of EV-to-EVSE communication and the potential impacts XFC could have on the grid," said Gerdes. "We want to help provide answers. This research will raise the bar for attackers by proposing countermeasures that are difficult to defeat."

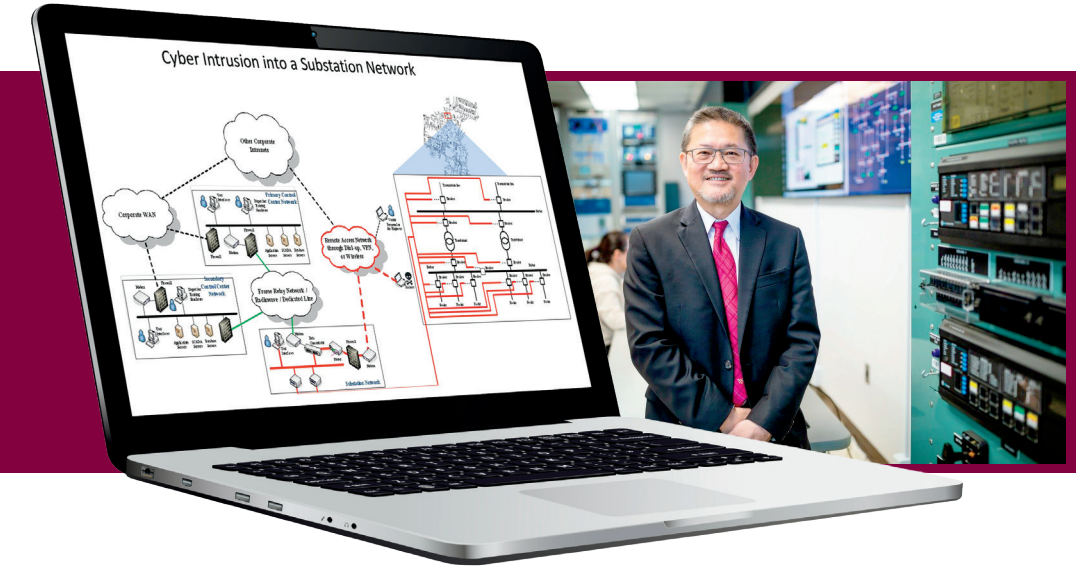
Preventing Grid Cyberattacks With the Flip of a Switch

Electrical substations could be considered the "middle-man" of the power grid. But unlike the middleman targeted for elimination in most business transactions, substations play a key role in the journey of electricity from grid to consumer.

This journey has always been a complex and multistep process, and now, because of the risks of cyberattacks on the grid, things just got a little more complicated. Chen-Ching Liu, American Electric Power Professor and director of the Power and Energy Center, is working alongside academics, industry professionals, and the DOE for the next three years to improve grid cybersecurity.

The $3 million grant comes at a time when cyberattacks on the grid are possible and demonstrably devastating. In 2015, six substations in Ukraine's electrical grid were attacked through remote control of the circuit breakers, resulting in a large-scale blackout that lasted nearly six hours.

Substations are usually unstaffed and in remote locations making them a prime target for cyberattackers looking to cause large-scale damage. To combat these risks, Liu and team are developing Cyber-REsilience for SubsTations (CREST) technology.



Operating in three main phases: detection, mitigation, and recovery, this methodology emphasizes the detection of cyberthreats and mitigation of these threats by enhancing cyber resilience.

"In the past, power system restoration has been primarily concerned with recovery of the physical grid from weather-related events," said Liu. "Recovery of compromised cyber systems together with the physical grid is a new issue."

Using machine-learning and AI, the team will mimic cyberattacks that can be detected and stopped in their tracks to prevent spread to other points in the grid.

While detection and mitigation are preferred, the team understands that recovery methods will still be necessary. To aid in recovery, Ming Jin, assistant professor and machine-learning expert, will develop Smart Cyber Switching technology. This smart switch will allow for compromised intelligent electronic devices to switch over to their healthy counterparts, restoring electricity and preventing further damage and infiltration.

To test the methodology, the Commonwealth Cyber Initiative has provided the use of its testbed, which is "critically needed to provide a realistic environment to create a wide range of attack scenarios."

Liu and his team are optimistic about the future of this technology and the impacts it could have in terms of cyberattack prevention.

"As we adopt the technologies to increase efficiency and reliability of the grid, we must also develop the 'shock absorption' to detect cyberattacks and mitigate their impact."

Left | *Through remote access, hackers can navigate through the substation IT network and open physical circuit breakers in the substation (RED), creating a catastrophic outage. The proposed CREST technology provides the intrusion detection and shock absorption capabilities to sustain the data acquisition and control functions for operation of the power grid.*

Improving 6G Access for All

We live in a world that is becoming more and more connected. In fact, there are 6.648 billion smartphone users in the world, which translates to more than 83 percent of the global population. Despite such a large number of mobile devices and users, connectivity can still pose problems for consumers in rural areas.

Lingjia Liu, director of Wireless@VT, has been awarded an $800,000 grant by the National Science Foundation (NSF) to help create next generation (NextG) mobile broadband networks that increase the availability of access to users by providing seamless wireless coverage and supporting varying service requirements.

This research is part of the NSF's Resilient and Intelligent NextG Systems program, which combines resources and support from government agencies as well as major U.S.-based telecommunications companies. The goal is to focus exclusively on NextG wireless, networking, and computing systems that may have potential impacts for the future of NextG standards.

To improve network resiliency, Liu will develop the fundamental research necessary to integrate and operate terrestrial and non-terrestrial networks, termed Ground and Air Integrated Networks (GAINs). The project will focus on the use of artificial intelligence and advanced machine learning algorithms to improve communication and computing efficiencies under this extremely dynamic environment.

Terrestrial networks, also called ground networks, include marine and submarine servers, cloud servers, fiber optic cables, ground stations, and any other connection located on the ground or in the water. These networks have provided connection for several decades and have seen improvements over the last several years; however, signals at ground level can be blocked and are vulnerable to natural disasters or artificial infrastructure damages.

Non-terrestrial networks include both aerial and space networks. The aerial network includes high-altitude platforms, such as aircrafts and airships, that are situated in the stratosphere and low-altitude platforms, such as drone swarms. Aerial networks enhance communication performance because of their flexible mobility, but their battery capabilities are limited.

Space networks, also non-terrestrial, support global information exchange and act as a "last resort" for communicating in remote areas.

Recognizing that each of these networks has unique benefits as well as limitations, Liu's research will focus on integrating the ground and non-terrestrial networks to create the GAINs. Developing a solution that allows each of the networks to complement each other will provide users with improved and flexible services.

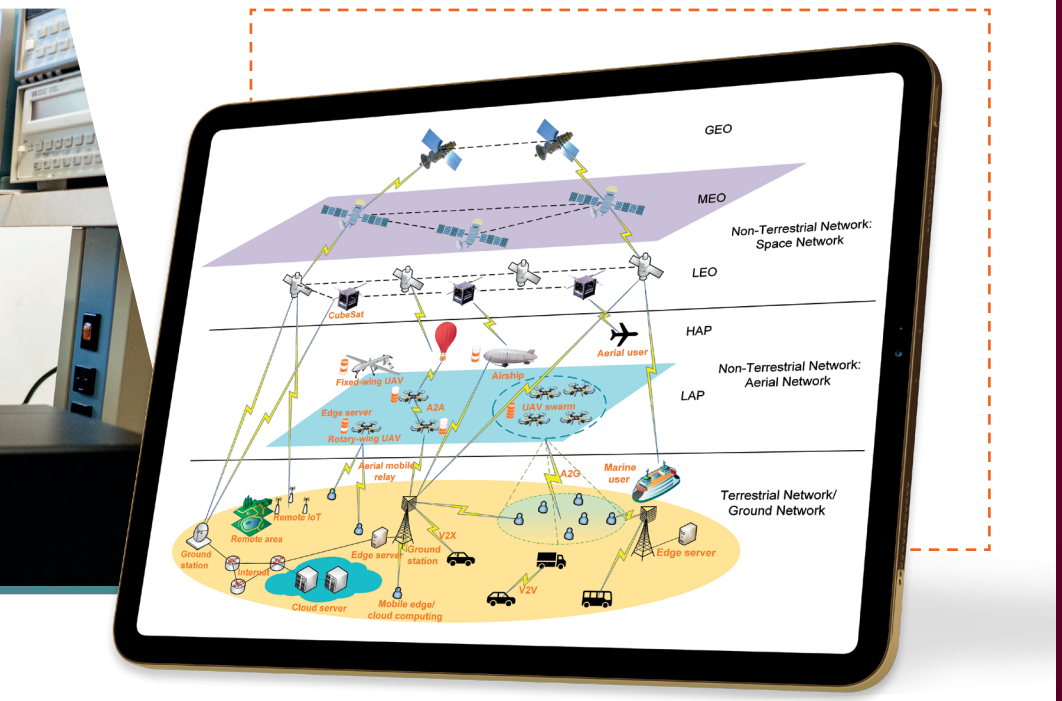
The research team includes professors from Duke University as well as Carnegie Mellon University, along with students from all three research institutions.

"Machine learning has been adopted in many fields; however, NextG systems are very different," Liu said. "Because the non-terrestrial network is highly dynamic and heterogeneous, real-time and resilient machine learning is key in this project."

The researchers will incorporate a new 2D modulation technique that transforms information carried from one communication source to another.

Liu is most excited about the opportunity to collaborate with academic partners, industry, and government to make these NextG systems a reality.

"Since NextG will be governed by industry and industry standards, it is critical for academia to work and collaborate with industry partners," said Liu. "Our hope is that the whole wireless community will benefit from this research."



Associate Professor Ali Mehrizi-Sani Weighs in on 5G Networks and Climate Change at a Fireside Chat With U.S. Sen. Mark Warner

In November 2022, Commonwealth Cyber Initiative (CCI) researcher and Associate Professor Ali Mehrizi-Sani attended an event hosted by Punchbowl News. The journalist-founded and member-based news source invited Mehrizi-Sani to join Sen. Mark Warner and Nick Ludlum, senior vice president and chief communications officer at CTIA, for a fireside chat about 5G's impact on climate change.

Sen. Mark Warner touched on his support for 5G and how it creates an opportunity to grow the Internet of Things (IoT), which can help advance smart buildings, smart cities, smart grid, and more.

Mehrizi-Sani and Ludlum joined in to talk about working toward this end-goal. Both mentioned the importance of deploying these 5G networks to enable the use of other renewable energies. Mehrizi-Sani and his team have been working on a 5G testbed for a little over three years in preparation for implementing more renewable energy sources and ensuring their efficiency and cybersecurity.

Mehrizi-Sani hopes that more policymakers and influencers begin to invest in the electric grid and 5G/NextG technologies because without them, integrating renewable energy sources will be difficult and the grid could be at risk of cyberattack.

Scan to read more and watch a full recap.

A recent poll from Pew Research Center found that 69 percent of Americans favor taking steps to become carbon neutral by 2050. Virginia Tech continues to champion these efforts; for example, the university's Climate Action Commitment pledges to use 100 percent renewable electricity on campus by 2030.

The Metaverse: Where Reality and Virtual Reality Collide

The Metaverse. A misunderstood place where avatars roam and virtual reality almost seems like, well, actual reality.

Walid Saad, a professor and member of the Wireless@VT research group, wants to help close the knowledge gap related to the Metaverse. He's starting with digital twins, or virtual models of real-world objects. They are a key constituent of the Metaverse.

Saad received a grant from the National Science Foundation to explore a new type of connectivity for digital twins in hopes of enhancing their role within the Metaverse and beyond.

The research team will address current challenges of connectivity in these digital replicas by introducing the *Internet of Federated Digital Twins* (IoFDT). Similar to the Internet of Things (think different electronics powered and controlled by Alexa), the *Internet of Federated Digital Twins* will create a platform for interconnected digital replicas that can "talk to each other" through the use of fundamental theoretical and artificial intelligence-based tools.

What is a Digital Twin Exactly?

By definition, a digital twin is an exact digital replica of a physical entity. They can be used for many purposes like simulations, testing, real-time control, maintenance, or monitoring of a real-world system/process.

Many industries are transitioning to virtual reality or digital twin testbed technologies to understand how, for example, proposed modifications to a piece of equipment will perform before physical changes are implemented. Benefits include more efficient training, cost savings, and the ability to increase seamless collaboration. This technology can even allow workers to operate on physical equipment from their own home through digital twin replicas.

Although many consumers may associate digital twins and the Metaverse with exorbitant spending and negative media coverage, this virtual reality world is much more than a place to play video games.

"The Metaverse is an opportunity to experience a digital world for everyone, everywhere. It can help reduce distances and facilitate novel methods for social and business interactions," said Saad. "During the pandemic, we saw the crucial need for online interactions. The metaverse can take video calls to a whole new level. Holographic meetings would allow you to not just see and speak to the other person, but interact with them with all five senses, as if they were sitting next to you."

A New Approach

Saad's research envisions a new concept of an *Internet of Federated Digital Twins* that holistically integrates two different and physically separated digital twins within a single framework. This concept will allow for simultaneous and real-time changes to be made to a model, such as that of a Boeing airplane. These virtual airplane models could be separated by thousands of miles and vast oceans but, if they are both connected and can communicate via wireless networks, the geographical boundaries of work on physical objects are eliminated.

The proposed wirelessly connected network of digital twins will require improvements on the AI front. This calls for novel techniques from Saad and team using the idea of lifelong learning, whereby a machine learning algorithm can "grow" over time with the information it receives, just like a child develops their skills over their lifetime.

The research is being done in collaboration with Tokyo Institute of Technology where a testbed has been created at the Smart Mobility Research & Education Field. The testbed will allow the research team to better understand how digital twins interact with physical systems by using autonomous vehicles on campus.

The Future of Society is 5.0

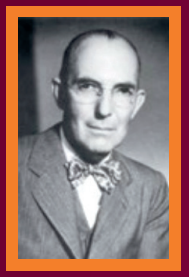
Saad and his team are contributing to a much broader purpose with the enhancement of Digital Twins and their inter-connected networks. The *Internet of Federated Digital Twins* will provide a major leap toward the vision of Society 5.0, which aims to "balance economic advancement with the resolution of social problems by using a system that integrates cyberspace and physical space."

This transformative research will also help revolutionize several industries. Additionally, it will play an instrumental role in creating programmable, autonomous virtual spaces that can grow and adapt to data, eventually leading to smart city infrastructure.

"I expect that in the next 5-10 years we could see a more mainstream adoption of digital twins and the metaverse by industries and consumers looking for an immersive experience," said Saad. "Breaking through the negative stereotypes associated with this technology and encouraging adoption is going to greatly change the way we live, work, and play."

Left | *Walid Saad.* **Top left |** *Ph.D. student Omar Hashash tries out a VR headset similar to those often used when interacting with digital twins in the Metaverse.* **Top middle |** *Professor Kei Sakaguchi stands alongside an autonomous vehicle, which will be used as a testbed for the collaborative digital twin research. Photo courtesy of Kei Sakaguchi.* **Top right |** *Walid Saad and Ph.D. student Omar Hashash analyze a drone and compare it to its digital twin replica on the screen at a lab space in Arlington, VA.*

Bradley & Webber Honors



Harry Lynde Bradley

The Bradley Endowment

The late Mrs. Marion Bradley Via established an endowment for ECE in honor of her late father, Harry Lynde Bradley, who was a pioneer in the electric motor control industry and cofounder of the Allen-Bradley Company of Milwaukee, which is now part of Rockwell Automation. In recognition, the department is called The Bradley Department of Electrical and Computer Engineering. The endowment funds scholarships, fellowships, and professorships in an ongoing effort to improve our ECE programs.

William B. Webber

William Webber Undergraduate Scholarship

William B. Webber (EE '34) established a fund to encourage women engineers. Webber's career took him to Westinghouse, the U.S. Signal Corps, then to a booming company co-founded by an army buddy— Tektronix Inc. Today, the William B. Webber Fellowship is awarded to high-achieving women pursuing a graduate degree in ECE.

To date, more than 220 undergraduate and graduate students have full scholarships by the endowment as Bradley Scholars and Bradley Fellows. These scholarships and fellowships are among the most competitive in the country and are awarded to the best students who study with the department.

Bradley & Webber Fellows | 2022-2023

Benjamin Biggs

BSEE '18 Brigham Young University
MSEE '20 Virginia Tech

Advisor | Daniel Stilwell

Biggs is developing algorithms to maximize the effectiveness of search paths in a large search space where finding optimal paths is currently infeasible and communication is unreliable.

Mark Cairnie

BSEE '19 Pennsylvania State University
MSEE '21 Virginia Tech

Advisor | Christina DiMarino

Cairnie is designing high-density power converters that are integrated into overhead power cables to replace conventional substations.

Eric Danson

BSCPE '22 Virginia Tech

Advisors | Dong S. Ha & Jeffrey Walling
Honors | New Horizon Graduate Scholar

Danson is developing a wireless receiver front-end for scalable mmWave-phased arrays.

Alexander DeRieux

BSEE '16, BSCS '16, and MSEE '22 Virginia Tech

Advisor | Walid Saad

DeRieux is developing quantum algorithms and machine-learning architectures to advance classical artificial intelligence paradigms.

Rebecca DeSipio

BSEE '21 Pennsylvania State University

Advisor | A. Lynn Abbott

DeSipio is developing machine-learning methods for classifying and rating the tremor severity of Parkinson's Disease patients from spiral drawings.

Davis Earley

BSEE '20 Auburn University
MSEE '22 Virginia Tech

Advisor | Elena Spinei Lind

Earley is researching observational methods to improve air quality measurements using Differential Optical Absorption Spectroscopy.

Richard F. Gibbons III

BSEE '21 Virginia Tech

Advisor | Jonathan Black

Gibbons is developing a satellite platform to design, build, and test small satellites.

Danielle Lester

BSEE '21 Virginia Tech

Advisor | Christina DiMarino

Lester is focused on fabrication refinements for multi-chip power modules with wire bond-less interconnects. The work will improve the yield of high-voltage power modules with advanced packaging techniques. The application spaces of her work include renewable energy and all-electric transportation.

(continued ->)

Tyler McGrew

BSEE '21 Miami University

Advisor | Qiang Li

Tyler McGrew is modeling and developing techniques to reduce electromagnetic noise in high-frequency power converters.

Megan Moore

MSEE '21 Virginia Tech
BSEE '19 Virginia Tech

Advisors | William C. Headley and R. Michael Buehrer
Honors | New Horizon Graduate Scholar

Megan Moore is developing an improved GPS system and waveform for low Earth orbit.

Sam Shebert

MSEE '22 Virginia Tech
BSEE '20 SUNY Oswego

Advisor | R. Michael Buehrer

Sam Shebert is developing signal classifiers that fuse classical signal processing with recent advances in machine learning.

Joseph G. Thomas

BSEE '18 Virginia Tech
MSEE '20 Virginia Tech

Advisor | Yizheng Zhu

Joe Thomas is developing optical imaging techniques to quantify soft-tissue mechanics and metal alloy corrosion and using machine learning to improve parameter estimation for optical sensing.

Alec Yip

BSEE '22 Virginia Tech

Advisor | Steven Ellingson

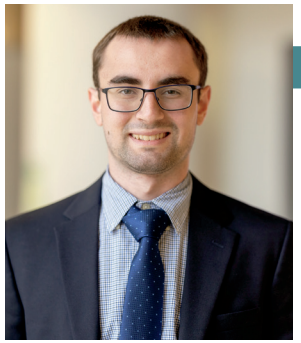
Developing a model for electronic reconfigurable surfaces (ERS) for Gregorian-dual-reflector antennas.

Bradley Scholars

Nicholas Burant

General Engineering

Nicholas is an ambitious scholar and critical thinker. He has a strong interest in the world-changing capabilities within the field of ECE and intends to study Energy and Power Electronics Systems.



Andrew Merdes

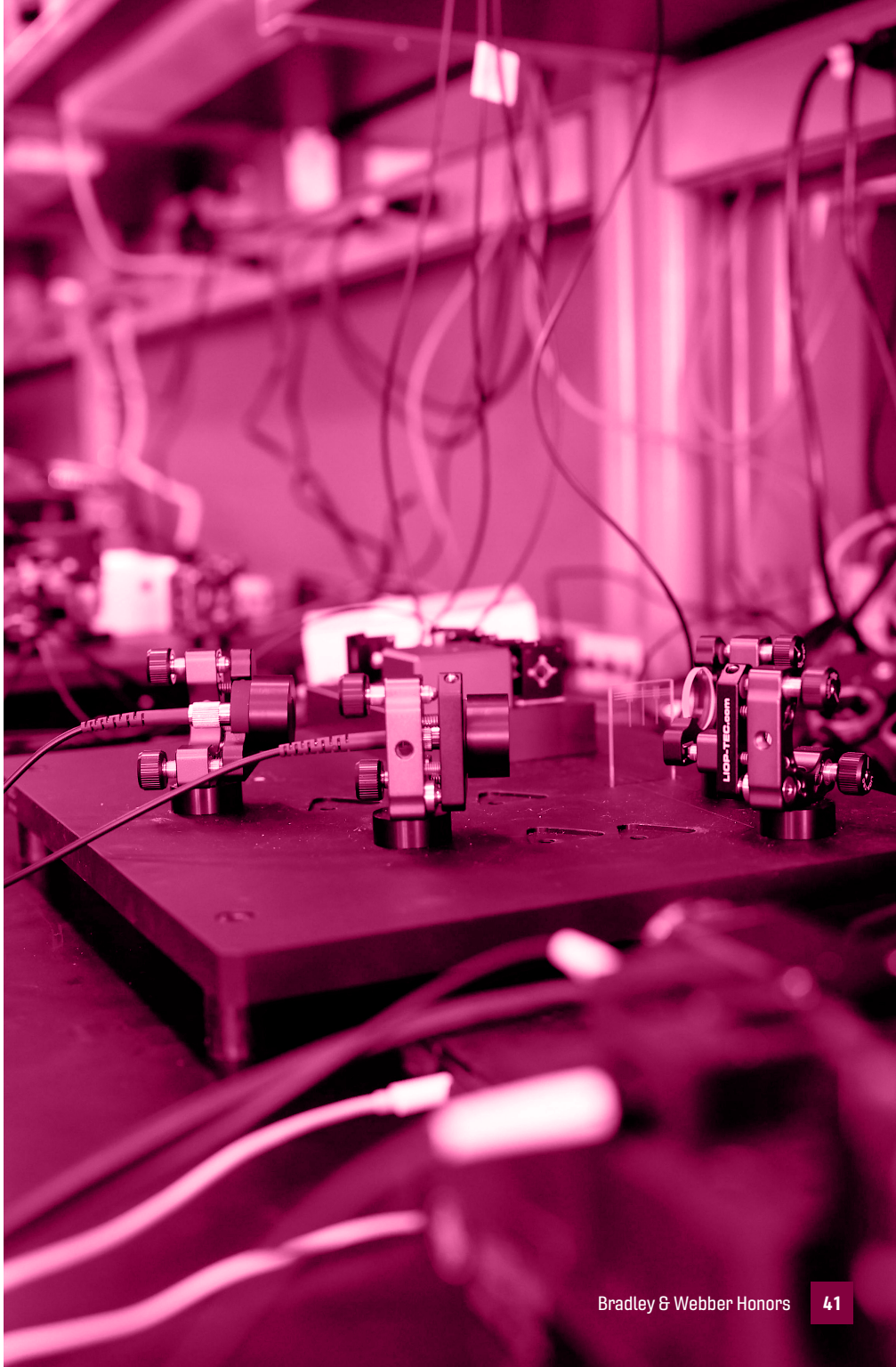
Computer Engineering

Merdes is finishing his sophomore year in ECE. He enjoys various clubs on campus, including Board Game Club, Tennis, and Pickleball. His most memorable experience at Virginia Tech so far was visiting the FRITH lab and seeing all the tools and machines students can use.

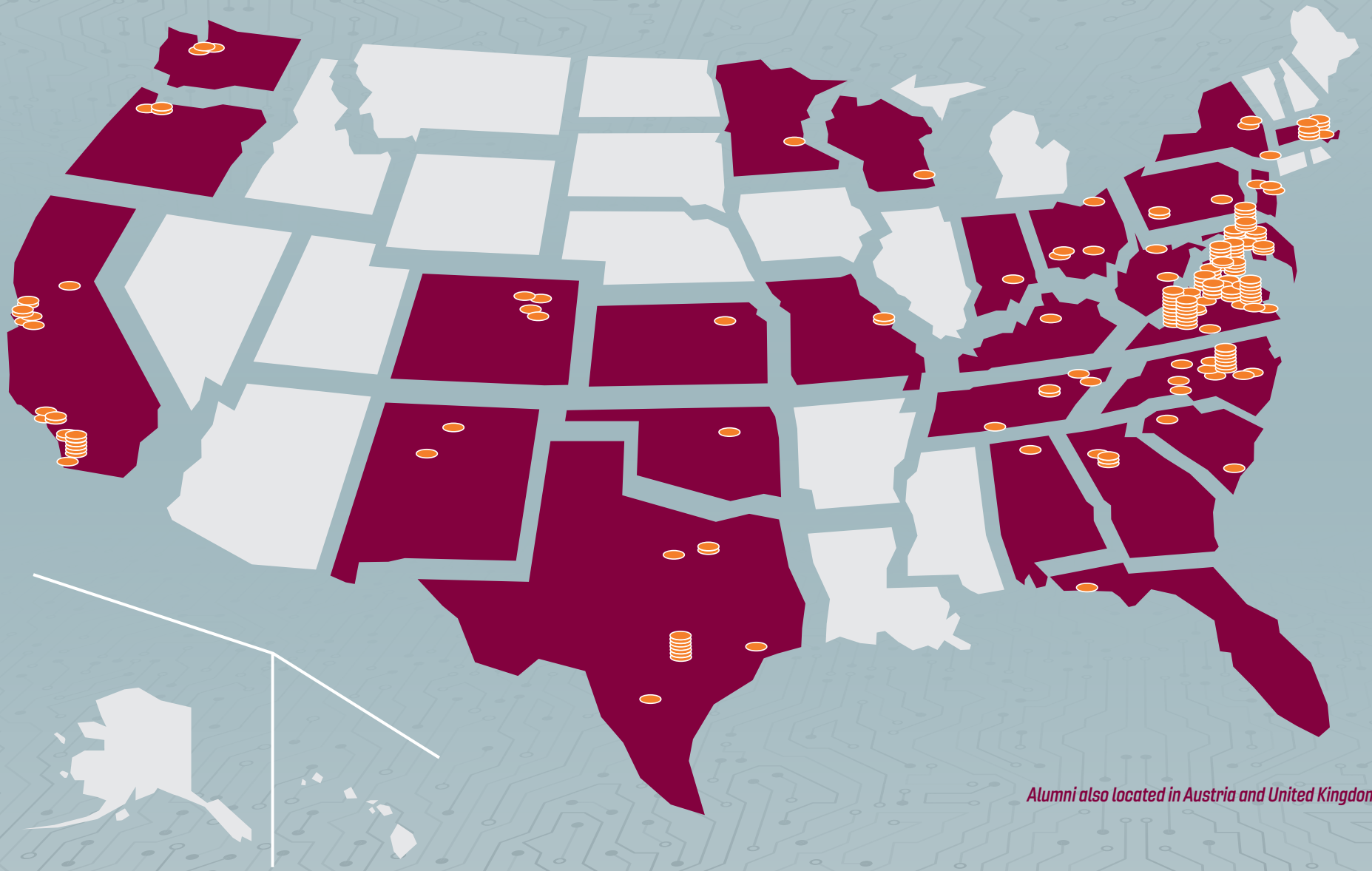
James Mislay

Computer Engineering

Mislay has been passionate about ECE from a young age, starting with robotics and circuits kits and solidifying in his high school programming class. In Summer 2022, he completed an internship with HX5, supporting NASA with his Radio Frequency Mass Gauge (RFMG) project.



Bradley Alumni Located Across the U.S.



Alumni also located in Austria and United Kingdom.

Bradley Alumni S | Scholars F | Fellows

2022

Nathan Moeliono / S
BSCPE '22

Maymoonah Toubeh / F
MSCPE '18, Ph.D. '22

2021

Virginia Li / F
BSEE '13, Ph.D. '21

2020

Shane Coyle / F
MSEE '20

2019

Jonathan Bunting / F
MSCPE '19

Michael Emanuel / F
BSEE '18, MSEE '19

Bryse Flowers / F
BS '14, MS '19

Christopher Goodkind / S
BSCS '19

Jonathan Graf / S
BSCPE '02, MSCPE '04, Ph.D. '19

Paul Kennedy / F
BSEE '17, MSEE '19

Hannah Mohr / F
MSEE '19

2018

Jacques Delport / F
Ph.D. EE '18

Christina DiMarino / F
MSEE '14, Ph.D. EE '18

Sean Douglass / F
MSCPE '18

Janay Frazier / F
MSEE '18

Elizabeth Hutz / S
BSCPE '18

Jason Ziglar / F
Ph.D. '18

2016

Colin Burgin / F
BSEE '16

Michael Cogswell / F
BSMATH '13, BSCS '13, MSCPE '16

Michael Fraser / F
MSEE '12, Ph.D. '16

Kristen Hines / F
MSCPE '16

Walker Sensabaugh / F
BSCPE '16

Richard Tillman / F
BSEE '12, MSEE '14, Ph.D. '16

2015

Paul U. David / F
MSEE '15

William C. Headley / F
BSEE '06, MSEE '09, Ph.D. '15

Christopher Jelesnianski / F
MSCPE '15

Javier Schloemann / F
Ph.D. '15

Amy M. Ridenour / F
MSEE '15

2014

Lucy Del Barga / F (was Lucy Fanelli)
MSEE '14

Michael Hopkins / F
Ph.D. '14

Callie Johnston / S
BSCPE '14

Nicholas Kaminski / F
BSEE/CPE '10, MSEE '12, Ph.D. '14

Nathan Kees / F
BSEE '08, MSEE '14

2013

Thurman Shaver Deyerle IV / F
BSEE '10, MSEE '13

Kevin D. Jones / F
BSEE '09, MSEE '11, Ph.D. '13

Parrish Ralston / F
BSEE '06, MSEE '08, Ph.D. '13

David Uliana / F
BSCPE '11, MSCPE '13

Ben York / F
MSEE '10, Ph.D. '13

Phillip Andrew Zellner / F
BSEE '07, MSEE '12, Ph.D. '13

2012

Brittany Clore / S
BSCPE '10, MSCPE '12

Thomas Alan Cooper / S
BSEE '10, MSEE '12

Ryan Irwin / F
Ph.D. '12

David Reusch / F
BSEE '04, MSEE '06, Ph.D. '12

Ethan Swint / F
Ph.D. '12

2011

Amy Malady / F
BSEE '09, MSEE '11

David Mazur / S/F
BSEE '11

Benton Thompson / F
MSEE '11

Jerry Towler / S
BSEE '08, MSEE '11

2010

Ricky Castles / S
BSCPE '03, MSCPE '06, Ph.D. '10

David L. Kleppinger, Jr. / S
BSCPE '04, MSCPE '08, Ph.D. '10

Evan Lally / F
BSEE '03, MSEE '06, Ph.D. '10

Jacob R. Simmons / S
BSCPE '08, MSEE '10

2009

Benjamin Alan Beasley / S
BSEE '09

Matthew Carter / F
BSEE '09

Ross Clay / S
BSCPE '09

Daniel Friend / F
Ph.D. '09

Daniel Hager / S
BSCPE '08, MSCPE '09

Zachary La Celle / S
BSCPE '09

Matt Welch / S
BSEE '09

2008

Mark Baldwin / F
BSEE '93, MSEE '05, Ph.D. '08

David Casteel / S
BSCPE '08

Stephen Douglas Craven / F
Ph.D. '08

R. Matthew Gardner, Sr. / F
BSEE '03, MSEE '05, Ph.D. '08

Mark Alan Lehne / F
Ph.D. '08

Rebecca Kay Shelton / F
MSEE '08

Neil Steiner / F
MSEE '02, Ph.D. '08

2007

Aric Blumer / F
Ph.D. '07

Nathan Harter / F
MSEE '07

Edward Andrew Jones / S
BSEE '07

Brian Joseph McGiverin / S
BSCPE '96, MSIT '07

Linh My Pham / S
BSCPE '07, BSPHYS '07

Gray Roberson / F
Ph.D. '07

Thomas Rondeau / S/F
BSEE '03, MSEE '06, Ph.D. '07

Adam Keith Shank / S
BSCPE '07

Juan Suris / F
Ph.D. '07

Richard Zimmermann / S
BSCPE '07

2006

Christopher R. Anderson / S/F
BSEE '99, MSEE '02, Ph.D. '06

Daniel Dae Cho / S
BSEE '06

Jeffrey R. Clark / F
MSEE '03, Ph.D. '06

Jamie N. Riggins / S/F
BSEE '04, MSEE '06

Daniel J. Tebben / F
Ph.D. '06

2005

Nathaniel August / F
BSCPE '98, MSEE '01, Ph.D. '05

Brian M. Donlan / F
MSEE '05

David Craig Schroder / S
BSEE '05

Ian Schworer / F
BSCPE '03, MSEE '05

Michael Gordon Vondrak / S
BSCPE '05

2004

Matthew R. Anderson / S
BSCPE '04

Mark B. Bucciero / F
BSCPE '01, MSCPE '04

Ryan Fong / S/F
BSCPE '01, MSCPE '04

Daniel J. Hibbard / F
BSEE '02, MSEE '04

(continued –>)

Ellery L. Horton / S
BSCPE '04

Charles Lepple / F
BSEE '00, MSEE '04

Annie Martin / F
BSEE '04

Stephanie Martin / S
BSEE '04

Christopher A. Maxey / S
BSCPE '02, MSEE '04

Abigail Harrison Osborne / S
BSCPE '04

Christian Rieser / F
BSEE, MSEE '01, Ph.D. '04

Alexander James Taylor / F
BSEE '02, MSEE '04

Rose Trepkowski / F
BSEE '04, MSEE '04

Michael Lee Webber / F
BSEE '02, MSEE '04

2003

Cass Dalton / S
BSCPE '03

Brian Gold / S
BSEE '01, MSCPE '03

Timothy Gredler / S
BSCPE '03

Adam P. Hahn / S
BSCPE '03

Alexander Hanisch / S
BSCPE '03, BS MATH '03

James E. Hicks / F
MSEE '00, Ph.D. '03

Hugh E. Hockett / S
BSCPE '03

Spencer Hoke / S
BSCPE '03

Andrew S. Hollingsworth / S
BSCPE '03

Ryan Hurrell / S
BSEE '03

Dimosthenis Katsis / F
BSEE '95, MSEE '97, Ph.D. '03

Patrick McDougle / S
BSEE '03

David R. McKinstry / F
MSEE '03

Michael Mera / S
BSEE '03

Stephen Nash / S
BSCPE '03

Pablo Max Robert / F
MSEE '98, Ph.D. '03

Amy Rose / S
BSCPE '03

Roger Skidmore / F
BSCPE '95, MSEE '97, Ph.D. '03

Douglas Sterk / F
BSEE '00, MSEE '03

Samuel S. Stone / S
BSCPE '03

Kristin Weary / S
BSEE '03

Paul C. Weinwurm / F
BSEE '03

2002

William D. Barnhart / S/F
BSEE '00, MSEE '02

Kevin B. Cooley / S
BSEE '02

Christopher Griger / S
BSCPE '02

Keith Cristopher Huie / F
MSEE '02

Basil Thomas Kalb / S
BSEE '98, MSEE '02

Michael F. Mattern / S
BSEE '02

James W. McLamara / F
BSEE '02

Vin Menon / S
BSCPE '02, BSISE '02

Carl E. Minton / F
BSEE '97, MSEE '02

Troy Nergaard / F
MSEE '02

Kashan Ali Shaikh / S
BSCPE '02

Raymond Ashley Sharp / S
BSEE '02

Seema Sud / F
Ph.D. '02

Jason S.K. Wienke / S
BSEE '02

William Worek / S
BSCPE '99, MSCPE '02

2001

Sarah S. Airey / S
BSCPE '01

Brian Berg / F
BSEE '90, MSEE '91, Ph.D. '01

Carey Buxton / F
Ph.D. '01

Eric D. Caswell / F
Ph.D. '01

Kevin Flanagan / S
BSCPE '00, MSCPE '01

Matt Helton / S
BSEE '01

Ben Henty / F
MSEE '01

Erik Hia / F
BSCPE '99, MSCPE '01

Daniel A. Johnson / F
BSEE '98, MSEE '01

Adam Steven Kania / S
BSEE '01

Janie A. Hodges Longfellow / S
BSCPE '01

Daniel L. Lough / F
BSCPE '94, MSEE '97, Ph.D. '01

Richard Steven Richmond / F
MSEE '01

Jonathan Scalera / F
MSCPE '01

Amanda Martin Staley / S/F
BSEE '99, MSEE '01

Christian Twaddle / S
BSCPE '01

Jason Yoho / F
MSEE '98, Ph.D. '01

2000

Bryan Browe / F
BSEE '97, MSEE '00

Carrie Aust Cox / F
MSEE '00

Bradley A. Davis / F
BSEE '86, MSEE '88, Ph.D. '00

Scott Davis / S
BSCPE '00

Gregory D. Durgin / F
BSEE '96, MSEE '98, Ph.D. '00

Jason E. Lewis / S/F
BSEE '99, MSEE '00

Garrett Mears / S
BSCPE '00

Joseph Allen Payne, Jr. / S
BSEE '00

William B. Puckett / F
MSEE '00

Yaron Rachlin / S
BSEE '00

1999

Richard Ertel / F
Ph.D. '99

Jason Hess / F
BSEE '97, MSEE '99

J. Eric Nuckols / F
BSEE '97, MSEE '99

Neal Patwari / S
BSEE '97, MSEE '99

Jeffrey T. Scruggs / F
BSEE '97, MSEE '99

Jeff Smidler / S
BSEE '99

Matthew C. Valenti / F
BSEE '92, Ph.D. '99

1998

Robert Adams / F
MSEE '95, Ph.D. '98

Matthew Carson / S
BSEE '98

Brian Flanagan / S/F
BSEE '97, MSEE '98

Jayda Blair Freibert / S
BSEE '98

Eric J. Mayfield / S
BSEE '97, MSEE '98

John Morton / F
MSEE '98

Paul Nguyen / S/F
BSEE '98

1997

Ray Bittner / F
BSCPE '91, MSEE '93, Ph.D. '97

Thomas H. Drayer / F
BSEE '87, MSEE '91, Ph.D. '97

Bradley H. Gale / S
BSEE '97

Paul A. Kline / F
Ph.D. '97

Jeff Laster / F
BSEE '91, MSEE '94, Ph.D. '97

Matthew A. Yaconis / S
BSEE '97

1996

Shawn Addington / F
BSEE '90, MSEE '92, Ph.D. '96

R. Michael Buehrer / F
Ph.D. '96

Todd B. Fleming / F
BSCPE '94, MSEE '96

William Kuhn / F
BSEE '79, Ph.D. '96

Jennifer Hastings Steele / S
BSEE '96

1995

William Ashley Eanes / S
BSEE '95

Daniel J. Gillespie / S
BSCPE '95

David Kapp / F
MSEE '93, Ph.D. '95

Joseph C. Liberti / F
BSEE '89, MSEE '91, Ph.D. '95

Cheryl Duty Martin / S
BSEE '95

Kai Xu / S
BSEE '95

1994

JoAnn Adams / S
BSEE '94

Kirsten Ann Rasmussen Brown / S
BSEE '94

Charles Bunting / F
MSEE '92, Ph.D. '94

Scott Cappiello / S
BSCPE '94

Zion Lo / S
BSEE '94

Michael Newkirk / F
BSEE '88, MSEE '90, Ph.D. '94

Thomas Rose / S
BSEE '94

1993

John Todd Hutson / S
BSEE '93

John McHenry / F
BSEE '88, MSEE '90, Ph.D. '93

Graham David Stead / S
BSCPE '93

Scott Stern / S
BSEE '93

Wesley T. Wade / S
BSEE '93

1991

Phillip A. Danner / S
BSCPE '91

Bradley Duncan / F
Ph.D. '91

Dwayne Allen Hawbaker / F
BSEE '89, MSEE '91

Steven Schulz / F
MSEE '91

Anne Palmore Stublen / S
BSEE '91

David L. Tarnoff / F
BSEE '87, MSEE '91

Gregory A. Zvonar / S/F
BSEE '90, MSEE '91

1989

Steven Edward Bucca / F
BSEE '87, MSEE '89

Unspecified

Stephen P. Bachhuber / F
BSEE

Keith McKenzie

Nicole Ogden / F

Ian Roessle / F
Ph.D. CPE

Patents Issued | 2022/2021

Hybrid Optical Phase Array and MEMS Beamsteering for Chip-Scale Lidar System

Patent # | 11474206-B2
Issued | October 18, 2022
Inventors | Timothy J. Talty, Michael Mulqueen, Richard Kremer

Hybrid-Current Mode Switching-Cycle Control

Patent # | 11,368,103
Issued | June 21, 2022
Inventors | Dushan Boroyevich, Rolando Burgos, Jun Wang

Low Impedance Multi-Conductor Layered Bus Structure With Shielding

Patent # | 11,335,649
Issued | May 17, 2022
Inventors | Dushan Boroyevich, Rolando Burgos, Joshua Stewart, Jun Wang, Yue Xu

Learning Approximate Estimation Networks for Communication Channel State Information

Patent # | 11,334,807
Issued | May 17, 2022
Inventors | Thomas Charles Clancy, Kiran Karra, Timothy O'Shea

Vehicle Anti-Collision Forewarning Method, System and In-Vehicle Computer Device

Patent # | 11,312,375
Issued | April 26, 2022
Inventors | Xiaofei Li, Xiao Wang, Cheng Xu, Lisheng Yang, Dezhao Zhang, Lei Zuo

Treatment Planning for Immunotherapy Based Treatments Using Non-Thermal Ablation Techniques

Patent # | 11,311,329
Issued | April 26, 2022
Inventors | Rafael Davalos, Natalie White

Core Loss Characterization and Measurement

Patent # | 11,307,266
Issued | April 19, 2022
Inventors | Rolando Burgos, Yuliang Cao, Dong Dong, Minh Ngo

Articulated Multi-Link Robotic Tail Systems and Methods

Patent # | 11,305,420
Issued | April 19, 2022
Inventors | Pinhas Ben-Tzvi, Yujiong Liu, William Rone, Wael Saab

Bidirectional Architectures With Partial Energy Processing for DC/DC Converters

Patent # | 11,290,022
Issued | March 29, 2022
Inventors | Rolando Burgos, Yuliang Cao, Dong Dong, Minh Ngo, Ning Yan

Medium Voltage Planar DC Bus With Distributed Capacitor Array

Patent # | 11,271,492
Issued | March 8, 2022
Inventors | Rolando Burgos, Dong Dong, Lakshmi Ravi, Joshua Stewart

High-Electron Mobility Transistors With Charge Compensation

Patent # | 11,171,203
Issued | November 9, 2021
Inventors | Yuhao Zhang

System and Method for Monitoring Eye Health

Patent # | 107,072,528B
Issued | July 2, 2021
Inventors | Matthew Rickard, Creed Jones

Thin Film Door Switch With Integrated Lighting

Patent # | 10985756-B2
Issued | April 20, 2021
Inventors | Jonathan L. Oakes, Timothy J. Talty, Andrew H. Leutheuser, Donald K. Grimm

Interleaved Multi-Channel Multi-level Multi-Quadrant DC/DC Converters

Patent # | 10,978,948
Issued | April 13, 2021
Inventors | Y. Du, E. Aeloiza, R. Burgos

Honors & Achievements

Honors & Awards

Harpreet S. Dhillon | Named a 2023 IEEE fellow for his contributions to heterogeneous cellular networks

Harpreet S. Dhillon | Elected an Asia-Pacific Artificial Intelligence Association (AAIA) Fellow in 2022 in recognition of "outstanding achievements in the area of Machine Learning for Communication Systems"

Harpreet S. Dhillon and Walid Saad | Included in the list of 100 most-cited scholars in the area of Internet of Things by AMiner, Tsinghua University, in 2022

Dong Dong | Received a CAREER award in 2022 to build more efficient power conversion platforms for high-voltage systems
NSF CAREER Awards are designated for faculty members early in their career who are expected to become leaders in their field

Michael Hsiao | Received the Virginia Cooperative Extension 2022 Educational Technology Award (State Winner), 2022

Ruoxi Jia | Received a NSF CAREER Award in 2023 to advance data valuation using new computational frameworks and machine learning algorithms

Alan Michaels | Elected fellow of the National Academy of Inventors in 2022

Alan Michaels | Finalist in the American DataHub Consortium Innovation Challenge
Michaels is the inventor of 44 awarded U.S. patents with approximately 80 more international issuances

Saifur Rahman | Currently serving as the 2023 IEEE President and CEO
He is the first-ever Virginia Tech faculty member to be elected as the IEEE President

Walid Saad | Named one of Clarivate's Most Highly Cited Researchers in the World for 2022

Tim Talty | Received the 'Boss Kettering' from General Motors in 2022
The Boss Kettering is awarded for outstanding product innovation. Over his career at GM, numerous patents have been integrated into GM products. He has over 200 patents for inventions and improvements ranging from technologies for autonomous vehicles, telematics, and wireless sensor networks

Haining Wang | Named the ACM Distinguished Member for Outstanding Scientific Contributions to Computing

2022 Dean's Awards for Excellence

The Dean's Awards for Excellence recognize our faculty members' incredible work, which has directly or indirectly impacted the success of our students.

Arthur Ball
Excellence in Teaching

Christina DiMarino
Outstanding New Assistant Professor

Kendall Giles
Certificate of Teaching Excellence

Changwoo Win
Faculty Fellow

Guoqiang Yu
Excellence in Research

Yuhao Zhang
Faculty Fellow

Exceptional National & International Services

Christina DiMarino | Elected to serve a second term as a Member-at-Large for the IEEE Power Electronics Society (PELS) in Jan. 2023. She previously served as a Member-at-Large for PELS from 2020 to 2022.

Christina DiMarino | Elected Vice-Chair of the IEEE Power Electronics Society (PELS) Technical Committee on Power Components, Integration, and Power ICs from 2021-2023.

Scott Dunning | Serves on the ABET Board of Delegates representing the American Society for Engineering Education (ASEE).

Scott Midkiff | Serves as the ABET Program Evaluator and is a Member-at-Large of the IEEE Committee on Engineering Accreditation Activities.

Scot Ransbottom | Serves as the ABET Program Evaluator and is a Member-at-Large of the IEEE Committee on Engineering Accreditation Activities.

Jeff Reed | Serves as a National Academies Committee member for study reviewing FCC Order 20-48 (authorizing Ligado Networks to operate a terrestrial radio network near the GPS band), August 2021-October 2022.

Keynote Addresses

Luiz DaSilva | *"What Does it Take to Achieve Ultra Reliability in Next G?"* | IEEE Globecom Workshop on Next Generation Access Networks, December 2022, Rio de Janeiro, Brazil *(virtual)*

Harpreet S. Dhillon | *"Drone-Assisted Cellular Networks: Modeling and Fundamentals"* | ACM MobiCom, Workshop on "DroneCom: 4th International Workshop on Drone Assisted Wireless Communications for 5G and Beyond", March 2022, New Orleans, LA

Christina DiMarino | *3D Power Electronics Integration and Manufacturing (3D-PEIM)* | International Symposium, February 2023, Miami, FL

Dong Dong | *"Design and Integration of SiC-Based High-Density, High-Speed, and High-Altitude Inverter/Rectifier for Aviation Applications"* | General Electric Electrification Symposium, October 19, 2022, Niskayuna, NY

T.-C. Poon | *"Holographic Approach to 3D Object Recognition"* 5th International Conference on Control and Computer Vision (ICCCV), August 19-21, 2022, Xiamen, China

Saifur Rahman | *In 2022, Saifur Rahman gave 18 keynote addresses in seven countries including the following:*

- *"Role of Smart Grid in Facilitating the Integration of Renewables into the Power Grid"* | Webinar, ASEAN Electrotechnical Symposium & Exhibition, March 17, 2022, Kuala Lumpur, Malaysia
- *"The Global Electric Power Sector Working towards a Net-Zero Carbon Future"* | Webinar, 2022 International Conference in Electrical Engineering, June, 29, 2022, Seoul, South Korea
- *"The Existential Threat of Climate Change: How Should We Respond"* IEEE CalCon, December, 10, 2022, Kolkata, India

Walid Saad | *In 2022, Walid Saad gave five keynotes addresses in five countries spanning the topics of 6G, AI for wireless networks, Metaverse, digital twins, and urban air mobility including the following:*

- *"Learning and Communications for Urban Air Mobility (UAM)"* | Wireless World Research Forum (WWRF), Abu Dhabi, UAE
- *"Towards a Wireless Metaverse: Synchronized Digital Twins and Connected Virtual Worlds"* | Workshop, IEEE Vehicular Technology Conference, September 2022, London, UK *(virtual)*
- *"Towards AI-Native Wireless 6G System"* | Workshop, IEEE Vehicular Technology Conference, June 2022, Helsinki, Finland
- *"Learning and Communications for Urban Air Mobility (UAM)"* | Workshop, IEEE International Conference on Communications (ICC), May 2022, Seoul, South Korea
- Distinguished Speaker at the ECE Department, Northeastern University

Short Courses & Lecture Series

Harpreet Dhillon | Delivered a week-long short course on "Application of Machine Learning to Wireless Communication" during an Indo-US event organized by Indian Institute of Technology (IIT) Bhubaneswar as a part of the joint SPARC project between Virginia Tech and IIT Bhubaneswar.

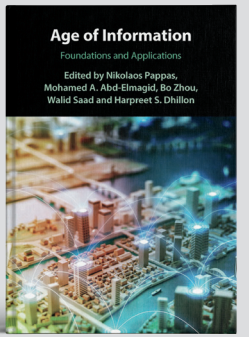
T.-C. Poon | *Lecture Series in Wave Optics and Holography* Nanjing University of Science and Technology/Kunming University of Science and Technology, December, 2022, China

Publications

Age of Information: Foundations and Applications

N. Pappas, M. A. Abd-Elmagid, B. Zhou, W. Saad, H. S. Dhillon

Cambridge University Press, Feb. 2023



Conference Chairs

Luiz DaSilva | *General Chair* | IEEE Military Communications Conference (MILCOM), 2023

Harpreet Dhillon | *Technical Program Committee Co-Chair* | IEEE Wireless Communications and Networking Conference (IEEE WCNC), 2022, Austin, TX

Harpreet Dhillon | *Workshop Co-Chair* | DroneCom: 5th International Workshop on Drone Assisted Wireless Communications for 5G and Beyond, ACM MobiCom, October 2022, Sydney, Australia

Harpreet Dhillon | *Workshop Co-Chair* | BlockSecSDN: Blockchain for Secure Software-Defined Networking in Smart Communities, IEEE International Conference on Communications, May 2022, Seoul, South Korea

Tom Hou | *Executive Chair* | IEEE INFOCOM 2022 ***(virtual)***, *Co-Chair* | IEEE MILCOM Workshop on Fundamental Advances in Information Latency, November 28, 2022, Rockville, MD

T.-C. Poon | *General Chair* | 2Optica Annual Meeting Frontiers in Optics (FiO) Conference, October 2022, Rochester, NY

Haining Wang | *General Co-Chair* | The Tenth Annual IEEE Conference on Communications and Network Security (IEEE CNS), 2022

Paper Reviews & Awards

Dong Dong, Rolando Burgos, and students Lakshmi Ravi, Xingchen Zhao | Won IEEE IAS Transportation Systems Prize Paper Award, IEEE Industry Application Society (IAS) for their paper "Electrical Insulation Design and Qualification of a SiC-Based Generator-Rectifier Unit for High-Altitude Operation," IEEE Energy Conversion Congress and Exposition (ECCE), *2021.*

M. Kim, W. Saad, M. Mozaffari, and M. Debbah | Received the IEEE ICC 2022 Best Paper Award and the IEEE Communications Society's Transmission, Access, and Optical Systems (TAOS) Technical Committee Best Paper Award, "On the Tradeoff Between Energy, Precision, and Accuracy in Federated Quantized Neural Networks," IEEE International Conference on Communications (ICC), Green Communication Systems and Networks Symposium, *Seoul, South Korea, May 2022.*

Walid Saad, Mehdi Bennis and Mingzhe Chen | Received the prestigious IEEE Communications Society Fred W. Ellersick Prize 2022 for their paper, "A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems" IEEE Network, *vol. 34, no. 3, pp. 134 -142, May 2020.*

Yuhao Zhang | Recently published a review on the field of power semiconductors and power electronics in *Nature Electronics* in collaboration with faculty from the University of Cambridge and the University of Southern California.

Editorial Roles in Scholarly Journals

Luiz DaSilva | *Associate Editor,* IEEE Transactions on Wireless Communications

Harpreet Dhillon | *Executive Editorial Committee Member,* IEEE Transactions on Wireless Communications; *Senior Editor,* IEEE Wireless Communications Letters; *Editor,* IEEE Transactions on Green Communications and Networking; *Guest Editor,* IEEE Journal on Selected Areas in Communications; *Guest Editor,* IEEE Wireless Communications Magazine; *Guest Editor,* IEEE Network Magazine

Christina DiMarino | *Associate Editor,* IEEE Transactions on Power Electronics

Dong Dong | *Associate Editor,* IEEE Transactions on Power Electronics

Tom Hou | *Editor at Large,* IEEE Transactions on Network Science and Engineering; *Associate Editor,* ACM Transactions on Sensor Networks

Ming Jin | *Associate Editor,* IEEE Systems Journal

Ali Mehrizi-Sani | *Associate Editor,* IEEE Transactions on Energy Conversion; *Associate Editor,* IEEE Power Engineering Letters; *Editor,* IET Generation, Transmission & Distribution

T.-C. Poon | *Editor,* Applied Sciences; Specialty Chief Editor, Frontiers in Photonics

Jeff Reed | *IEEE Press Editorial Board Member,* Wiley

Walid Saad | *Inaugural Editor-in-Chief,* IEEE Transactions on Machine Learning in Communications and Networking; *Area Editor,* IEEE Transactions on Communications

Ph.D. Degrees Awarded | 2021-2022

Musaed Alrashidi

A Coordinated Voltage Management Method Utilizing Battery Energy Storage Systems and Smart PV Inverters in Distribution Networks with High PV and Wind Penetration

Committee Chair | Saifur Rahman

Xiaoxin An

On Reducing the Trusted Computing Base in Binary Verification

Committee Chair | Binoy Ravindran

Morteza Banagar

Drone Cellular Networks: Fundamentals, Modeling, and Analysis

Committee Chair | Harpreet Singh Dhillon

Shuchismita Biswas

Power Grid Partitioning and Monitoring Methods for Improving Resilience

Committee Chair | Virgilio A. Centeno

Hao-Hsuan Chang

Deep Reinforcement Learning for Next Generation Wireless Networks With Echo State Networks

Committee Chair | Lingjia Liu

Yongce Chen

Modeling, Analysis, and Real-Time Design for Many-Antenna MIMO Networks

Committee Chair | Yiwei Thomas Hou

Biplav Choudhury

Information Freshness: How to Achieve it and its Impact on Low-Latency Autonomous Systems

Committee Chair | Jeffrey H. Reed

Ho-Ren Chuang

On Optimizing and Leveraging Distributed Shared Memory for High-Performance, Resource Aggregation and Cache-Coherent Heterogeneous-ISA Processors

Committee Chair | Binoy Ravindran

Avik Dayal

Practical Algorithms and Analysis for Next-Generation Decentralized Vehicular Networks

Committee Chair | Jeffrey H. Reed

Gokcen Yilmaz Dayanikli

Electromagnetic Interference Attacks on Cyber-Physical Systems: Theory, Demonstration, and Defense

Committee Chair | Ryan M. Gerdes

Jaya Kartheek Devineni

Ambient Backscatter Communication Systems: Design, Signal Detection, and Bit Error Rate Analysis

Committee Chair | Harpreet Singh Dhillon

Justin Fishbone

Highly Robust and Efficient Estimators of Multivariate Location and Covariance With Applications to Array Processing and Financial Portfolio Optimization

Committee Chair | Lamine M. Mili

Mahsa Foruhandeh

Security Solutions for Cyber Physical Systems

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Chen Gao

Learning Consistent Visual Synthesis

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Ashraful Haque

A Deep Learning-Based Dynamic Demand Response Framework

Committee Chair | Saifur Rahman

John Hodge, II

Reconfigurable Intelligent Metasurfaces for Wireless Communication and Sensing Applications

Committee Chair | Amir I. Zaghloul

Ali Hosseini Fahraji

New Way of Generating Electromagnetic Waves Using Permanent Magnet

Committee Chair | Majid Manteghi

Jiewen Hu

Integration Challenges in High-Power-Density Wide-Bandgap-Based Circuits for Transportation Applications

Committee Chair | Rolando Burgos

Ye Hu

Game Theory and Meta Learning for Optimization of Integrated Satellite-Drone-Terrestrial-Communication Systems

Committee Chair | Walid Saad

Jorge Jimenez

Advances in the Use of Finite-Set Statistics for Multitarget Tracking

Committee Chair | Daniel J. Stilwell

Georgios Kontoudis

Communication-Aware, Scalable Gaussian Processes for Decentralized Exploration

Committee Chair | Daniel J. Stilwell

Joseph Kozak

Hard-Switched Robustness of Wide-Bandgap Power-Semiconductor Devices

Committee Chair | Yuhao Zhang

Xiaolong Li

3D Deep Learning for Object-Centric Geometric Perception

Committee Chair | Amos L. Abbott

Yousi Lin

Spectrum Management Issues in Centralized and Decentralized Dynamic Spectrum Access

Committee Chair | Yaling Yang

Fariborz Lohrabi Pour

High-Performance RF Circuit Design: High-Temperature, Ultra-Low Phase Noise, and Low Complexity

Committee Chair | Dong S. Ha

Shengchang Lu

Packaging of Enhancement-Mode Gallium Nitride High-Electron-Mobility Transistors for High-Power-Density Applications

Committee Chair | Guo Quan Lu

Alfred Mayalu, Jr

Beyond LiDAR for Unmanned Aerial Event-Based Localization in GPS Denied Environments

Committee Chair | Kevin Bruce Kochersberger

Tanmaya Mishra

Defending Real-Time Systems Through Timing-Aware Designs

Committee Chair | Thidapat Chantem

Slavko Mocevic

Enhanced Gate-Driver Techniques and SiC-Based Power-Cell Design and Assessment for Medium-Voltage Applications

Committee Chair | Dushan Boroyevich

Wonil Nam

Bio-Interfaced Nanolaminate Surface-Enhanced Raman Spectroscopy Substrates

Committee Chair | Wei Zhou

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Remote Sensing of the Lower Atmosphere: From Surface Concentration to Mixing Layer Height

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Predictable Connected Traffic Infrastructure

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Stochastic Geometry Perspective of Massive MIMO Systems

Committee Chair | Harpreet Singh Dhillon

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Investigation of Bragg Gratings in Few-Mode Fibers with a Femtosecond Laser Point-by-Point Technique

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Partial Discharges: Experimental Investigation, Model Development and Data Analytics

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Seied Ali Safiabadi Tali

Multiresonant Plasmonics With Spatial Mode Overlap

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Archanaa Santhana Krishnan

Top-Down Approach to Securing Intermittent Embedded Systems

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Link Stability Analysis of Wireless Sensor Networks Over the Ocean Surface

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Unmanned Aerial Vehicles and Edge Computing in Wireless Networks

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Optimization, Learning, and Control for Energy Networks

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Sayedsina Taheri Hosseinabadi

Fast and Scalable Power System Learning, Analysis, and Planning

Committee Chair | Vasileios Kekatos

Ali Taleb Zadeh Kasgari

Reliable Low-Latency Machine Learning for Resource Management in Wireless Networks

Committee Chair | Walid Saad

Jaber Valinejad

Measuring and Enhancing the Resilience of Interdependent Power Systems, Emergency Services, and Social Communities

Committee Chair | Lamine M. Mili

Le Wang

Power Converters for Piezoelectric and Pyroelectric Materials

Committee Chair | Rolando Burgos

Remy Wehbe

Probabilistic Topologies With Applications in Security and Resilience of Multi-Robot Systems

Committee Chair | Ryan K. Williams

Hao Wen

High-Efficiency and High-Frequency Resonant Converter Based Single-Stage Soft-Switching Isolated Inverter Design and Optimization With Gallium-Nitride (GaN)

Committee Chair | Jih S. Lai

Yang Xiao

Blockchain and Distributed Consensus: From Security Analysis to Novel Applications

Committee Chair | Wenjing Lou

Yuan Yao

Towards Comprehensive Side-Channel Resistant Embedded Systems

Committee Chair | Patrick Robert Schaumont

Jianghui Yu

High-Frequency Design Consideration and EMI Mitigation in SiC-Based Multilevel Converters

Committee Chair | Rolando Burgos

Tengchan Zeng

Joint Communication, Control, and Learning for Connected and Autonomous Vehicles

Committee Chair | Walid Saad

Zhou Zhou

Machine Learning-Based Receiver in Multiple Input Multiple Output Communications Systems

Committee Chair | Lingjia Liu

Yuliang Zou

Label-Efficient Visual Understanding With Consistency Constraint

Committee Chair | Jia-Bin Huang

Corporate & Industrial Affiliates

CPES Industry Consortium Members | 2022

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NXP Semiconductors
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Windstream

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AI Squared

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Norfolk Southern

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University of Georgia

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UT-Arlington

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VP
Microsoft

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ECE Department Head
Virginia Tech

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Chief Technology Officer
ATF

Stephanie Palermo
BSStat, MSStat
Vice President, Head of Executive Compensation and Talent Management
Capital One

Raymond Sharp
BSEE '02, MSEE '03
Director of Programs
Northop Gruman

Christine Whiteside
BSEE '17
Microprocessor Yield Engineering & Characterization
IBM

Members of the ECE advisory board were officially inducted into the Heta Lambda Beta Society at the Spring 2022 IAB Meeting.


Latham Ballroom B
C220
VIRGINIA TECH

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Illinois '90

Masoud Agah
Virginia Microelectronics Consortium (VMEC) Professor
Michigan '05

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Cornell '04

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Colorado '95

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MIT '11

Ming Jin
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Berkeley '17

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Vassilios Kovanis
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Changwoo Min
Assistant Professor
Sungkyunkwan '14

Leyla Nazhandali
Professor
Michigan '06

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Caltech '84

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Harvard '19

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Maryland '08

Angelos Stavrou
Professor
Columbia '07

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Professor
Johns Hopkins '99

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Toledo '96

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M.S. Virginia Tech '00

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Jeff Walling
Associate Professor
Washington '08

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Dalian '90

Haining Wang
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Michigan '03

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Maryland '95

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Assistant Professor
Southern California '14

Christopher L. Wyatt
Associate Professor
Wake Forest School of Medicine '02

Wenjie Xiong
Assistant Professor
Yale '20

Yong Xu
Professor
Caltech '01

Jason J. Xuan
Professor
Maryland '97

Yaling Yang
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