2017

# Electrical and Computer Engineering Annual Report 2017

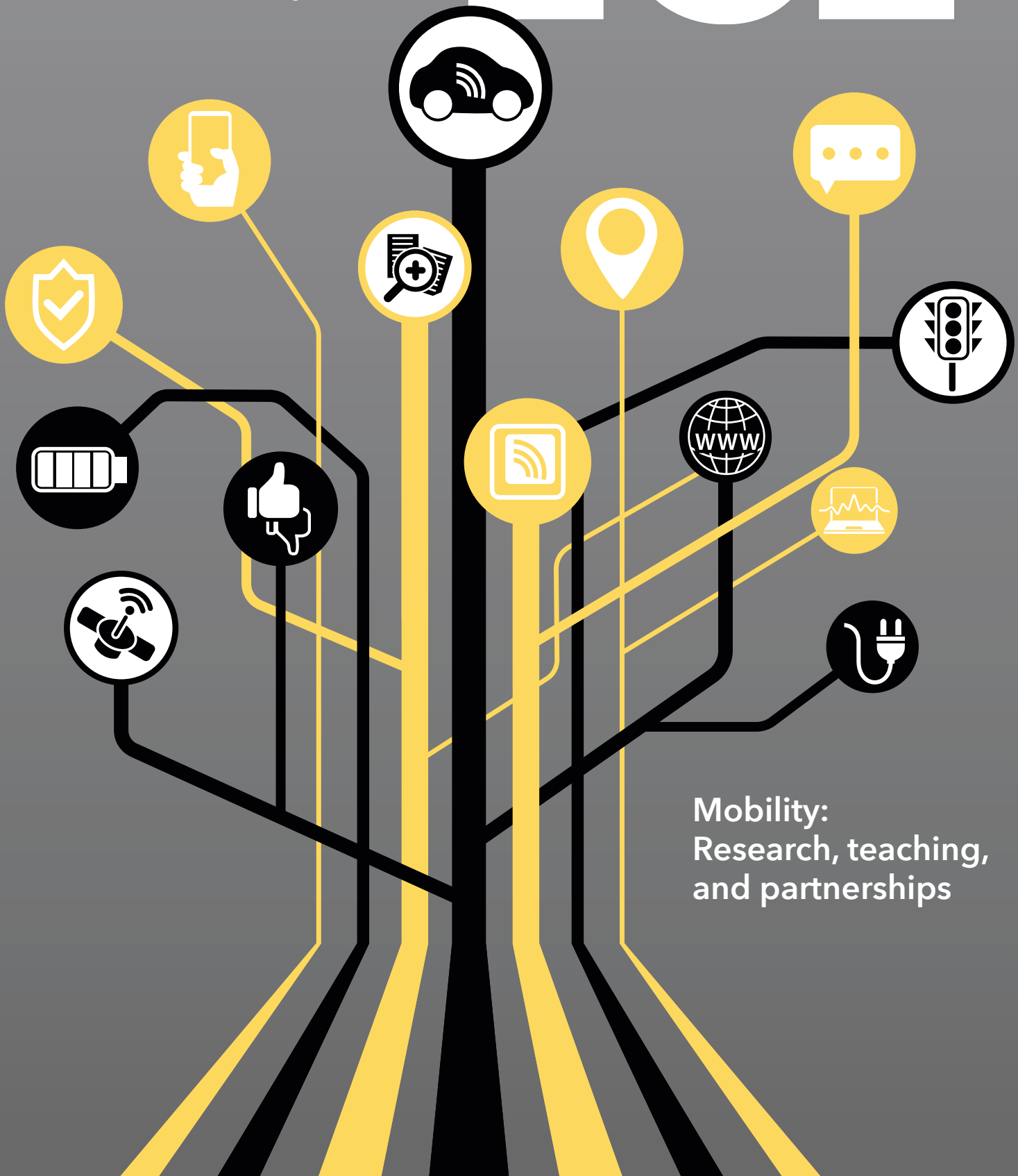
Department of Electrical and Computer Engineering, Michigan Technological University

Michigan Technological University

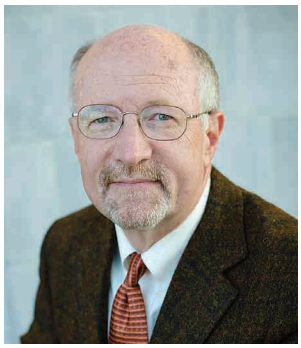
Electrical and Computer Engineering

# ECE

## Annual Report 2017




**Mobility: Research, teaching, and partnerships**



Greetings to all from Houghton, Michigan, and the Department of Electrical and Computer Engineering at Michigan Tech!

It is my pleasure to bring to you our 2017 Annual Report, which covers activity in the ECE Department for the 2017 fiscal year, running from July 1, 2016 to June 30, 2017. This has been a tumultuous time across the country, but in our corner of the world we continue to press forward in pursuit of excellence in teaching and research in electrical and computer engineering—doing what we can, in our own way, to make the world a better place. Technological advances are happening at a rapid pace, faster than ever before in human history, and we need to be there to shape the research agenda and prepare our students for the 21st century.

Everything we do is the result of the hard work of our faculty, and I am pleased to report that the faculty, especially our younger faculty, are having considerable success in their career development. Three of our assistant professors received major early career awards: Lucia Gauchia and Zhaohui Wang are recipients of the National Science Foundation CAREER awards, which are five-year awards given to the best and brightest faculty members in the country while they are still on the tenure track. Jeremy Bos is the recipient of an equivalent early career award from the US Air Force Young Investigator Program. Meanwhile, Sumit Paudyal is proving to be one of the most valuable faculty members in the Department through his large courses in power system optimization and control, his outstanding student course evaluations, and his growing externally funded research program.

The Department has been hard at work developing our capabilities in the areas of robotics, control, and automation. I see this as a strategic growth area for the Department and also for our obligations to the state of Michigan. This is closely related to what we are doing in mobility, which is the new term for everything related to movement of people, information, and things. Mobility is the theme of the research section of the report this year, and I have more to say about it elsewhere.

In May of this year we celebrated a nice milestone, with the 50th anniversary of the first female graduate of the Michigan Tech EE department, Pat Anthony. We invited Pat back to campus, included her in all the commencement activity, and inducted her into the ECE Academy. It was a wonderful moment.

Throughout the nine years I have been at Michigan Tech, I have been blessed to have an extraordinarily capable and hardworking business manager and technical communications specialist, Lisa Hitch. Lisa keeps the finances, personnel issues, and communications in the Department running smoothly, and she has been an invaluable personal assistant to me in day-to-day administrative duties. I don't know what I would do without her. In this issue, we make up for a lot of lost time as we feature Lisa in our staff profile.

As always, I welcome feedback about what we are doing in the ECE Department. If you see something you like, or something we could be doing better, just let me know.

Daniel R. Fuhrmann
Dave House Professor and Chair
Department of Electrical and Computer Engineering
fuhrmann@mtu.edu



# Early Career Awards

**Lucia Gauchia**

Lucia Gauchia received a five-year, $500,000 NSF CAREER Award to conduct research in how ecological systems can inspire better battery design and scalability. Gauchia, the Richard and Elizabeth Henes Assistant Professor of Energy Storage, who holds a joint appointment in ECE and Mechanical Engineering-Engineering Mechanics, studies what is called a battery's second life—when it is repurposed for a new use after it has been drained.

According to Gauchia, testing a battery is like studying a fish in a pond. "In engineering, we take the fish out of the pond and expect to be able to tell how it's going to live in the pond; ecologists do not extract their subjects from their environment."

Gauchia plans to test a number of batteries in first- and second-life stages under a variety of conditions. She will then use Bayesian networks to inform ecology-based methods to discern patterns in the data; with those patterns, she can do cross-level testing to see what holds true from batteries to packs to modules. The analyses should help better predict when a battery might fail in any of its life stages, which could lead to improved energy storage and longer battery life.

**Zhaohui Wang**

Zhaohui Wang, an assistant professor of electrical and computer engineering, received an NSF CAREER Award to improve underwater acoustics networks to maximize information delivery.

A major challenge in any communication system is getting a signal from a transmitting node to a receiving node. "For communications, what really matters is the signal-power-to-noise-power ratio," Wang says, explaining that maximizing the ratio underwater depends on two other factors.

First, bodies of water are not serene or static; they're landscapes rich with sound. The ambient soundscapes of the ocean floor or Lake Superior are full of background noise, which can interfere with an acoustic signal, or a signal can interfere with natural sound, such as whale whistles. Also, underwater environments change seasonally, daily or even hourly, which can also alter a signal's strength by the time it reaches the receiver.

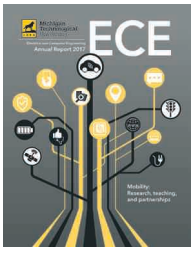
Wang's goal is not only to improve node-to-node communication but to create an adaptive network that learns its underwater environment.

**Jeremy Bos**

Jeremy Bos is a 2016 recipient of a Young Investigator Program (YIP) Award through the Air Force Office of Scientific Research (AFOSR). Bos, an assistant professor of electrical engineering who studies atmospheric optics, will use this three-year grant to piece together images affected by anisoplanatism– when parts of an image are extremely distorted–over long distances.

“Receiving the YIP award is a great honor and underscores the importance of basic imaging research in the area of extreme anisoplanatism,” Bos says. "The objective is to see better and farther." His work will also improve long-range optical communication systems and "defend against threats using laser light."

The YIP is open to scientists and engineers at research institutions across the US who received PhD or equivalent degrees in the last five years and who show exceptional ability and promise for conducting basic research. In 2016, AFOSR received more than 230 proposals for the prestigious award.




*Cover: ECE faculty and students work to solve current and future challenges in the broad area of mobility.*



# Faculty Directory

**Ashok Ambardar**
Associate Professor
PhD, Electrical Engineering, University of Wyoming
Signal processing, medical imaging

**Glen Archer**
Principal Lecturer/Associate Chair
PhD, Electrical Engineering, Michigan Technological University
Image processing, security, information operations

**Paul Bergstrom**
Professor
PhD, Electrical Engineering, University of Michigan
MEMS, nanotechnology

**Leonard Bohmann**
Professor/Associate Dean, College of Engineering
PhD, Electrical Engineering, University of Wisconsin
Power systems, renewable energy

**Jeremy Bos**
Assistant Professor
PhD, Electrical Engineering, Michigan Technological University
Atmosphere optics, image processing, machine intelligence

**Duane Bucheger**
Professor of Practice/Senior Design Coordinator
PhD, Sensing and Signal Processing,
Michigan Technological University
Signal processing, power electronics

**Jeffrey Burl**
Associate Professor
PhD, Electrical Engineering, University of California–Irvine
Adaptive control, robust control, image motion estimation

**Bo Chen**
Dave House Associate Professor of Mechanical Engineering and Electrical Engineering
PhD, Mechanical and Aeronautical Engineering, University of California–Davis
Intelligent mechatronics, embedded systems

**Christopher (Kit) Cischke**
Senior Lecturer
MS, Computer Engineering, University of Minnesota
Parallel computing and UPC

**Zhuo Feng**
Associate Professor
PhD, Computer Engineering, Texas A&M University
VLSI computer-aided design, multiphysics modeling and simulation

**Daniel R. Fuhrmann**
Dave House Professor and Chair
PhD, Electrical Engineering and Computer Science,
Princeton University
Statistical signal and image processing

**Lucia Gauchia**
Richard and Elizabeth Henes Assistant Professor of Energy Storage Systems
PhD, Electrical, Electronic, and Automation Engineering, University of Carlos III of Madrid, Spain
Energy storage systems, state estimation for batteries and supercapacitors

**Durdu Guney**
Associate Professor
PhD, Electrical and Computer Engineering, University of California—San Diego
Metamaterials and plasmonics, quantum computing, communications and cryptography

**Timothy Havens**
William and Gloria Jackson Associate Professor
PhD, Electrical and Computer Engineering, University of Missouri
Pattern recognition and machine learning, signal and image processing

**Shiyan Hu**
Associate Professor
PhD, Computer Engineering, Texas A&M University
Computer-aided design of VLSI circuits and combinatorial optimizations

**Roger Kieckhafer**
Associate Professor
PhD, Electrical Engineering, Cornell University
Computer architecture, fault-tolerant computing

**John Lukowski**
Associate Professor
Chair, Undergraduate Programs Committee
MS, Electrical Engineering, Michigan Technological University
Power, energy, factory automation, robotics

**Christopher Middlebrook**
Associate Professor
PhD, Optics, University of Central Florida
Infrared detectors, optics, photonics, radiometry

**Bruce Mork**
Dennis Wiitanen Professor of Electric Power Systems
PhD, Electrical Engineering, North Dakota State University
Power system transients (ATP/EMTP), nonlinear dynamics and chaos theory, power system protection

**Saeid Nooshabadi**
Professor
PhD, Integrated Circuits (VLSI), Indian Institute of Technology Delhi
High-performance computer architecture, embedded systems

**Aurenice Oliveira**
Associate Professor
PhD, Electrical Engineering, University of Maryland, Baltimore County
Optical fiber communications, automation, wireless communication

**Sumit Paudyal**
Assistant Professor
PhD, Electrical Engineering, University of Waterloo, Canada
Smart-grid technologies, optimization techniques in power systems

**Joshua Pearce**
Professor
PhD, Materials (Engineering option), The Pennsylvania State University
Photovoltaic materials and devices, energy system analysis and policy, 3-D printing and additive manufacturing

**Warren Perger**
Professor
PhD, Physics, Colorado State University
Theoretical atomic physics, electrophysics

**Michael Roggemann**
Professor
Chair, Graduate Program Committee
PhD, Electro-Optics, Air Force Institute of Technology
Optics, image reconstruction and processing, pattern recognition

**Timothy Schulz**
Professor
DSc, Electrical Engineering, Washington University in St. Louis
Statistical signal processing, computational photography

**Elena Semouchkina**
Associate Professor
PhD, Materials (Engineering option), The Pennsylvania State University
Electromagnetic metamaterials, computational electromagnetic analysis

**Min Song**
Dave House Professor and Chair, Department of Computer Science
Director, Institute of Computing and Cybersystems
PhD, Computer Science, The University of Toledo
Wireless networks and wireless sensor networks, computer security, mobile computing

**Chee-Wooi Ten**
Associate Professor
PhD, Electrical Engineering, University College Dublin
Power infrastructure cybersecurity, future control center framework, SCADA/EMS/DMS applications

**Zhaohui Wang**
Assistant Professor
PhD, Electrical and Computer Engineering, University of Connecticut
Communications, signal processing, communication networks, and network security

**Wayne Weaver**
Dave House Associate Professor of Electrical Engineering
PhD, Electrical Engineering, University of Illinois at Urbana-Champaign
Power electronics systems, microgrids, hybrid and electric vehicles

**Seyed (Reza) Zekavat**
Professor
PhD, Communication, Colorado State University
Wireless localization systems, wireless power transfer, statistical signal processing

# Faculty Highlights


**Joshua Pearce** was promoted from associate professor with tenure to professor with tenure. The ECE Department congratulates Professor Pearce on this accomplishment and on all his achievements in research and teaching.

## Awards

**Glen Archer** received the 2017 Jackson Center for Teaching and Learning Award for Large Class Teaching.

**Duane Bucheger** was honored as Professor of the Year by the Michigan Tech Chapter of Eta Kappa Nu (HKN), the student honor society of IEEE.

**Jeff Burl** was awarded an Erskine Fellowship to teach spring semester 2017 at the University of Canterbury, Christchurch, New Zealand.

**Lucia Gauchia** was promoted to IEEE senior member.

**Saeid Nooshabadi** received the Royal Society International Exchange Award for collaboration between the University of Newcastle and Michigan Technological University.

## Professional Service

**Glen Archer** was appointed to serve as an Accreditation Board for Engineering and Technology (ABET) Engineering Accreditation Commission (EAC) evaluator.

**Leonard Bohmann** is the Treasurer of the IEEE Education Society and serves on the board of governors. He is a member of ABET EAC and serves as a team chair on accreditation visits. He serves on the Finance Committee of the Women in Engineering ProActive Network (WEPAN) and is the faculty advisor for Michigan Tech's chapter of the engineering honor society, Tau Beta Pi.

**Jeremy Bos** was reappointed SPIE Scholarship Committee chair for 2018 and serves as a conference chair for Laser Propagation through Atmospheres and Oceans. Bos serves as an associate editor for *Applied Optics*.

**Bo Chen** serves as associate editor of the *IEEE Transactions on Intelligent Transportation Systems*.

**Durdu Guney** serves on the editorial board of *Nanotechnology* as associate editor for *Nanodevices*.

**Tim Havens** serves as associate editor of *IEEE Transactions on Fuzzy Systems*, was appointed executive director of Michigan Tech's Data Science Program, and serves on the Technical Program Committee for IEEE International Conference on Fuzzy Systems.

**Bruce Mork** serves as the IEEE Working Group (WG) chair on Ferroresonance, the IEEE WG chair for Power Globe, and is a member of the Scientific Advisory Board for the Norwegian Smart Grid Center.

**Saeid Nooshabadi** presented a full-day tutorial in flagship International Symposium on Circuits and Systems 2017 in Baltimore, Maryland, on the topic circuits and systems on machine learning. He also presented a full-day tutorial in the Canadian Conference in Electrical and Computer Engineering 2017 on the topic circuits and systems on statistical data processing.

**Aurenice Oliveira** was appointed to serve as an ABET EAC evaluator. Oliveira has also joined the Pavlis Honors College leadership program as faculty site coordinator for a new project site in Brazil.

**Sumit Paudyal** serves on the Customer Systems Committee for the IEEE Power & Energy Society Smart Buildings – Loads.

**Chee-Wooi Ten** is a member of the editorial boards for the *IEEE Transactions on Smart Grids* and *Sustainable Energy, Grids, and Networks* (SEGAN).

**Reza Zekavat** served as workshop chair on Space Solar Power for the IEEE WiSEE Conference 2017. He also served as a steering committee member for IEEE ISMICT 2016, and serves on the editorial board of the Springer International *Journal on Wireless Information Networks* and GSTF *Journal on Mobile Communications, Networking and Applications*.

# Mobility at Michigan Tech

When the University was founded in 1885, the internal combustion engine was still in its early stages of development. Tech's founding legislation included the mandate to "seek to promote the welfare of the industries of the state." The University has played a vital role in the growth of the Michigan automotive industry. The two entities have shaped each other over the years, and much of Michigan Tech's current organization, and success, can be traced to that relationship.

It should come as no surprise, then, that as the automotive industry undergoes major disruptive changes, and the state of Michigan seeks to remain front and center, Michigan Tech will continue to play an important role. The very term "automotive industry" is falling by the wayside today, in favor of the broader, more inclusive term *mobility*.

Mobility refers to all products, services, and infrastructure that are designed to move people, information, and things from one place to another. While the automobile as a manufactured product remains an important component in this mix, the way we view transportation and automobile ownership and use are rapidly changing, and a host of new technologies are driving that transformation.

The "electrical content" in automobiles has increased rapidly during the past few decades, first with the advent of microprocessors for electronic control of a variety of automotive subsystems, and then in the drivetrain itself with the introduction of hybrid electric and all-electric vehicles. The electrical content has created a demand for more electrical engineers in the workforce and many ECE graduates are a part of that. More recently, the "computing content" of automobiles has taken a quantum leap forward with research and development in autonomous vehicles. The idea of self-driving cars has captured the imagination of automotive manufacturers, information technology companies, and universities, and Michigan Tech is no exception.

The idea of the automobile as the centerpiece of our transportation needs is also challenged by new technologies. Ride-hailing services like Uber and Lyft reduce our dependence on owned or rented vehicles, and keep many cars out of the garage, where they are least useful. Vehicle-to-vehicle and vehicle-to-infrastructure communication hold the promise of greater efficiency and safety in congested areas. Autonomous vehicles create a shift in our thinking about urban planning, as cars no longer need to be parked close to the humans that use them. Multimodal transportation, including walking, bicycles, automobiles, buses, and other forms of mass transit can be seamlessly integrated using modern information technology.

With technological development happening so quickly, we at Michigan Tech believe it is valuable to explore what we are doing in the mobility space across campus, and to promote both the collaborations among ourselves and the visibility of the University as a partner to the state of Michigan. In April 2017, we held a Mobility Summit, a half-day event that brought everyone together. The ECE Department played a big part in that event. We have nine faculty members, or a third of the Department, working on mobility-related issues. As the theme of this year's annual report, we hope you will find within these pages challenges to your own thinking about cars, transportation, and electrical and computer engineering.

– Daniel R. Fuhrmann

# Taking Autonomous Vehicles Off-Road


**Jeremy Bos**

**Assistant Professor**

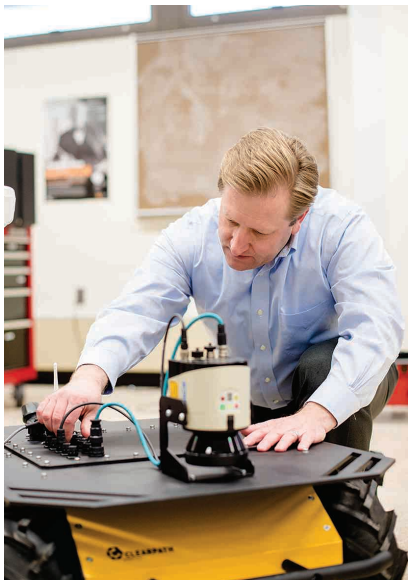
Many people have seen videos of autonomous vehicles roaming around California. But what about in Houghton in the winter? Can autonomous vehicles go off-roading?

Jeremy Bos focuses on operation of autonomous vehicles (AV) in winter weather when road markings are not visible and tire and road conditions are unknown. He is also interested in operation of vehicles in off-road trail environments (sand, mud, snow), as well as leader/follower scenarios in unstructured environments. To that end, Bos is exploring low-cost sensors for use in off-road and severe winter weather.

Bos will be putting his AV research to the test as Michigan Tech is one of eight universities selected to participate in the AutoDrive Challenge sponsored by General Motors and SAE International. As an AutoDrive team lead, Bos' team Prometheus Borealis, a collaboration between ECE, Mechanical Engineering-Engineering Mechanics, and Computer Science, has a goal to reach level SAE 4 Autonomy in closed test environment, which means that a human driver is present but no interaction is required to travel from origin to destination on urban mixed-use environment (pedestrian, bicycles, and automobiles). During year one the team will complete a concept design as well as an on-site evaluation to include straight roadway driving and object avoidance and detection. Year one final competition will be hosted at GM's Desert Proving Ground in Yuma, Arizona in May.

You can follow Prometheus Borealis **@MTUAutoDrive** on Twitter.

Bos serves as advisor to the Robotics Systems Enterprise (RSE). Under his advising, the Clearpath Team maintains the ECE Department's fleet of Autonomous Ground Vehicles (AGVs), creates demonstrations for outreach, and develops training materials for new RSE recruits.



The Remote Operated Vehicle (ROV) Project sponsored by Great Lakes Research Center (GLRC) modifies the current OpenROV platform to be towed behind GLRC research vessels and creates stereo maps of lake bottoms more affordably than commercial solutions.

# Underwater Communications

**Zhaohui Wang**

**Assistant Professor**

From studying marine animals to tactical surveillance to offshore oil and gas drilling, underwater mobile platforms are used for underwater exploration and monitoring in oceans and lakes. Integrated operation of the mobile platforms requires underwater acoustic communication for delivery of data and control messages. However, efficient and reliable acoustic communication has been challenged by the spatial-temporal variation of the ambient soundscape and the variation of the sound propagation loss from one point to another. The variation can be drastic due to changes in the variety of natural, anthropogenic, and biological ambient sound sources, water surface conditions, and the sound speed that is a function of water salinity, temperature, and pressure.

Zhaohui Wang and her students in the Underwater Acoustic Networked Systems (UANS) Lab develop underwater acoustic communication and networking techniques to maximize information delivery among underwater mobile platforms that may distribute over a vast geographical area, and meanwhile maintain harmonious coexistence with other acoustic systems, such as marine mammals.

Funded by NSF, Wang and her students investigate intelligent acoustic communication networks that can proactively adapt to the underwater acoustic environment dynamics. The key to building such a network is using approaches like passive listening—hydrophones that detect changes in the soundscape—along with active probing—using the signal itself to assess the sound transmission loss between nodes—and then using machine learning principles to model and predict underwater dynamics in real time. Doing so helps the design of adaptive and eco-friendly acoustic communication and networking strategies.

Additionally, Wang's research goes under ice. With the northern ice-bound coastal climate of the Upper Peninsula, Wang and her students go out every winter to conduct under-ice acoustic communication experiments on the Keweenaw Waterway to study the under-ice soundscape and the acoustic propagation characteristics. The research outcome and the field experimental datasets will contribute to the Arctic maritime domain awareness.

Teaching and outreach are a natural part of Wang's work and vital to propagating not just sound waves but future research. Along with extensive field experiments in open water or under ice, students in Wang's lab have plenty of opportunities to get their feet wet.

Visit **pages.mtu.edu/~zhaohuiw** to learn more.

# Multi-sensor Fusion on Mobile Platforms

**Timothy Havens**

**William and Gloria Jackson Associate Professor of Computer Systems**

An important goal for many mobile platforms—terrestrial, aquatic, or airborne—is reliable, accurate, and on-time sensing of the world around them. One way that these platforms accomplish this goal is by combining multiple different types of sensors, all of which complement one another to sense the world.

"The idea is to produce a total combined measurement that is better than just the sum of the individual sensors," Havens says.

Havens and the Pattern Recognition and Intelligence Machines Engineering (PRIME) Lab explores the area of sensor-fusion from both a practical, application-focused standpoint, and also from a theoretical learning-theory approach to information fusion.

Havens and his students are investigating multi-sensor fusion for many applications, including explosive hazard detection and infrastructure inspection from terrestrial vehicles and unmanned aerial vehicles (UAVs). An important goal for the US Army is to mitigate the threat of explosive hazards. Havens develops algorithms and signal processing approaches to combine radars, imaging sensors, and LIDAR to detect these threats at a safe distance. On the civilian side, the Michigan Department of Transportation is interested in using UAVs for inspection of roadways, bridges, confined spaces, and for traffic monitoring. Havens has developed a sensor-fused UAV pod that uses LIDAR, video cameras, and inertial sensors to produce accurate 3-D representations of road and bridge surfaces.

The PRIME Lab also focuses on more theoretical aspects of sensor and information fusion. Participants have published several articles on optimizing the fusion of uncertain information from humans and sensors to produce the best, and most informative, outputs.

"The students in the PRIME Lab are doing really exciting, creative work," Havens says. "They continually surprise me with their enthusiasm and innovation."

Visit **icc.mtu.edu/datasciences or mtu.edu/data-science**, or explore **prime.ece.mtu.edu** to learn more.



# Battery Mobility Across Applications

**Lucia Gauchia**

**Richard and Elizabeth Henes Assistant Professor of Energy Storage Systems**

Batteries are engaged in mobility as part of transportation solutions such as vehicles and drones, but also across applications. For example, when electric vehicle batteries reach their end of lives, there remains in them considerable usable capacity. The batteries are extracted from the vehicle, re-assembled in new packs and repurposed in a milder application, giving a second life to these batteries. The success of the mobility between application is three-fold: 1) Identifying the battery aging state, which is challenging as batteries come with different aging stages, technologies, form factors, and locations; 2) Selecting the cells that will configure the second-life battery pack and matching them to an application; and 3) Adaptation of the management system during the battery second life to account for the degraded conditions.

At the Energy Storage Systems and Sustainability Lab (E3S), Gauchia and her students are developing new low-cost, large-scale testing that includes battery mobility stages in their real in-the-field conditions. This will produce a large dataset that will be used to train aging estimation networks. To study real operation conditions, Gauchia and her students are looking at effects of driving and vehicle-to-grid services on battery aging to better understand the aging process batteries experience during their first mobility application. Gauchia and her students are also testing aging dispersion inside a battery pack with the help of MSc students trained through the energy storage course.

Additionally, Gauchia and her students are looking forward to next summer's research experience for underrepresented female students.

This battery mobility research is funded by a 2017 NSF CAREER Award.

Visit **e3s-lab.com** to learn more.

# Agile Electrical Networks

**Wayne Weaver**

**Dave House Associate Professor of Electrical Engineering**

Energy on naval ships and aircraft has traditionally been distributed through mechanical, hydraulic, and electrical systems. But there is a growing demand for highly flexible, reliable, and agile methods to meet the operational needs of newer technologies such as rail guns and electric aircraft launch assist. Therefore, there is a push to convert most power distribution on a ship or aircraft into an electrical energy network.

Wayne Weaver and his students are working on new analysis and control techniques to optimize the electrical energy networks in US Navy ships and US Air Force aircraft.

"These naval and aircraft systems have highly demanding operations in harsh environments and under stressful situations" Weaver says. "It is critical that the electrical network operate reliably and efficiently to let the sailors and the pilots do their jobs safely."

Weaver and his students are modeling the complete energy flows in the system. They incorporate not just the electrical energy distribution, but also the mechanical and thermal aspects of the loads in the modeling and control process.

"Heat is a large factor in the design because not only is there limited cooling available, the heat can also cause drastic changes in how the system operates," Weaver says.

New loads such as lasers and rail guns generate a tremendous amount of heat, and can cause unpredictable and unstable behavior in the electrical system. The controls and algorithms in development by Weaver's research group, and in the Center for Agile and Interconnected Microgrids (AIM), encompass the complete overall picture of energy in the system and not just the electrical power cables.

"The students and faculty in AIM are doing exciting and important work that breaks down many of the traditional walls between disciplines like electrical and mechanical engineering," Weaver says.

Visit **aim.mtu.edu** to learn more.

# Powertrain Control for Connected Vehicles

**Bo Chen**

**Dave House Associate Professor of Mechanical Engineering and Electrical Engineering**

The Laboratory of Intelligent Mechatronics and Embedded Systems (IMES) led by Chen is developing advanced control strategies and optimization algorithms for vehicle powertrain control and Electric Vehicle-Smart Grid integration.

Connected vehicle (CV) technologies are emerging to improve the safety, mobility, and efficiency of transportation systems. Connected vehicles are able to communicate with nearby vehicles and roadway infrastructure through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. Connectivity makes available to on-board vehicle controllers real-time traffic information, road surface conditions, and surrounding vehicle information to achieve predictive vehicle/powertrain control. The US Department of Transportation and Department of Energy have supported the research and development of CV technologies in recent years to demonstrate their benefits in real-world transportation systems.

With funding from the ARPA-E NEXTCAR program, Michigan Tech in collaboration with General Motors is developing and demonstrating the benefit of connected vehicle technologies and powertrain optimization using a fleet of eight 2017 Chevrolet Volts. Chen leads the control thrust of the Michigan Tech NEXTCAR program. A model predictive control system is under development; the system utilizes the information provided by the vehicle connectivity and incorporates vehicle/powertrain dynamics for making the control decisions on vehicle operating mode selection and powertrain energy management. The control system consists of two layers. The upper layer determines optimal vehicle velocity and power trajectory based on speed bounds from real-time traffic simulation, road grade, V2V/V2I data, vehicle/powertrain dynamics, and powertrain physical constraints. Given future velocity trajectory and power demand, the most efficient powertrain control law can be found through the lower layer model predictive controller.

Chen and her students have published a number of papers on connected vehicles and powertrain optimization, optimal energy management of hybrid electric vehicles, driving pattern recognition, impact of electric vehicle charging on the power grid, and the mitigation strategy of this impact.

Visit **me.sites.mtu.edu/chen** to learn more.

# Vehicular Communications and Networking

**Aurenice Oliveira**

**Associate Professor**

Vehicular networking technologies have emerged as critical technologies capable of enabling a variety of applications in the areas of safety, traffic-efficient and eco-friendly transportation, and infotainment. These technologies are expected to reduce vehicle crashes by 80 percent, provide better traffic and travel condition information, and provide convenience services, such as e-parking and toll payment. Through vehicle-to-vehicle (V2V) in-car warnings, drivers will be alerted to imminent crash situations, such as merging trucks, cars in the driver's blind spot, or when a vehicle ahead brakes suddenly. By communicating with vehicle-to-infrastructure (V2I), drivers will be alerted when they are entering a school zone, if workers are on the roadside, and if an upcoming traffic light is about to change. V2V and V2I are also collectively referred as V2X (vehicle-to-anything), including bicycles, cellphones, etc.

Oliveira's current research on vehicular communications and networking includes intra-vehicle communications (CAN, LIN, MOST, FlexRay), inter-vehicle communications (V2V, V2I, V2X), and the interface between the two domains.

Vehicular Ad Hoc Network (VANET) is the supporting network for intelligent transportation services including V2V, V2I, V2X. Despite VANET's many advantages, its main characteristics are quite challenging: Frequent topological changes due to high node (vehicle) mobility, time constraints (latency), low penetration of vehicles in certain areas leading to poor connectivity and performance degradation, and security and user privacy issues.

Oliveira's group working in the Communication Systems and Vehicular Network Technologies (CSVNet) Lab focuses on technologies that will advance the reliability and deployment of connected and autonomous vehicles. Solutions to support VANET and V2X applications are the core of this effort. The performance evaluation of these solutions needs to be tested using state-of-the-art simulation platforms and vehicular testbeds, which are in further development and updated by the CSVNet group. The new cohort of students in the CSVNet Lab is very enthusiastic and looks forward to contributing to the new, intelligent transportation era.

Visit **blogs.mtu.edu/oliveira** to learn more.



# The Evolution of Automotive Control

**Jeff Burl**

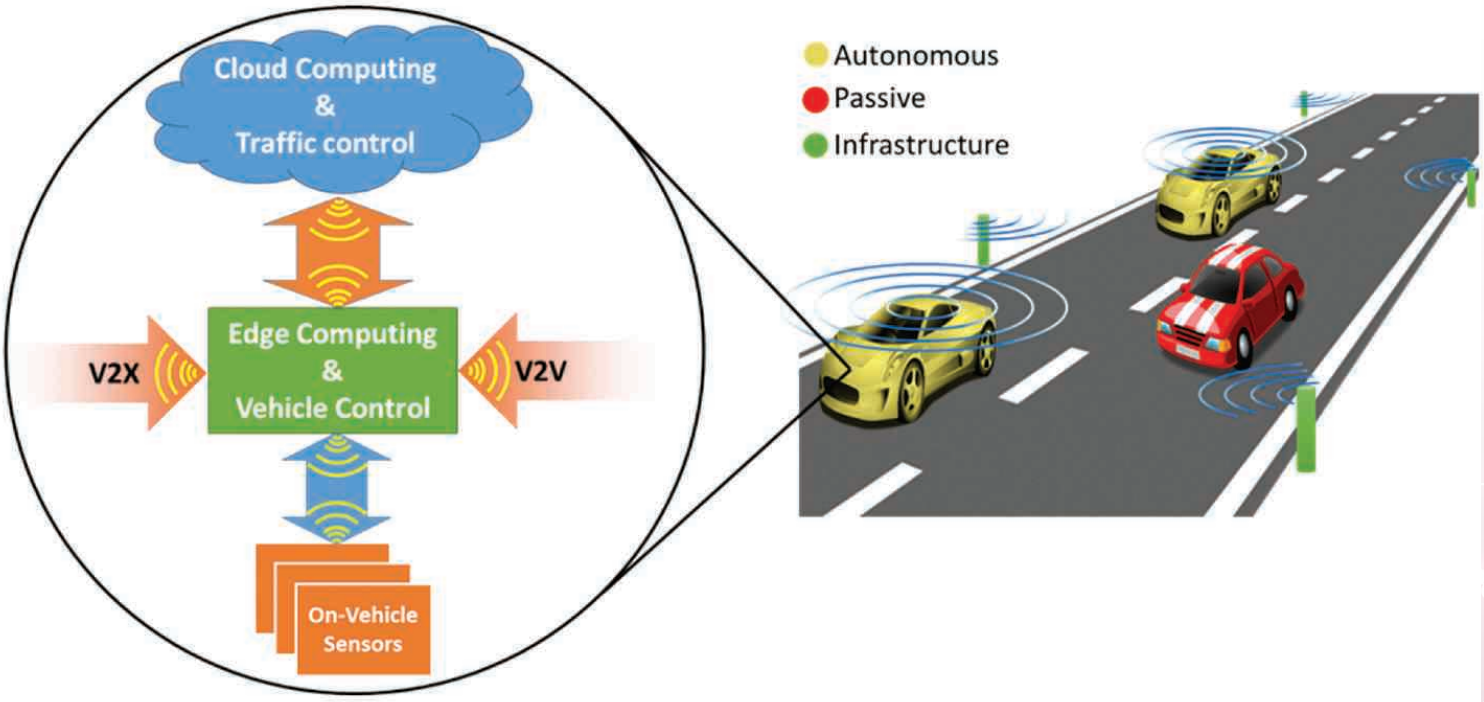
**Associate Professor**

Modern mobile systems employ sensing and control to improve driveability, comfort, efficiency, and decrease emissions. Control systems are critical components of the heating, audio, steering, and fuel systems, the engine, and numerous subsystems. Control of vehicles will become more important in the future as we add autonomous drive.

Burl has recently developed a new graduate class titled "Automotive Control Systems." This course provides students with theory and case studies for a number of automobile control systems including fuel, spark, idle speed, traction, transmission, stability, cruise, and hybrid electric vehicle power split. This course is especially fun because the auto industry has developed a number of specialized tricks over the years. These tricks increase the students' control playbook significantly over what is usually taught at universities. This popular course is offered both on campus and online as part of the new certificate program in Automotive Systems and Control for graduate engineers.

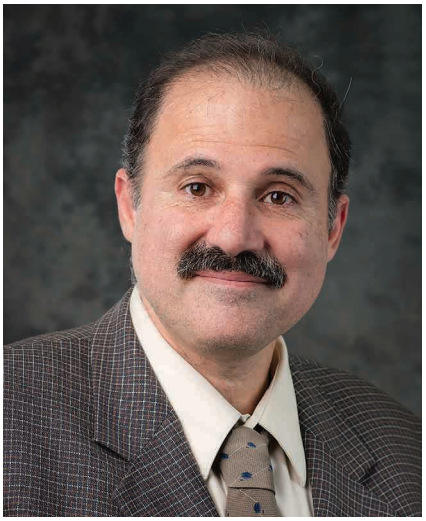
Over the years, Burl has conducted research on a number of automotive control systems. His current research is in the area of power split control for hybrid electric vehicles. Burl and his students have developed a novel adaptive equivalent consumption minimization strategy that is formulated to ensure energy-saving opportunities can be captured when available. An example of this is making sure the battery is not fully charged when an opportunity for regenerative braking occurs. Similarly, another strategy is to make sure battery power is available when the electric motors will keep the engine running in an efficient manner. In addition, modifications to this control system yield a balance between fuel economy and battery life.

Burl expects automotive controls to continue to gain in popularity because of the demand for automotive engineers with control experience.




# Navigation Within a Semi-Autonomous World





**Reza Zekavat**

**Professor**

The Internet of Things (IoT) enables the connection of numerous sensors and devices through Edge and Cloud computing. In our connected world, artificial intelligence and deep learning will incite new waves of technological revolution that modify our homes, highways, work places, communities, and economy. Intelligent and autonomous mobiles such as drones, cars, and tracks that optimally navigate within roads or air are emerging rapidly. These mobiles apply deep-learning processes to the data collected from numerous sensors (within or outside of the mobile) to enable their safe autonomous motion through rigorous control procedures. IoT principles enable sharing raw or processed sensor data across neighboring mobiles. Addressing latency and reliability in processing and communication while maintaining security is key to the proper operation of autonomous mobiles.

We will experience a semi-autonomous world while moving from the current non-autonomous state to a fully autonomous one—a transition period that may take years if not decades. The semi-autonomous world defines stimulating problems for engineers because both non-autonomous and autonomous mobiles will operate within the same environment. On the highways of the future, to minimize the risk of accidents, autonomous vehicles should optimally drive in conjunction with non-autonomous vehicles via control signals received from Cloud or Edge processing units—a procedure that exploits huge volumes of data generated by numerous sensors. As the first step to create control signals, the Cloud should extract the driving behavior of non-autonomous vehicles through deep-learning algorithms. Here, exploiting the variety of data reduction and data analytics to support low-latency deep learning becomes critical.

Zekavat and his students at the Wireless Local Positioning System Lab are working closely with Ford Research Labs to investigate latency and reliability problems associated with the implementation of autonomous driving within a semi-autonomous world. Location-based data reduction, sensor-to-Edge, and Edge-to-Cloud communication, and data-propelled driving behavior assessment through deep learning are examples of the problems that the Wireless Lab team is tackling to move the implementation of autonomous mobiles in a semi-autonomous world one step closer to reality.

Visit **www.ece.mtu.edu/ee/faculty/rezaz** to learn more.

# Faculty Publications

## Books

A. Kwasinski, **W. Weaver**, and R. Balog, *Microgrids and Other Local Area Power and Energy Systems*, Cambridge University Press, July 2016.

## Book Chapters

**T. Havens**, D. Anderson, K. Stone, J. Becker, and **A. Pinar**, "Computational Intelligence Methods in Forward-Looking Explosive Hazard Detection," Chapter 1 in *Recent Advances in Computational Intelligence in Defense and Security*, pp. 13-44, Springer International Publishing, 2016.

**C. Kendrick** and Joan Redwing, "Silicon Micro/Nanowire Solar Cells," Chapter 6 in *Semiconductor Nanowires II: Properties and Applications*, vol. 94 of Semiconductors and Semimetals, pp. 185-225, Elsevier, 2016.

## Journal Articles and Selected Conference Publications

M. Savaikar, **P. Bergstrom**, and J. Jaszczak, "Physical mechanisms leading to the Coulomb blockade and Coulomb staircase structures in strongly coupled multi-Island single-electron devices," *J. Solid State Science and Technology*, vol. 5, no. 7, pp. 131607, May 2016.

J. Ramamurthy and **L. Bohmann**, "Wind plant interaction in a 345-kV series-compensated power system—electromagnetic transient program modeling and event analysis," *Electric Power Components and Systems*, vol. 44, no. 15, pp. 1745-1756, August 2016.

**J. Bos**, V.S. Gudimetla, and J. Schmidt, "Differential piston phase variance in non-Kolmogorov atmospheres," *J. Optical Soc. America A*, vol. 34, no. 8, pp. 1433-1440, July 2017 (online June 2017).

M. Cheng and **B. Chen**, "The model integration and hardware-in-the-loop (HiL) simulation design for the analysis of a power-split hybrid electric vehicle with electrochemical battery model," *SAE Intl. J. Passenger Cars—Electronic and Electrical Systems*, vol. 10, no. 2, August 2017 (online March 2017).

C. Cao, L. Wang, and **B. Chen**, "Mitigation of the impact of high plug-in electric vehicle penetration on residential distribution grid using smart charging strategies," *Energies*, vol. 9, no. 12, December 2016.

L. Wang, C. Cao, and **B. Chen**, "Grid-tied single-phase bi-directional PEV charging/discharging control," *SAE Intl. J. Passenger Cars—Electronic and Electrical Systems*, vol. 9, no. 2, pp. 275-285, August 2016 (online April 2016).

**Z. Feng**, "Spectral graph sparsification in nearly-linear time leveraging efficient spectral perturbation analysis," in Proc. 53rd IEEE/ACM Design Automation Conference (DAC), Austin, TX, June 2016.

L. Han and **Z. Feng**, "TinySPICE Plus: Scaling up statistical SPICE simulations on GPU leverating shared-memory based sparse matrix solution techniques," in Proc. 2016 IEEE/ACM Conf. Computer-Aided Design (ICCAD), Austin, TX, November 2016.

Z. Zhao and **Z. Feng**, "A spectral graph sparsification approach to scalable vectorless power grid integrity verification," in Proc. 54th IEEE/ACM Design Automation Conference (DAC), Austin, TX, June 2017.

M. La Manna and **D. Fuhrmann**, "Cramer-Rao lower bounds comparison for 2-D Hybrid-MIMO and MIMO radar," *IEEE J. Selected Topics in Signal Processing*, vol. 11, no. 2, pp. 404-413, March 2017.

S. Castano-Solis, **L. Gauchia**, D. Serrano-Jimenez, and J. Sanz, "Off-the-shelf and flexible hybrid frequency and time domain experimental architecture setup for electrochemical energy modules testing under realistic operating conditions," *IEEE Trans. Energy Conversion*, vol. 32, no. 2, pp. 620-628, June 2017.

S. Castano-Solis, D. Serrano-Jimenez, **L. Gauchia**, and S. Javier, "The influence of BMSs on the characterization and modeling of series and parallel Li-Ion packs," *Energies*, vol. 10, no. 273, pp. 1-13, February 2017.

A. Kantamneni, R. Winkler, **L. Gauchia**, and **J. Pearce**, "Emerging economic viability of grid defection in a northern climate using solar hybrid systems," *Energy Policy*, vol. 95, pp. 378-389, August 2016.

J. Davies, C. Rickerd, M. Grimes, and **D. Guney**, "An n-bit general implementation of Shor's quantum period-finding algorithm," *Quantum Information and Computation*, vol. 16, no. 7-8, pp. 700-718, May 2016.

A. Ghoshroy, W. Adams, X. Zhang, and **D. Guney**, "Active plasmon injection scheme for subdiffraction imaging with imperfect negative index flat lens," *J. Optical Soc. America B*, vol. 34, no. 7, pp. 1478-1488, June 2017.

C. Zhang, J. Gwamuri, S. Cvetanovic, M. Sadatgol, **D. Guney**, and **J. Pearce**, "Enhancement of hydrogenated amorphous silicon solar cells with front-surface hexagonal plasmonic arrays for nanoscale lithography," *J. Optics*, vol. 19, pp. 1-11, June 2017.

X. Zhang, W. Adams, and **D. Guney**, "Analytical description of inverse filter emulating the plasmon injection loss compensation scheme and implementation for ultrahigh-resolution hyperlens," *J. Optical Soc. America B*, vol. 34, no. 6, pp. 1310-1388, June 2017.

W. Adams, M. Sadatgol, X. Zhang, and **D. Guney**, "Bringing the 'perfect lens' into focus by near-perfect compensation of losses without gain media," *New J. Physics*, vol. 18, pp. 1-10, December 2016.

X. Zhang, W. Adams, M. Sadatgol, and **D. Guney**, "Enhancing the resolution of hyperlens by the compensation of losses without gain media," *Progress in Electromagnetics Research C*, vol. 70, pp. 1-7, November 2016.

C. Zhang, **D. Guney**, and **J. Pearce**, "Plasmonic enhancement of amorphous silicon solar photovoltaic cells with hexagonal silver arrays made with nanosphere lithography," *Materials Research Express*, vol. 3, pp. 1-14, October 2016.

W. Adams, M. Sadatgol, and **D. Guney**, "Review of near-field optics and superlenses for sub-diffraction-limited nano-imaging," *AIP Advances*, vol. 6, no. 10, October 2016.

H. Deilamsalehy, **T. Havens**, and J. Manela, "Heterogeneous multi-sensor fusion for mobile platform 3D pose estimation," *J. Dynamic Systems, Measurement, and Control*, vol. 139, no. 7, pp. 071002, April 2017.

S. Yazdanparast and **T. Havens**, "Modularity maximization using completely positive programming," *Physica A: Statistical Mechanics and its Applications*, vol. 471, no. 1, pp. 20-32, April 2017.

D. Anderson, P. Elmore, F. Petry, and **T. Havens**, "Fuzzy Choquet integration of homogeneous possibility and probability distributions," *Information Sciences*, vol. 363, pp. 24-39, October 2016.

L. Wang, **S. Hu**, G. Betis, and R. Ranjan, "A computing perspective on smart city," *IEEE Trans. Computers*, vol. 65, no. 5, pp. 1337-1338, May 2016.

C. Chen, X. Zhang, L. Krishna, **C. Kendrick**, E., S-L. Shang, E. Toberer, Z-K. Liu, A. Tamboli, and J. Redwing, "Synthesis, characterization and chemical stability of silicon dichalcogenides, Si (SexS 1- x) 2," *J. Crystal Growth*, vol. 452, pp. 151-157, October 2016.

A. Hosseinzadeh and **C. Middlebrook**, "Highly linear dual ring resonator modulator for wide bandwidth microwave photonic links," *Optics Express*, vol. 24, no. 24, pp. 27268-27279, November 2016.

J. Ramamurthy, H. Høidalen, N. Chiesa, **B. Mork**, N. Stenvig, A. Manty, "Influence of voltage harmonics on transformer no-load loss measurements and calculation of magnetization curves," *Electric Power Systems Research*, vol. 146, pp. 43-50, May 2017 (online January 2017).

S. Hajmohammadi and **S. Nooshabadi**, "Parallel blind deconvolution reconstruction using phase diversity for three-dimensional imaging," *Optical Engineering*, vol. 56, no. 4, pp. 043104, April 2017.

L. Hu and **S. Nooshabadi**, "Massive parallelization of approximate nearest neighbor search on KD-tree for high-dimensional image descriptor matching," J. *Visual Communication and Image Representation*, vol. 44, pp. 106–115, April 2017 (online January 2017).

H. Jang, **S. Nooshabadi**, H. N. Lee, and K. Kim, "Circular sphere decoding: A low complexity detection for MIMO systems with general two-dimensional signal constellations," *IEEE Trans. Vehicular Technology*, vol. 66, no. 3, pp. 2085-2098, March 2017.

J. Garcia, J. Montiel-Nelson, and **S. Nooshabadi**, "High performance single supply CMOS 0.45-1V input to 1.1V output level up shifter," *Microelectronics J.*, vol. 60, no. 2, pp. 82–86, February 2017.

C. Jiang and **S. Nooshabadi**, "Parallel multiview video coding exploiting group of pictures level parallelism," *IEEE Trans. Parallel and Distributed Systems*, vol. 27, no. 8, pp. 2316-2328, August 2016.

B. Bhattarai, K. Myers, B. Bak-Jensen, and **S. Paudyal**, "Multi-time scale control of demand flexibility in smart distribution networks," *Energies*, vol. 10, no. 37, pp. 1-18, January 2017.

G. Bharati and **S. Paudyal**, "Coordinated control of distribution grid and electric vehicle loads," *Electric Power Systems Research*, vol. 140, pp. 761-768, November 2016.

G. Bharati, M. Razmara, **S. Paudyal**, M. Shahbakhti and R. Robinett, "Hierarchical optimization framework for demand dispatch in building-grid systems," in Proc. 2016 IEEE Power and Energy Society General Meeting (PES-GM), Boston, MA, July 2016.

R. Michaels and **J. Pearce**, "3-D printing open-source click-MUAC bands for identification of malnutrition," *Public Health Nutrition*, vol. 20, no. 11, pp. 2063-2066, August 2017 (online May 2017).

B. Wittbrodt and **J. Pearce**, "3-D printing solar photovoltaic racking in developing world," *Energy for Sustainable Development*, vol. 36, pp. 1-5, February 2017 (online August 2016).

A. Pringle, R. Handler, and **J. Pearce**, "Aquavoltaics: Synergies for dual use of water area for solar photovoltaic electricity generation and aquaculture," *Renewable and Sustainable Energy Reviews*, vol. 80, pp. 572-584, December 2017 (online May 2017).

E. Petersen and **J. Pearce**, "Emergence of home manufacturing in the developed world: Return on investment for open-source 3-D printers," *Technologies*, vol. 5, no. 7, pp. 1-15, February 2017.

**J. Pearce**, "Emerging business models for open source hardware," *J. Open Hardware*, vol. 1, no. 1, p. 2, March 2017. DOI: http://dx.doi.org/10.5334/joh.4

S. Zhong, P. Rakhe, and **J. Pearce**, "Energy payback time of a solar photovoltaic powered waste plastic recyclebot system," *Recycling*, vol. 2, no. 10, pp. 1-16, June 2017.

M. Arie, A. Shoshtari, R. Tiwari, S. Dessiatoun, M. Ohadi, and **J. Pearce**, "Experimental characterization of heat transfer in an additively manufactured polymer heat exchanger," *Applied Thermal Engineering*, vol. 113, pp. 575-584, February 2017 (online November 2016).

D. Denkenberger, D. Cole, M. Abdelkhaliq, M. Griswold, A. Hundley, and **J. Pearce**, "Feeding everyone if the sun is obscured and industry is disabled," *Intl. J. Disaster Risk Reduction*, vol. 21, pp. 284-290, March 2017 (online January 2017).

A. Haselhuhn, P. Sanders, and **J. Pearce**, "Hypoeutectic aluminum-silicon alloy development for GMAW-based 3-D printing using wedge castings," *Intl. J. Metalcasting*, vol. 11, no. 4, pp. 1-14, October 2017 (online January 2017).

S. Periasamy, V. Sasirekha, R. Venkatesan, J. Mayandi, **J. Pearce**, J. Selj, and R. Veerabahu, "Micro-Raman scattering of nanoscale silicon in amorphous and porous silicon," *Zeitschrift für Physikalische Chemie*, vol. 23, no. 19, September 2017 (online March 2017).

K. Dhankani and **J. Pearce**, "Open source laboratory sample rotator mixer and shaker," *HardwareX*, vol. 1, pp. 1-12, April 2017 (online October 2016).

J. Laureto and **J. Pearce**, "Open source multi-head 3-D printer for polymer-metal composite component manufacturing," *Technologies*, vol. 5, no. 2, pp. 1-22, June 2017.

H. Chandra, S. Allen, S. Oberloier, N. Bihari, J. Gwamuri, and **J. Pearce**, "Open-source automated mapping four-point probe," *Materials*, vol. 10, no. 2, pp. 1-17, February 2017 (online January 2017).

E. Prehoda and **J. Pearce**, "Potential lives saved by replacing coal with solar photovoltaic electricity production in the U.S.," *Renewable and Sustainable Energy Reviews*, vol. 80, pp. 710-715, December 2017 (online June 2017).

S. Wadhawan and **J. Pearce**, "Power and energy potential of mass-scale photovoltaic noise barrier deployment: A case study for the U.S.," *Renewable and Sustainable Energy Reviews*, vol. 80, pp. 125-132, December 2017 (online May 2017).

R. Krishnan, A. Haselhuhn, and **J. Pearce**, "Technical solar photovoltaic potential of scaled parking lot canopies: A case study of Walmart USA," *RISUS–J. Innovation and Sustainability*, vol. 8, no. 2, pp. 104-125, June 2017.

N. Tanikella, B. Wittbrodt, and **J. Pearce**, "Tensile strength of commercial polymer materials for fused filament fabrication 3D printing," *Additive Manufacturing*, vol. 15, pp. 40-47, May 2017 (online March 2017).

J. Laureto, J. Tomasi, J. King, and **J. Pearce**, "Thermal properties of 3-D printed polylactic acid-metal composites," *Progress in Additive Manufacturing*, vol. 2, no. 1-2, pp. 57-71, June 2017 (online April 2017).

A. Mundada, E. Prehoda, and **J. Pearce**, "U.S. market for solar photovoltaic plug-and-play systems," *Renewable Energy*, vol. 103, pp. 255-264, April 2017 (online November 2016).

E. Prehoda, C. Schelly, and **J. Pearce**, "U.S. strategic solar photovoltaic-powered microgrid deployment for enhanced national security," *Renewable and Sustainable Energy Reviews*, vol. 78, pp. 167-175, October 2017 (online May 2017).

A. Mundada, Y. Nilsiam, and **J. Pearce**, "A review of technical requirements for plug-and-play solar photovoltaic microinverter systems in the United States," *Solar Energy*, vol. 135, pp. 455-470, October 2016 (online June 2016).

S. Baum, D. Denkenberger, and **J. Pearce**, "Alternative foods as a solution to global food supply catastrophes," *Solutions*, vol. 7, no. 4, pp. 31-35, July 2016.

**J. Pearce**, "Are you overpaying your academic executive team? A method for detecting unmerited academic executive compensation," *Tertiary Education and Management*, vol. 22, no. 3, pp. 189-201, May 2016.

D. Denkenberger and **J. Pearce**, "Cost-effectiveness of interventions for alternate food to address agricultural catastrophes globally," *Intl. J. Disaster Risk Science*, vol. 7, no. 3, pp. 205-215, September 2016.

B. Wijnen, E. Petersen, E. Hunt, and **J. Pearce**, "Free and open-source automated 3-D microscope," J. Microscopy, vol. 264, no. 2, pp. 238-246, November 2016 (online August 2016).

J. Laureto and **J. Pearce**, "Nuclear insurance subsidies cost from post-Fukushima accounting based on media sources," *Sustainability*, vol. 8, no. 12, pp. 1-16, December 2016.

Y. Nilsiam and **J. Pearce**, "Open source database and website to provide free and open access to inactive U.S. patents in the public domain," *Inventions*, vol. 1, no. 24, pp. 1-13, November 2016.

J. Laureto, S. Dessiatoun, M. Ohadi, and **J. Pearce**, "Open source laser polymer welding system: Design and characterization of linear low-density polyethylene multilayer welds," *Machines*, vol. 4, no. 3, pp. 14, July 2016.

A. Laplume, G. Anzalone, and **J. Pearce**, "Open-source, self-replicating 3-D printer factory for small-business manufacturing," *Intl. J. Advanced Manufacturing Technology*, vol. 85, no. 1-4, pp. 633-642, July 2016.

E. Louie and **J. Pearce**, "Retraining investment for U.S. transition from coal to solar photovoltaic employment," *Energy Economics*, vol. 57, pp. 295-302, June 2016.

C. Abinaya, M. Marikkannan, M. Manikandan, J. Mayandi, P. Suresh, V. Shanmugaiah, C. Ekstrum, and **J. Pearce**, "Structural and optical characterization and efficacy of hydrothermal synthesized Cu and Ag doped zinc oxide nanoplate bactericides," *Materials Chemistry and Physics*, vol. 184, pp. 172-182, December 2016 (online September 2016).

A. Haselhuhn, M. Buhr, B. Wijnen, P. Sanders, and **J. Pearce**, "Structure-property relationships of common aluminum weld alloys utilized as feedstock for GMAW-based 3-D metal printing," *Materials Science and Engineering A*, vol. 673, pp. 511-523, September 2016 (online July 2016).

N. Tanikella, B. Savonen, J. Gershenson, and **J. Pearce**, "Viability of distributed manufacturing of bicycle components with 3-D printing: CEN standardized polylactic acid pedal testing," *J. Humanitarian Engineering*, vol. 5, no. 1, pp. 8-17, 2016.

S. Ziaeefard, B. Page, **A. Pinar**, and N. Mahmoudian, "Effective turning motion control of internally actuated autonomous underwater vehicles," *J. Intelligent and Robotic Systems*, https://doi.org/10.1007/s10846-017-0544-3, April 2017.

B. Page, S. Ziaeefard, **A. Pinar**, and N. Mahmoudian, "Highly maneuverable low-cost underwater glider: Design and development," *IEEE Robotic and Automation Letters*, vol. 2, no. 1, pp. 344-349, January 2017.

S. Nuchitprasitchai, **M. Roggemann**, and **J. Pearce**, "Factors effecting real-time optical monitoring of fused filament 3D printing," *Progress in Additive Manufacturing*, vol. 2, no. 3, pp. 133-149, June 2017.

S. Nuchitprasitchai, **M. Roggemann**, and **J. Pearce**, "An algorithm for reconstructing three dimensional images from overlapping two dimensional intensity measurements with relaxed camera positioning requirements,"*Intl. J. Modern Engineering Research*, vol. 6, no. 9, pp. 69-81, September 2016.

B. Seifi, **E. Semouchkina**, and M. Lanagan, "Approaches to designing micro-solenoidal RF probes for 14 T MRI studies of millimeter-range sized objects," *Concepts in Magnetic Resonance Part B: Magnetic Resonance Engineering*, vol. 46B, no. 4, pp. 178-185, October 2016.

N. Gandji, A. Palle, G. Semouchkin, and **E. Semouchkina**, "Field-simulation based engineering of RF antenna probes with non-uniform substrates for high-field magnetic resonance imaging systems," *Applied Computational Electromagnetic Society J.*, vol. 31, no. 5, pp. 492-497, May 2016.

Y. Guo, **C. Ten**, **S. Hu**, and **W. Weaver**, "Preventative maintenance for advanced metering infrastructure against malware propagation," *IEEE Trans. on Smart Grid*, vol. 7, no. 3, pp. 1314-1328, May 2016.

C. Wang, **C. Ten**, Y. Hou, and A. Ginter, "Cyber inference system for substation anomalies against alter-and-hide attacks," I*EEE Trans. Power Systems*, vol. 32, no. 2, pp. 896-909, March 2017.

**C. Ten**, A. Ginter, and R. Bulbul, "Cyber-based contingency analysis," *IEEE Trans. Power Systems*, no. 31, vol. 4, pp. 3040-3050, July 2016.

Y. Zhang, L. Wang, Y. Xiang, and **C. Ten**, "Inclusion of SCADA cyber vulnerability in power system reliability assessment considering optimal resources allocation," *IEEE Trans. Power Systems*, vol. 31, no. 6, pp. 4379-4394, November 2016.

X. Kuai, S. Zhou, **Z. Wang**, E. Cheng, "Receiver design for spread-spectrum communications with a small spread in underwater clustered multipath channels," J. *Acoustical Soc. America*, vol. 141, no. 3, pp. 1627-1642, March 2017.

**Z. Wang** and C. Wang, "Signal alignment for secure underwater coordinated multipoint transmissions," *IEEE Trans. Signal Processing*, vol. 64, no. 23, pp. 6360-6374, December 2016.

**W. Weaver**, R. Robinett, D. Wilson, R. Matthews, "Metastability of pulse power loads using the Hamiltonian surface shaping method," *IEEE Trans. Energy Conversion*, vol. 32, no. 2, pp. 820-828, June 2017.

R. Jane, G. Parker, **W. Weaver**, R. Matthews, D. Rizzo, and M. Cook, "Optimal power management of vehicle sourced military outposts" *SAE Intl. J. Commercial Vehicles*, vol. 10, no. 1, pp. 132-143, March 2017.

K. Bunker and **W. Weaver**, "Multidimensional droop control for wind resources in DC microgrids," *IET Generation, Transmission and Distribution*, vol. 11, no. 3, pp. 657-664, February 2017.

M. Cook, G. Parker, R. Robinett, and **W. Weaver**, "Decentralized mode-adaptive guidance and control for DC microgrid," *IEEE Trans. Power Delivery*, vol. 32, no. 1, pp. 263-271, February 2017.

B. Moridian, N. Mahmoudian, **W. Weaver**, and R. Robinett, "Post-disaster electric power recovery using autonomous vehicles," *IEEE Trans. Automation Science and Engineering*, vol. 14, no. 1, pp. 62-72, January 2017.

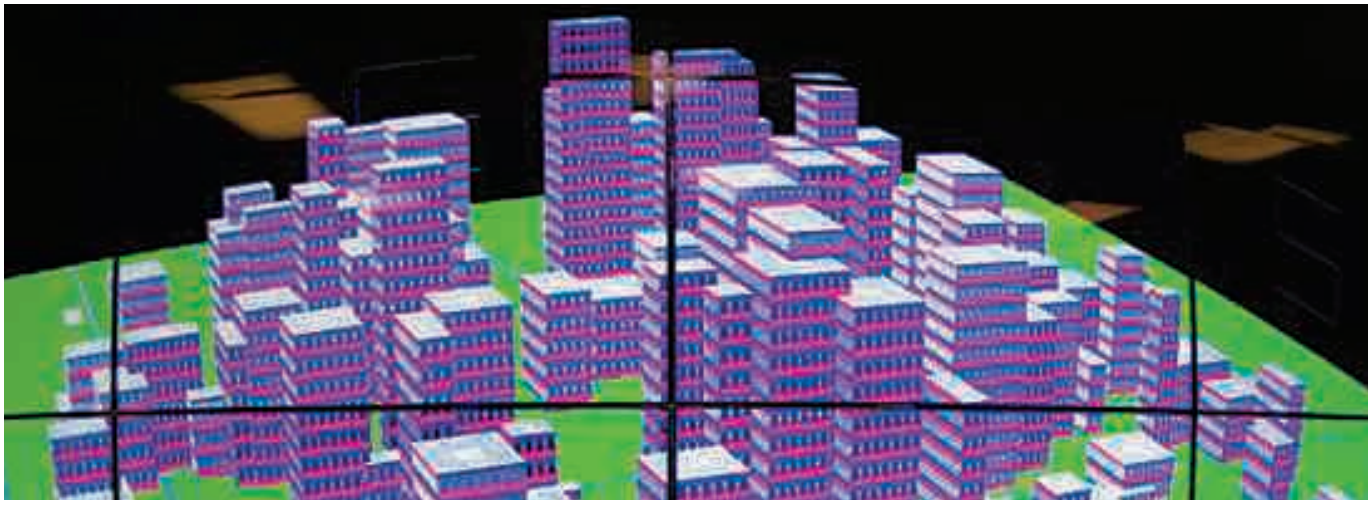
B. Banerjee, R. Kotecha, and **W. Weaver**, "Digital memory look-up based implementation of sliding mode control for DC–DC converters," *Control Engineering Practice*, vol. 54, pp. 1-11, September 2016.

M. Jamalabdollahi and **S. Zekavat**, "High resolution ToA estimation via optimal waveform design," *IEEE Trans. Communications*, vol. 65, no. 3, pp. 1207-1218, April 2017.

M. Jamalabdollahi and **S. Zekavat**, "ToA ranging and layer thickness computation in nonhomogeneous media," *IEEE Trans. Geoscience and Remote Sensing*, vol. 55, no. 2, pp. 742-752, February 2017.

A. Torabi, **S. Zekavat**, and K. Sarabandi, "Wideband wireless channel characterization for multi-antenna systems over a random rough dielectric ground," *IEEE Trans. Wireless Communications*, vol. 15, no. 5, pp. 3103-3113, May 2016.

A. Torabi and **S. Zekavat**, "Near-ground channel modeling for distributed cooperative communications," *IEEE Trans. Antennas and Propagation*, vol. 64, no. 6, pp. 2492-2502, June 2016.



# Staff Profile: Lisa Hitch

*Your title is business manager and technical communications specialist. What does that entail?*

Just about anything and everything involving funds and communication for the ECE Department. From proposal preparation, payroll, financial planning, P&T procedures, searches and onboarding, event planning, website management, social media, alumni newsletter, and this Annual Report, to list a few.

*That seems like a very diverse role. What is your background?*

I grew up in a family business. My father owned an engineering and architectural company in the area for more than 30 years. I remember manually collating design specifications all around our dining room as soon as I was old enough to keep the page numbering straight. We expanded a bit from there—more than 30 employees in three locations—and after graduating high school, I worked for Hitch, Inc. fulltime while attending Michigan Tech for business and marketing. It was a fantastic experience to prepare me for my role today. I learned a lot and the extra push to work hard and always try my best was a lifelong gift.

*What was the biggest change coming from industry into academia?*

In the business world everything was fiscal time—fiscal quarters and fiscal year end. I was also concerned with the calendar year for payroll and tax preparation. Coming into academia introduced another timing consideration: the academic year and summer semesters. More time periods and deadlines to coordinate.

Also—top of the hour actually means five after.

*What seems to be the same?*

The people who I work with have always been like family to me. Now my family is just a whole lot bigger.

*This November you will have been in your position for 10 years. What have you enjoyed the most over that time?*

Getting to know so many people from all around the world: From our students to alumni, faculty, and friends, each one brings a chance to learn more about different cultures and locations. I have always told my own children to explore and follow their dreams. That may be why my eldest daughter became a flight attendant right out of high school and my son has been to more than 30 countries so far; my youngest daughter has probably passed up my bucket list by now as well.

*Growing up and living in the Copper Country, are there things you find unique about the area?*

The amazing sunrises and sunsets. They never look the same and each location and season provides a different canvas. I've had the opportunity to stand at the edge of the Grand Canyon and though no one can deny how breathtaking the view, I've experienced the same feeling looking out at Lake Superior from the top of Bare Bluff.

*Is there anything else you'd like to tell us about yourself?*

I am extremely passionate about how we take care of ourselves. We are what we eat, do, and think. I'm forever learning and practicing what that is all about.

## Staff Directory

| | |
|---|---|
| **Joan Becker** | ECE Graduate Program Coordinator |
| **Judy Donahue** | ECE Undergraduate Advisor |
| **Trever Hassell** | CpE Undergraduate Advisor and Instructor |
| **Lisa Hitch** | Business Manager and Technical Communications Specialist |
| **Michele Kamppinen** | Staff Assistant |
| **Chito Kendrick** | Managing Director, Microfabrication Facility, and Instructor |
| **Chuck Sannes** | Laboratory Supervisor |
| **Mark Sloat** | Research Associate |

# Graduate Student Research in Mobility

**Mojtaba Bahramgiri** and his advisor, Reza Zekavat, are working to solve future problems associated with data overload or miscommunication in autonomous driving applications.

The location of a vehicle determined by GPS can be used for routing or location-based services, but the estimated location is not always accurate and cannot be relied upon for safe vehicle control. In the near future, there will be increasing sources of data from autonomous vehicles and around urban centers, and different sensor data can be combined to estimate the location with greater accuracy. However, complexity and processing time will increase significantly and this may affect performance, leading to a trade-off between accuracy and complexity. One way to address the complexity issue is to use data reduction on large datasets, but this requires evaluation of the loss of information, if any, that accompanies the data reduction.

Proposed autonomous driving systems rely mainly on cameras, LIDAR, and RADAR. However, environmental conditions impact the performance of these sensors, and in bad weather conditions the autonomous driving systems are not as reliable. Increasing the sources of data addresses information gaps, and if some sensors fail there are others to rely on. Vehicle-to-vehicle (V2V) communication enables an autonomous vehicle to use data from nearby vehicles to improve the control system performance, but to use this extra information, the location of these vehicles must be known. Thus, accurate Cloud-assisted location estimation can lead to a higher level of safety in autonomous driving systems with multiple cooperating vehicles.

**Mehdi Jafari** and his advisor, Lucia Gauchia, are working on battery aging and degradation estimation in electric vehicles.

The battery is one of the most expensive parts of a vehicle and should be replaced after 20 percent of its capacity is lost. Jafari's research examines battery performance under different driving behaviors, scenarios, and traffic conditions in addition to examining recharging options and vehicle-to-grid services. He is applying the probabilistic methods of Bayesian networks to the modeling and evaluation of vehicle battery health.

Jafari notes that because of growing interest in transportation electrification and production of electric vehicles, it is important to conduct research on different aspects of those vehicles. One of the most important aspects is driving range, which is directly dependent on battery health.

**Derek Chopp** and his advisor, Jeremy Bos, are exploring the autonomy of passenger vehicles in unstructured environments.

The majority of research and development in autonomous vehicles to date involves structured environments with lane markings, road signs, and other predictable features. In order for autonomous vehicles to be accepted in society as a viable technology, they will need to handle more than just ideal conditions. The Keweenaw Peninsula is the ideal location to consider autonomy in winter weather where non-ideal conditions will cause many current algorithms to fail due to incorrect assumptions about the environment. Chopp and Bos hope to provide a solution for autonomy in winter weather, therefore pushing autonomous vehicles closer to being a viable technology.

Derek is part of a multi-disciplinary team that also includes Nate Spike (MEEM), Joe Rice (CS), and Akhil Kurup (ECE). Together they serve as the graduate students for the Michigan Tech team known as Prometheus Borealis in the GM/SAE International AutoDrive competition. The competition builds foundational knowledge in autonomous passenger vehicles as well as implementation experience. Chopp and the other graduate students are developing technology and serving as mentors for a large group of undergraduates in Michigan Tech's Robotic Systems Enterprise. The team is developing algorithms and simulations to test on a donated Chevy Bolt, and ultimately will see how their solutions stack up against those of teams from seven other North American universities in the competition.

Chopp, a hobby machinist, has his own industrial mill and lathe. So far, he has designed and fabricated a desktop CNC machine, small electric vehicles, several robots, and more.

# Accelerating Our Master's Degree

The ECE Department has a long and distinguished history in undergraduate education, and has prepared more than 8,000 engineering students for meaningful careers since the Department's inception in 1928. The times are changing, however, and Michigan Tech is changing as well. Some 40 percent of the engineering students in the US now are graduate students. Our programs have been evolving during the past few decades to respond to this changing demographic and the needs of the marketplace.

ECE offers Master of Science (MS) degrees in electrical engineering and in computer engineering. The MS degree provides students an opportunity to receive advanced training and skills beyond what they learned as undergraduates; these students are able to take on more technically challenging projects and become increasingly valuable engineers for their employers or potential employers. While it is still possible to carry out research projects as part of the MS degree, today the most popular MS degree program is the coursework option, which requires 30 credits of advanced coursework beyond the baccalaureate.

Our MS enrollment quadrupled during the past 10 years. In the fall 2015 semester we had 200 MS students enrolled in the ECE Department. Although the MS enrollment has since dropped slightly from the high in fall 2015, we continue to have large graduate courses in popular areas, including power system analysis and automotive control systems.

In response to the growth in enrollment, ECE has created the new Graduate Academic Advisor position, which is divided into 50 percent advising and 50 percent teaching advanced courses in areas where we needed to grow. In the fall of 2016 we conducted a successful search and the position has been filled by John Pakkala, who is a PhD graduate of the ECE Department, spent many years as an engineering educator in Milwaukee, and is now returning to his roots in the Copper Country.

Our MS program has a strong international flavor, and we happily welcome and support students from all over the world. At the same time, many of our industry partners have openings for positions that require US citizenship. We meet state and national workforce needs, and the needs of many American students themselves, by convincing them that an advanced degree would be in their own best interest. Therefore, one of our goals is to increase the domestic side of our MS enrollment.

A few years ago the University quietly created the Accelerated Master of Science program to increase the number of domestic students in our MS programs by creating an incentive for our own undergraduates to stay in school for an extra year and earn that graduate degree. While the BS degree requires a minimum of 128 credits, and the MS degree 30 credits, students in the accelerated MS program may double-count six credits to apply toward both degrees simultaneously. This brings the total number of credits for the combined BS/MS package down to 152—a very good deal for our students.

Our MS programs continue to evolve in their technical emphasis as well as numbers of students. Today the ECE Department is paying special attention to robotics, control, automation, automotive systems and control (in cooperation with the Mechanical Engineering-Engineering Mechanics Department), and cybersecurity (in cooperation with the Computer Science Department). Our aim is to continue providing high-quality and relevant advanced educational opportunities that benefit both our students and their employers.

# Graduate Student Awards

**Sakineh Yazdanparast,** Jonathan Bara Award for Outstanding Graduate Teaching Assistant

**Mohsen Jamalabdollahi,** Matt Wolfe Award for Outstanding Graduate Research Assistant

## Fellowships

**Guna Bharati**
Finishing Fellowship, Graduate School

**Michael Briseño**
Earl R. and Ellanette F. Lind Memorial Endowed Fellowship

**Ian Cummings**
NSF Graduate Research Fellowship

**Evan Gawron**
Earl R. and Ellanette F. Lind Memorial Endowed Fellowship

**Arash Hosseinzadeh**
Finishing Fellowship, Graduate School

**Mehdi Jafari**
Oliver and Mary Winn Endowed Fellowship

**Marco La Manna**
David House Endowed Professorship (Fellowship)

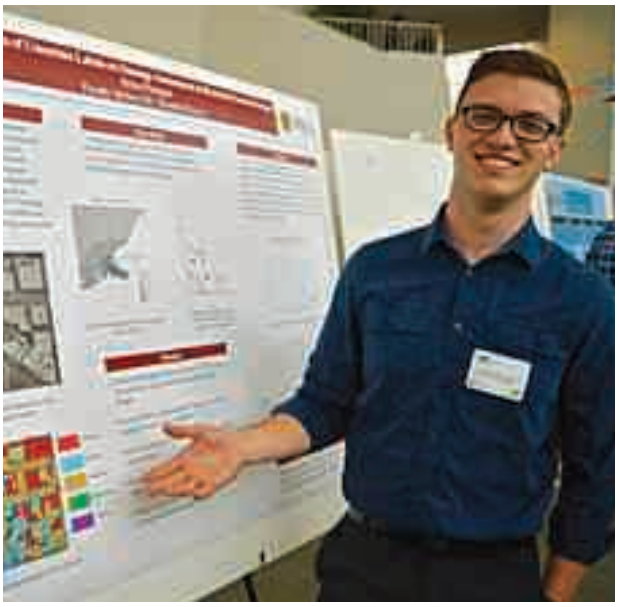
**Seyedmehdi Sadatgoltabarestani**
Finishing Fellowship, Graduate School

**Husam Sweidan**
William and Gloria Jackson Endowed Professorship (Fellowship)

## ECE Doctoral Degrees: Summer 2016 to Spring 2017

| PhD Graduate | Advisor | Major | Dissertation Title |
|---|---|---|---|
| Mohsen Jamalabdollahi | Reza Zekavat | Electrical Engineering | High Resolution Time-of-Arrival Ranging of Wireless Sensor Nodes in Non-Homogeneous Environments |
| Caoyang Jiang | Saeid Nooshabadi | Electrical Engineering | High Performance Multiview Video Coding |
| Marco La Manna | Dan Fuhrmann | Electrical Engineering | Hybrid MIMO Phased Array Radar Receive Signal Processing |
| Lin Liu | Shiyan Hu | Computer Engineering | Design Automation for Carbon Nanotube Circuits Considering Performance and Security Optimization |
| Yang Liu | Shiyan Hu | Electrical Engineering | Analysis and Detection of Cyberattacks in Smart Home Cyber-Physical Energy Systems |
| Yuenyong Nilsiam | Joshua Pearce | Computer Engineering | Low-Cost Open-Source GMAW-Based Metal 3-D Printing: Monitoring, Slicer, Optimization, and Applications |
| Anthony (Tony) Pinar | Tim Havens | Electrical Engineering | Feature and Decision Level Fusion Using Multiple Kernel Learning and Fuzzy Integrals |
| Amir Rezaei | Tim Havens | Electrical Engineering | An Optimal Energy Management Strategy for Hybrid Electric Vehicles |
| Seyedmehdi Sadatgoltabarestani | Durdu Guney | Electrical Engineering | Exotic Optical Properties of Metal-Dielectric Nano-Structures |
| Jennifer Winikus | Laura Brown & Tim Havens, co-advisors | Computer Engineering | Representation and Analysis of Multi-Modal, Nonuniform Time Series Data: An Application to Survival Prognosis of Oncology Patients in an Outpatient Setting |

# Undergraduate Student Highlights



*Brian Flanagan*

*Casey Strom and his wife, Becky.*

**Brian Flanagan** was among the winners of the 2017 Undergraduate Research Symposium held in March at Michigan Tech.

A record 71 abstracts and posters were submitted this year representing every school or college on campus. Flanagan, a Pavlis Honors College (PHC) Fellow, was awarded second place for his research on "The Effects of Uncertain Labels on Damage Assessment in Remotely Sensed Images." The research, conducted with faculty advisor Tim Havens, consisted of developing fuzzy classification algorithms for predicting disaster damaged areas in high-resolution satellite imagery using machine learning and computer vision methods.

The annual symposium is conducted by PHC and highlights the cutting-edge research conducted on Michigan Tech's campus by some of our best and brightest undergraduate students, and Flanagan was certainly one of them.

Flanagan earned the Dean's List distinction every year of his undergraduate studies. He was the recording secretary of Eta Kappa Nu, the student honor society of IEEE, and studied abroad for one semester at Trinity College Dublin, Ireland.

In May 2014, Flanagan was hired as an intern at CareTech Solutions and was immediately promoted to full-time employee, working until August 2015, where he remotely supported healthcare professionals at multiple hospitals across the nation for CareTech's software products. He was a member of Michigan Tech's IT Oxygen Enterprise, working on their Harman International and Ford/Target Mobile Teams.

Flanagan received the degree Bachelor of Science in Computer Engineering in April and is currently working toward an accelerated MS degree.

**Casey Strom** is what we would call a non-traditional student, meaning that he comes to our program with a fair amount of life experience under his belt. Already a Michigan Tech alumnus in surveying, Strom decided to return to Tech to earn a second degree in electrical engineering with a focus in power.

Strom lives and works on a family farm in Calumet with his wife and six children, and had his own surveying business at the time of his coming into the Department. In spite of these demands on his time, he completed all of his coursework in the ECE Department with near-perfect attendance, all homework completed on time, and many exams close to 100 percent.

As a result of his academic achievements, Strom was awarded a Systems Control Scholarship in 2015. Due to his status, he was ineligible for university financial aid other than unsubsidized student loans. When notified of his selection Strom said, "This scholarship provides capital to help fund my dream of pursuing a career in electric power engineering. This scholarship not only affects me, but my entire family, and makes this endeavor a possibility."

This spring, Strom received the ECE top student achievement award, the Carl S. Schjonberg Award for Outstanding Undergraduate Student in the ECE Department. Chair Dan Fuhrmann presented the award saying, "Casey represents the best of everything we try to do in the ECE Department and I couldn't be prouder to call him a Michigan Tech graduate."

Strom graduated, summa cum laude, in April, with the degree Bachelor of Science in Electrical Engineering and a Certificate in Power Engineering, and joined Systems Control as a full-time Senior Electrical Engineering Technician in May.

# Senior Design


*SD-6 Stryker team members (from left to right): Julio Rodriguez, Hailey Trossen, Elliott Meese, and advisor Trever Hassell. Not pictured are Dan Bragg and Yuguang Wang. SD-6 is the 2017 winner of the Larry Kennedy Industrial Innovation Award.*

Our Discover-Design-Deliver philosophy is at the core of our Senior Design program, during which students experience a project's entire design process as it unfolds in industry. Students enrolled in Senior Design work as teams on client-based engineering projects in consultation with a client representative and under the direction of a faculty advisor. Our department's Senior Design experience spans a full academic year, and by the end teams have delivered design reviews, a final report, a formal presentation, and an end product to the client.

## 2016-17 Senior Design Teams

| Project | Sponsor | Advisor |
|---|---|---|
| SD-1 / Traveling Wave Phase II | American Transmission Company (ATC) | John Lukowski |
| SD-2 / Paper Machine Simulation | Boise Paper | Trever Hassell |
| SD-3 / SCADA LTLS Coding & Control Monitoring Upgrade Qualification | DTE Energy | Chee-Wooi Ten |
| SD-4 / HMI Annunciator Replacement | ITC Holdings Corporation | Tony Pinar |
| SD-5 / dSpace Hardware in the Loop Development and Test | Nexteer Automotive | Tony Pinar |
| SD-6 / Surgical High Speed Drill Rotor Position via CAN bus • 2017 Larry Kennedy Industrial Innovation Award | Stryker Corporation | Trever Hassell |
| SD-7 / High-Voltage DAQ System | Advanced Power System (APS) Lab | Duane Bucheger |
| SD-8 / Jump Starter | APS Lab | Duane Bucheger |
| SD-9 / Design of a 2GH7 Trans-Impedance Amplifier | Electro-Optics Technology | Chris Middlebrook |

# Enterprise

## Blue Marble Security Enterprise

Blue Marble Security is made up of several sub-teams, each working on projects related to security. The goal of Blue Marble is to create sustainable, secure systems for our sponsors—either corporate or within the University. Though hosted in the Department of Electrical and Computer Engineering, Blue Marble team members come from a variety of other disciplines, including mechanical engineering, computer science, and business.

Advisor: **Glen Archer**

| Project | Sponsor |
|---|---|
| Vision system measurement verification of slab dimensions | ArcelorMittal |
| Alternative energy methods to more efficiently disperse products | Georgia-Pacific |
| Mechanical actuator system | Halla Mechatronics |
| In-suit waste management system | NASA |
| Autobot, for 2017 Intelligent Ground Vehicle Competition (IGVC) at Oakland University (Advisor: Jeff Burl) | ECE Department |
| LG, creation of a second-life plan for electric and hybrid electric car batteries | ECE Department |
| Website development for BMS | ECE Department |
| RC Car, improve autonomous vehicle control and communications | ECE Department |
| Outreach, create/host events to foster an interest in STEM among youth in the community and spark an interest in electrical engineering | ECE Department |

## Robotic Systems Enterprise

The Robotic Systems Enterprise is an innovation-driven student team that focuses on integrating knowledge in electronics, robotics, programming, and mechanical principles to solve real-world engineering problems. RSE projects come in all shapes and sizes, including a soil sample-collecting submersible robot, a power management system for weather buoys, and a counter UAV to prevent invading drones.

Advisors: **Glen Archer** and **Jeremy Bos**

| Project | Sponsor |
|---|---|
| Buoy power management system to prolong data collection period | Great Lakes Research Center |
| Submersible robot for lake bottom soil sample collection with onboard power and algorithm design to keep robot in place by use of sensors | ECE Department |
| Operation and modification of the modular Husky and Jackal robot platforms with the goal of autonomous data collection in hazardous weather conditions | ECE Department |
| Outreach, design of hardware and software to support challenging experiences for middle school, high school, and Michigan Tech students | ECE Department |

# Enterprise

## Wireless Communication Enterprise

The Wireless Communication Enterprise (WCE) focuses on wireless, optical, renewable energy, user interface, and biomedical technologies. WCE functions much like an engineering company with a variety of different projects. These small teams allow members to be involved in project work and provide ample opportunity to gain technical skills, business presentation skills, and leadership experience.

Advisor: **Kit Cischke**


WCE tied for second place at the 2017 Design Expo. During the overall competition, members Tino Moore and Libbey Held did an amazing job explaining WCE's processes, policies and structure, along with highlighting the following projects from academic year 2016-17.

| Project | Sponsor |
|---|---|
| Robotic Hand, artificial hand controlled wirelessly by the creation of a special glove | ECE Department |
| Drone Dock, automatically center a drone to begin a wireless (inductive) charging sequence | ECE Department |
| EV Coach, real-time performance feedback while driving electric and hybrid electric vehicles | Ford Motor Company |
| Drive Kitter, intelligent control systems to automatically install mounting hardware on traditional hard-disk drives and solid-state drives so that the drives can be installed in a text fixture, rather than burdening a human with this repetitive task | HGST |
| Tasty Beef Tracker, an app that allows ranchers to get information about their animals while out in the field | Real Food Ranch |
| Shuttle Display, a wirelessly triggered display to let passengers know how long it has been since the last shuttle has left the stop | Transportation Services |
| Wireless MIDI, design of reliable wireless triggers for on-stage sound effect | Visual and Performing Arts |

## Hybrid Electric Vehicle (HEV)

The HEV Enterprise is a collaborative activity between the Department of Electrical and Computer Engineering and the Department of Mechanical Engineering-Engineering Mechanics (MEEM). Members design, build, and test state-of-the-art hybrid electric vehicles. The current project vehicle is based on a 1949 Chevrolet truck. The team learns about the performance trade-offs of different types of hybrid powertrain architectures while fabricating and assembling various vehicle components and subsystems. Team members develop and use skills in leadership, project management, and vehicle calibration.

This year, HEV completed the installation and integration of the engine, electric motor, transmission, clutch, and driveshaft, and developed a control system for gear shifting and a supervisory vehicle control system. Other project teams within HEV Enterprise are finishing the cooling system for the vehicle and optimizing individual components to integrate all of the components together. Sponsors: General Motors, Milwaukee Tool

Advisors: **John Lukowski** and **Robert Page (MEEM)**

# Undergraduate Student Awards

**Sarah Wade**
ECE Departmental Scholar

**Jenna Burns**
ECE Woman of Promise/ Martha Sloan Scholarship

**Casey Strom**
Carl S. Schjonberg Award for Outstanding Undergraduate Student

# External Advisory Committee

The mission of the External Advisory Committee is to serve the Department of Electrical and Computer Engineering in an advisory capacity, providing counsel to the department chair and the faculty from the viewpoint of industry. The aim of these activities is to improve the quality of electrical and computer engineering education at Michigan Tech and provide ECE graduates, who are valuable assets, to industry employers.

**David Aho**
Eaton Cooper Power Systems

**Ellen M. Bauman**
IBM

**Keith Behnke**
Stryker Instruments

**Anthony Champagne**
Nexteer Automotive

**Rob Cooke**
GS Engineering

**Jonathan Doane**
MIT Lincoln Laboratory

**Ben Galloway**
Dematic Corporation

**Brett Giem**
Chrysler Technology Center

**Gordon Halt**
ITC Holdings

**Steve Kennell**
Retired

**David Rowe**
Systems Control, A Division of North Star Industries, Inc.

**William Lepak**
ArcelorMittal

**Eric Larson**
3M Corporate Research

**Ken Leisenring**
Ford Motor Company

**Steve S. Mathe**
Harris Corporation

**David Perry**
Independent Consultant

**Matt Schroeder**
General Motors

**Nirmal Singh**
Detroit Edison

# Contracts and Grants

Engineering research and development are key to technological progress and economic revitalization, and the ECE Department at Michigan Tech is busy doing its part. Our faculty, graduate students, and undergraduates work together in modern, well-equipped laboratories to bring practical solutions to real-world problems in signal processing, wireless communications, computer-aided design, energy systems, electronic materials and devices, photonics, and much more. We are eager to tackle new challenges and always look for new opportunities that are well matched to the interest and expertise of our faculty.

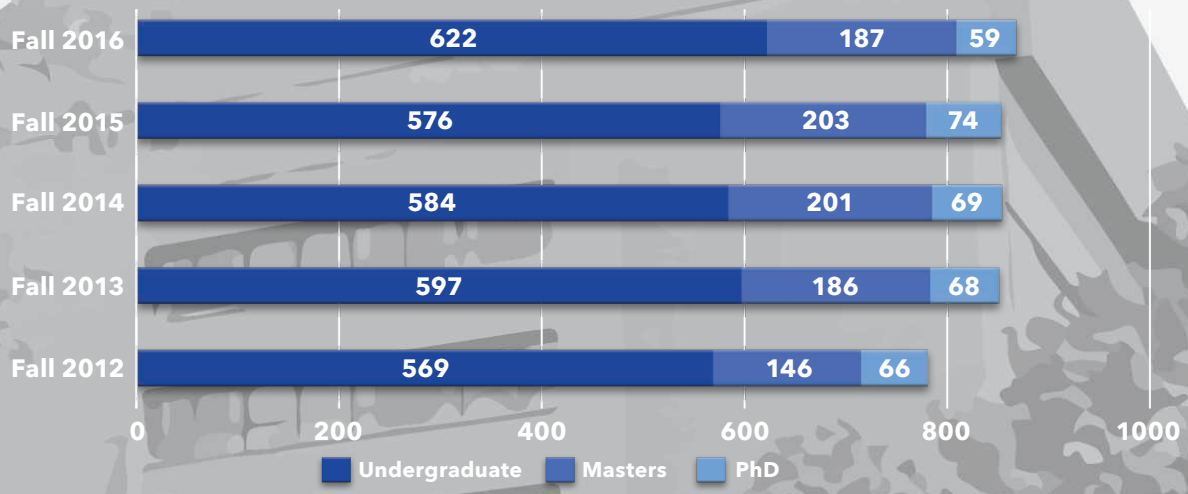
**ECE Contracts and Grants Awarded for FY17, July 2016 to June 2017**

| Title | Name | Sponsor | Award |
|---|---|---|---|
| Enterprise: Alternative Power Sources for Product Dispensers | PI: Glen Archer | Georgia-Pacific Consumer Products LP | $17,500 |
| Enterprise: Electric Assist Braking System–Phase III | PI: Glen Archer | Mando America Corporation | $17,500 |
| PFI: Air–TT: Blood Typing Device without Reagents: Sensing Electrodes to Replace Optics | co-PI: Paul Bergstrom | National Science Foundation | $12,000 |
| Imaging Theory and Mitigation in Extreme Turbulence-Induced Anisoplanatism | PI: Jeremy Bos | US Department of Defense | $106,032 |
| Enterprise Phase III: Development of Consumer Electric Vehicle Driving Efficiency Training System | PI: Kit Cischke | Ford Motor Co. | $15,000 |
| Enterprise: Smart Charging EV App Development | PI: Kit Cischke | Ford Motor Co. | $15,000 |
| Graduate Research Fellowship Program | PI: Ian Cummings<br>co-PI: Tim Havens | National Science Foundation | $138,000<br>($46,000 FY17) |
| CAREER: Leveraging Heterogeneous Manycore Systems for Scalable Modeling Simulation and Verification of Nanoscale Integrated Circuits | PI: Zhuo Feng | National Science Foundation | $523,618<br>($73,618 FY17) |
| CAREER: An Ecologically Inspired Approach to Battery Lifetime Analysis and Testing | PI: Lucia Gauchia | National Science Foundation | $500,000 |
| Senior Design: Paper Machine Simulation for Training Purposes | PI: Trever Hassell | Boise Paper | $17,500 |
| Senior Design: Surgical High Speed Drill Rotor Position via CAN bus | PI: Trever Hassell | Stryker Corp. | $17,500 |
| Heterogeneous Multisensor Buried Target Detection Using Spatiotemporal Feature Learning | PI: Tim Havens | US Department of Defense | $95,300 |
| CAREER: Integrated Research and Education in Physical Design Automation for Nanotechnology and VLSI Technology Co-Design | PI: Shiyan Hu | National Science Foundation | $335,790<br>($89,564 FY17) |
| Understanding and Mitigating Triboelectric Artifacts in Wearable Electronics by Synergic Approaches | co-PI: Shiyan Hu | National Science Foundation | $330,504 |
| Microfabrication Facility Services | PI: Chito Kendrick | Various Sponsors | $15,936 |
| Senior Design: Fault Location Identification on a Transmission Line Using Traveling Wave Theory & Protective Relaying–Phase II | PI: John Lukowski | American Transmission Company | $17,500 |
| PARA Board Build | PI: Chris Middlebrook | Alion Science and Technology | $24,345 |
| Power System Protection in a Smartgrid Perspective–Prosmart | PI: Bruce Mork | Norwegian University of Science and Technology | $319,809<br>($139,333 FY17) |
| Packetized Energy Management: Coordinating Transmission and Distribution | PI: Sumit Paudyal | University of Vermont | $346,504 |
| Senior Design: dSpace Hardware in the Loop Development and Testing–Year 3 | PI: Tony Pinar | Nexteer Automotive | $17,250 |
| Auris: A CubeSat to Characterize and Locate Geostationary Communication Emitters | co-PI: Mike Roggemann | Utah State University Research Foundation | $55,000 |
| Wave Optics of Deep Atmospheric Turbulence: From Underlying Physics Towards Predictive Modeling Mitigation and Exploring | PI: Mike Roggemann | University of Dayton (MURI grant) | $254,671<br>($51,859 FY17) |
| CAREER: Online Learning-based Underwater Acoustic Communications and Networking | PI: Zhaohui Wang | National Science Foundation | $500,000 |
| Meta-Stability of Pulsed Load Microgrids | PI: Wayne Weaver | Sandia National Laboratories | $76,000 |
| Autonomous Microgrids: Theory Control Flexibility and Scalability | PI: Wayne Weaver | US Department of Defense | $249,994 |

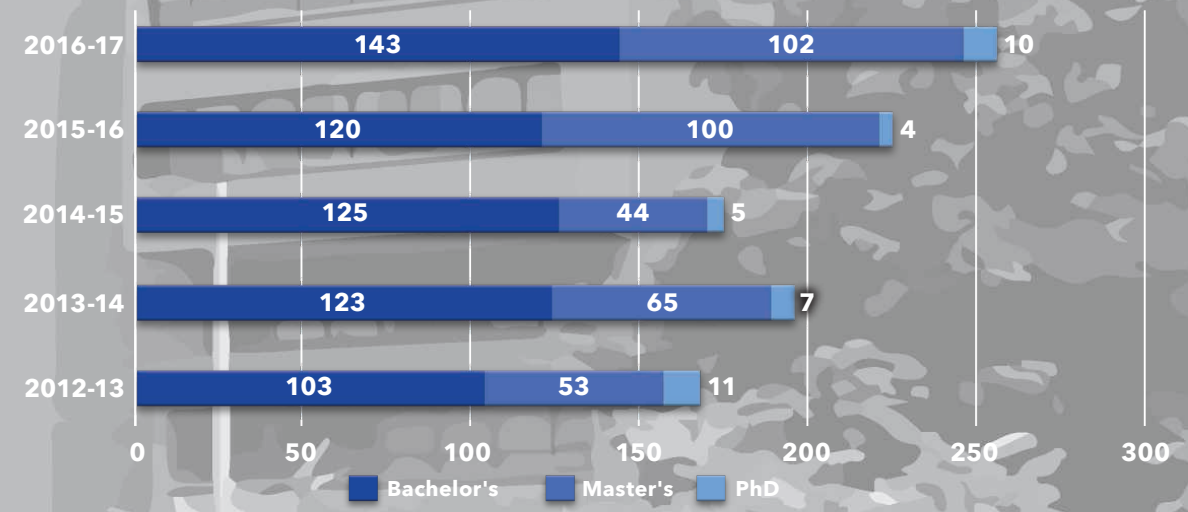
*Due to disclosure restrictions, some awards may not be listed.*

# Department Statistics

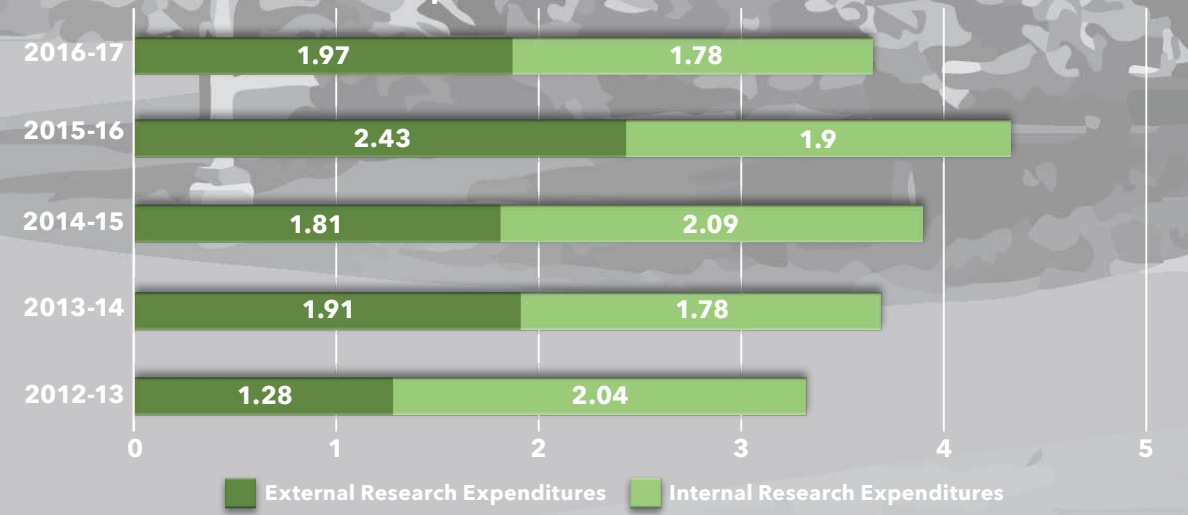
## ECE Enrollment




## ECE Degrees Awarded




## ECE Research and Sponsored Programs Expenditures in Millions



Michigan Technological University

**Department of Electrical and Computer Engineering**
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931-1295

# A Pioneer's Story

In the early 1960s, when Pat Anthony was in high school, her guidance counselor tried to talk her out of studying electrical engineering.

"She was appalled," Michigan Tech's first female electrical engineering graduate recalls. When Anthony scored off the chart on a math and science aptitude test, the counselor re-scored the test on "the boys' scale." Anthony hit the 90th percentile there, too.

She started writing to engineering schools. Several said they didn't accept women.

Michigan Tech was different. "Before Thanksgiving of my senior year, I had a scholarship to Michigan Tech," she says. "It was clear they wanted me."

Anthony wasn't the first woman to study electrical engineering at Tech. But the others never finished.

She found support from older female students in her dorm, and later in her sorority, Phi Lambda Beta. The sorority was "for serious students," Anthony says. "One of our songs went, 'We're here for our BS, not an Mrs.'"

By the time she was a junior, she was a pioneer. No woman had taken the classes she was taking. "It was all new ground."

After she graduated in 1967 and entered the workplace, she continued to feel like a pioneer.

"Everywhere I went, I was met with skepticism." But her faculty advisor told her time and again to let her work speak for her. "I used that advice every day of my career."

It has been 50 years since Anthony earned her EE degree at Tech. "I'd like to think things are better today," she says. "As the number of female engineers grows and they become successful, things improve."

She is doing her best to make sure the next generation knows they can dream big. She mentored young people wherever her career with IBM took her. "There is nothing more satisfying than seeing a young person dream of a future and believe it is possible," she says.

Anthony was inducted into the ECE Academy on April 28, 2017, and in recognition of her 50th anniversary, was honored during Michigan Tech's Spring Commencement.