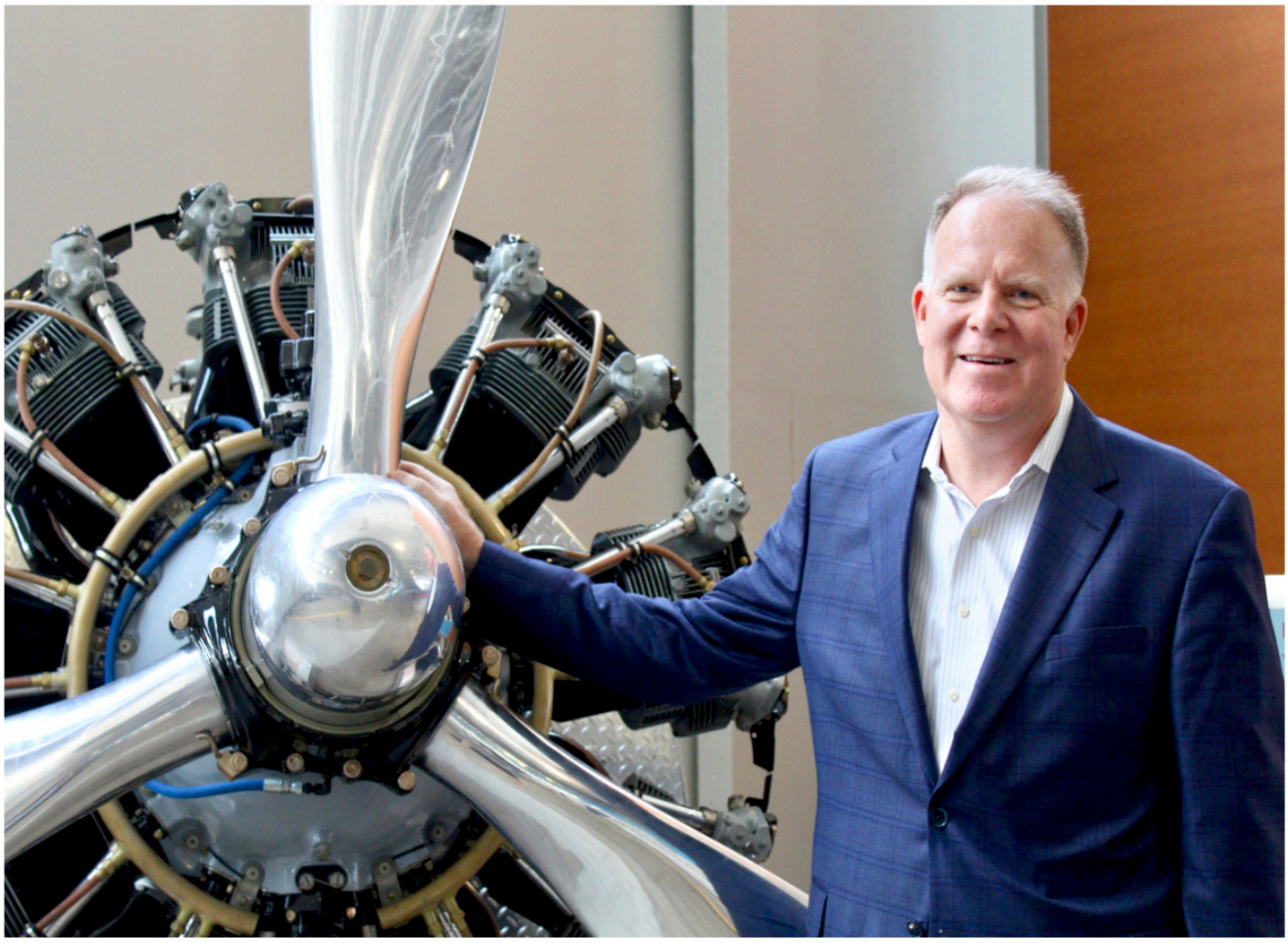
NC STATE Engineering

Fall / Winter **2019**

MAETRIX



MAE **AT A GLANCE**

2018-19 QUICK FACTS

RESEARCH EXPENDITURES

$13 MILLION PER YEAR

More than $7 million in external funding
(Federal, State and Industry)

44 **TENURED AND TENURE-TRACK FACULTY**

23 Full; **13** Associate; **8** Assistant

5 **FULL-TIME NTT TEACHING FACULTY MEMBERS**

4 **PART-TIME TEACHERS AND RESEARCHERS**

RESEARCH CONCENTRATIONS AND FACULTY MEMBERS

Aerodynamics, Fluid Mechanics, Propulsion and Space Explorations Systems

Bryant, Echekki, Edwards, Ewere, Ferguson, Gopalarathnam, Gould, Granlund, Hall, Kleinstreuer, Luo, Lyons, Mazzoleni, Narayanaswamy, Narsipur, Reyhanoglu, Saveliev, Silverberg, Subbareddy, Vermillion

Dynamics, Vibrations, Controls, and System Design

Bryant, Buckner, Ewere, Ferguson, Granlund, Hall, Jing, Keltie, Mazzoleni, Peters, Reyhanoglu, Saul, Silverberg, Strenkowski, Tran, Tu, Vermillion, Wu, Xu, Yuan

Structural Mechanics, Materials and Manufacturing

Dow, Eischen, Ewere, Huang, Jiang, Keltie, Mazzoleni, Muller, Ngaile, O'Connor, Pankow, Peters, Rabiei, Ryu, Silverberg, Strenkowski, Tu, Wu, Xu, Zhu, Zikry

Thermal Sciences and Energy Systems

Echekki, Ewere, Fang, Gould, Kribs, Kuznetsov, Liu, Lyons, Mazzoleni, Moore, Narayanaswamy, O'Connor, Saveliev, Silverberg, Terry, Tu, Vermillion

Biomedical and Biological Systems

Buckner, Huang, Jiang, Kleinstreuer, Kuznetsov, Mazzoleni, Muller, Saul

Nanoscale Science and Engineering

Chang, Jiang, Jing, Liu, Ryu, Zhu

UNDERGRADUATE

1150 Total number of undergraduate students

3.4 Average undergraduate GPA

282 Degrees conferred

275 ME / 93 AE New undergraduate students

350 MAE intended engineering first-year undergraduates

GRADUATE

385 Total number of graduate students

136 Degrees conferred

139 Ph.D. students

82 Aerospace graduate students

303 Mechanical graduate students

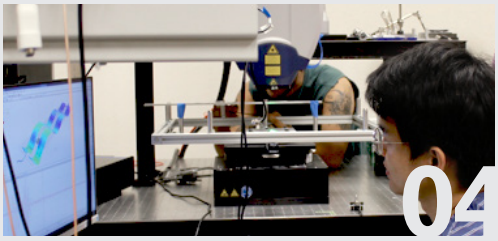
246 Master's degree students

102 Online graduate students

RANKINGS

- ***U.S. News and World Report:*** ME ranked 38th out of 179 graduate programs; AE ranked 30th out of 66 graduate programs
- **College Choice:**
  - ME graduate program ranked 22nd out of 35 for Best Masters in ME
  - ME ranked 5th of 15 for Most Affordable Online Masters
- **SR Education Group's Top 25 Best Online Master's:** ME masters program ranked 14th

IN THIS ISSUE



02

UPDATE FROM THE **DEPARTMENT HEAD**

Dr. Srinath V. Ekkad

DEAR FRIENDS AND ALUMNI OF MAE,

As we speak, the world is changing by the minute. We hear of machine learning, artificial intelligence, data analytics, autonomous systems, additive manufacturing, and other innovative technologies on the near horizon. We as engineers solve problems and address global challenges like the shortage of clean water, energy supply and demand, climate change, and rapid transportation. The need for mechanical and aerospace engineering degrees continues to be of significant value.

We are transforming the department and the student experience in an effort to produce the best ME and AE engineers in the country. Our graduates are ready to face any engineering challenge out there.

We have made significant changes to our senior design experience. The ME senior design course will now be a one-year course. Students will engage in a pre-design analysis and development process in the first semester. The second semester will consist of fabricating the approved design and testing of the prototype. The two-semester sequence will allow for more challenging projects from our industry partners. The ME senior design will be run by Dr. Chau Tran.

The AE senior design course will also undergo changes with two new design projects that include drone design and cube-sat design. AE students will also have their first ever industry funded project. The AE senior design will be run by Dr. Felix Ewere. We hope that these changes in senior design will really help heighten the overall student experience in both programs.

We are also pleased to announce the development of new state-of-the-art research labs in our research annex building, affectionately called MAE West. We hope to improve the facilities in the 10,000 square foot building to include many of our high-speed flow and combustion experiments. The laboratory will have improved flow handling capability with a high-pressure compressor, additional fuel capabilities, and more collaborative research opportunities for faculty and graduate students. The additional benefit is that this helps open up space in Engineering Building III (EB III) for our student motorsports teams in the High Bay building.

MAE students will also have access to a new design and maker space across the corridor from the senior design area on the first floor of EB III. Once the transition is complete, the entire first floor area in EB III will be a hub of student design activity.

We are planning to add display models of engines / aircraft / robots in the atria of EB III as well as a full size airplane (Long EZ aircraft) on the backside of the building. We hope that current and future students of MAE programs will feel inspired by the creations of past engineers and will aim for the sky.

Additionally, we are planning to introduce a professional master's degree program with a mechatronics concentration in the near future. We hope to finalize the curriculum and will soon start accepting applications for the program.

The faculty have accomplished a lot in the past year. We have taught our students well, developed new research ventures, proposed additional novel research ideas, published our technical accomplishments in major journals, and won a few awards along the way.

The red jacket we introduced for the MAE Hall of Fame ceremony is a big hit (*see page 28*). If you are interested in getting a red jacket with the MAE insignia, please contact us.

MAE is on the move and on its way to becoming one of the largest and best mechanical and aerospace engineering programs in the nation. As we look forward, we invite you to be a partner in the success of the department. Please come and join us and help us accomplish more.

We hope you continue to remain updated with our MAE news. We regularly update our website and social media, in addition to utilizing this newsletter to tell a few in-depth stories. If you ever want to stop by and visit, please email me at **sekkad@ncsu.edu**.

Best Regards,
Srinath V. Ekkad
Department Head and R.J. Reynolds Professor

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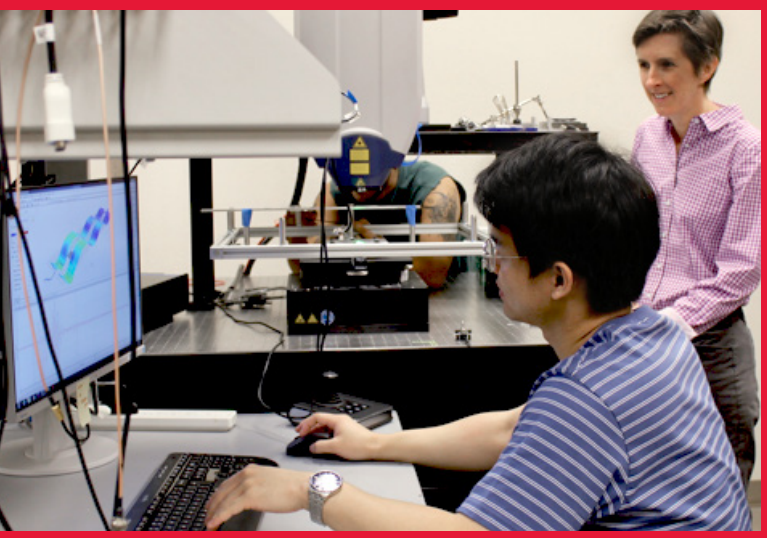
Featured Research

MAE IN THE WORLD



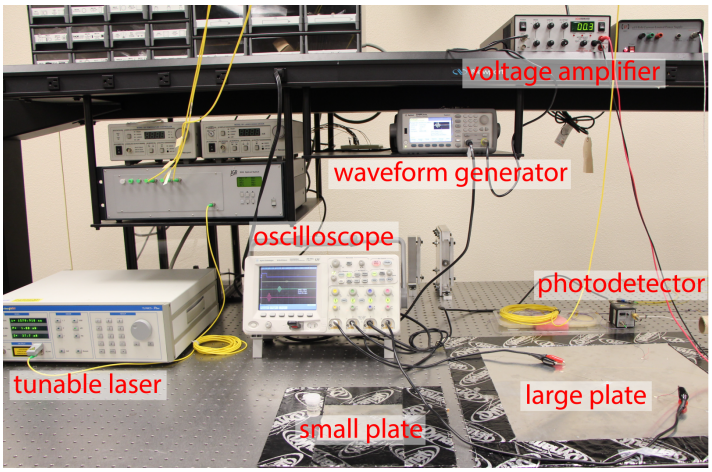
Dr. Kara Peters works with her research students.

Engineers use ultrasonic waves to inspect large structures

Engineers use ultrasonic waves for structural health monitoring of large structures, such as naval structures, wind turbines, aircraft and offshore platforms. The ultrasonic waves, generated by an actuator or by the formation of a crack or defect in the structure, are detected by sensors and their waveforms processed to analyze changes to the structure that are due to corrosion, fatigue or impact-induced damage. Some of the research in Dr. Kara Peters' laboratory focuses on the use of the optical fiber sensors to measure these ultrasonic signals. Optical fiber sensors are immune to electromagnetic interference and can survive in corrosive environments, and large numbers of sensors can be integrated into a single optical fiber. This is particularly advantageous for monitoring large structures where many different regions of the structure must be inspected.

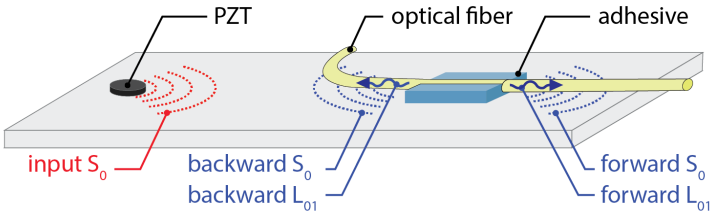
A major challenge to detecting these surface ultrasonic waves, however, is their

Faculty Researchers Explore Ultrasonic Waves and Muscle-Inspired Fluidic Actuators



Laboratory experiment to measure acoustic modes converted from aluminum plate to optical fiber modes and detected by optical fiber sensors.

low amplitude and therefore the low signal-to-noise ratio of the measured waveforms. Peters' research group has recently shown that the ultrasonic signal can be enhanced by instead converting the ultrasonic waves traveling through the structure into acoustic waves traveling along optical fibers. Optical-based sensors in the optical fibers then measure the longitudinal acoustic waves in the optical fibers, which have much higher amplitudes. The ultrasonic waves have also been demonstrated



Schematic of forward and backward ultrasonic wave coupling from structure (grey) to optical fiber (yellow), through adhesive bond (blue). Waves are excited in plate using piezoelectric (PZT) actuator.

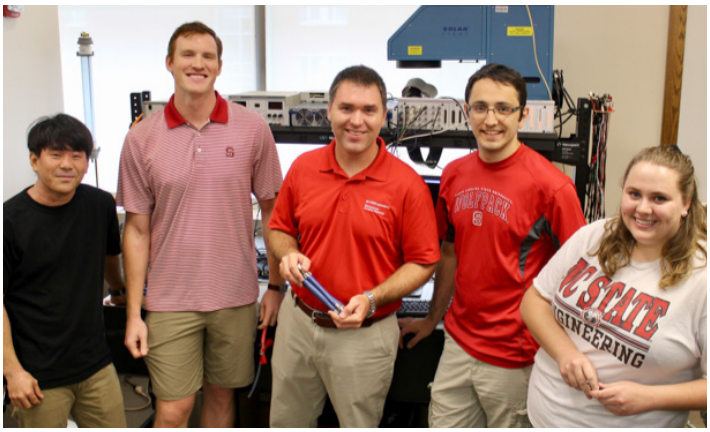
to couple in multiple directions in the optical fibers, which creates the opportunity to design sensor networks in which signals can interact and large structural regions can be monitored. The researchers have also coupled ultrasonic waves from optical fibers back in the structure to generate new ultrasonic waves for the inspection of the structure.

The most recent paper from this research, "Experimental study on directionality of ultrasonic wave coupling using surface-bonded FBG sensors," is published in the *Journal of Lightwave Technology*. Lead author of the study is Junghyun Wee, a graduate student at NC State. The paper was co-authored by Drew Hackney, a post-doctoral researcher in the MAE department and Philip Bradford with College of Textiles. The research was funded by the Office of Naval Research through grant number N000141410652. ■

Muscle-Inspired Fluidic Actuators to Improve Efficiency and Safety in Human-Assistive Robotics

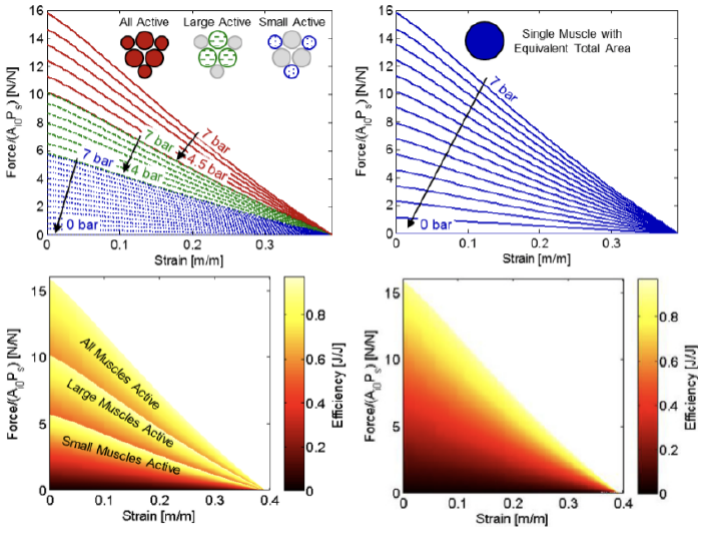
A new CAREER Award research grant from the National Science Foundation will develop soft hydraulic and pneumatic "artificial muscle tissues" with a selective-recruitment actuation and control strategy inspired by the motor unit architecture of natural muscles.

"Existing types of actuators like hydraulic pistons and servomotors work well for large industrial robots, but are poorly suited to wearable or human assistive robotics," says Dr. Matthew Bryant, the author of the grant and assistant professor. "If robots are to work safely and effectively with humans, they must use actuators that have similar compliance to human tissues and produce high energy efficiency in low-frequency and time-varying motions like human walking.

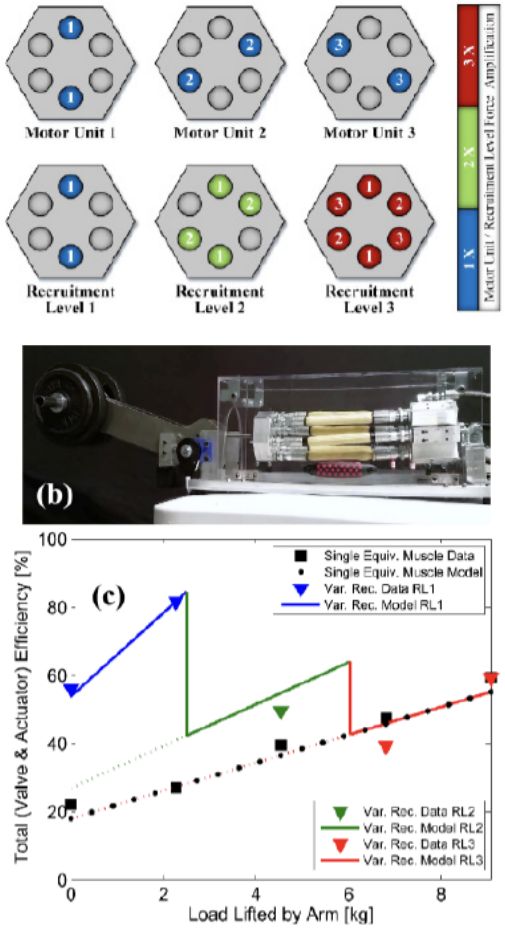


From left, Jeong Yong Kim, Tyler Jenkins, Dr. Matthew Bryant, Nicholas Mazzoleni and Lauren Warner.

Featured Research *(Continued)*



Comparison of isobaric force strain curves (upper row) and actuation efficiency over the working space (lower row) for selective-recruitment artificial muscle (left) and single actuator with equivalent total volume (right). Force is nondimensionalized by product of the source pressure and initial internal cross sectional area, a quantity equivalent to maximum force capacity of a piston-cylinder actuator of the same size.



Preliminary experiment testing selective-recruitment actuation of a one-joint robot arm showing (a) motor unit and recruitment level definitions, (b) arm setup, and (c) experimental and simulation results.

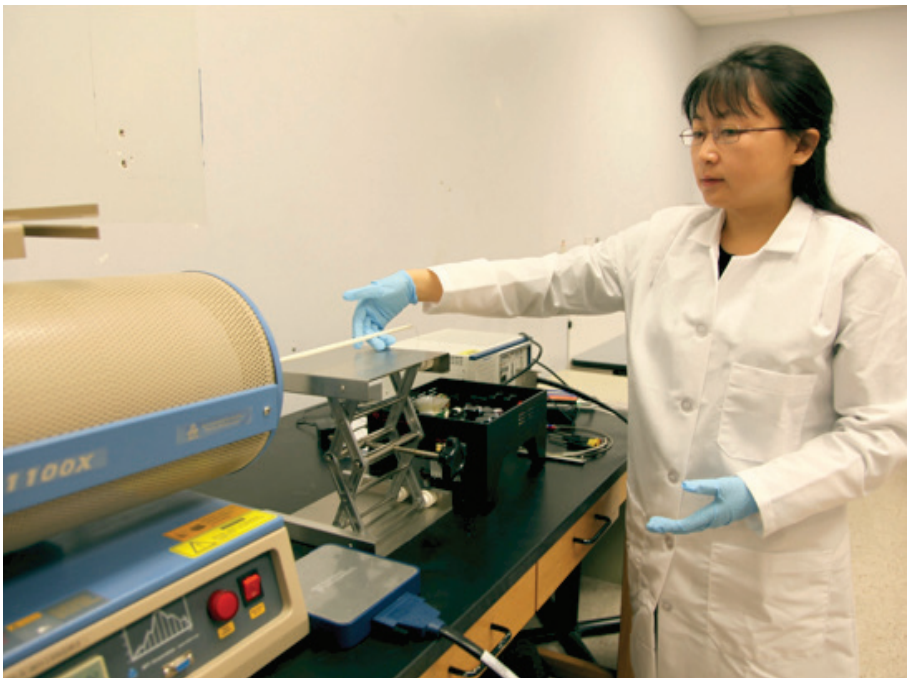
"The new approach we are pursuing is to create a soft 'artificial muscle tissue' of fiber-reinforced elastomer materials in which multiple internal chambers can be selectively inflated with pressurized working fluid to produce muscle-like force and contraction," Bryant says. "The key innovation is the selective-recruitment control approach — essentially you only pressurize as much of the artificial muscle tissue as needed to produce the force level required at a given instant. This allows the system to reduce working fluid consumption and minimize valve throttling losses, tune the stiffness of the actuator to a desired level, or improve response speed and bandwidth."

Natural human muscles use a similar control mechanism — thousands of individual muscle fibers, arranged in groups called motor units, make up each muscle. These motor units are hierarchically activated by the nervous system to produce a desired amount of force. Bryant and his team aim to draw inspiration from the control of natural muscles to develop a system that can intelligently control the pressurization state of the artificial muscle tissue to maximize performance.

Work by Bryant and his team has already led to several papers simulating the energetics, force production, and control of the artificial muscles tissues, as well as validating their model predictions in benchtop experiments and simple one-joint robotic arms. "Some of the key goals of the new grant are to understand and model the implications of pressurization transition criteria and design topology parameters like size, number, shape, and orientation of the actuator chambers within the artificial muscle on the performance and efficiency of the actuation system," Bryant says. "Creating this modeling framework will allow us to optimize the entire actuator and control architecture given the operating tasks and requirements for a desired robot application."

As a final objective, the team plans to build a fully functional example of their new actuation and control system and demonstrate it on a human-sized walking robot in the lab. "Ultimately, we are looking forward to seeing the results we have observed in bench experiments scaled up to the full system prototype." ■

Research Highlights



Dr. Cheryl Xu

RESEARCH AREAS IN CERAMIC MATERIAL MANUFACTURING FOR EXTREME CONDITION APPLICATIONS

Dr. Cheryl Xu and her team have developed a novel advanced manufacturing process to fabricate a new class of multifunctional ceramic nanocomposites, which demonstrates enhanced strength and Young's modulus, great flexibility, and good electrical and thermal conductivity. The tensile strength of such ceramic composites is 536 MPa and Young's modulus is 118 GPa. This material demonstrates excellent flexibility — it can be bent to 100% of the original length and the flexibility testing is repeated 1,000 times without any crack or performance degradation. This ceramic composite is electrically conductive, has high-temperature survivability, excellent oxidation and hot-corrosion resistance. It can be used in water vapor and acid fume environment. It can be suitable for surface coatings on curved surfaces on hypersonic vehicles for thermal management.

Another area is to utilize the exceptional electrical and dielectric properties for high temperature sensor applications, including turbines, engines, power plants, and nuclear reactors. The researchers have developed wireless temperature / pressure sensor demonstrating high temperature survivability, oxidation and corrosion resistance, and high gauge factors. The exponentially increased permittivity of polymer derived ceramics (PDCs) at elevated temperatures makes it possible for wireless sensing signal transmission and remote high temperature measurement. The contribution of this research topic is significant for both the aerospace sector, as well as, propulsion and power generation sectors.

BEHIND EMSSL

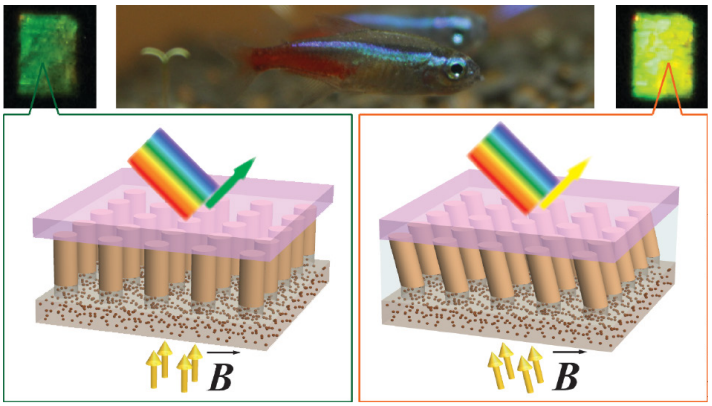
Dr. Andre Mazzoleni is the director of the Engineering Mechanics and Space Systems Lab (EMSSL) at NC State. Mazzoleni and his team at the EMSSL apply the principles of engineering mechanics to develop new technologies and solve problems in the areas of space exploration systems, renewable energy, and biomechanics.

In the area of space exploration systems, EMSSL team members are working on the development of bio-inspired rovers (e.g. "Tumbleweed" rovers) to explore the moon and Mars, trajectory control systems for high-altitude balloons, advanced space propulsion technologies, and a tether / ballast system to deflect Earth-threatening asteroids.

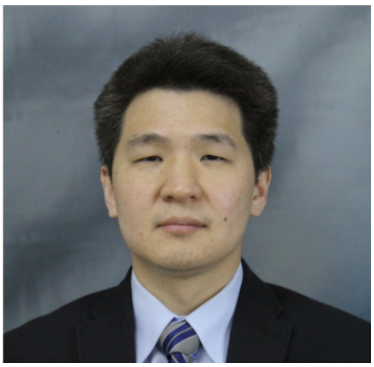
In the area of renewable energy, EMSSL team members are working on ocean-based compressed air energy storage systems, airborne wind energy, and tethered underwater turbine systems for extracting renewable energy from the Gulf Stream and other ocean currents. In the area of biomechanics, EMSSL team members are using finite element methods to help spine surgeons develop more effective techniques to treat patients with degenerative disk disease and scoliosis.

Dr. Andre Mazzoleni

Research Highlights *(Continued)*



MAGNETICALLY ACTUATED DYNAMIC IRIDESCENCE INSPIRED BY THE NEON TETRA

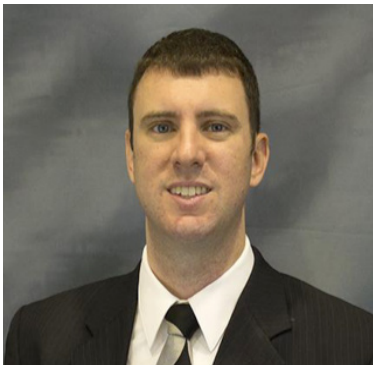


Dr. Chih-Hao Chang

Dr. Chih-Hao Chang and his Ph.D. student Zhiren Luo have developed a material to shift the material's color by using a magnetic field to change the orientation of an array of nanocolumns. This work is inspired by the flashing colors of the tropical fish neon tetra.

The material is based on three components. The magnetic polymer incorporates a regular array of micron-wide pedestals, making the bottom polymer layer resemble a LEGO® brick. The middle layer is an aqueous solution containing free-floating iron oxide nanoparticles. This solution is held in place by a transparent polymer cover. When a vertical magnetic field is applied beneath the substrate, it pulls the floating nanoparticles into ordered columns, aligned over the pedestals.

By changing the orientation of the magnetic field, researchers can change the orientation of the nanoparticle columns and the corresponding interference effect, resulting in color change. The researchers are working toward the goal of developing applications ranging from reflective displays to dynamic camouflage. "We are also planning to work on the development of integrated electromagnets that would allow for more programmable color shifts," Chang says.



Dr. Chris Vermillion

CORE LAB

Dr. Chris Vermillion's Control and Optimization for Renewables and Energy Efficiency (CORE) Lab is leveraging advanced design optimization and optimal control algorithms in tackling a host of problems involving the way we harvest and use energy. In particular, his lab is developing economic iterative learning control techniques for optimizing repetitive crosswind / cross-current flight of energy-harvesting kites, stochastic optimal control algorithms for harvesting renewable resources within a spatiotemporally varying environment, and economic model predictive control strategies for maximizing the fuel economy of future autonomous heavy-duty trucks.

The CORE Lab's latest sponsored project, supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and in collaboration with Drs. Andre Mazzoleni and Kenneth Granlund in MAE, involves the device and optimal control system design of an energy-harvesting ocean kite. This project will put in place, at multiple prototyping scales, the iterative learning control techniques developed within the lab throughout the past several years and will fuse the optimal control of kite-based energy systems with the hydro/aerodynamic and structural design. More information about this recent project can be found at bit.ly/2X9iS6f and additional information regarding all of the CORE Lab's activities can be found at www.mae.ncsu.edu/corelab. ■

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PROGRAM **UPDATES**

Undergraduate news from Dr. Jack Edwards, Associate Department Head and Director of Undergraduate Programs

The MAE Undergraduate Program continues to attract high-achieving, talented students to our two programs, mechanical engineering (ME) and aerospace engineering (AE). Highlights of this academic year included the second annual POP (Post Orientation Party), which was held in September 2018 and included catering by Neomonde, live music, and student club exhibits. The ME program is creating a new one-year senior design experience that will be piloted in academic year 2019-20 that will give the students more time to conduct design tradeoff studies, analyze their designs using modern engineering tools, and re-build prototypes as necessary to improve the design. MAE continues to expand our undergraduate student experience by offering various technical electives in cutting-edge areas including aeroelasticity, computational aerodynamics, energy conservation, internal combustion engines, and digital manufacturing. ASME and AIAA student clubs reported strong increases in student participation, and six AE students attended AIAA's Region II Student Conference, with Vishnu Oruganti winning the Stan Powell Prize for the best undergraduate student research paper. Our ASME student design team placed fifth at the EFEST North Student Design Competition and the High-Powered Rocketry team won first prize for altitude at NASA's Student Launch competition. The Wolfpack Motorsports Baja team placed 13th in the suspension and traction category at the 2019 Tennessee Tech competition and the Formula team placed first in the SAE Carolina section presentation event and 14th / 18th respectively out of 145 teams in the Skidpad and Acceleration events at the 2019 Michigan FSAE competition.

Graduate news from Dr. Kara Peters, Professor, Director of Graduate Programs, Associate Department Head

The MAE graduate program offers master's and doctoral degrees in both aerospace engineering and mechanical engineering with 413 students currently enrolled. Of these students, 106 are currently enrolled in our distance education master's program through Engineering Online. We have 46 tenure-track faculty members conducting active and cutting-edge research projects in more than 30 sub-concentration areas and offering more than 50 graduate courses that span all topics of aerospace engineering and mechanical engineering. In March 2019, we held the fifth annual graduate research symposium that featured 66 poster presentations, nine keynote oral presentations all by current Ph.D. students and a keynote seminar by Timothy Lieuwen from Georgia Tech. In fall 2019, the MAE graduate program will welcome three new recipients of the Provost Doctoral Fellowship and one new recipient of the Dean Doctoral Fellowship. We will also welcome a recipient of the Bridging to the Doctorate Fellowship, a new fellowship program sponsored by the National Science Foundation to increase the participation of underrepresented minorities in Ph.D. programs in the College of Engineering. ■

Drs. Jack Edwards and Kara Peters.

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Update

FEATURE **STORY**

The MAE Department along with the NC State Engineering Foundation is looking to make a major investment in both the undergraduate and graduate student experience for the future. In order to support our growing student population, we are hoping to create the MAE Graduate Innovation Center (GIC) to be housed in what is currently known as "MAE West."

MAE West and EB III Makerspace

UNKNOWN TO MANY, the MAE Department at NC State has a facility across from Highway 440 near university surplus, called the Annex facility, or simply MAE West. This facility was heavily used by faculty for laboratory space prior to 2010 when the department was in Broughton Hall. Since the move to the Centennial Campus Engineering Building III (EB III), the space has been used by the Motorsports teams and some research groups, but primarily for storing old equipment. The facility's 10,000 sq.ft. of space was left largely underutilized.

Fast forward to 2019, the department has added at least 10 more faculty members who are very active in research, and our number of undergraduate students has also grown. The department now has proposed to make MAE West a research activity hub and plans to move the Motorsports teams to Centennial Campus. This creates many opportunities for the department, faculty, and the students.

MAE West will be upgraded to a world-class facility to house our high-speed flow, combustion facilities as well as some advanced manufacturing research activities. This move will allow a cohesive group of researchers working on similar topics to interact and build innovative research projects. The hope is that there will be at least six to seven faculty research groups working on complex flow and combustion related research. The additional space will also help potentially develop new test rigs which the research groups lack.

The Motorsports teams will be housed in the High Bay building, directly behind EB III. We have three rooms with garage doors which will be ideal for the teams. The teams will

The MAE students and department thank our patrons and alumni for their support with this exciting project.

To support the GIC / UDL Project, please contact:

Dr. Srinath Ekkad,
MAE Department Head
sekkad@ncsu.edu | 919.515.2368
EB III, Room 3002 | Raleigh, NC 27695

have access to the student machine shop on the first floor of EB III. The proximity to the building will potentially allow more students to join the Motorsports teams. Our teams have been doing well in competitions with bare minimum groups of committed students due to the displaced location at MAE West. The presence of the Motorsports teams on Centennial Campus can also push more prominence for sponsorship of these teams and provide a fantastic recruitment tool. We are also potentially looking at using Motorsports activities to substitute for Senior Design in the near future.

As some of the combustion facilities will move to MAE West, there is potential to re-use the recovered space in EB III for student activities. We are proposing to convert one of the large labs (room 1208) into a student design and makerspace. The

MAE West and EB III Makerspace

space will provide collaborative tools, smart boards, benches, and 3-D printers for undergraduate student teams to interact, build, and test unique designs. This area could also become a major hub of design and fabrication activity with the student machine shop located right across the corridor. Technician expert support will be available for the student teams during working hours.

The overall vision is to provide students with a better overall experience, create a hub of design and fabrication activity on Centennial Campus, and build more cohesive research groups in the renovated MAE West space. The College of Engineering has already pledged support for developing MAE West and we hope that each of you will support these activities, financially or otherwise, to help us achieve these goals in the near future. ■

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STUDENT **SPOTLIGHT**

Shreyas Ashok

Year of Accomplishments with Shreyas Ashok

Shreyas Ashok of Apex, NC, is a junior majoring in mechanical engineering. Ashok is a member of the University Honors Program and a recipient of the John Estes Conway Scholarship. Additionally, he has received a grant from the NC Space Grant Consortium for undergraduate research. Under this grant, Ashok conducted a computational study on fires in reduced-gravity conditions, studying the effects of gravity on a phenomenon called backdraft. This research was supervised by Dr. Tarek Echekki, professor in the Department.

Last summer, Ashok was an intern for the Haas Formula 1 Team. He helped implement automation code to prepare CAD models of the Formula 1 car for CFD simulations. Additionally, this fall, Ashok will be interning at Key Tech, a product design firm based in Baltimore, Maryland.

Ashok is also a member of the ASME Design Team. This year, the NC State team placed fifth overall at the ASME E-Fest North Student Design Competition held at Michigan State University.

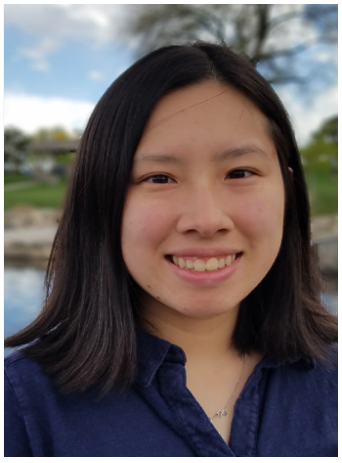
In his free time, Ashok learns Carnatic, or South Indian classical vocal music. He has given several performances in the U.S. and in India.

Engineering Senior Award Nominees

From left, Dr. Eischen, Olivia Gartz, Erin Beaton, and Madison Maloney at the Engineering Awards Ceremony.

Each year, the College of Engineering recognizes the accomplishments of graduating senior students with the Engineering Senior Awards. Receiving these awards is one of the highest forms of recognition for a senior in the College. The awards were presented by Dr. Jerome Lavelle (Associate Dean, Academic Affairs for the College of Engineering) at the Engineering Awards Dinner on Monday, April 29th. The MAE nominees for the college wide competition were: Madison Maloney — Scholarly Achievement (College wide winner), Erin Beaton — Citizenship and Service, and Olivia Gartz — Leadership.

Liao, Maloney and McKenna Earn 2019 NSF Graduate Fellowships



Ashlee Liao

Madison Maloney

Carly McKenna

The National Science Foundation's (NSF) Graduate Research Fellowship Program (GRFP) has announced the offer of more than 2,000 fellowship awards, following a national competition. MAE recent graduates, Carly McKenna, Madison Maloney, and Ashlee Liao are recipients of the 2019 NSF GRFP Award. Stephen Schuerele and Samuel Fedeler graduated in fall 2018 and also received awards and are now in graduate school at Purdue and University of Colorado Boulder, respectively. Other winners Charlotte DeVol, Sophia Tushak, and Emily Fawcett also received awards. They were graduates of the Joint UNC / NC State Department of Biomedical Engineering program at NC State, but conducted undergraduate research with Dr. Kate Saul in MAE.

The program recruits high-potential, early-career scientists and engineers and supports their graduate research training in science, technology, engineering and mathematics (STEM) fields. Launched in 1952 shortly after Congress established NSF, GRFP represents the nation's oldest continuous investment in the U.S. STEM workforce.

The new awardees were selected from more than 12,000 applicants and come from all 50 U.S. states, as well as the District of Columbia and U.S. territories. Honorable mention recognition went to 1,540 individuals.

GRFP provides three years of financial support within a five-year fellowship period — a $34,000 annual stipend and $12,000 cost-of-education allowance to the graduate institution. That support is for graduate study that leads to a research-based master's or doctoral degree in a STEM field. ■

Q&A

Emily McCain

"The opportunity to apply engineering design skills toward improving the quality of life of any clinical population is incredibly rewarding."

EMILY McCAIN is a graduate student in the Movement Biomechanics Lab (MOBL) advised by Dr. Katherine Saul. McCain was recently awarded the National Research Service Award (NRSA) for predoctoral students from the National Institute of Health. Her research goal is to understand the impact of ankle exoskeleton design on post-stroke walking performance using analyses of mechanics, energetics, and musculoskeletal computer simulations. Working alongside Saul, and co-advisors Drs. Gregory Sawicki and Michael Lewek, McCain recently published a first-author work in the *Journal of NeuroEngineering and Rehabilitation* (JNER).

Behind the Research with Emily McCain

WE ASKED EMILY A FEW QUESTIONS ABOUT BEING PUBLISHED. HERE'S WHAT SHE HAD TO SAY:

1. Describe the unique benefits to a multidisciplinary project.

Having diverse perspectives around the table allows our team to more comprehensively tackle our research questions, which leverage understanding of robotics, biomechanics, and neurological changes following a stroke. We benefit tremendously from Dr. Saul's expertise in musculoskeletal computer modeling and experimental assessment of human movement and Dr. Sawicki's expertise in the evaluation of human physiological response to lower-limb robotics. We are further enriched by Dr. Lewek's clinical and research experience with walking recovery following stroke. The opportunity to work on a team with these professional perspectives is not only beneficial to project design, synthesis, and publication in the *Journal of Neuroengineering and Rehabilitation*; it is also valuable for me to learn a wide set of approaches and strategies from these leaders that I can take to future projects.

2. What special considerations are necessary when research involves working with human participants?

The opportunity to apply engineering design skills toward improving the quality of life of any clinical population is incredibly rewarding. However, anyone conducting research with human participants needs to complete specialized training for safe and ethical research. Before a project is launched, it is vital to secure prior approval from an ethics review board that independently reviews the research plan. When the participants are part of a clinical population, there can be additional challenges associated with their clinical condition (e.g. fatigue, reduced stability, difficulty communicating), and therefore data collection protocols need to consider and mitigate these risks as much as possible. However, these challenges are always outweighed by the value that comes from working with patients and interacting first hand with the population we are hoping to serve.

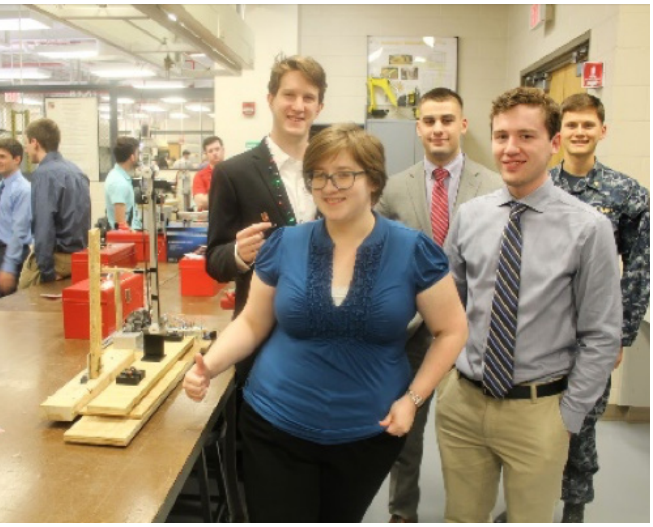
3. What type of skills did you have to gain for this project?

Our ongoing research uses an exoskeleton emulator system, which is a device that can apply torque at the ankle to aid walking and can rapidly change the control parameters without having to change devices. It uses a powerful off-board actuation and control system, a flexible Bowden cable transmission, and a lightweight exoskeleton end effector. Working with any new system requires a learning curve, and the exoskeleton emulator is no exception. While I became familiar with this technology, I gained experience in real-time data collection software and interfacing with off-board control drives and actuators. Currently we're preparing for another data collection; these preparations have required extensive project management skills. Our complex experimental protocol involving a clinical population requires developing an optimized schedule to accommodate lab needs and subject availability, mentoring undergraduate student research assistants, and managing research materials to maintain adequate data collection supplies.

4. What did you learn from the process of writing a predoctoral grant?

The NRSA focuses equally on the research plan and on the training plan that details all relevant skills that should be gained or improved throughout the doctoral research project. I am thrilled to receive the NRSA, and excited to use the training plan I developed during the application process as a blueprint for how I can optimize my time as a Ph.D. student. The development of the proposal also illuminated how the proposed work required the diverse guidance of Drs. Saul, Sawicki and Lewek, without whom this project would not have been possible. ■

Senior Design



MAE 416 Capstone Design

Each semester, mechanical engineering seniors are given a real-world problem to solve in the MAE 416 Capstone Design course, and they showcased their solutions during Senior Design Day. The semester-long project is designed to prepare students for the workplace through hands-on experience in the design and prototyping of real-world solutions to industry-sponsored projects. This semester's projects were provided by our sponsors, Pentair, Caterpillar, Zurn, DENSO and the ETF Committee. The event starts in the morning with formal presentations where each team outlines their design process, describes the proposed device, and advocates for how their work has satisfied the project goals and constraints.

After presentations are complete, everyone breaks for the annual Burger Bash lunch provided by ASME. Then it's right back to the action as the student groups demonstrate the designs for their sponsor. The top three teams for each project are recognized by the sponsors with certificates and a monetary award.

"By sponsoring NC State MAE 416, prospective students are now more aware of DENSO and its global footprint. DENSO has many opportunities for graduating mechanical engineers and after more than six years of project sponsorship, the company now has a steady flow of applicants from NC State — many leading to rewarding careers at DENSO," said Josh Longworth, advanced project manager for NA Production Innovation Center at DENSO. ■

For more information on how your company can participate in and sponsor a Senior Design Project, contact Mike Walsh at mpwalsh2@ncsu.edu.

Student Motorsports

DENSO grant will benefit Student Motorsports

The MAE Department's Student Motorsports team received a $40,000 grant from mobility supplier DENSO for programs focused on science, technology, engineering, and math (STEM).

Grants were awarded to programs focused on design, materials management, mechanical and electrical engineering principles, thermodynamics, robotics and more. With this grant, the Department plans to improve the NC State Student Motorsports Fabrication and Design Shop by purchasing a CNC waterjet system and a CNC laser tube cutting system.

The grant, which is made possible by the company's philanthropic arm, DENSO North America Foundation (DNAF), is one of 26 grants awarded by DENSO in 2019 to colleges and universities throughout North America. The donations are part of DENSO's broader efforts to cultivate tomorrow's workforce and prepare young thinkers to lead a new era of innovation.

"We are grateful for the continued and significant support from DENSO North America Foundation," said Dr. Richard Gould, professor in the department and faculty advisor for NC State Motorsports. "DENSO recognizes that students who participate in Society of Automotive Engineering (SAE) competitions learn important skills (teamwork, problem solving, budget and time management, trade-off and design) that poise them for successful engineering careers. To that goal, DENSO, through this grant has truly partnered with NC State to help provide differentiating experiences for our students."

DNAF has supported STEM education through grants at colleges and universities since 2001, enabling students to access tools, technology and experiences that better prepare them for technical careers after graduation. DENSO education grant proposals are invite-only and evaluated based on technical merit, student experience, and alignment with industry needs.

"Investing in tomorrow's workforce is critical to ensuring we have individuals who are equipped to help DENSO fulfill its vision of creating software and products that enhance safety and reduce environmental impact," said Bill Foy, senior vice president of engineering at DENSO and a DENSO North American Foundation board member. "Through these grants, we hope to create a generation of innovators who inspire new value for the future of mobility."

Headquartered in Kariya, Japan, DENSO is a $48.3 billion global company that develops advanced technology and components for nearly every vehicle make and model on the road today. With manufacturing at its core, DENSO invests in its 221 facilities in 35 countries to produce thermal, powertrain, mobility, electrification, and electronic systems, to create jobs that directly change how the world moves. In North America, DENSO employs more than 27,000 engineers, researchers and skilled workers across 31 sites in the U.S, Canada and Mexico. In the U.S. alone, DENSO employs more than 17,000 employees across 13 states and 25 sites. ■

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NEW FACULTY AND STAFF

Tonja Austin
Graduate Assistant

June Bowles
Front Office Coordinator

Jessica Sudduth
Executive Assistant

Dr. Cheryl Xu
Associate Professor

Briana Goins
Public Communications Specialist

Iyana Porter
Graduate Program Coordinator

Dr. Felix Ewere
Teaching Assistant Professor

Dr. Jong Eun Ryu
Assistant Professor

Dr. Chris Vermillion
Associate Professor

Emma Munson
Undergraduate Programs Assistant

Awards and Honors

JIANG ELECTED AS A FELLOW OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

Dr. Xiaoning Jiang was elected as a Fellow of the American Society of Mechanical Engineers (ASME), an honor bestowed on only 3% of members. Fellow is the highest elected grade of membership within ASME, the attainment of which recognizes exceptional engineering achievements and contributions to the engineering profession.

The ASME Committee of Past Presidents confers the Fellow grade of membership on worthy candidates to recognize their outstanding engineering achievements. Nominated by ASME Members and Fellows, an ASME Member has to have 10 or more years of active practice and at least 10 years of active corporate membership in ASME.

Jiang has been a member of ASME since 1999 and has been actively involved in ASME activities by publishing with ASME, serving as an editorial board member in an ASME journal and chairing in ASME conferences.

YUAN EARNS GRADUATE PROFESSORSHIP AWARD

Dr. Fuh-Gwo Yuan, Samuel P. Langley Distinguished Professor, was selected as an awardee for the 2019 Alumni Association Distinguished Graduate Professorship Award. The selection committee was unanimous in their praise of Yuan's exceptional history of promoting and supporting multiple facets of graduate education at NC State. Particularly impressive were the letters of nomination written by former and current students, which attested to the extraordinary quality of mentoring that he has provided during and after their graduate studies at NC State. Each year, the Alumni Association honors faculty members who excel in the classroom, laboratory and in the field through outstanding graduate-level teaching. Nominations are made for these awards by deans, department heads, peers and students. Faculty members receive recognition at the spring awards ceremony, honoring their dedication and commitment to NC State's core values — teaching, research, and extension. With each of these awards, the professor receives a $4,000 stipend.

SAUL NAMED 2019 UNC SYSTEM FACULTY FELLOW RECIPIENT

Dr. Katherine Saul, head of the Movement Biomechanics Lab (MoBL), was selected as a 2019 Faculty Fellow of the University of North Carolina System.

As a Fellow, Saul will spend one year researching academic affairs. Each institution is able to nominate one individual for each focus area, and the nominee must be tenured with at least three years on campus.

"I look forward to investigating the cutting-edge technology available for classroom transformation, including what is currently used within the UNC System and new strategies that could be leveraged; methods for using technology to enhance learning and translation of concepts into practical skills; approaches for improving efficiency and classroom management for faculty; and considerations of accessibility for students with disabilities or other requirements for learning support. I anticipate creating new recommendations for implementation of technology in the UNC System, with an eye toward providing context for the different needs of courses depending on campus, enrollment, course topic, and student background," says Saul.

O'CONNOR NAMED UNIVERSITY FACULTY SCHOLAR

Dr. Brendan O'Connor, associate professor, was named a University Faculty Scholar for the 2018-19 academic year.

Awards and Honors *(Continued)*

Additional Department Honors

- **8 AIAA** Associate Fellows
- **9 ASME** Fellows
- **7 NSF CAREER** Awardees
- **1 AFOSR YIP**
- **1 ONR YIP**
- Several **ASME / AIAA** level awards
- Several **best paper** awards
- **17** faculty members with **H-index** of 20 or more

Faculty members across the university receive this designation due to their significant academic achievements and contributions to NC State through their teaching, research and community engagement.

Nearly 150 faculty members have been named University Faculty Scholars since the program's founding in 2012. Faculty members selected as University Faculty Scholars carry the title for the duration of their faculty appointment at NC State and receive an increase to their base salary.

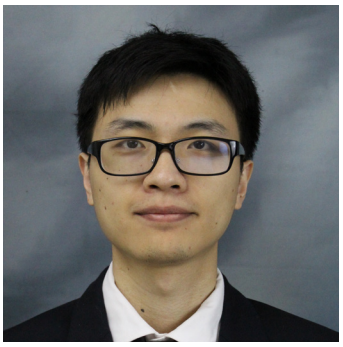
TERRY RECEIVES THE OUTSTANDING EXTENSION AWARD

Dr. Steven Terry, research assistant professor, received the Outstanding Extension Award. This award encourages and recognizes members of the faculty and EHRA staff who are nominated and selected by their respective colleagues, schools or units on campus for their outstanding contributions to extension or engagement. The award recipients will become nominees for induction into the Academy of Outstanding Faculty in Extension and Engagement and also be considered to receive an Alumni Award, which includes a monetary stipend.

BRYANT NAMED FACULTY EARLY CAREER DEVELOPMENT AWARD RECIPIENT

Dr. Matthew Bryant, assistant professor, has received a Faculty Early Career Development award, also known as the CAREER Award, from the National Science Foundation (NSF). The award is one of the highest honors given by NSF to young faculty members in science and engineering.

NSF will provide $500,000 in funding over five years to support his project, "Muscle-Inspired Load-Adaptive Actuation for Compliant Robotics."



JING RECEIVES THE ULTRASONICS EARLY CAREER INVESTIGATOR AWARD

Dr. Yun Jing, associate professor, received the Ultrasonics Early Career Investigator Award at the 2018 IEEE International Ultrasonics Symposium on October 24, 2018, in Kobe, Japan.

Awarded for his contributions to numerical modeling wave propagation, Jing has been at the frontier of developing fast and accurate algorithms for modeling acoustic wave propagation in complex biological tissues. These algorithms can facilitate high intensity focused ultrasound treatment planning, transducer characterization, and the design of transducers.

RABIEI NAMED ALCOA FOUNDATION RESEARCH AWARD RECIPIENT

Dr. Afsaneh Rabiei received the Alcoa Foundation Distinguished Engineering Research Award, made to a senior faculty member for research achievements over a period of at least five years at NC State. ■

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ALUMNI CORNER

CAREER OVERVIEW

Gil West is senior executive vice president and chief operating officer for Delta Air Lines. He leads the team responsible for safe, reliable operations across the globe, including more than 70,000 employees in airport customer service; cargo; corporate safety, security and compliance; Delta Connection; Delta Private Jets; fleet and technical procurement; flight operations; in-flight service; operations analysis and performance; operations and customer center; and technical operations.

Previously, West served as senior vice president — airport customer service and technical operations, overseeing Delta's airport operations, customer service, contracted services, workplace safety, and operational IT strategy as well as maintenance activities, flight safety and regulatory compliance and aircraft modifications. Joining Delta in March 2008, West led the Delta and Northwest airport and customer service merger integration and helped champion customer service and operational improvements, which have resulted in consistent annual ranking improvements from the Department of Transportation.

Prior to Delta, West worked for Laidlaw Transit Services as president and chief executive officer and also held leadership roles at Northwest Airlines, United Airlines and The Boeing Company. He currently serves on the board of directors for Forward Air Corporation, and the board of trustees for Brevard College in Brevard, NC.

West attended North Carolina State University, where he earned a bachelor's degree in mechanical engineering. Additionally, he received his MBA from National University in San Diego.

Name: Gil West
Graduating Class: BSME 1984

MAE Takes Flight

Paul Neil: As the Executive VP and COO of Delta, what does a day in the life of Gil West look like?

Gil West: In the airline industry, there is never a dull moment, no two days are alike. In general, we have well established our management and reporting systems. So the first thing I do every day is review our performance from the prior day, along with month to date and year to date performance. We typically have an array of meetings focused on continuing to improve the business through enhancing our operational performance, customer experience and financial performance. I also devote time to spend time with our team one-on-one in group settings and in the workplace to ensure clear communication lines are open.

P: What is the single most important experience or understanding you gained during your time in the MAE department at NC State?

G: The ability to solve problems through an engineering discipline. Identifying key variables, mining data and analytical skills, coupled with logical reasoning and experimentation have enhanced my problem solving skills.

P: Today, we're constantly making things better, faster, less expensive, and even smarter through various improvements of technology — what does this mean for Delta?

G: We're on a journey of continuous improvement. We set record performance every year and move the bar higher for next year. That requires us to continuously sharpen the saw. There are four areas of focus that drives our continuous improvement journey: process improvements, innovation, capital allocation (ie. infrastructure) and execution. We have disciplined management operating systems in which we set aggressive goals, focus the business on the right things, measure and analyze performance and reward results.

P: Tell me about a project or an accomplishment that you consider to be most significant in your career.

G: Canceling cancelations. Seven years ago, Delta never had one day in our history that we didn't cancel at least one flight. Now it's become the norm to have zero cancellations in a day. Last year we had 252 days of perfect days (zero cancelled flights). It's been an ongoing march to reduce cancelations for maintenance (annual rate of 5500 maintenance cancellation per year to 55, a 99% reduction), flight crews and weather.

P: What's the best professional advice that you could offer to a current MAE students and future graduates?

G: Never stop learning — make learning a lifetime habit. Go where the problems are and master the art of "turnaround" — fix problems and never be satisfied with how well things are performing. Business is a team sport, so put your team's performance ahead of your personal needs.

P: What's something you learned during your time as a ME student at NC State that you use every day for your current position?

G: Data analytics. The ability to see patterns in data and to analyze trends and performance are key skills in our business.

Q&A with Gil West

Senior Executive Vice President and Chief Operating Officer of Delta Air Lines, Inc.

P: Tell us about the best aircraft in your current fleet.

G: That's like asking which of your children do you love most. We have a very dense fleet of aircraft that have different missions. Over the last two years we've introduced three new aircraft fleets that are performing very well: Airbus A220 (a small narrow-body for long thing routes which replaces regional jets), A330 NEO (wide-body aircraft for trans-Atlantic and shorter trans-Pacific routes) and A350 (our flagship for long trans-Pacific routes).

P: Delta turned you down the first time you applied, what made you try again and what would you say set you apart the second time?

G: I tried to become part of Delta from the time I graduated in 1984 until I was hired in 2008. Building experience, relationships and a reputation ultimately allowed me to become part of the Delta team.

P: Have you worked with other MAE graduates in the industry or otherwise kept in touch with classmates from your time at NC State?

G: My first job after graduation was at Boeing in Seattle as an engineer. Unfortunately I didn't have the opportunity to work with fellow Wolfpack graduates until I arrived at Delta. Although we're still in the minority at Delta as we're surrounded by Georgia Tech engineers.

P: How did your education in engineering influence your career path? Has your engineering background helped you excel in certain roles?

G: My MAE education allowed me to have a strong technical base to understand complex aircraft systems throughout my career. It's the base which has enabled me to design aircraft aerospace systems, operate technical advances aircraft and to successfully manage an extremely complex business at scale. ■

By: Paul Neil IV
a senior in aerospace engineering
from Winston-Salem, NC.

Paul serves as chair for the NC State Student Branch of AIAA, the American Institute of Aeronautics and Astronautics. Paul is a member of the engineering honor society, Tau Beta Pi and aerospace engineering honor society, Sigma Gamma Tau. He has a patent application filed for an aircraft seat headrest he developed during an internship with Collins Aerospace. Most recently, he interned with GE Aviation in Cincinnati, Ohio, where he worked on jet engine simulations.

Q&A

WOMEN IN ENGINEERING

SIX QUESTIONS WITH MAE ALUMNI REBECCA AHNE AND DEBORAH ADAMS

1. What sparked your interest in engineering? Can you describe the moment you realized this was the field that you wanted to pursue?

Rebecca: My father served in the U.S. Air Force for 27 years, so I grew up on air bases, watching jets fly over our house. In the summer we would attend the local 'open house' air shows, and I spent hours climbing over the parked aircraft displays. As I got older, I had the opportunity to be around pilots on a regular basis and would listen to their stories about flying. I wanted a career that would allow me to work with and be near military aircraft, and a degree in aerospace engineering provided me with that opportunity.

Deborah: I found my love of math and science (physics) in middle school. My interests in airplanes and space started as a child since I grew up within 30 miles of a major Navy base and spent many summers on family vacations in Florida, which included visits to Kennedy Space Center.

2. What would you say was the most challenging part of your college experience at NC State within MAE? Did you ever experience uncertainty?

R: I wish I could say I was a student who picked up on fundamental aerospace concepts easily, but I wasn't! My undergraduate experience was tough, and I had to really apply myself to learn and understand the principles we were being taught. It was hard work, but I never considered quitting. I knew what I wanted to do, and I wasn't going to let hard work stand in the way. Some days were harder than others, but I had a great cohort in my class and we helped each other make it through.

D: Attempting to break the paradigm on women in engineering. In my AE graduating class, only 3 out of the class of 24 students were women. While our peers treated us as equals, there was always the stigma that we had to work a little bit harder in order to be selected as team leaders of the senior design project, or to be on the leadership team of the student professional society. I don't believe that stopped any of us. I was the Branch Chairman for AIAA in 1994-95 as well of one of four speakers for our senior design presentation for the AE class of 1995.

3. Tell us about your first job vs. your job now. What are some valuable things that you've learned along the way?

R: My first job was hands-on and involved very 'traditional' engineering tasks and responsibilities; I evaluated the condition of turbofan engine parts and created repair processes when needed. My current position is very much a 'desk job,' and my schedule is typically filled with meetings to discuss far less technical issues. Earlier in my career, it was difficult to see how a management position could be interesting or fulfilling, but as I've progressed I've learned the value of participation in the organizational decision-making process. I enjoy using my technical experience to create policies and processes that will have a lasting effect on the workforce.

with **Rebecca Ahne** and **Deborah Adams**

D: My first job was as a co-op student at NAS Pax River. I worked at Manned Flight Simulator as a software engineer for the aerodynamic model for the F-14 research, development, test and evaluation (RDT&E) simulator. I have spent my entire career at NAS Patuxent River, but in several roles including engineering, program management and test and evaluation. In my current position, I am the assistant program manager for test and evaluation (APMT&E) for the F/A-18 E/F Super Hornet. My first job was very much focused on engineering. My current job is a program management job where the technical background I have built is key to my success, but the focus is on managing resources that include aircraft, facilities, and people.

4. Many people imagine engineers sitting in their offices throughout the day, making calculations. What would you say are some big misconceptions about your job?

R: The position I hold now serves more of a policy and oversight function, which is something I never thought I would find interesting. However, the issues I'm faced with every day are more complex than the technical problems I encountered early in my career, and often have secondary and tertiary impacts. The job that requires me to 'sit in my office' (surprisingly) provides me with opportunities to tackle topics that are equally challenging to those I faced as a young engineer.

D: As a program manager I am far from doing calculations at my desk. I plan and manage the resources of an entire fleet of test aircraft across two Navy test squadrons in two different locations. While I am not designing new aircrafts, my role is significant in that the technical skills I have learned allow me to make timely, educated decisions in order to best use the limited resources we have that ultimately benefit the Warfighter of the U.S. Navy.

5. Why is it exciting to do what you do at Pax River Naval Air Station?

R: Every day, I get to see U.S. Naval airplanes, helicopters and unmanned systems fly overhead. I get to interact with program managers, testers, engineers, laboratory scientists and innovators. It's a unique workplace, and I'm inspired every day by the people I work with.

D: As the APMT&E for F/A-18 E/F Super Hornets, I am at the tip of the spear of naval aviation. I am able to work directly with naval fighter aircraft, both USN/USMC test pilots and civilian flight test engineers. While my primary job is planning resources and test events, I am able to witness those various testing events. These events are direct impacts to our USN Fleet. I am also testing technology that benefits other aspects of naval aviation such as the upgrade of the Naval Flight Demonstration Squadron (NFDS), otherwise known as the Blue Angels, to the F/A-18 E/F Super Hornet. I am afforded opportunities to take continuous learning classes through the local university satellite campus and through the Naval Test Pilot School. I am an integral team member in mishap investigations when needed, I test cutting edge technology, and I am afforded travel opportunities. I have had the opportunity to go aboard two aircraft carriers while underway and experienced both a catapult takeoff and an arrested landing onboard a C-2A Greyhound.

6. What advice do you have for women interested in MAE?

R: Take the leap! The opportunities in mechanical and aerospace are endless, and women provide important perspectives in all of them. Getting a degree in MAE will present you with challenges, but it's worth it. My choice to follow my aerospace engineering career dream has been very rewarding, and I love what I do each day.

D: Push yourself and don't make excuses! If you are an aerospace engineering student, do not limit yourself to "planes and rockets." There are many opportunities to look into that will build off your coursework such as HVAC, NASCAR, entertainment (simulators at Disney World), etc. Make connections with people in industry in any field, even outside of MAE. Find a mentor within the faculty at NC State as well as out in industry. Contact alumni to help establish those relationships. ■

2018 **Alumni Hall of Fame**

The Department of Mechanical and Aerospace Engineering at NC State is proud to honor the accomplishments of our outstanding graduates through the MAE Alumni Hall of Fame.

The MAE Alumni Hall of Fame was established to inspire our current students and to celebrate accomplishments of those extraordinary graduates who have used their education to excel in a profession, career or service. The nomination is based on professional and service achievement, entrepreneurship and contributions to professional societies.

With more than 12,000 MAE alumni, only 116, including this year's class, have been inducted into the MAE Alumni Hall of Fame. The department honored the 2018 class through the prestigious Alumni Hall of Fame ceremony on Nov. 3rd, 2018. ■

Dr. Jack Edwards, Jr.
BSAE '88, MSAE '90, PhDAE '93

Mr. Shepard Hockaday, P.E.
BSME '84

Dr. Shaik Jeelani
PhDME '75

Dr. Dean Kontinos
MSAE '91, PhDAE '94

Mr. Clyde Neely, P.E. Posthumously
BSME '51

Dr. John Olds
BSAE '87, PhDAE '93

Dr. Paul Orkwis
MSAE '87, PhDAE '90

Mr. Christopher Rolfe
BSME '72

Dr. Bill Sharpe, Jr.
BSME '60, MSME '61

Dr. Tony Sigmon
BSESM '74, MSESM '75, PhDESM '77

Dr. Allie Smith
BSME '56, MSME '61, PhDME '66

Dr. W. Glenn Steele
MSME '70, PhDME '74

Mr. P. Donald Yelton
BSAE '66

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SUPPORT MAE AT NC STATE

A gift to the Department of Mechanical and Aerospace Engineering is an investment in our future.

Gifts support scholarships, fellowships, professorships, academic programs, faculty and student research and other initiatives that are not typically supported through state appropriations. This private philanthropy creates excellence in research and education.

To learn more about supporting the department, contact Michael Walsh, at **919.515.7237** or **mpwalsh2@ncsu.edu**.

1,000 copies of this document were printed at a cost of $4,582.00.

THE YEAR AHEAD: *Upcoming Events*

THURSDAY, SEPT. 19
MAE POP (Post Orientation Party)

FRIDAY, NOV. 8
MAE Alumni Hall of Fame

FRIDAY, NOV. 15
Hassan A. Hassan Lecture Series

www.mae.ncsu.edu