NC STATE Engineering

Fall **2020**

MAETRIX

MAE **AT A GLANCE**

2019-20 QUICK FACTS

RESEARCH EXPENDITURES

$13 MILLION PER YEAR

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

45 TENURED AND TENURE-TRACK FACULTY MEMBERS
21 Full; **13** Associate; **11** Assistant

6 FULL-TIME NTT TEACHING FACULTY MEMBERS

6 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

1264 Total number of undergraduate students

3.4 Average undergraduate GPA

341 Degrees conferred

974 ME / 290 AE Undergraduate students

343 MAE intended engineering first-year undergraduates

GRADUATE

413 Total number of graduate students

102 Degrees conferred

163 Ph.D. students

82 Aerospace graduate students

331 Mechanical graduate students

139 Master's degree students on campus

111 Online master's graduate students

RANKINGS

- ***U.S. News and World Report:***
  ME ranked 37th of 184 graduate programs;
  AE ranked 29th of 66 graduate programs
- **College Choice:**
  - ME graduate program ranked 22nd of 35 for Best Master's in ME
  - ME ranked 5th of 15 for Most Affordable Online Master's
- **SR Education Group's Top 25 Best Online Master's:** ME master's program ranked 14th

IN THIS ISSUE

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UPDATE FROM THE **DEPARTMENT HEAD**

Dr. Srinath V. Ekkad

DEAR FRIENDS AND ALUMNI OF MAE,
these are strange times. The world is facing a challenge and we are all adjusting to a new normal. As expected, MAE and NC State University are also facing similar challenges to serve our students and community in the best way possible. All our classes went suddenly online in March and that has continued through summer. We have slowly and carefully opened up research labs over the summer. Many graduate students and faculty have resumed research operations. On August 10th, the classes on-campus resumed and students are back on-campus for face-to-face or hybrid classes. All the faculty, staff, and students are wary and eager at the same time as to how this scenario will unfold. Students and faculty are required to wear masks when in class. All campus buildings have safety plans to protect occupants during this crisis. However, human behavior will decide how successful we are to create the on-campus experience for our students.

Since March, your MAE Department has been moving forward. Our faculty and graduate students together with department resources such as the machine shop and technical staff, have fabricated over 15,000 face shields and over 100 intubation cases for North Carolina hospitals. This group has been able to work over 10 weeks together to innovate, fabricate, and manufacture PPE for a variety of health service organizations. The effort has been the feature of many news reporting sites across the state and country. The department is glad that our resources and expertise have been instrumental in this massive effort.

The MAE Department has continued to focus on developing the infrastructure for the future of the department. The MAE West Annex building development has moved forward with many test rigs relocated from EB III to create a new state-of-the-art research lab space. The supersonic tunnel is one of the test rigs that is now operational at MAE West. In addition, several combustion, high flow, and wind tunnel rigs have been moved to the new space. The NC State Motorsports teams are now housed in the High Bay building behind EB III. This location makes the motorsports team activities more accessible to our students and also builds on increasing connectivity between our senior design machine shop and our motorsports activities that includes the Formula SAE, Mini Baja SAE, and Solar Car Competition teams. There will also be a new MAE space called Student Design Activity Center across from our senior design fabrication shop in the near future. The department is looking for external support to provide this unique space as a collaborative, high-tech space for our students. We hope that many of our alumni will step forward to help us achieve this goal.

The department continues to attract excellent new faculty. This year, we are bringing in Dr. Edmon Perkins from Auburn University as an assistant professor, Dr. Hooman Tafreshi from VCU as an associate professor, and Dr. Steve Berg as a teaching assistant professor. We are excited to have them on our team. There is a short introduction to each one of them in the newsletter.

Dr. Jack Edwards, who has been our associate department head for undergraduate programs, steps down from that role and will now be director of aerospace research programs. Dr. Jeff Eischen has also stepped down from his role as director for undergraduate advising which will now be filled by Ms. Cheryl Tran. Dr. Yong Zhu also steps into a new role as director of mechanical research programs.

The department undergraduate (UG) and graduate programs continue to draw the best of students from inside and outside the state. Our UG programs are the first choice of engineering first-year students. We have applications for our graduate programs from all over the world. We expect that our program will continue to be strong even after this virus crisis. The department takes pride in the way we prepare our students to be productive engineers for the world. We will continue to use the new means and ways to educate our students and build their knowledge for the future of our society and world. Our faculty are committed to maintaining excellence with empathy and understanding as we navigate this new normal.

We hope you continue to remain updated with our MAE news. We regularly update our website and utilize this newsletter to tell a few in-depth stories. If you ever want to learn more about our programs and what kind of support we need, please email me at **sekkad@ncsu.edu**.

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

04

RESEARCH HIGHLIGHTS

Research Highlights

TIDAL AND OCEAN CURRENT RESOURCES possess an estimated 334 TWh / year (enough to power approximately 30 million homes) and 163 TWh /year (enough to power approximately 15 million homes) of usable energy. Furthermore, there exists a $1.5 trillion / year "Blue Economy," comprising off-grid ocean resources, such as observation stations, navigational aids, underwater vehicles and surface vehicles, all of which can benefit from the harvesting of marine energy resources. However, traditional marine hydrokinetic energy systems are burdened by significant bulkiness, often driving levelized costs of energy to prohibitively high values. High lift-to-drag kite systems, through the use of power-augmenting cross-current flight control, enable hydrokinetic energy harvesting using an order of magnitude less material than conventional tidal and ocean current energy concepts require. Drs. Chris Vermillion, Kenneth Granlund, Andre Mazzoleni, and Matt Bryant are pursuing multiple research projects that focus on the optimal design, control, and scaled experimental prototyping of underwater kite systems.

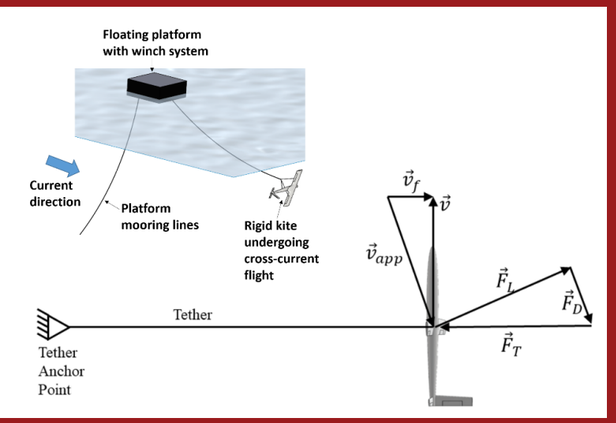


Figure 1: Illustration of a kite executing cross-current flight off of a floating platform (top) and the key forces and corresponding velocities at play during cross-current flight (bottom).

MAE Researchers Develop Underwater Kite Systems for Energy Harvesting

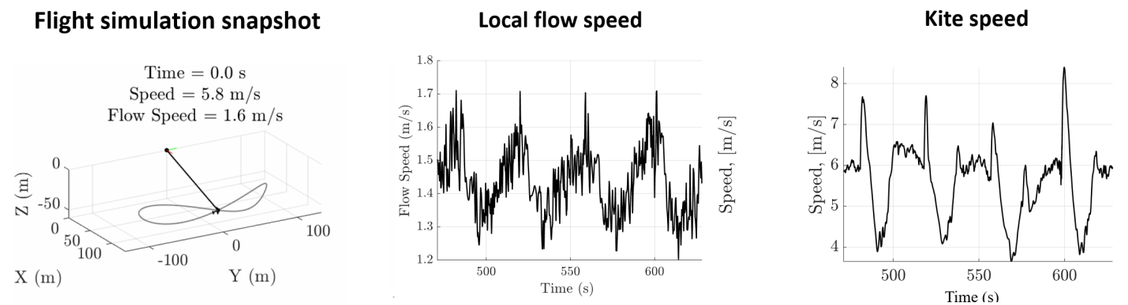


Figure 2: Snapshots of simulated kite motion in a turbulent, spatially varying flow environment, illustrating the velocity augmentation potential of cross-current flight.

The core concept behind cross-current flight lies in the fact that a high lift-to-drag kite can fly many times faster than the prevailing current speed, thereby resulting in a large apparent flow speed that translates to a very large power output (which varies cubically with the apparent flow speed) per unit area. Maximizing the power output from kite-based systems is therefore contingent on (figure 1) carefully designing the kite to achieve a very high lift-to-drag ratio while remaining highly maneuverable and (figure 2) developing control strategies that optimize and track efficient flight paths under a wide variety of sea conditions. To this end, the team has developed a combined geometric and structural co-design tool for optimizing the kite geometry while adhering to structural design limitations. The team has also developed an extensive dynamic modeling tool, which allows for characterization of the kite dynamics in realistic turbulent flow environments, accounting for the impacts of surface waves on the kite's flight performance. Finally, the team has developed optimal control tools that utilize concepts from iterative learning control to maximize power production in real time, under changing environmental conditions.

A large part of the team's research effort involves experimental validation of its kite designs, dynamic modeling tools, and control tools at progressively larger scales. This progressive experimental validation has begun with the lab-scale characterization of kite designs in the MAE water channel, run by Granlund. Here, the team has performed two sets of experiments: (figure 1) controlled motion experiments, in which 3D kite motions are approximately replicated through a 2D controlled motion platform, for the purpose of hydrodynamic model validation; and (figure 3) closed-loop flight experiments, wherein 3D printed models of kites are tethered and "flown" in the water channel, for the purpose of dynamic model validation.

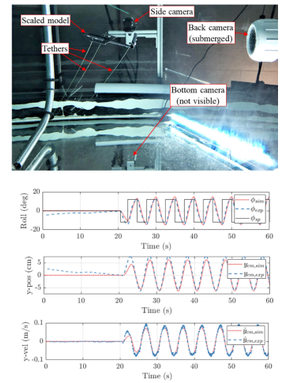


Figure 3: Water channel experimental setup for closed-loop dynamic characterization (top) and model vs. data comparison for select variables (bottom).

So far, the underwater kite design and control research taking place within the MAE Department has been supported by two large ongoing federal awards from the U.S. Department of Energy and Defense Advanced Research Projects Agency (DARPA), each of which was awarded in the last 14 months, in addition to support from North Carolina's Renewable Ocean Energy Program. Through the combination of these projects, the research has supported nine graduate students and has resulted in seven peer-reviewed publications submitted or accepted to-date.

Research Highlights

Figure 1: Two RFVs. While on the ground the rotors provide thrust, steering, and orientation control while the cage/wheels are passively towed. (left) The spherical RFV (SRFV). A spherical carbon fiber cage permits rolling locomotion and provides protection. The 3-axis gimbal system decouples the quadrotor from the cage, permitting omnidirectional rolling while reducing sensitivity to disturbances. (right) A two-wheeled RFV (WRFV).

MULTIROTOR, ROLLING-FLYING, MOBILE ROBOTS FOR SUBTERRANEAN EXPLORATION

MAE researchers are developing a new class of autonomous robotic vehicles that combine the mobility of flight with the endurance of rolling locomotion for mapping and exploring subterranean spaces. Led by doctoral students Stefan Atay and Tyler Jenkins and faculty advisors Drs. Gregory Buckner and Matthew Bryant, this project aims to address the needs of the U.S. Army Special Operations Command (USASOC) personnel who must operate in uncharted, and potentially hostile, underground environments. The lack of satellite imagery and the inefficacy of GPS and other radio communications technology underground makes these operations exceptionally dangerous for special operations forces; they must execute their operation in a dangerous, underground maze, in the dark, with no map. The team's research focuses on developing mobile robotic mechanisms that are suited for subterranean operation. These mobile robots must exhibit excellent mobility and maneuverability (traversing any obstacles, navigating narrow passages, etc.) and great endurance (the ability to operate for extended periods over great distances) in a GPS-denied environment. Typical mobile robotic solutions demonstrate either excellent mobility and maneuverability (e.g. multirotor craft) or excellent endurance and efficiency (e.g. terrestrial rovers). The team's bi-modal rolling-flying vehicles (RFVs) combine these complementary virtues in a single robot. The RFV, shown in the above figure to the right, combines a multirotor vehicle with a passive rolling mechanism. The spherical RFV (SRFV) uses a spherical cage for rolling, while the wheeled RFV (WRFV) uses two wheels. In both cases, the rotors provide the sole source of propulsion and lift.

Since rolling locomotion is extremely efficient, the RFV may preferentially roll along the ground whenever possible. Upon encountering an obstacle that cannot be traversed by rolling, the RFV may temporarily transition to flying. Once the obstacle is cleared, it may resume energy-conserving rolling.

The first step of the research was to quantify the advantages of rolling over flying. The energetics of rolling locomotion powered by rotary wings was not something that had been thoroughly explored until now (figure 1, figure 2). Atay found that the freedom to orient the multirotor vehicle within the RFV provides an extra "knob" which influences power consumption independent of the vehicle's motion. Therefore, this knob can be used to optimize the RFV's operation to either minimize electrical power consumption or maximize range. The image below demonstrates the superior efficiency of the RFV's optimized rolling to a conventional flying multirotor vehicle.

The mechanics of RFVs are so substantially different from those of conventional multirotor craft that a unique mathematical model and control system is required for their optimal operation (figure 3). Therefore, use of off-the-shelf quadrotor controllers is not an option for controlling RFVs. In addition to designing model-based control algorithms, the researchers also designed custom electronic hardware on which to execute their algorithms.

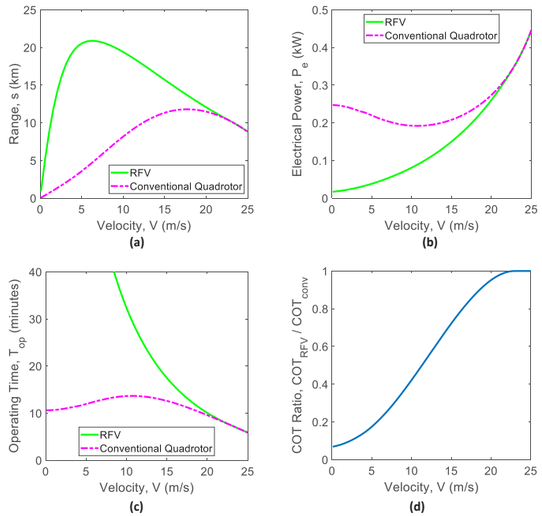


Figure 2: (a) Range, (b) power, (c) operating time, and (d) cost of transport (COT) ratio for the RFV as a function of velocity.

Creating a physical embodiment of an RFV that is sturdy enough to operate in rough terrain yet light enough to fly is a substantial engineering challenge, and the team exploited multiple fabrication techniques to create the unique mechanical designs.

Furthermore, operating in a GPS-denied environment means the vehicle must perform odometry (i.e. measure its motion) via other means. The SRFV is equipped with angle sensors on each axis, as well as an inertial navigation system that estimates the vehicle's orientation with respect to the Earth's gravitational and magnetic fields. These measurements are combined to estimate the SRFV's velocity and position, which the on-board computer uses as feedback to control the motion of the vehicle. In the image below, the SRFV is autonomously executing a figure-8 pattern using the odometry system.

This project is multi-dimensional, and these researchers are focused on several significant pieces of a broader puzzle. They are the first to demonstrate the controlled, autonomous locomotion of this class of bi-modal vehicle without the use of extrinsic sensing, such as GPS. ■

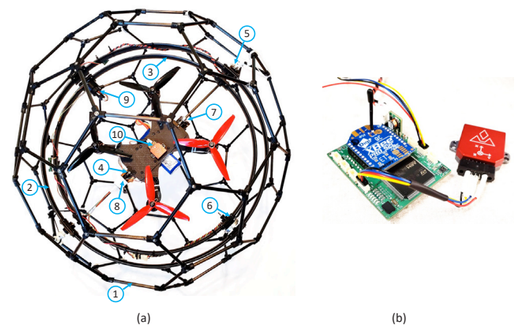


Figure 3: (a) The hardware SRFV. The circled numbers identify the following components: 1 - Carbon fiber icosahedral cage, 2 - Gimbal G_1, 3 - Gimbal G_2, 4 - Gimbal G_3, 5 - G_1 quadrature encoder, 6 - G_2 quadrature encoder, 7 - G_3 quadrature encoder, 8 - inner slip ring, 9 - outer slip ring, 10 - inertial navigation system. (b) Custom electronic control board. The on-board computer handles all processing, sensing, control and communications.

08

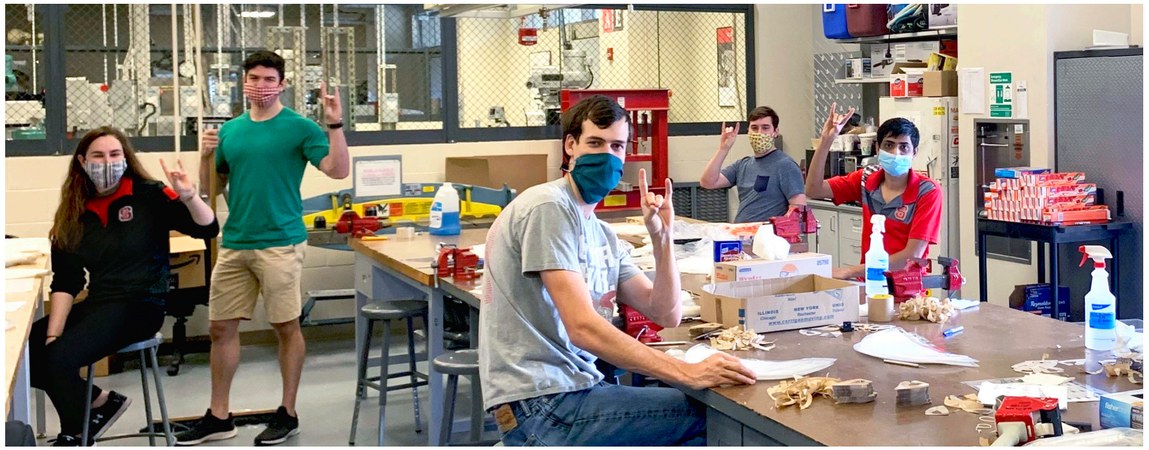
FEATURE
STORY

Student researchers for the COVID-19 response team pictured: Katie Berkowitz, Harry Schrickx, Jordan Tsolis, Kaushik Nonavinakere Vinod, Kishore Ranganath Ramakrishnan, Ogheneovo Idolor, Omkar Kaskar, Pratik Bhansali, Rishabh Guha, Sam Miller, Austin Bogue, Sydney Yount, Abinash Sahoo, and Andrew Rocco. Not pictured: Kishore Ramakrishna, Omar Kaskar, Sydney Yount, and Jordan Tsolis.

COVID-19 RESPONSE EFFORTS in the Mechanical and Aerospace Engineering Department began in earnest on March 20, when Dr. Francis Castiller, an ICU physician at UNC Rex Hospital, reached out to Dr. Landon Grace for help fabricating a specific type of protective lens system for use on a powered air purifying respirator (PAPR) in the ICU. This disposable lens was part of a helmet-based PAPR used across UNC Health and other hospital systems in the state and across the country. The supply of these critical protective items was dwindling, and lead times were months long. Grace and his graduate students began prototyping solutions at 11:00 p.m. that night after a discussion with Castiller. A final prototype was fitted on the PAPR system at Rex on March 23, followed by evaluation by UNC Health's Infection Control Department shortly thereafter. In less than a week, production had started to ramp up in the machine shop in EB III.

Update

MAE COVID-19 Response Team Meets the Need for Healthcare Workers



Initial production was 80 lenses per day, with a total estimated need of 3,000. A team of 10-12 graduate students worked full-time in the shop to meet demand, stopping only to eat lunch provided daily by the department. Throughout the process, the team was encouraged to innovate and improve the product and the process; to make the lenses better and more reliable and to make the fabrication process more efficient. Resourcefulness was key in a time when material supply was depleted and delivery times were weeks-long; these life-saving items were needed immediately. The front line workers relying on these PAPR systems could not wait days, much less weeks. The team responded as expected. In one example, the team designed a heat welding fixture from a dismantled electric griddle purchased from Target for $25. That fixture worked perfectly, and soon three such fixtures were in constant use for welding TPU film to PETG lenses.

Over the next few weeks, demand grew substantially. Because of the innovation of the team, daily production reached a peak of 1,650 lenses per day in the machine shop in EB III. Shortly thereafter, demand grew across the state and across the country, with the PAPR lens assemblies being shipped to New York, California, and Illinois. The majority of MAE-fabricated lens assemblies stayed within North Carolina — over 50,000 units have been made to date and delivered to UNC Health, Cone Health, and WakeMed, with nearly 100,000 more on order.

Fortunately, Grace worked to identify a local medical device manufacturer to partner with early in the process in order to limit the manual labor of assembly and remain focused on innovation. Polyzen, of Apex, NC, has gradually taken over most of the production of these critical items using the processes and tooling developed and built by Grace, department graduate students, and the machine shop staff led by Chris Anderson.

In addition to PAPR lens assemblies, Grace and his team spearheaded efforts in a number of other COVID-19-related areas. The MAE team designed and manufactured nearly 100 intubation shields used in hospitals across the state for high risk procedures. Castiller at UNC Rex was again instrumental in the design and validation of this device. The team also led the MAE effort toward a rapidly-manufactured ventilator in conjunction with local industry, the governor's office, and UNC-Chapel Hill. The team has also designed and continues to 3D print dozens of critical components of medical equipment, from ventilator circuit components (splitters, valves, etc.) to broken components of PAPR systems. Some of this work is in close collaborations with the Non-Wovens Institute — combining filters manufactured at NWI with custom components built in MAE. In addition, the team worked with community members with at-home 3D printers to rapidly fabricate thousands of general face shields for use in local hospitals and clinics. These general face shields continue to be distributed to local organizations in need. ■

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STUDENT **SPOTLIGHT**

From left: Trisha Hess and Alina Creamer.

Trisha Hess

Hess is a senior majoring in aerospace engineering. She is a member of the University Scholars Program, as well as co-lead ambassador for the Department of Mechanical and Aerospace Engineering and co-president of Women in Mechanical and Aerospace Engineering. In the past, she has been a recipient of the NC Space Grant. Hess' passion is aviation. She is currently a student pilot, training and studying to earn her Private Pilot's License. Over the last three summers she has had an internship with the U.S. Navy working for NAVAIR on board MCAS Cherry Point for Fleet Readiness Center East. She has supported the V-22, F-35, and H-53 platforms.

Alina Creamer

Creamer of Chesapeake, Va., is a senior majoring in aerospace engineering. Creamer is a member of the University Scholars Program and a recipient of the Park Scholarship. She is an active member of the co-op program, having completed two terms at Northrop Grumman Innovation Systems and four terms at various NASA centers during her undergraduate career.

Currently, Creamer is a Pathways intern at NASA Johnson Space Center where she has aided in testing of spaceflight hardware for the Orion crew vehicle and International Space Station. Before graduating in December 2021, She will complete her final Pathways rotational assignments in the Space Vehicle Mockup Facility and the Habitability and Human Factors Branch.

Creamer serves as a lead in the MAE ambassadors program and a member of the co-op ambassador team. She has served as co-president of the NC State Women in Mechanical and Aerospace Engineering organization for two years. Additionally, she organizes the Park Peer Mentor Program and volunteers at the Feed the Pack food pantry on campus. ■

Lila Crick

Sreevishnu Oruganti

Annette Gray

Paul Neil

Halen Mattison

Engineering Students Awards

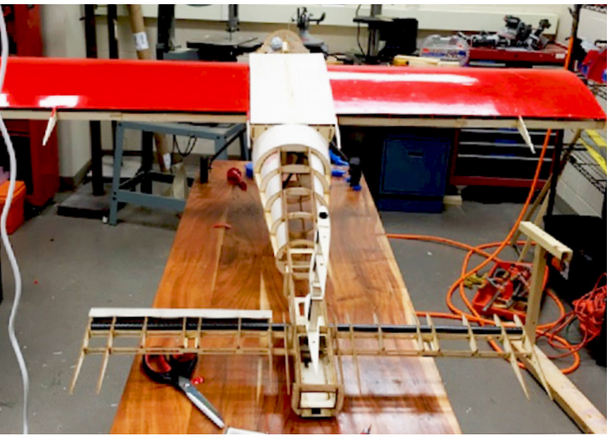
Each year the College of Engineering recognizes the accomplishments of graduating senior students with the Engineering Senior Awards. Receiving these awards is one of the highest forms of recognition for a senior in the College.

The awards were presented by Dr. Jerome Lavelle, associate dean, academic affairs, at the virtual Engineering Awards Ceremony on Wednesday, May 6th. The Mechanical and Aerospace Engineering nominees for the college-wide competition were: Lila Crick — Citizenship and Service, Sreevishnu Oruganti — Scholarly Achievement, Annette Gray — Humanities, and a tie between Paul Neil and Halen Mattison — Leadership.

Crick was selected as the College Of Engineering Senior Award winner for Citizenship and Service. Crick is a recent graduate from the aerospace engineering program. During her time at NC State, she participated in a multitude of different departmental and college-level clubs, such as the Society of Women Engineers in which she served as the fundraising chair and the president, while also excelling academically and working a full-time job.

We are extremely proud of our students' achievements and wish them all the best in their future endeavors. ■

Senior Design



MAE 480 Capstone Senior Design

Each academic year, aerospace engineering seniors are given a real-world problem to solve in the MAE 480 Capstone Senior Design course, and they showcased their solutions during senior design day. The projects are 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 year's projects were provided by our sponsors Bob Barker Inc., Caterpillar, Denso, Pentair, Techtics, Zurn, Corvid, Blue Force Technologies, Flowserve, and Hendrick Motorsports. Due to COVID-19, senior design day for the spring 2020 semester was held over Zoom and prototype demonstrations were cancelled. The students' formal presentation, held virtually, gave each team an opportunity to outline their design process, describe the proposed device, and advocate for how their work has satisfied the project goals and constraints.

The spring projects were split into two sections: flight and space. Teams worked on projects ranging from designing, building and flying an unmanned, remote-controlled bush plane capable of both transporting passengers and towing advertisement banners to the design, development, and launch of a reusable rocket and payload. The top three teams for each project are recognized by the sponsors with certificates and a monetary award. ■

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

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NEW FACULTY AND **STAFF**

Steven Berg
Lecturer

Summer Fulcher
Temp Admin / Office Support Staff

Tim Horn
Assistant Professor

Arun Kota
Assistant Professor

Jaideep Pandit
Assistant Teaching Professor,
Director of ME Undergraduate Labs

Edmon Perkins
Assistant Professor

Hooman Tafreshi
Associate Professor

Jie Yin
Assistant Professor

Awards and **Honors**

HUANG NAMED OUTSTANDING TEACHER

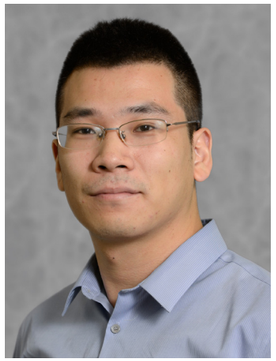
Dr. Hsiao-Ying Shadow Huang, associate professor, was named an Outstanding Teacher for 2019-20.

The award recognizes excellence in teaching at all levels and is a prerequisite for being considered for the Board of Governors Award for Excellence in Teaching and the Alumni Distinguished Professor Award. Recipients become members of the Academy of Outstanding Teachers for as long as they are NC State faculty members. Recognition is given at commencement, the Celebration of Academic Excellence and the Teaching and Learning Symposium.

SILVERBERG NAMED NOMINEE FOR 2020 OUTSTANDING GLOBAL ENGAGEMENT AWARD

For his work with the Namibia Wildlife Aerial Observatory in providing educational opportunities for students while also assisting Namibian parks and game reserves, **Dr. Larry Silverberg** was named a nominee for the 2020 Outstanding Global Engagement Award.

The Outstanding Global Engagement Award encourages and recognizes outstanding accomplishment in globally engaged teaching, student support, research, extension, and / or engagement and economic development by faculty and non-faculty professionals of NC State University. Nominees for this award should have made important international contributions in one or more of the following aspects of the University's mission: Research and Discovery, Teaching and Learning, or Engagement, Extension and Economic Development with documented impacts and accomplishments.



LIU RECEIVES NSF CAREER AWARD

Dr. Jun Liu, 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 $518,775 in funding over five years to support his project, "Pushing the Lower Limit of Thermal Conductivity in Layered Materials."

ZHU SELECTED TO RECEIVED 2019 ASME GUSTUS L. LARSON MEMORIAL AWARD

Dr. Yong Zhu, professor, has been selected to receive the 2019 ASME Gustus L. Larson Memorial Award by the American Society of Mechanical Engineering (ASME) and Pi Tau Sigma.

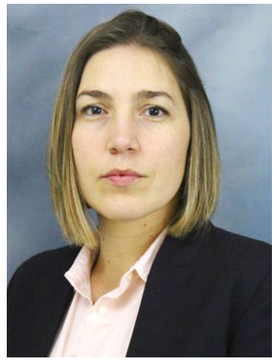
The prestigious award is presented to an engineering graduate who has demonstrated outstanding achievement in mechanical engineering, within 10 to 20 years following graduation with a bachelor's degree in mechanical engineering or related field.

MULLER RECEIVES ICU EARLY CAREER AWARD

At the 2019 International Congress on Ultrasonics in Belgium, **Dr. Marie Muller**, assistant professor, was awarded the ICU Early Career Award (the "Silver Whistle Award") for her outstanding contributions to the promotion of the ultrasound world community.

The ICU Early Career Award is presented to an individual who is relatively early in his / her professional career (about 10-15 years of active career), has been active in the affairs of ultrasound through his / her national society, other national societies, and / or regional or international organizations, and has contributed substantially, through published papers, to the advancement of theoretical or applied ultrasound or both.

Awards and Honors



HUANG NAMED RECIPIENT OF PRESIDENTIAL AWARD FOR YOUNG SCIENTISTS AND ENGINEERS

Dr. Hsiao-Ying Shadow Huang, associate professor, has been named a recipient of the 2019 Presidential Early Career Award for Scientists and Engineers (PECASE).

The PECASE, established in 1996, acknowledges the contributions made by scientists and engineers to the advancement of science, technology, engineering, and mathematics education and to the community through scientific leadership, education, and community outreach. It is the highest honor bestowed by the U.S. government to outstanding scientists and engineers pursuing their independent careers.

EWERE EARNS PATENT

Teaching assistant professor **Dr. Felix Ewere** recently earned a patent for an airflow sensor that mimics protuberances on a humpback whale flipper. The self-sufficient sensor can be used to monitor wind velocities in difficult and hard to access areas to warn about potential storms and hurricanes. ■

STAFF SPOTLIGHT

Chris Anderson
Research Operation Manager

Anderson joined MAE in September of 2019 as a research operation manager. His background includes precision manufacturing in the aerospace and robotics industry with knowledge utilizing multi-axis CNC machining and turning centers. He has experience in production management and safety supervision.

"After joining the Mechanical and Aerospace Engineering Department, I instantly felt like I was a part of the best team! The faculty and staff all share a passion to ensure the students are equipped with the knowledge they need to be successful. I am honored to be a part of MAE and enjoy working with the students every day."

Elizabeth Baker
Contracts and Grants Manager

Baker is a senior contracts and grants manager with the MAE Department. She attended UNC Wilmington, earning a M.S. in accountancy in 2013. In 2014, Elizabeth won the title of Miss Garner and represented the town of Garner at the 2014 Miss North Carolina Pageant. In her spare time, she enjoys running, traveling, gardening and most importantly spending time with her family, friends, fiancé, Jon, and dog Barkley.

She recently celebrated five years with MAE. "This department is so special to me and it's an honor to work with such prestigious and professional faculty and staff. It's like a big family in MAE and my position has been a job that I love coming to every day! Assisting faculty with their research grants has been so rewarding and it reminds me daily that I'm a part of something big that will ultimately shape the future and change the world." ■

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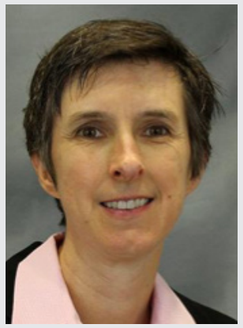
PROGRAM **UPDATES**



Drs. Jack Edwards and Kara Peters.

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). We unrolled our new one-year senior design experience for the ME program, led by Dr. Chau Tran. The AE senior design experience was also significantly re-vamped, led by Dr. Felix Ewere. ASME and AIAA student clubs reported strong increases in student participation, furthered by various professional-development activities and guest speakers from industry, government, and academia. One highlight was Dr. John Olds' seminar as part of the Hassan Lecture Series where he gave an insider's perspective on the prospects of commercial applications of space travel. Dr. Art Grantz from Boeing gave an engaging talk focused on the X-37 long-duration Orbital Test Vehicle. The ASME Design Team placed second in the IMECE Student Design Competition, held in Salt Lake City in November, 2019, and placed third at the EFEST (virtual) design competition held in April. With the onset of COVID-19 lockdown in March, MAE quickly shifted to an online mode of course delivery. The faculty and students worked together to make this experience the best that it could be. The MAE faculty saluted their graduates in a 'drive-by' graduation. This, plus the accompanying video, was well received by our students and their families.

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 391 students currently enrolled. Of these students, 113 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 and offering more than 50 graduate courses that span all topics of aerospace engineering and mechanical engineering. This academic year, 30 Ph.D. students defended their dissertation and graduated. The MAE annual graduate research symposium held in March was well attended with 60 poster presentations by our graduate students. Obviously our graduate students faced many challenges in continuing their education and research due to the COVID-19 situation, but I am proud that our graduate students have done an excellent job at managing these challenges. Several graduate students stepped up to fabricate face-shields for health workers during the spring on top of their other responsibilities. We look forward to welcoming our fall 2020 graduate entering class, including six recipients of the NC State Provost Doctoral Fellowship, the largest number ever for our department. Two of our current graduate students were also awarded the National Science Foundation Graduate Research Fellowship. ■

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ALUMNI **CORNER**

CAREER OVERVIEW

Dr. Basil Hassan earned his B.S. (1988), M.S. (1990) and Ph.D. (1993) degrees in aerospace engineering from NC State. Upon completing his doctoral degree, he joined Sandia National Laboratories in Albuquerque, New Mexico, and has held a variety of management and staff positions. Hassan has focused predominately on the thermal, fluid, and aero science technology areas helping Sandia to accomplish its national security mission. He is currently the Director of the Chief Research Office and serves as Sandia's Deputy Chief Research Officer. In this role, he leads Sandia's research strategy development including the execution of the Laboratory Directed Research and Development program and oversees Sandia's external partnership and technology transfer programs.

He is a Fellow of the American Institute of Aeronautics and Astronautics, including serving on its Board of Directors from 2008-17, where he held the roles of director and vice president. He has also served on review boards for the National Academies, NASA, and Air Force Office of Scientific Research. He currently serves on the NC State Mechanical and Aerospace Engineering Educational Advisory Board and has served on similar boards for New Mexico State University, Texas A&M University, University of Texas at Austin and University of New Mexico.

Name: Dr. Basil Hassan
Graduating Class: BSAE 1988, MSAE 1990, PhDAE 1993

Alumni Corner

Q&A with Dr. Basil Hassan

Director and Deputy Chief Research Officer for Sandia National Laboratories

From top: Briana Goins, Dr. Basil Hassan, Dr. Srinath Ekkad, and Michael Walsh.

In your current role(s), what are your main responsibilities?

Dr. Basil Hassan: As a Director and Sandia's Deputy Chief Research Officer, I lead Sandia's almost $200M internal R&D program which funds much of our basic and applied research. Additionally, I am responsible for leading our tech transfer and external partnership programs, primarily those strategic relationships with universities. Over my career, I have been involved in a wide spectrum of research projects and served on many government and academic advisory boards so that made this job very attractive to me.

How did you become interested in this field and how did you begin your career?

B: As a kid, I was always interested in airplanes and space. Many of the planetary space probes and the development of the space shuttle occurred when I was in middle school and high school. My dad also took me to a lot of AIAA lectures and I was hooked. After receiving my Ph.D. in aerospace engineering at NC State, concentrating in hypersonics, I had two job offers and both were post docs, one at NASA Langley Research Center in Hampton, Va., the organization that funded the bulk of my graduate research, and one at Sandia National Laboratories in Albuquerque, N.M. I had heard nothing but good things about Sandia from former NC State alums who worked there, and I was very impressed with the breadth of work opportunities it offered. I spent nine years as a staff member working in a variety of areas, including hypersonics, low speed wake flows, and multiphase combustion flows. In 2002, I entered management and have served in a variety of line and program roles since then. While NASA would have been great too, I feel very fortunate to work at Sandia.

What skills, abilities, and personal attributes are essential to success in your job / this field?

B: First and foremost, receiving a solid education at NC State in the fundamentals was key. When I first got to Sandia, a lot of the aero work dried up. I went from working hypersonics Mach numbers to dealing with low speed incompressible flows and multi-phase flows. What I realized is that if you mastered the fundamentals, you could work on almost anything. Luckily hypersonics came back and I could contribute in those areas as well. In my management roles, which are completely different jobs, I had to focus on more people skills. While I still had to be able to represent the technical work, I had to be able to sell what we were doing to both internal and external sponsors, as well as dealing with personnel issues. I also found that I had to juggle a lot of balls in the air at the same time, so having the ability to work a lot of issues simultaneously has been key. Working with people and building strong and trusting relationships takes work, but it is critical for these kinds of roles.

Tell us about AIAA (American Institute of Aeronautics and Astronautics).

B: AIAA is the professional society for the aerospace community. I joined as a freshman back in 1984 and have been a member ever since. When I left NC State, I was fortunate enough to have one of my mentors from NASA Langley suggest that I get on an AIAA Technical Committee. Little did I know that some 27 years later that I would be the Institute's president. AIAA has been a key part of my success. The networking and relationship building have been extremely important in both my technical and managerial career. I will contend that in all the various roles of leading volunteers, I have enhanced my skills as a leader, which has helped me tremendously at Sandia.

As President of AIAA, how have you all responded to COVID-19? How do you think AIAA will look moving forward?

B: The COVID-19 pandemic has certainly been a challenge. Luckily our members and our resilient staff responded quickly and in a matter of weeks, turned our typical in person Aviation Forum into a completely virtual event. We had more than 2,000 virtual attendees, including over 600 students participate. We are going to have to do the same for our upcoming events later in the year, but the eventual goal is to have combined in-person and virtual events in the future. This will enable us to reach out to those in our profession who might not normally travel to these events. Additionally, I mentioned that networking was an important aspect of my career growth. While not the same as face-to-face, AIAA is trying to offer many virtual events every month to allow people to at least interact in some fashion. One of my goals as president is to increase the number of student members with the hope that we retain them when they begin their professional careers. Now is the time when the students and young professionals need us so we will target much of our programming in their direction. It will be a lot of work, but in the end, I am confident AIAA will be a better organization for all involved.

What are some exciting things currently happening at Sandia National Laboratories?

B: We have a lot going on at Sandia, which is the Department of Energy's top engineering lab. We have nearly doubled in size since I started in 1993. Right now, we are simultaneously executing six modernization efforts for our nuclear deterrent programs. We must make sure the deterrent is safe, secure and reliable, should we ever need it. As a national security laboratory, we also do quite a bit of work for other government agencies, including NASA, the Department of Defense, the Intelligence Community and Department of Homeland Security, just to name a few. We are one of the leading players in the nation's hypersonics programs, helping to support air and satellite reconnaissance through novel sensors, as well as making advances in engine combustion and renewable energy.

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

B: As I think over my career, three things stand out. First, as a staff member, I was part of a team that created one of the first coupled aero / thermal / trajectory simulation techniques to predict thermal protection material ablation on hypersonic flight vehicles. Even though that work has been advanced more recently by others at Sandia, much of our original work is still cited in the literature. Next, shortly after going into management, I led Sandia's support of the Columbia Accident Investigation, where we helped NASA determine that the foam strike caused the wing damage that lead to the vehicle breakup. I spent over seven weeks at NASA Johnson in Houston and my relationships with NASA personnel were key to Sandia being a credible partner. Finally, I was part of the team that flew the first successful, long range hypersonics maneuvering reentry system for defense applications. That work has formed the basis for the current national hypersonics strategy.

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

B: I have so many great memories from being at NC State. Many of my lifelong friends and colleagues were classmates. AIAA was a big part of everything we did as students. I can think of two memorable experiences. During undergrad, the successful flight of our senior design project was extremely

Q&A with Dr. Basil Hassan

satisfying. I was the vehicle design and aero lead for our team. I designed the outer mold line and did all the aero calculations using a panel code (1980s version of a modern CFD code). That provided me the hands-on experience that brought my undergrad education together. I felt like an engineer. In graduate school, the opportunity to spend five summers at NASA Langley was invaluable. I got to work side by side with some of the best NASA engineers on both undergraduate and graduate research. I felt like my research had meaning. Being able to span research to development to applications formed the basis for my staff and management experience at Sandia.

Your father, Dr. Hassan A. Hassan, was also very involved in the department for many years. Tell us a little about that.

B: Yes, my dad arrived at NC State in 1962 to help start the aero program at NC State. Previously there was an aeronautical option in ME, but he and then Department Head Robert Truitt came to NC State to build up the aerospace program. They were later followed by other influential former faculty like Fred DeJarnette, John Perkins, and others and they essentially put this department on the map, creating one of the most respected aerospace programs in the country. He once told my mom not to expect to stay in Raleigh more than three to five years. Well that did not happen, and he was a mainstay in the department until he ended phased retirement in 2018. He ended up being the longest tenured professor in NC State's history. He loved this department and being a professor was more of a hobby than a job. As you know he passed away about six months later, but he kept doing what he loved until the end and that was probably the best way for him to go.

Do you have any professional advice that you'd like to offer our current MAE students and future graduates?

B: We could spend a lot of time talking about advice. I would say that students should realize that even when they leave school, after a B.S., M.S. or Ph.D., that you always have opportunities to continue learning. As I mentioned earlier, with a foundation in either AE or ME, you can work in almost any professional role. There are two mottos I try to live by. The first is, "Tomorrow is the first day of the rest of your life." It means that no matter what happens in the past, you can control what happens in the future. The final motto is, "Take care of the people who take care of you." No matter where you go or what you do, people will always be involved. I believe that I have enjoyed some success because mentors and colleagues looked out for me. I have committed myself to investing in the success of others and forming those relationships is the key to success.

What educational preparation would you recommend for someone who wants to advance in this field? On a similar note, are there any clubs or organizations that you could recommend for someone that is interested in your field?

B: Right now I believe that getting an advanced degree (M.S. or Ph.D., as appropriate) is critical to be both successful and enjoy one's engineering career. Today's jobs are very multi-disciplinary and require some extra specialization to move forward. The B.S. degree is very good, but with reductions in hours to graduate since I was in school, students today are not getting exposed to everything we learned. For most jobs a M.S. degree should be fine, but if you want to teach or get into hardcore research you probably need a Ph.D. I also am a big proponent of advanced degrees where you do a thesis or dissertation. That will truly prepare you to be successful in this profession. As far as clubs or organizations, you probably got the message that I am a big proponent of AIAA (or ASME for the ME students, where I was a member for 30 years). Being involved in AIAA is the best professional decision I ever made. I would not be where I am today without it, as that is where I made my most important professional connections. Additionally, I would encourage the students to get involved in some club. The Design Build Fly team, the High-Powered Rocketry team, the Aerial Robotics Team (or the others for the ME students) are all excellent ways to get the hands-on experience of what life in this industry will be like. You get to apply your technical talents, but just as important you get to develop important teaming and leadership skills. I believe in these activities so much, that I have targeted my charitable contributions to both NC State and AIAA to help enhance these experiences for current and future students. ■

WOMEN IN ENGINEERING

CAREER OVERVIEW

Dr. Jennifer Rhatigan earned her B.S. in mechanical engineering from the University of Florida (1982), M.S. in mechanical engineering from NC State (1987), and Ph.D. from the Department of Mechanical and Aerospace Engineering at Case Western Reserve University (2001). She is an aerospace professional recognized for her leadership and personal contributions in advancing technology in spaceflight for exploration, research and defense. Her 38-year career in the profession is marked by creative and unique contributions in the design, development, and operations of complex aerospace system. She served 25 years with NASA, notably on the early design of the International Space Station (ISS) through the bulk of its construction, and on the start-up of NASA's Constellation Program, taking the next step in human space exploration with the development of the Orion spacecraft and the Space Launch System (SLS). She currently advises and instructs early to mid-career Naval officers as Professor of the Practice, Department of Mechanical and Aerospace Engineering, at the U. S. Naval Post-Graduate School (NPS) in Monterey, CA.

In addition to earning the highest ratings from the Naval officers she advises and instructs, she is a regular mentor and judge, most recently at an AIAA student conference. She is also chapter advisor for her sorority at the STEM-focused UC-Merced campus in the under-served Central Valley of California. She currently holds the rank of Associate Fellow of the AIAA. Rhatigan is the author of more than 40 peer-reviewed publications and holds a professional engineer's license in the State of Florida.

Name: Dr. Jennifer Rhatigan
Graduating Class: MSME 1987

Q&A with Dr. Jennifer Rhatigan

Professor of Practice at the Naval Postgraduate School

1. *Please introduce yourself and tell us about your career.*

Dr. Jennifer Rhatigan: I'm currently Professor of Practice at the Naval Postgraduate School in Monterey, Calif. I arrived there in 2011 as the NASA Chair in the Space Systems Academic Group. I was with NASA for 25 years. After my master's degree at NC State, I was fortunate enough to start with NASA at the beginning of the space station design, so I spent 17 years on that, and was part of the early construction of the ISS. I also worked on the Constellation Program, which included the Orion spacecraft and the Space Launch System. I worked internationally on building a coalition of space agencies interested in returning to the moon with NASA, this time to stay.

Now I teach the spacecraft design sequence to U.S. military officers and do research in spacecraft design for the DoD .

2. *How or why did you choose engineering as a career path / area of study? Can you describe the moment you realized this was a field you'd like to pursue?*

J: I always wanted to do work in what we now call the STEM fields, and loved science. My father was a doctor and introduced me to lab work and the scientific thought processes. I didn't know what engineering was, however. I was dating a guy as an undergraduate who was majoring in engineering, and one day I was looking over his textbooks. I can remember thinking, "Hey, I could do that!" I started asking questions about engineering and eventually switched majors.

My mom later found an aptitude test from ninth grade that said I should be a mechanical engineer. My guidance counselors had ignored that and pushed me towards nursing! Funny that I found the right career for me anyway.

3. *Tell us about your first job. What did you learn there that you couldn't have learned in the classroom?*

J: In my first job after my BSME, with an architect-engineering firm, they handed me a hard hat and I was soon in the field. I spent a summer tracing steam trap lines in a power plant, with a drafter in tow. We were updating all of the as-built drawings for the steam lines, in order to bring the plant into compliance with the latest ASME boiler and pressure vessel code. I definitely hadn't imagined that in the classroom!

> "Align yourself with organizations, companies, industries, or government agencies that treat women well. Don't bother with those who don't — they will either have to change or just get left behind, but they are not worth your talent and effort."
>
> **DR. JENNIFER RHATIGAN**

4. *What is it like to be a woman in engineering? Do you feel that your gender gives you a different perspective and experience from your male counterparts? Any advantages?*

J: It is sometimes isolating. I still have to prove myself over and over. When I started as an engineer 40 years ago, my expectation was that we would be near parity in engineering by now, and my skills would be a given based on my degrees and experience. These experiences have certainly given me great empathy toward others who face discrimination of any form, and it's important to me to be a part of changing our society and our field to be more accepting and welcoming.

5. *What inspires you about engineering?*

J: I like the quote "The greatest use of life is to spend it on something that will outlast it" by William James.

There is so much of what we do in engineering that meets this criteria. Working for NASA on the ISS and the machines to take us back to the moon has been so rewarding because it has real impact on our nation's future. In my teaching role, I believe I am reaching into the future via my students.

6. *What skills, abilities, and personal attributes are essential to success in your job / this field?*

J: We can't discount an aptitude for math and science. You don't have to like math to do it, but it must be mastered. With my students, I emphasize critical thinking skills. I can't predict what they may encounter as engineering challenges in the future, but I know that they can apply critical thinking to any problem. I also want my students to have the skills to teach themselves anything new, so learning to do that for yourself is key.

In terms of personal attributes, I think grit is underrated. Challenges teach us more lessons than easy successes, and being able to pick yourself up after a failure or disappointment and move on with new knowledge is invaluable.

7. *Describe a memorable experience that you have had at NC State during your time in the Mechanical and Aerospace Engineering Department.*

J: I was teaching the Instrumentation Lab in the basement of Broughton Hall the day of the Challenger explosion in 1986. We had a TV on a wheeled stand in the lab, and I pushed that near the lab tables and we all watched the aftermath. I don't recall the lab we were doing, but I do remember discussing with the students that NASA would need good engineers to recover.

8. *Are there any clubs and / or organizations that you'd recommend?*

J: I'm a member of both AIAA and ASME. I've been recently enthused with the efforts AIAA is making toward diversity and inclusion, and I'm a fan of our current AIAA president Dr. Basil Hassan. We were students in the MAE Department at the same time. I'm disappointed that ASME is not making similar efforts.

9. *What would you say to young women in school / college who may be considering engineering as a career choice / study option? What kinds of practical experience should they have? What technical skills should they pick up?*

J: It may be tempting to take shortcuts or avoid the experiences that will require you to grow. Don't sell yourself short — take on the challenges and master the skills needed for the next steps. Engineering can be an extremely rewarding career, as we are, in so many ways, building the future.

Align yourself with organizations, companies, industries, or government agencies that treat women well. Don't bother with those who don't — they will either have to change or just get left behind, but they are not worth your talent and effort.

10. *What are your hopes for the future of engineering?*

J: I know that strong and skilled engineers are a key to our nation's future. My hope is that our profession continues to broaden. Diversity will strengthen us — it's not something to discount or fear. ■

> "When I started as an engineer 40 years ago, my expectation was that we would be near parity in engineering by now, and my skills would be a given based on my degrees and experience. These experiences have certainly given me great empathy toward others who face discrimination of any form, and it's important to me to be a part of changing our society and our field to be more accepting and welcoming."
>
> **DR. JENNIFER RHATIGAN**

2019 **Alumni Hall of Fame**

The Department of Mechanical and Aerospace Engineering named 10 new members to the MAE Alumni Hall of Fame on Friday, November 8, 2019.

MAE alumni traveled from all corners of the world to be recognized for their achievements which built upon their common educational foundation, NC State University.

The MAE Alumni Hall of Fame was established in 2012 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 over 12,000 MAE alumni, only 142, including this year's class, have been inducted into the MAE Hall of Fame. The MAE Department is honored to celebrate this prestigious ceremony with the 2019 class. ■

Charles Arvey
BSAE '67

Bruce Baldwin
BSME '92

Dr. Robert Baurle
BSAE '90, MSAE '92, PhDAE '95

Dr. Robert Cassanova
BSME '64

Dr. Neil Cheatwood
BSAE '83, MSAE '87, PhDAE '91

Dr. David Glass
MSME '82, PhDME '86

Dr. Arthur Grantz
PhDAE '89

Dr. Jim Keenan
PhDAE '94

John Privette
BSME '81

Steve Rea
BSME '80, MSME '87

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MAE TOP EMPLOYERS

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- NAVAIR
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- Newell Brands
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HOW TO GIVE BACK TO MAE

There are many ways to give back to the MAE Department that help our students and faculty:

1. **By making a gift to the MAE Enhancement Fund**, you are helping to fund some of the greatest needs within the department that directly support student programs and faculty research.
2. **Establish an endowed scholarship**, graduate fellowship or professorship that will generate support in perpetuity for our students and faculty.
3. **Give a gift to name a space in Engineering Building III** to help support critical research and learning experiences for our faculty and students.
4. **Your company can give back by becoming a member of the MAE Corporate Partners** program through sponsorship of a senior design project or by making a corporate contribution to the department.

MIKE WALSH
Senior Director of Development

MAE engages with alumni, friends and companies because we know that strong partnerships are imperative and help fuel success. In addition to financial support, you can give back to MAE by mentoring a student, volunteering for one of our advisory boards, recruiting students to your company or partnering with faculty to support their research. By partnering with MAE, you will gain access to top students and faculty at one of the premier MAE departments in the country.

500 copies of this document were printed at a cost of $1,802.35.

MAE ADVANCEMENT OVERVIEW

The purpose of the MAE Advancement Office is to help support key funding needs in the department by partnering with alumni, friends and companies through philanthropic giving. Our office is focused on creating and maintaining a group of key stakeholders who are interested in supporting the MAE Department. And the contributions that they make give our students and faculty the best learning and research environment on campus.

TOP EMPLOYERS OF MAE GRADUATES

■ Duke Energy ■ Denso
■ Caterpillar ■ John Deere
■ GE ■ BMW ■ NAVAIR