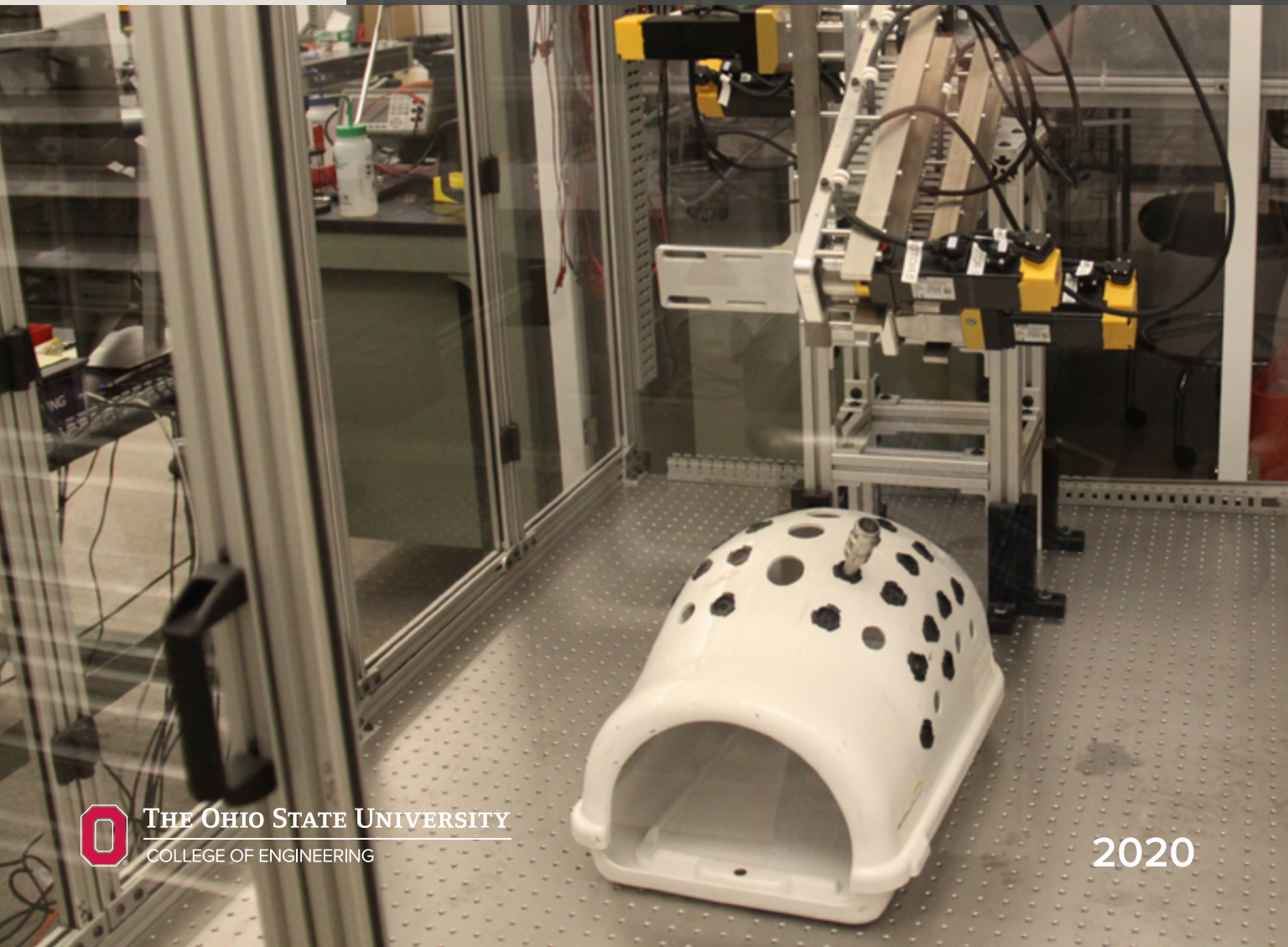
Mechanical

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

RESEARCH IMPACT



THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

2020

Message from the Chair

Jim Gregory

The Department of Mechanical and Aerospace Engineering at The Ohio State University builds on its diversity of people and ideas to cultivate a range of advancements in mechanical, aerospace and nuclear engineering.

From gears to cancer research, our mechanical engineers are experts in an array of specialty areas. Our strengths in both aeronautical and astronautical engineering boost the impact of our aerospace engineers. And, with an on-site nuclear reactor–and high-achieving graduates throughout industry and government–our nuclear engineers value collaboration.

To best showcase the unique achievements of each of our programs, we have created separate research publications. In this Research Impact: Mechanical, you will see samples of our advancements in mechanical engineering over the past year.

We responded quickly to the growing need for personal protective equipment for medical professionals amidst the COVID-19 global pandemic (page 5), developed a surgical robot capable of printing tissue through minimally invasive surgery (page 7), led new research that has the potential to revolutionize the field of multifunctional robots and machines (page 11) and begun prototyping a foldable probe for ultrasound-based cancer surgery (page 15.)

All of this was accomplished with our talented students, who continue to be our primary focus. They are involved in every facet of our research.

I invite you to read on to learn about our recent cutting-edge innovations.

Jim Gregory
Chair, Mechanical and Aerospace Engineering
Professor, Mechanical and Aerospace Engineering

Cover: MAE collaboation. Graduate student Andrej Simeunović, professor David Hoelzle and MAE machinist Kevin Wolf collaborated to make a surgical robot that is now ready for testing. See more: Page 7

DEGREES CONFERRED

Academic Year 2019- 2020

BS	248 MECHANICAL	69 AEROSPACE	
MS	73 MECHANICAL	20 AEROSPACE	3 NUCLEAR
PHD	26 MECHANICAL	7 AEROSPACE	3 NUCLEAR

STUDENT ENROLLMENT

Autumn Semester 2019

BS	608 ME MAJOR	561 ME PRE-MAJOR	164 AE MAJOR	286 AE PRE-MAJOR
MS	107 MECHANICAL	21 AEROSPACE	3 NUCLEAR	
PHD	147 MECHANICAL	38 AEROSPACE	22 NUCLEAR	

Statement from the Chair: We must change.

The Ohio State University's Department of Mechanical and Aerospace Engineering stands with all black people – faculty, staff, students, colleagues, friends, and members of our community. The injustice that we see has been painfully brought to light by the long chain of lives needlessly and shockingly lost due to unjust and flagrant abuses of power – George Floyd, Ahmaud Arbery, Breonna Taylor, Botham Jean, and many others stretching over decades and centuries of our history. Many of us are experiencing deep pain - we share that pain, and together we long for justice and a better future.

We stand with all black people in vocally exclaiming that things must change. We will labor together to pursue ever greater justice, to advance towards an equitable society, to warmly embrace diversity, and to thoughtfully create a respectful and inclusive environment.

But this isn't just about what's happening in the world around us: the problem is here with us. In fact, my eyes are being opened to the ways that many of us contribute to and are complicit with systemic injustice. Just a few days ago in an engineering community dialogue, I listened to the voices of young African American Engineering students who shared their experiences of racism – injustices that they have experienced in our presence and from us. Excluded from groups. Seen as a threat. Isolated. Othered.

I am confronted by this stark reality. This is not who we want to be! It is not a reflection of the values of compassion, community, respect, justice, equity, diversity, and inclusion to which we aspire.

So, we must change. Please join me in boldly confronting these failures to live up to our values – this is what we have the most direct agency to change. I invite you to process with me in assessing our own role. We'll need to humbly and unflinchingly confront the ways that we contribute to injustice. Yes, there is racism among us. Yes, the injustice is systemic. And yes, we can do better.

I freely admit that I am not fully aware of the injustice and the problems, and that I need to learn. The effects of systemic injustice run deep and may be difficult to bring to light. But we must – for the good of all of us.

While I don't have any answers today, I am committing our department to listening, to learning, and to change. These are a few initial steps that we will take:

- We will reflect on the history of our department and learn from it. Let's examine the origins of our department and our role in society over the years - we'll need clarity as we bring the systemic injustices to light.
- We will proactively listen to our own students, staff, and faculty – to hear their experiences; to ask careful questions; and to compassionately commit to change. We will respond with care and committed action when we learn of reports of racist or unjust behavior or attitudes.
- We will partner with the College of Engineering and the University on broader change where we can play a role.

We are deeply grieved by the injustice that we see in the world, injustice that has been with us for a long time. And, we acknowledge that there are many ways that each of us is a part of the systemic injustice in our world. Together, we will courageously move forward on a pathway of listening, learning, advocacy, and change. Thanks for your partnership with us as we pursue an equitable and just learning environment and broader society.

Jim Gregory
Chair, Mechanical and Aerospace Engineering
Professor, Mechanical and Aerospace Engineering

FACING THE PANDEMIC: ENGINEERS' RAPID RESPONSE TO PPE NEEDS

The COVID-19 pandemic has depleted supplies of personal protective equipment (PPE) for healthcare professionals nationwide.

Dr. Karilyn Larkin is a hematologist at The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute. She and her colleagues were experiencing PPE shortages firsthand last month. She wondered if Ohio State engineers might be able to help—and she happened to know one. In her dual role as a College of Medicine assistant professor, she had been collaborating with Mechanical and Aerospace Engineering Professor **Carlos Castro** on leukemia research.

On March 21, she contacted Castro to ask about 3D printing face shields. According to infectious disease experts, face shields protect the face from fluids, spray, and droplets, while extending the life of N95 face masks.

"The answer was yes – Ohio State is full of collaborative people, and Carlos didn't hesitate. He quickly secured support from college leadership, assembled a team and took action to figure out how the College of Engineering could do something to help healthcare workers – and do it quickly," said Larkin.

While Castro's research focus is DNA origami nanodevices for biomedical applications, he is surrounded by experts in prototyping and manufacturing in Scott Laboratory and other nearby engineering buildings. Furthermore, these experts have state-of-the-art equipment at their disposal for research and student projects, which largely came to a halt when campus was closed in mid-March.

Believing that the convergence of expertise, equipment and sudden availability could be a solution to local PPE shortages, Castro reached out to his colleagues and department chair, **Vish Subramaniam**. A design and manufacturing task force quickly took shape.

Student Shop Supervisor **Kevin Wolf** was Castro's first call. "He oversees our department's 3D printers for research projects, which I thought would be our best initial option for producing face shields," Castro said. "Once he was in, the project started rolling."

On March 27, with guidance from Larkin, Castro and Ohio State Wexner Medical Center Senior Supply Chain Process Engineer Joe Zuroweste, Wolf began printing plastic visor prototypes and attaching clear face shield material. Castro and Wolf recruited others with 3D printers—Department of Engineering Education's Neil Gardner and Knowlton School of Architecture's Michael Baumberger—to increase production capacity. On March 30, Zuroweste presented prototypes to Ohio State's Division of Epidemiology team.

Carlos Castro holds one of the molded visor parts coming out of the injection molding machine in the ISE manufacturing lab.

"The feedback was positive, and they suggested a couple modifications," Castro recalled. "At that point we felt optimistic we could make something that could help keep healthcare workers safe."

After maneuvering some material sourcing hurdles, Baumberger and Josh Wooten from the College of Nursing's Innovation Studio led the laser cutting of clear shields. But Castro said they all soon realized the medical center's needs would far outweigh the task force's production capabilities. As revolutionary as it is, 3D printing is not a very scalable approach in terms of time required and cost of materials. "Even with three teams and 28 printers, it was likely we could have only produced around 100 per day maximum," he said.

Nearly all mass produced plastic products are made by injection molding. Fortunately a Department of Integrated Systems Engineering (ISE) manufacturing lab includes injection molding equipment. Castro knew the lab well. His father, Professor Jose Castro, runs it.

Within a few days, the elder Castro and Engineering Shop Supervisor Chad Bivens were running tests on injection molds. By April 6, they were producing injection molded visors in addition to 3D printing. A first batch of 312 fully-assembled face shields were delivered to the Wexner Medical Center on April 13. Since then, more than 2,000 have been delivered and are being used by Buckeye healthcare professionals.

The team can now produce over 400 face shields per day with the help of additional ISE and MAE staff members Rachmat Mulyana, Josh Hassenzahl, Bill Tullos, Chris Adams and Joe West. Upon learning of the College of Engineering's capabilities, Columbus Public Health also requested shields. Castro said 600 were delivered this week, ramping up to a total of about 3,000 over the next three weeks.

"This has been a true interdisciplinary team effort with important contributions from faculty and many staff members," said Castro, "and it sparked a realization within Engineering that we could provide rapid support for our healthcare colleagues in tangible ways." Recently, engineers at the Center for Design and Manufacturing Excellence and Institute for Materials Research began leading production of COVID-19 test kit nasal swabs for the state of Ohio.

Other universities are responding in a similar fashion, but each problem and solution are unique to their regions. Although the phrase "think globally, act locally" is most often associated with environmental conservation, the actions it describes occur every day throughout the U.S. in the fight against COVID-19.

Read about the MAE response to COVID-19: go.osu.edu/maeresponse

by the College of Engineering

Complete face shields with injection molded visors are ready for delivery after assembly in ISE manufacturing lab

SURGICAL ROBOT BROUGHT TO LIFE BY MAE GRADUATE STUDENT AND OSU MACHINIST

The ability to print human tissues is hard to fathom for most people. Also, minimally invasive surgery using surgeon-controlled robots is an astounding achievement.

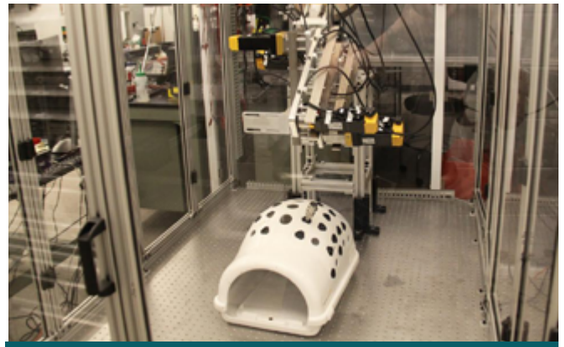
But combining the two ideas and creating a surgical robot that actually prints human tissue while inside the body is reality for two Ohio State researchers.

Dr. David Hoelzle, a professor in the Department of Mechanical and Aerospace Engineering, and Dr. Desmond D'Souza, a surgeon at The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute, are working in tandem to develop a device that will be able to print soft tissues, bones, and someday even organs inside the human body during surgery. Believing that the convergence of expertise, equipment

For the creation of the physical device, **Andrej Simeunović**, a NSF Graduate Fellow in Ohio State's Hoelzle Research Lab, and **Kevin Wolf**, the 3D Printing Laboratory Supervisor, Research Machinist, and Student Shop Supervisor at Ohio State's machine shop, collaborated to make a surgical robot that is now ready for testing.

"A lot of research is purely theoretical, whereas this project is the opposite. Most of my time is spent making the device and making it work correctly, so we can then use it to demonstrate real-world outcomes," Simeunović said. "For me personally, that is something I really value."

This would be the world's first endoscopic surgical robotics tool to print tissues inside the body using minimally invasive "keyhole" incisions - something



Mounting for 3D printing surgical arm with a device for practicing minimally-invasive surgery.

Simeunović finds very compelling.

"This project, in particular, was exciting to me for not just the fact that we are doing something brand new in terms of tissue engineering delivery," Simeunović said, "but also how many different clinical areas it has the potential to work in."

For Wolf, this project is a special opportunity.

"I found it extremely rewarding because there were many different factors that had to be taken into consideration when building something this complex," Wolf said. "Being on the manufacturing side of research, you don't necessarily get to be very involved with the science behind the project at times. Making this one that much more interesting to me."

The project includes working with material scientists and clinicians in the medical school, as well as

"This project, in particular, was exciting to me for not just the fact that we are doing something brand new in terms of tissue engineering delivery, but also how many different clinical areas it has the potential to work in."

- Andrej Simeunović

Andrej Simeunović with the hand built electrical components for the robot.

principles from biology and electrical engineering among many others to bring the robot to life.

Simeunović was in charge of designing and programming the robot and to learn more about surgical robots observed a robotic surgery at the Wexner Medical Center. He also visited two separate times to take measurements on existing surgical robots.

To go about the manufacturing of the actual device, Simeunović went to Wolf in the machine shop just one floor above Hoelzle's lab. There the two began to prototype and make models with a 3D printer.

After a few prototypes that were smaller, benchtop mockups, Simeunović and Wolf began actually putting a full-sized device together.

The final machine is made up of a metal base and a large robotic arm that has several points of movement. At the end of the robotic arm is a set of four micro motors situated in an area the size of a deck of cards that allows for several degrees of precise motion inside the body.

The motors also control a plunger that pushes synthetic tissue material down a rod about a half meter long to a nozzle where the actual printing occurs in the body. The combination of motions outside and inside the body allows for safe printing in the body using minimally invasive tools.

Wolf said he spent over 200 hours manufacturing, and then assembling with the help of Simeunović. Simeunović created the code to control the motion and printing of the device and hopes to create a more user friendly interface in the future.

Simeunović highlighted the role the machine shop played in bringing this project into reality.

"It is so helpful to have something like the machine shop and other resources we have both in our department and around the campus," Simeunović said. "You can very quickly make physical prototypes and find out what about them works and what doesn't. More importantly, our shop's teaching and technical expertise as well as their commitment to helping students is invaluable in improving our designs. It's this synergy that allows for outcomes bigger than the sum of their parts."

Wolf echoed this sentiment.

"I believe we can certainly fast track research quite a bit more often when researchers decide to collaborate with the manufacturing team early on," he said.

The device is now beginning testing on tissue-like substrates like agarose and chicken breast, with the goal to move to animal models in the future.

by Jake Rahe, Department of Mechanical and Aerospace Engineering

NATION-WIDE EFFORT TO REDUCE VEHICLE FUEL CONSUMPTION OF HEAVY DUTY TRUCKS BY TWENTY PERCENT

A new team of researchers at The Ohio State University are part of a nation-wide collaborative research effort to use connected and autonomous vehicle technologies to reduce a vehicles fuel consumption by 20 percent.

Stephanie Stockar, PhD, an assistant professor in the Department of Mechanical and Aerospace Engineering has brought her research and research group to The Ohio State University from Pennsylvania State University. Stockar and her team are part of a collaborative effort that aims to reduce the fuel consumption of semi-trucks by 20 percent.

"We are assuming that connected and autonomous vehicles have been established and that there is an exchange of information between vehicles on the road and infrastructure like traffic lights. We use that information to control the vehicle intelligently to save fuel," said **Stephen Boyle** a graduate student in the Department of Mechanical and Aerospace Engineering, who came with Stockar to Ohio State.

This project is a multi-institutional endeavor lead by Penn State and involving Volvo Trucks North America, and students and faculty at Penn State, University of Maryland, Clemson, University of North Carolina and now, Ohio State.

The control structure consists of four layers, each developed by different institutions. Each layer performs its calculations and passes that information down to the subsequent layers. The first layer is the routing layer, that selects the route for the vehicle to follow by avoiding features that would increase fuel consumption, like high traffic areas or hills. The second layer is speed trajectory optimization, which optimizes vehicle velocity based on terrain and traffic light timing. The third layer is transmission control, which selects the most fuel-efficient gear. Finally, the fourth layer, engine and accessory control, is the focus of Stockar's team's research.

Scale models of the truck in a platoon formation being tested in a wind tunnel to measure the aerodynamic drag reduction from platooning.

Scale models of the truck in a platoon formation being tested in a wind tunnel to measure the aerodynamic drag reduction from platooning."The control hierarchy is structured by different layers- as a four-layer hierarchical control structure. The higher layers have been developed by other members of the team at other institutions and they provide a command profile that the engine should follow, but because of assumptions made by those layers, the engine is not able to do it exactly. My algorithm processes the desired control profile and translates it into something that the engine is capable of achieving without violating any constraints," Boyle said. "For example, one problem is emissions. A rapid increase in the requested engine torque is met by instantaneously increasing the fueling rate. In a Diesel engine this will result in a sub-optimal combustion process, that will lead to increased engine emissions. Another problem is driver comfort, if you command too much torque too quickly the vehicle will accelerate sharply resulting in poor drivability."

The truck on the chassis dynomometer at the Larson Transportation Institute.

As part of the accessory control, Dr. Stockar's team is currently focusing on the engine cooling optimization. This is motived by the use of vehicle platooning, a strategy in which you have vehicles driving in a line together, that reduces aerodynamic drag on the vehicles, which will help save on fuel consumption.

"The vehicle spacing required to achieve this benefit would be unsafe for human drivers to maintain, but autonomous vehicles in communication with each other can react more quickly, and remain safe at close following distances. But, when the vehicles are so close together, you block the air flow from the radiator, which could result in higher engine temperatures. Our engine cooling algorithm helps keep the engine cool, while minimizing the extra load the cooling fan puts on the engine." said **Brian Block**, a graduate student in the Department of Mechanical and Aerospace Engineering, who worked with Stockar during his undergraduate studies at Penn State, and is now continuing his work in the PhD program here at Ohio State.

Currently the team is conducting engine-in-the loop testing. An engine on a dynamometer at Volvos test facility is being used to test their algorithms. While the vehicle dynamics are being simulated, the team is able to see exactly how a real engine reacts to their control strategies, and experimentally quantify their economy claims.

The layer that Stockar's team is working on will save 2 to 3 percent on fuel consumption. While that number may not seem like a lot, for large shipping companies, it could equate to millions of dollars in savings. By integrating these strategies in the hierarchy, the team is projected to meet their 20 percent goal.

by Muhammed Al Refai, Center for Automotive Research

NEW RESEARCH FROM OHIO STATE PROFESSOR COULD POTENTIALLY REVOLUTIONIZE THE FIELD OF MULTIFUNCTIONAL ROBOTS AND MACHINES

New research from Ohio State assistant professor **Renee Zhao** can have an impact in a variety of fields from morphing antennas to soft robotics and even heart surgery.

The research focuses on creating shape-shifting soft materials that transform with the use of two types of embedded magnetic particles that are manipulated using remote-controlled electromagnetic fields. This new material is called the Magnetic Shape Memory Polymer.

It is building off Zhao's previous research which used magnets as an actuation method to change the soft material into a different shape. The new material can be heated to make it pliable and then cooled to lock it to a desired shape, with the goal of creating a new class of materials that can be used across many different disciplines of engineering.

"The new functional soft material enables the development of new advanced material systems that could potentially revolutionize multifunctional robots and machines," Zhao said.

The material actuation speed is based on the percentage of iron oxide in the polymers make-up. This allows for sequencing of when the material moves and locks, which can be used in electrical engineering for the creation of logic gates.

The material is adaptive to extreme conditions, which allows it for an array of uses, Zhao said.

"The degree of freedom is limited in conventional robotics," Zhao said. "With soft materials, that degree of freedom is unlimited."

Soft robotics is a subfield of robotics dealing with construction robots using material that can be controlled in very specific ways — often mimicking those found in living organisms. For example, the muscles that control an arm can be tighten, lengthen, and manipulated in a way that the user has complete control.

Creating materials like this does not come without its challenges, and because of this many existing soft materials only have one or two ways they can be manipulated.

"One of the big challenges in the soft active materials field is how to integrate various shape manipulations into one material system for multifunctional purposes, as many such manipulations are contradictory to each other," Zhao said. "For example, fast reversible shape change requires that the material can respond to external stimulus rapidly, but shape locking needs the material to have no response or needs to maintain the external stimulus, which requires a constant energy input."

To overcome these challenges, the team combined the advantages of magnetic soft active materials using strong magnets made with neodymium, shape memory polymers, and iron oxide.

The team used a high frequency magnetic field to heat and cool the shape memory polymer to make it changeable and lock it into place, and used a low frequency magnetic field to achieve multi-functional shape manipulation.

Zhao believes that these materials could have in the biomedical field from heart surgery to drug delivery.

"This work opens up a lot of opportunities in the biomedical field for applications in minimally invasive surgeries," said Zhao. "One future direction is to develop a system that can be potentially used in the human body."

Besides, this research could have an impact on the fundamentals of science.

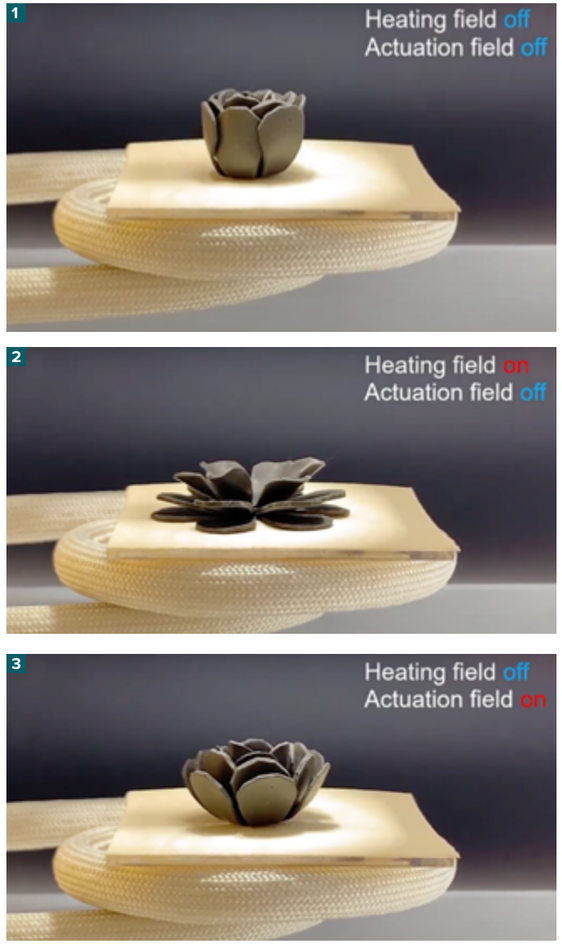
"From the fundamental science aspect, this research creates a new material that utilizes multi-physics responses for functional operations," Zhao said. "The involved thermal, magnetic, and mechanical behavior generates a series of fundamental questions."

This research highlights the interdisciplinary work being done within the Department of Mechanical and Aerospace Engineering and was published in the December 9th issue of Advanced Materials. The work was also selected as the front cover. Advanced Materials is considered one of the most prestigious journals in general material science.

The main contributors are postdoc **Qiji Ze**, students **Shuai Wu** and **Rundong Zhang**, from the Soft Intelligent Materials Lab, directed by Professor Ruike (Renee) Zhao at Ohio State, and postdoc Xiao Kuang, students Janet Wong and S. Macrae Montgomery from the Mechanics of Soft Active Materials and 3D Printing Lab, directed by Professor H. Jerry Qi at Georgia Tech.

The work is supported by the Haythornthwaite Foundation Research Initiation Grant, The Ohio State University Materials Research Seed Grant Program, funded by the Center for Emergent Materials, an NSF-MRSEC, grant DMR-1420451, the OSU Center for Exploration of Novel Complex Materials, the OSU Institute for Materials Research, AFOSR FA9550-19-1-0151, and US Department of Energy under Grant No. DE-SC0001304.

by Jake Rahe, Department of Mechanical and Aerospace Engineering



[1] The polymer holds its structure in a normal state
[2] A high frequency magnetic field is used to heat and cool the polymer, either manipulating its shape or locking it in place
[3] A low frequency magnetic field is used to achieve multi-functional shape manipulation

Watch the soft-robotics in action: go.osu.edu/softrobotics

THE GRADUATE SPECIALIZATION IN AUTOMOTIVE SYSTEMS AND MOBILITY: A STUDENT'S PERSPECTIVE

The Ohio State College of Engineering's Department of Mechanical and Aerospace Engineering is offering a new way for MS and PhD students to acquire specialized training in their fields.

The Graduate Specialization in Automotive Systems and Mobility (GS-ASM) provides a unique opportunity for students to acquire unique skills and real-world experience in their area of interest, which will enhance their degree with a focus on automotive systems and smart mobility.

"As a new graduate student, you don't really know what courses to take, the specialization allows you take courses which are structured in a cohesive manner," said **Simon Trask** who completed the program in 2019. "This kind of structure offers something to say, 'these are the courses that you should take to help you excel in industry'. I may not have taken a course in diagnostics otherwise. The courses in this specialization have really helped me open doors in my career and in my network."

Trask received master's degrees in both mechanical and electrical engineering and was a team lead for EcoCAR 3 and EcoCAR Mobility Challenge at the Center for Automotive Research (CAR) with a research focus on systems engineering. While working at CAR, Trask decided to pursue the GS-ASM program. He is now a TRACK Engineer focusing on Hybrid and Battery-Electric Vehicle Controls at General Motors.

Students participating in the GS-ASM program are required to regularly attend seminars that focus on cutting-edge research and development in the broad area of automotive systems and transportation. These seminars feature a range of speakers and themes, and industry experts are often invited to share their insight with students. Generally, seminars focus on current work in automotive-related research, conveyed from the perspectives of practicing automotive engineers and managers.

"The seminars allow you to learn from other researchers, industry professionals and students, learn strategies that aren't field specific, and learn ideas that can go from aerospace to automotive," Trask said. "Most innovations that come from either academics or industry have already been done somewhere else, it's just a matter of creating that bridge to bring that information into your field or into your area of discipline and these seminars really offer that opportunity."

To learn more about the specialization, visit the GS-ASM webpage: go.osu.edu/gsasm

by Muhammed Al Refai, Center for Automotive Research

A prototype of the foldable, ultrasound transducer. It's ability to manipulate shape and guide intense soundwaves based on its shape can bean effective development in cancer treatment. Read more (pg 15)

FIGHTING CANCER WITH ULTRASOUND

Ohio State researchers **Ryan Harne**, a mechanical and aerospace engineering professor, and Dr. Frederick Davidorf, a Wexner Medical Center ophthalmologist, have begun development on a prototype probe *(pictured page 13)* for ultrasound-based cancer surgery. The pair received donor funds to develop their prototype in late 2019.

The foundations for the technology began in 2015 with Harne's research on origami-inspired structures. Early attention in this research was directed to applications of adaptive communications. Harne's Laboratory of Sound and Vibration Research developed a two yard-long, shape-changing, origami-inspired loudspeaker array as a demonstration of the principles of foldable acoustic arrays that may guide and steer sound waves according to the folded shape.

LSVR origami-inspired loudspeaker

However, the attention was quickly redirected to the use of the folding structure concept to design small scale, medical ultrasound devices. There are many medical uses of ultrasound that could benefit by devices that may change from miniature folded configurations to larger deployed shapes. Together, Davidorf and Harne created the idea to use a reconfigurable ultrasound-focusing transducer to attack ocular melanoma, a cancer in the eye.

High intensity focused ultrasound (HIFU) is the practice of guiding intense sound waves through the body to a point location where high heat develops. This heat is used as a safe and minimally invasive way to ablate prostate cancer without the side effects of other cancer treatment methods–surrounding healthy tissue remains unharmed in a HIFU procedure.

The success of this emerging cancer treatment is promising. There is a 100% 5-year survival rate for HIFU treatment of prostate cancer. On the other hand, current HIFU probes are large and cannot access most cancers.

Harne and Davidorf's idea is to design ultrasound probes that can articulate and fold, enabling a way for the probe to fold up into a highly compact shape. Then, the device may be inserted into the body through minimally invasive surgery and unfolded at the point of care, allowing the transducer to focus ultrasound energy on diseased tissue.

"HIFU is demonstrating spectacular success treating prostate cancer. If you can take this fundamental technology and redesign it in a way that allows access all throughout the body, then there is a clear opportunity to broaden the impact of this cancer treatment procedure in a transformative way," said Harne.

The development of the probe isn't without its challenges. The transducer must be small enough to best target cancerous tissue with the focused ultrasound, while the mechanical and material design complexity increases for the smaller transducer designs.

These challenges have motivated Davidorf and Harne to collaborate with a major domestic manufacturer of HIFU equipment.

Once fully developed and tested, Harne and Davidorf hope their idea may give hope to millions by vastly increasing accessibility to a successful and proven, minimally-invasive, ultrasound-based cancer treatment.

by Sam Cejda, department of mechanical and aerospace engineering

SCHOLAR-ENTREPRENEUR TAPPED TO DIRECT OHIO STATE'S SMART MOBILITY PROGRAM

A technology-based small-business owner with higher education and federal agency experience has been recruited to The Ohio State University to direct its Smart Mobility Program.

Chris Atkinson, also a professor of mechanical and aerospace engineering, will lead and collaborate with faculty, students and staff to integrate mobility-related research and education across academic units. As director of the Smart Mobility Program, he will report to both the College of Engineering and the Office of Research.

"We have created a position that will think broadly enough to be able to integrate all of the mobility-related research and development activities on the Ohio State campus with the city, the region, the state and nationally to create opportunities for large research programs," said Giorgio Rizzoni, the Ford Motor Company chair in Electromechanical Systems and director of the Center for Automotive Research.

"Chris, as an outgoing director of a federal agency, is incredibly well connected in Washington, D.C., in the national labs and industry. His prior experience in academe and in the private sector make him the ideal candidate for this role. He will be able to lead initiatives that will bring large research programs to Ohio State and also continue the effort to bring the campus together with a more unified approach to how we understand mobility."

Atkinson will work to enhance Ohio State's existing research centers and institutes in the mobility sciences, including the Center for Automotive Research and Transportation Research Center, the Center for Urban and Regional Analysis, the Campus Transit Lab and other mobility-related initiatives, and will collaborate with industry partners to increase corporate, foundation, state and federal partnerships.

"There's a very coherent transportation and mobility focus at Ohio State that permeates from the university to the city to the county to the state," Atkinson said. "Ohio is very strong in all things automotive from an economy and industry and economic development point of view.

"It's unique, and I use that word correctly. It is one of a kind."

The Smart Mobility Program will identify existing and create new initiatives that position Ohio State to address and transform the mobility industry. Atkinson will build business relationships with essential local, state and federal partners as well as strategic national and international industries to understand their future and emerging needs and to identify opportunities to collaborate on mobility-related research-based initiatives.

"My attraction to Ohio State is the fact that it has a very strong underpinning in transportation, a very strong commitment to smart mobility and a very close integration with the city, the county, the state and beyond," he said.

Atkinson joins Ohio State from the Advanced Research Projects Agency-Energy (ARPA-E) in the U.S. Department of Energy. He served as program director, developing programs to fund high-risk, high-reward innovative energy technologies for generation, storage, distribution and usage. He is the founder of Atkinson LLC, a company specializing in engine control and calibration, fuel efficiency optimization and emissions reduction.

Before he joined the Department of Energy, Atkinson was a professor in the Department of Mechanical and Aerospace Engineering at West Virginia University and director of the Center for Alternative Fuels, Engines and Emissions.

He holds a BS in chemical engineering from the University of Natal, South Africa, an MS in mechanical engineering from West Virginia University and an ScD in mechanical engineering from Massachusetts Institute of Technology.

by Muhammed Al Refai, Center for Automotive Research

FACULTY RECOGNITION

Professor Bharat Bhushan announces retirement

Since 1991, professor **Bharat Bhushan** has been an Ohio Eminent Scholar and the Howard D. Winbigler Professor in the department of mechanical and aerospace engineering. His research interests include fundamental studies with a focus on scanning probe techniques in the interdisciplinary areas of bio/nanotribology, bio/nanomechanics and bio/nanomaterials characterization and applications to bio/nanotechnology, and biomimetics.

During his time at Ohio State, Bhushan has been prolific in his publishing. He has published 10 scientific books, over 100 book chapters, and over 900 scientific papers. He has edited over 50 books and holds more than 25 U.S. and foreign patents. Professor Bhushan has become an internationally recognized researcher and is one of the top 1500 highly cited researchers in the world.

Prof. Bhushan has been recognized with numerous awards, most recently the ASME May Hershey Award, presented for lifetime contributions to the field of tribology.

In addition to his technical work, professor Bhushan advised 28 PhD students and 43 masters students.

Professor Cheena Srinivasan announces retirement

Cheena Srinivasan has been a part of the Ohio State community for 40 years. For 12 years (2000-2012) he served as the Chair of the department of mechanical and aerospace engineering.

Professor Srinivasan's key contributions to the department include leading capital campaign efforts that led to the building of Scott Laboratory. He oversaw the merger of mechanical and nuclear engineering with aerospace engineering in 2010. And he was able to establish and sustain extensive relationships with department alumni networks.

Srinivasan also served as Associate Dean for Research in the College of Engineering (1998-2000), and as Program Director for the Manufacturing Machines and Equipment Program at the National Science Foundation (1992-1994). He also helped advance MAE alumni relations as Faculty Director for Alumni Relations (2016-2018).

Many students and faculty in the department of mechanical and aerospace engineering have benefitted from professor Srinivasan's knowledge and experience. He will continue to engage in academic activities including teaching and researching as an Emeritus Faculty.

Renee Zhao receives 2 NSF awards in Spring 2020

Renee Zhao, an assistant professor of Mechanical and Aerospace Engineering, has received two awards from the National Science Foundation (NSF) in Spring 2020.

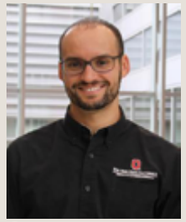
Earlier this year, Zhao received a five-year, $562,511 NSF Faculty Early Career Development (CAREER) Award for her research in the mechanics of soft intelligent materials.

More recently, NSF announced she will be awarded $398,773 over three years for the project "Micromechanics of Interactions Between Hard Magnetic Particles and Soft Matrix on Magneto-Mechanical Actuation."

"The two grants will facilitate the investigation of the mechanical behavior of the magnetic soft materials," Zhao said. "These materials are composites with hard-magnetic particles embedded in soft matrixes. Upon the application of an external magnetic field, the composite could provide untethered, fast and reversible deformation with large shape changes. The magnetic soft materials have already demonstrated potentials in designing morphing structures and actuators for various engineering applications.

Read more: go.osu.edu/ReneeZhao

Canova and Serrani Recognized with Lumley Interdisciplinary Research Award



Canova

Marcello Canova, associate professor in the Department of Mechanical and Aerospace Engineering, as well as **Andrea Serrani**, professor in the Department of Electrical and Computer Engineering were awarded the College of Engineering's Lumley Interdisciplinary Research Award.

Serrani

This award is presented annually to faculty and/or research scientists within the College of Engineering who have demonstrated significant research collaboration that cuts across departmental or discipline boundaries.

"This team is well recognized nationally and internationally, and has made a significant contribution to the advancement of feedback control technology and its applications to advanced powertrain systems," said Hesham El Gamal, professor and chair of the Department of Electrical and Computer Engineering.

Because of the interdisciplinary nature of their work and its balance between methodological depth and industrial relevance, Canova and Serrani have received significant research funding from the National Science Foundation (NSF) as well as Ford Motor Company.

Ryan Harne awarded the ASME Gary Anderson Early Achievement Award

Ohio State mechanical engineering professor **Ryan Harne** was awarded the ASME (American Society of Mechanical Engineers) Gary Anderson Early Achievement Award for his contributions to the field of Adaptive Structures and Material Systems.

Harne

The outcomes of Dr. Harne's research efforts have included one patent, multiple patents pending, one book, over 50 journal publications, over 50 conference proceedings, and numerous students mentored and guided through their academic programs.

Professor named International Society for Optics and Photonics fellow

Marcelo Dapino, professor of mechanical and aerospace engineering, the Honda R&D Americas Designated Chair in Engineering, and director of the NSF IUCRC Smart Vehicle Concepts Center has been named a fellow of the International Society for Optics and Photonics (SPIE).

Dapino was selected for outstanding technical contributions in the field of smart materials and structures and for extensive service over the past 20 years to the SPIE Smart Structures and Nondestructive Evaluation conference.

Prof. Dapino is widely recognized in the field of smart materials for

the development of transitional research programs that approach foundational research with an industrial focus. Along with his students and collaborators, Dapino has authored 250 technical articles and book chapters while serving as primary advisor on over 50 dissertations and theses.

Professor Bharat Bhushan receives ASME Mayo D. Hersey Award for lifetime achievement in tribology

Professor Bharat Bhushan, Ohio Eminent Scholar and Howard D. Winbigler Professor and Director of Nanoprobe Lab for Bio- & Nanotechnology and Biomimetics has received the 2020 Mayo D. Hersey Award from the American Society of Mechanical Engineers (ASME).

The ASME Mayo D. Hersey Award was established in 1965. It is given in recognition of distinguished and continued contribution over a substantial period of time to the advancement of lubrication science and engineering, according to ASME. The award is regarded as the highest honor in the field given by ASME.

For more than four decades Dr. Bhushan has made outstanding contributions to the advancement of tribology as a prolific author and internationally recognized expert at the micro-to-nano scales. He has authored 10 scientific books, over 100 handbook chapters, and over 900 scientific papers. He also edited more than 50 books and holds more than 25 U.S. and Foreign Patents. He is a Highly Cited Researcher in materials science, biology, biochemistry, and cross-field category. His research was listed as one of the Top Ten Science Stories of 2015 and he has received two semi-honorary and three honorary doctorates. Bhushan is also recognized as a pioneer of the tribology of magnetic storage devices, whose influence has extended to the interdisciplinary areas of biological and materials science.

Jim Gregory to become chair of Mechanical and Aerospace Engineering

Professor James W. Gregory will become the new chair of the Department of Mechanical and Aerospace Engineering (MAE) at The Ohio State University, effective June 1, 2020. He will succeed Professor Vish Subramaniam, who has served as chair since 2016.

Currently an MAE professor and Director of the Aerospace Research Center (ARC), Gregory came to Ohio State in 2008. Under his leadership, ARC has expanded interdisciplinary collaborations to include colleagues from industrial engineering, electrical engineering, mechanical engineering and medicine. The center's research output also has grown substantially, with a doubling of research expenditures over the past two years. In August 2017, Gregory led a team of researchers and students in setting official world records for speed and distance for an autonomous drone.

Gregory's innovative teaching methods helped him earn numerous awards throughout his career, including the McCarthy Engineering Teaching Award, the Department of Aerospace Engineering Outstanding Professor Award, and SAE's Ralph R. Teetor Educational Award. He has produced a video lecture series on the Science of Flight, in collaboration with the Great Courses and the Smithsonian Institution's Air & Space Museum.

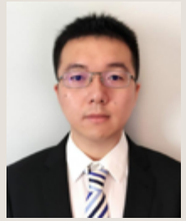
NEW FACULTY APPOINTMENTS

Chris Atkinson

Professor Atkinson joined the departmen of mechanical and aerospace engineering in June, and is the Director of Smart Mobility Program. Most recently, Atkinson was Director of ARPA-E in Washington, DC where he led a diverse portfolio of energy research funded by the agency.

STUDENT RECOGNITION

Ming Yang selected as Ohio State Presidential Fellow



Ohio State mechanical engineering PhD student **Ming Yang** was selected as one of this year's recipients of the Ohio State Presidential Fellowship.

Yang is advised by Dr. **Soheil Soghrati** and is a fourth year doctoral candidate who came to Ohio State from China.

The fellowship is given to students who "embody the highest standards of scholarship" in the graduate programs at the university going into the last stages of their dissertation research or terminal degree project. Recipients are given a monthly stipend for living expenses so they can focus solely on completing their research, as well as help with travel expenses to present at national conferences.

Yang's research focuses on creating an efficient numerical framework, including microstructure reconstruction, mesh generation, finite element simulation, and deep learning algorithms, for the computational modeling of novel materials with complex microstructures. It will significantly reduce the time and labor cost associated with the modeling process.

Read more: go.osu.edu/MingYang

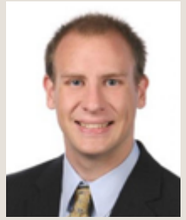
MAE PhD student awarded SMART fellowship

PhD student, **Jordan Thayer** has been awarded a SMART Fellowship by the United States Department of Defense (DOD). Thayer is advised by MAE professor **Jack McNamara**, and works in the Multiphysics Interactions Research Group (MIRG) directed by McNamara. Through MIRG Thayer also works in collaboration with professor **Datta Gaitonde.**

The Science, Mathematics And Research for Transformation (SMART) Scholarship for Service Program is an opportunity for students pursuing an undergraduate or graduate degree in Science, Technology, Engineering, and Mathematics (STEM) disciplines to receive a full scholarship and be gainfully employed upon degree completion. The award provides full tuition, health insurance, living expenses, and employment at a DOD facility after graduation. Selection for an award is based on an essay, letters of reference, and educational/work background information.

Thayer's fellowship was awarded by The Air Force Research Laboratory Aerospace Systems Directorate (AFRL) at Arnold Air Force Base. His research will focus on fluid-structure interactions in high-speed, unsteady flow environments.

MAE PhD student selected to receive a NDSEG Fellowship Award



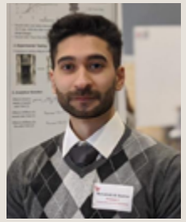
Ohio State mechanical engineering PhD student **Rob Clark** has been selected to receive a 2020 National Defense Science and Engineering Graduate (NDSEG) Fellowship Award.

Clark's research was advised by Dr. **Jeffery Bons** and focused on deposition of particulates in high temperature environments, notably gas turbine engines.

For his proposal to NDSEG, Clark focused on the thermodynamic design, modeling, and optimization of thermal management systems for future military aircraft.

The fellowship is awarded in recognition of his academic excellence in science, technology, engineering and math achievements from over 4176 applications that were received this year, according to NDSEG. NDSEG fellowships need to promote education in science and engineering disciplines relevant to the mission of the Department of Defense.

Graduate student and assistant professor receive fellowship from AFRL/DAGSI



The team of mechanical engineering graduate student **Mohamad Al Nashar** and assistant professor **Alok Sutradhar** have received a fellowship award to support their research in materials and manufacturing.

The fellowship comes from the Air Force Research Laboratory Dayton Area Graduate Studies Institute (AFRL/DAGSI). Sutradhar and Al Nashars' fellowship title is "Topology Optimization of Coupled Mechanical and Electromagnetic Designs."

"In this project, we combine mechanical and electromagnetic topology optimization to design novel electromagnetic systems," said Sutradhar.

The design proposed by the project will lead to new performance and integration opportunities. This includes systems that are lighter, more compact and affordable.

The focus of the work is topology optimized electromagnetic designs, and creating CNN-based neural network surrogate models for electromagnetic field distribution. Sutradhar and Al Nashar plan to begin their project in the summer.

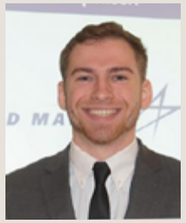
Wen Cai receives Ohio State Presidential Fellowship

Ohio State mechanical engineering PhD student **Wen Cai** was selected as one of this year's recipients of the Ohio State Presidential Fellowship.

The fellowship is given to students who "embody the highest standards of scholarship" in the graduate programs at the university going into the last stages of their dissertation research or terminal degree project. Recipients are given a monthly stipend for living expenses so they can focus solely on completing their research, as well as help with travel expenses to present at national conferences.

Wen's research focuses on the investigations on nonlinear energy harvesters in complex vibration environments for robust direct current power delivery. With the research she hopes to combine the advancements of mechanical and electrical sub-systems to ensure sustainable direct current power delivery in complex vibration environments. Her advisor was Ohio State mechanical engineering professor **Ryan Harne.**

Ohio State student wins first prize at international student conference



Collin O'Neill, an Ohio Space Grant Consortium Fellow and a graduate student pursuing a master's in aerospace engineering, won the first prize in the international student conference in the undergraduate category on Jan. 6 at the American Institute of Aeronautics and Astronautics (AIAA) SciTech Forum in Orlando, Florida.

O'Neill competed against six other regional-winning contestants from around the world with his research, presentation and paper. The competition was based on several categories like quality of the presentation and paper, impact on industry and how novel the work is.

The research focused on active flow control for offset diffusers for aircraft engines. Diffusers provide the required airflow for aircraft engines and are typically straight, but O'Neill's research focused on using plasma actuators to solve the problems with flow that arise when an aircraft uses a diffuser that is offset.

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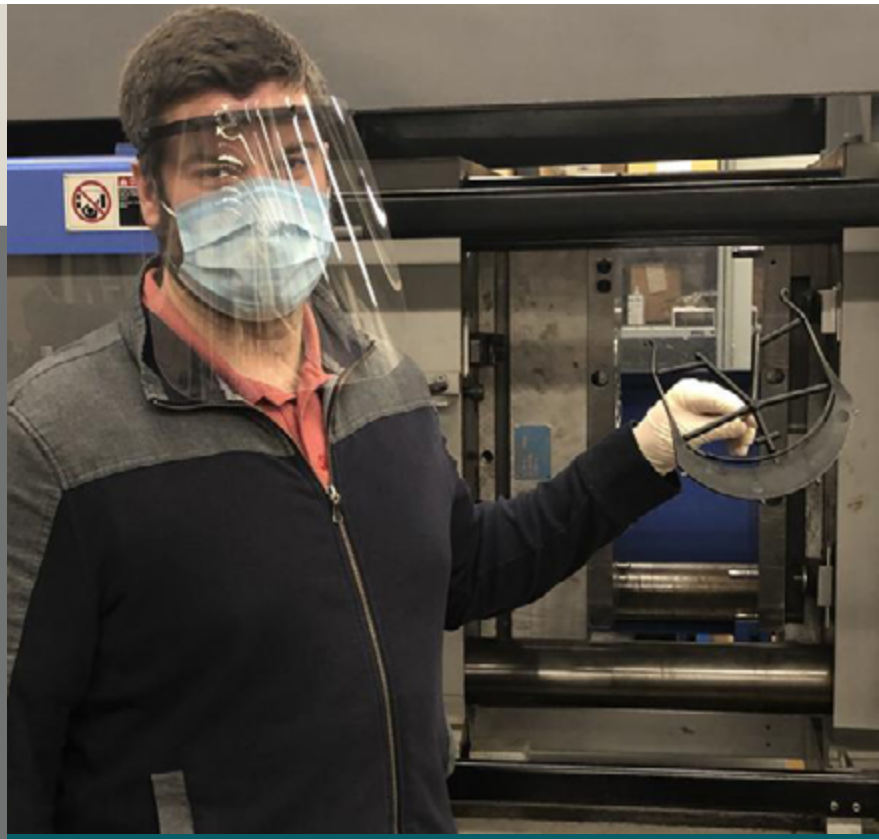

MAE Professor Carlos Castro holds a protective faceshield, developed by a team of College of Engineering faculty and staff to be delivered as Peronal Protective Equipment to Wexner Medical Center. (page 5)