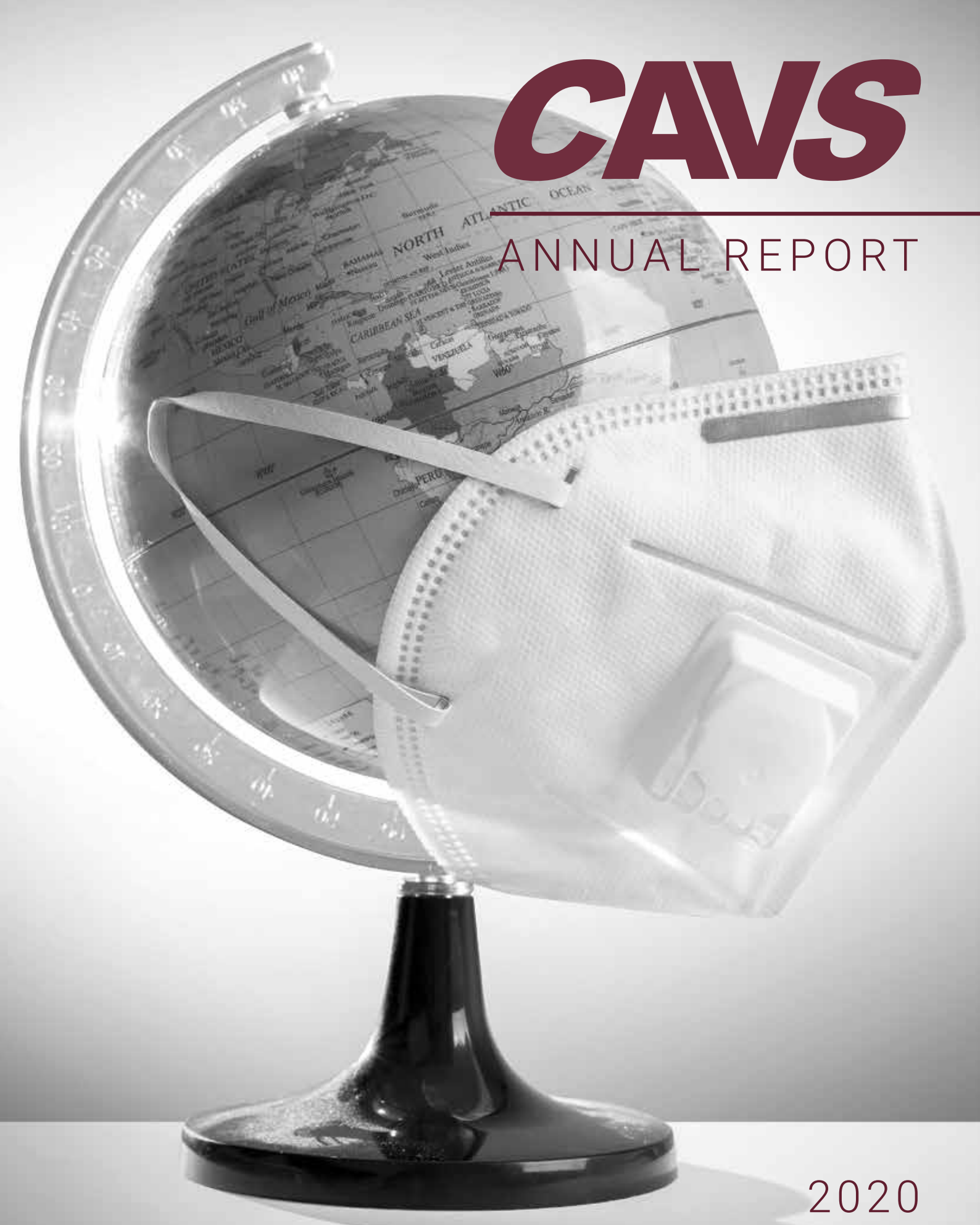

CAVS

ANNUAL REPORT

2020

MISSISSIPPI STATE UNIVERSITY

WWW.CAVS.MSSTATE.EDU

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- Clay Walden
CAVS executive director

DIRECTOR'S MESSAGE

It is always a pleasure to reflect on the year and to see the accomplishments of our CAVS team. I am proud that we were able to report another record year in terms of research activity, particularly considering the difficulties related to the COVID-19 pandemic. Our faculty and staff worked together through the uncertain times and produced a record number of research proposals leading to another record year in award funding. I am pleased to report that we have received over $34 million in awards. Working with the researchers, staff and students across our four units, CAVS Research, CAVS Extension, ISER, and I2AT is something I look forward to each day and always exceeds my expectations.

In this report, we have chosen to highlight a wide variety of our projects and capabilities.

- Continuing progress in off-road, autonomous mobility.
- Licensing of a new material testing instrument for intermediate and high strain rate testing.
- Expansion and growth in our Athlete Engineering program through new partnerships and engagements with professional athletic teams.
- Piloting of emerging wearables for the industrial athlete through our partnership with East Mississippi Community College's Communiversity.
- Expanded imaging and virtual capabilities to support advanced manufacturing and maintenance within the state's industry.
- Ongoing efforts to expand training to improve workplace productivity through Lean and Six Sigma Certifications.

We are also proud to include a special section highlighting several articles that focus on how we assisted communities, hospitals and industries around the state deal with the COVID-19 pandemic.
We look forward to continuing our work next year and growing our research and engagement impact around the state and nation.

Please keep track of our progress throughout the year through our social media presence on Facebook, Twitter, Instagram and LinkedIn.

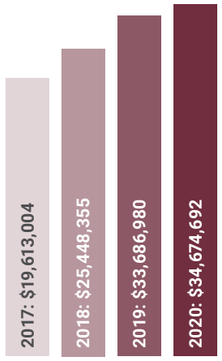
As always, it is a great pleasure for us to serve our state and nation.

Hail State!

Clayton T. Walden
Executive Director
Center for Advanced Vehicular Systems

OUR VISION

The Center for Advanced Vehicular Systems (CAVS) will be a global leader in interdisciplinary education and research for the development of engineering solutions that expand and enhance the design, technology, production, and infrastructure necessary for sustainable mobility.



2017-2020
TOTAL AWARDS
$113,423,031

OUR MISSION

CAVS strives to be a world-class center of excellence for research, technology and education equipped to address engineering challenges facing US mobility industries. Utilizing high performance computational resources and state-of-the-art analytical tools for modeling, simulation and experimentation, CAVS will provide a distinctive interdisciplinary environment wherein next-generation engineers and scientists train alongside field experts to investigate, design and verify novel solutions in materials, propulsion and design for efficient human and vehicle mobility. Harnessing our broad impact research along with our state, national and international industrial alliances, CAVS will support economic development and outreach activities throughout the State of Mississippi.

SOMETHING TO PROVE: MSU MAKES ITS MARK IN OFF-ROAD AUTONOMY

BY JAMES CARSKADON | PHOTOGRAPHY BY BETH WYNN

Autonomous vehicles have made significant advancements over the last generation, but at least one major limitation remains for most—the ability to reliably travel off-road, which encompasses the majority of Earth's terrain.

Using a combination of advanced computer simulation capabilities and a newly acquired 50-acre off-road test track, researchers at Mississippi State's Center for Advanced Vehicular Systems are at the forefront of creating and testing the systems that will open a new world of possibility for autonomous vehicles. The advancements developed at MSU could have applications for the military, as well as industries such as agriculture, energy, construction and forestry.

Clay Walden, executive director of the center, said Mississippi State's decades of automotive research experience, unrivaled high-performance computing capability, and the university's rural surroundings combine to make an ideal setting for autonomous vehicle development and testing.

"I don't think there's anywhere else with our advanced computing capabilities, which we can use to model and simulate the sensors these systems run on, combined with the ability to quickly validate what's happening," Walden said. "It's a great combination of virtual and physical testing in an off-road environment, and I think it gives our partners in the Department of Defense something unique."

This fall, CAVS put the finishing touches on the MSU Proving Ground, 50 acres of diverse terrain adjacent to the research center. The property contains swampy areas, flats, steep inclines and tall grass, all of which can be used to test vehicles in a variety of environments.

The Proving Ground will increase the center's ability to carry out U.S. Army ground vehicle research. Last fall, CAVS received $3.08 million from the U.S. Army Engineer Research and Development Center, headquartered in Vicksburg, to conduct research in areas such as human performance in manned and autonomous systems, soil-terrain interaction, remote sensing capabilities, and more. The work will help the Army assess manned and unmanned tactical vehicles.

As part of the research, CAVS has acquired two new vehicles, with a third on the way. The first to arrive was a Polaris MRZR, a lightweight versatile vehicle that can carry up to four people and has uses in a wide range of tactical environments. The second was a Warthog amphibious, unmanned ground vehicle, which can be used to carry supplies in support of a mission. The third vehicle, an amphibious tracked vehicle operated by a joystick, is scheduled to arrive in late 2020 or early 2021.

Daniel Carruth, CAVS associate director for advanced vehicle systems, said the different vehicles will help the researchers train algorithms and sensors to adapt to different environments and uses.

"The military is looking at vehicle support in a lot of different ways," Carruth said. "You could have scenarios where you drive for a distance, then get out and walk the last mile to the combat zone and you can call the vehicle to pick you up in a hurry. They envision vehicles that can do reconnaissance and overwatch, and then extraction. So, essentially, vehicles that can protect themselves and then come get you when you needed."

Another benefit for the armed forces is that self-driving vehicles free up personnel for other aspects of the mission. It could also reduce the number of people needed to handle transportation and supply chain logistics, which often are a dangerous part of a mission.

"If you have three people in a vehicle and you can take out the driving aspect, they can focus on things like security, management, communications with other vehicles or the forward operating base," Carruth said. "If you can reduce persons in a vehicle, it reduces potential casualties."

THE IMPORTANCE OF SIMULATION

In addition to the physical 50-acre site, CAVS is creating a "digital twin" of the Proving Ground for simulations. This will allow researchers to use the physical data collected at the test track to train the systems and sensors that the autonomous vehicles use to navigate the terrain.

This process involves collecting information about the property's soil, topography, trees, plants and more so the digital twin replicates the real thing as closely as possible. The researchers noted that the quality of the data going into any algorithm or simulation plays a significant role in determining the capabilities of the artificial intelligence systems that will use those algorithms to make decisions. The team developed the MSU Autonomous Vehicle Simulator, or MAVS, to conduct in-house testing of navigation software in virtual environments.

To make decisions with 95% confidence, an autonomous driving system needs billions of miles worth of training. That is where the capabilities of MSU's High Performance Computing Collaboratory come in.

While CAVS researchers are preparing vehicles to drive on the Proving Ground, they can also use the machine learning capabilities of one of the world's most powerful

"With agriculture, forestry and other fields, there are opportunities for ground vehicle coordination with unmanned aerial vehicles. That gives you perspectives from the ground and from the air."

supercomputers to help prepare the vehicles to drive in unknown environments. By running thousands of simultaneous drive simulations, the research team can gain valuable insights into how the autonomous systems respond to different changes in the environment.

"In a matter of months, you could have one of our vehicles driving most of the trails on the Proving Ground," Carruth said. "But if I took that vehicle to another property, it's not going to be able to drive at all. The modeling and simulation tools will let us train that vehicle to drive in the desert or in the mountains. In the simulation, we can put it in any imaginable environment and see how the vehicle performs there.

"On the high-performance computing system, we can simulate 100,000 rides in an environment, which could tell us, for example, what level of rainfall makes a system fail," he continued. "It lets us build environments and run lots of different trials with different variables to see how those variables affect the vehicles."

Carruth is leading efforts with NATO, through its Science and Technology Organization working groups, to examine and compare current autonomous modeling and simulation tools. He is leading a NATO competition that will benchmark currently available simulation tools and test them in physical environments, some of which could potentially be done on the Proving Ground. The NATO research group is working through 2023 to determine standards for autonomous modeling and simulation tools.

LETTING STUDENTS GET HANDS-ON EXPERIENCE

CAVS regularly involves undergraduate and graduate students in the wide-ranging research at the center. Computer science graduate students Payton Ray and Marc Moore are among the first to get to carry out research on the Proving Ground and the new vehicles being used for the project.

Ray, from Olive Branch, studied computer science and linguistics as an undergraduate at MSU. In graduate school, she is focusing on artificial intelligence and how humans interact with computers and robots. At CAVS, she is outfitting the Warthog robot with sensors that collect data from the Proving Ground. That data then informs how the vehicles react in the simulation software.

"My background is mainly in software, but for this you have to be a mini expert in all of it," Ray said. "You have hardware with the sensors, then you have to get out there and actually collect the data. There are a lot of problems to solve, but it's a lot more fun than sitting in a cubicle."

Moore, who came to Mississippi from San Diego before enrolling at MSU as an undergraduate, is doing similar work for the MRZR. He said it is exciting to work in off-road autonomy, where every problem is still "in its infancy." In addition to getting to work alongside world-class researchers, Moore said he enjoys the opportunity to work with top-of-the-line equipment.

"Lidar systems are not cheap at all, but right now they are the cornerstone of autonomous driving," Moore said. "We have access to lidar systems. We can test new algorithms. We can gather data. That's a practical level of experience that very few research institutions provide. The skills we're learning will be relevant for a long time."

STAYING AT THE FOREFRONT

Walden said he can envision collaborations with MSU faculty in agriculture and forestry that utilize the Proving Ground. Because MSU is a national leader in unmanned aerial systems research, CAVS will also be well-positioned to explore unmanned ground and air vehicle interactions in an off-road environment.

"With agriculture, forestry and other fields, there are opportunities for ground vehicle coordination with unmanned aerial vehicles," Walden said. "That gives you perspectives from the ground and from the air."

The work at CAVS also opens up the opportunity for research into autonomous cars that handle both on- and off-road environments. Additionally, the research could overlap in areas that are beneficial to on-road autonomy.

"The Army is not going to want an autonomous vehicle that is either on-road or off-road," Carruth said. "At some point, you need a vehicle that is capable of doing both. It would have to recognize the context it is operating in. We're potentially interested in that transition from on-road to off-road operations and how you build a system that can recognize the context change and operate equally well in both environments."

CAVS RESEARCHERS INVENT SIGNIFICANT ADVANCEMENT IN HOPKINSON BAR TECHNOLOGY

BY JAMES CARSKADON | PHOTOGRAPHY SUBMITTED BY STANDARD DYNAMICS-REL-MSU

Mississippi State University researchers have patented and licensed a major advancement in split Hopkinson pressure bar technology, significantly reducing the amount of space needed for intermediate and high-strain rate testing.

While conducting research on infant head trauma, researchers at MSU's Center for Advanced Vehicular Systems needed a way to conduct impact testing with biological materials. While a traditional Hopkinson bar system, an apparatus commonly used for testing impact and strain on materials, would have worked, it would have taken up hundreds of feet in length—space that was not available at the bustling research center. However, CAVS engineer Wilburn Whittington, with the support of colleagues Haitham El Kadiri and Hongjoo Rhee, was able to prototype a serpentine bar that can accomplish the same task in only 20 feet of space.

Whittington is an assistant professor in MSU's Department of Mechanical Engineering. El Kadiri is an associate professor in the Department of Mechanical Engineering and holds the Coleman-Whiteside Professorship. Rhee is an associate professor at the same department and is an associate director at CAVS.

"We've already used this product in our work for the military, national labs, and automotive companies," said Whittington. "This has tremendous potential for universities and laboratories, as well as any company making materials or looking at crash testing and other tests like that."

After the research team patented the new technology, it gained interest from the scientific community and REL, a Michigan-based manufacturer that makes and sells Hopkinson bar systems. Working with MSU's Office of Technology Management, El Kadiri, Rhee and Whittington were able to license the serpentine bar technology to REL, which began marketing the product this week at The Minerals, Metals & Materials Society annual conference in San Diego, California.

Whittington said the serpentine bar can be used as a new product and also used to enhance old products, making shorter Hopkinson bar systems capable of conducting tests that previously required significantly more space. He noted that in labs that conduct high-speed tests with radioactive materials, these materials must be handled in specialized rooms, which puts space at a premium.

"People test things like explosives and armor on these systems," Whittington said. "Like with biological materials, these labs have to be specialized, so a serpentine bar gives them more testing abilities."

El Kadiri, Rhee, and Whittington were able to commercialize their invention through a Mississippi University Research Agreement, which allowed them to form a private company to market the technology, Standard Dynamics, LLC. In addition to showcasing the technology in San Diego this week, MSU and REL personnel will highlight the serpentine bar at the Society of Experimental Mechanics annual conference this summer in Orlando, Florida.

For more on the Office of Technology Management, visit www.otm.msstate.edu.

CREATING MACHINE LEARNING ALGORITHMS TO CALCULATE APPROXIMATE SOLUTIONS TO COMPLEX PROBLEMS

BY DIANE GODWIN | PHOTOGRAPHY BY BETH WYNN

Doyl Dickel, assistant professor in Mechanical engineering, and Sungk¬wang Mun, assistant faculty researcher at CAVS, are working to develop machine learning algorithms for computational models to simulate the interaction between organic and inorganic materials at the atomistic scale level. It is a feat that has not been accomplished by any other computational scientist throughout the world.

A key feature of today's computational models is that they are able to help scientists study biological and non-biological material systems at multiple levels, but the models run separately; they are not programmed to interact due to the distinctively different characteristics in each system. Thus scientists can't predict how inorganic composites and organic molecules interact. For instance, there is the case of how a biological implant made of various polymer and metallic materials would connect with the organic cells in the body.

By utilizing the same machine learning techniques that guide self-driving cars, speech recognition software, or your phone's autocomplete function, researchers at CAVS are rapidly creating the next generation of molecular models.

"Machine learning adds so much power and flexibility to what we can predict. Our goal is to give the researchers the ability to reproduce whatever material or combination of materials they want and be able to make meaningful predictions," Dickel said. "They will see the titanium plate, the polyethylene that is holding it in place, the organic

cells and fibers that are growing onto it, and they will see how it all works together and exists in one coherent computational simulation."

The computational capabilities at Mississippi State's High Performance Computing Collaboratory have vastly ex-panded, which enables Dickel and Mun to develop new and sophisticated mathematical formulas that can reveal the nature of foreign body responses.

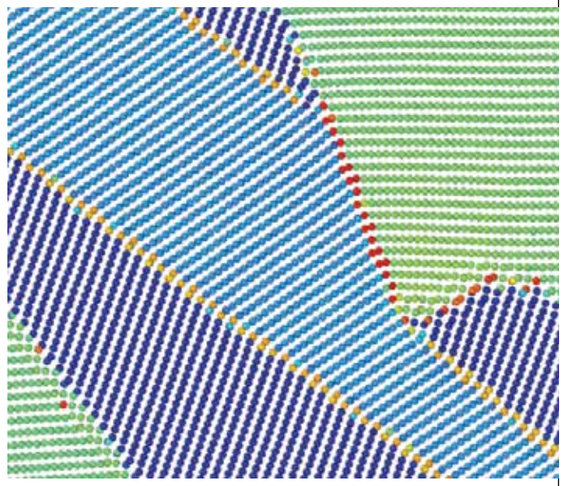
"Unlike other machine learning methods that are purely data-driven, we are using the physic-based Modified Embedded Atom Method as a base model equation, for which enables physically admissible prediction of properties that are not trained for. Due to the flexibility of our developed machine learning model, it can handle inorganic and organic materials in a single unified formalism," Mun explained. "We are trying to provide the calculation software as well as the development kit for their own research problem."

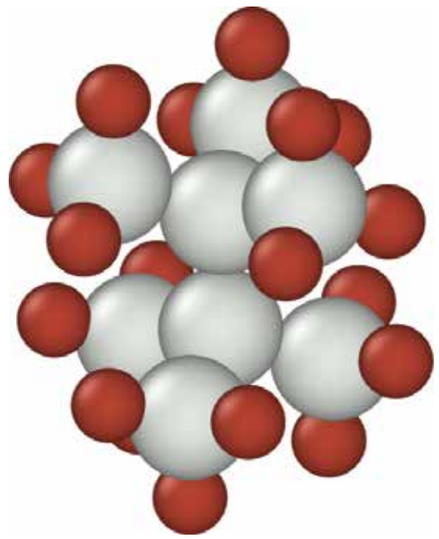
The MEAM formalism has been very popular for metallic systems since its invention years ago. Mun and Dickel are working to extend this method to include polymer and organic material as well. Machine learning allows them to move beyond this initial method and make modifications to the original equations to distinguish between the different compositions of the metal, polymer, and organic systems. Their efforts have already produced a new machine learning model for titanium which was published earlier this year.

"Our goal is that researchers will be able to create their own recipes and run their own simulated experimentations to create and test new products as a result of using our universal formalism," Mun said.

The idea with simulation is computational models can sample the same 10,000 things in the 10th of the time for a thousandth of the cost and has the ability to reveal the final five simulations that should produce the results expected when actually building the experimental tests.

Dickel explained, "When it is at its most optimal, computational simulation is not cutting just half the cost and time, it is 10 to hundreds of thousands of times cheaper if you can trust the model. That is what we are doing is making sure that the things we predict reflect the true underlying physics."





HIGHLIGHTS OF EXPERIMENTAL CAPABILITIES IN MATERIALS RESEARCH

PHOTOGRAPHY BY MEGAN BEAN, BETH WYNN AND HAILEY HANNIS

ABB IRB 2600 ROBOTIC WELD CELL

The ABB weld cell outfitted for Wire Arc Additive Manufacturing (WAAM) uses traditional welding technologies to quickly deposit large quantities of material for larger builds. The integrated WAAM3D process monitoring end effector allows for gas shielding and temperature and arc monitoring during the process.

BEAM MODULO 250

The Modulo 250 is a 5-axis directed energy deposition (DED) laser additive manufacturing system with a 500W laser and dual powder hoppers. The DED system provides the capability to build in free space with the ability to produce functionally graded chemistries. Because of the open build area, repair of existing parts is also possible.

RENISHAW AM400

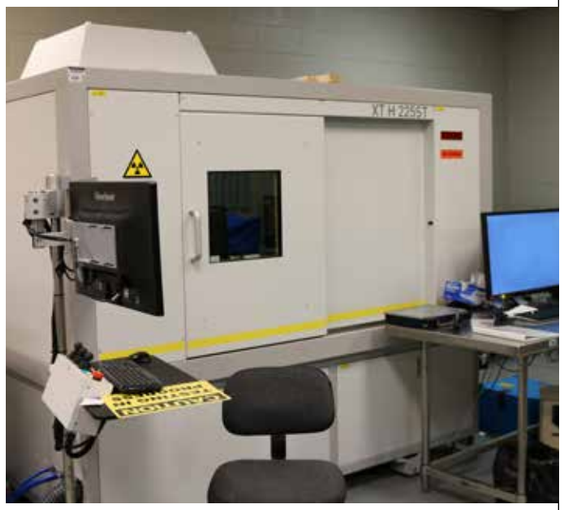
The Renishaw AM400 laser powder bed fusion (L-PBF) system with a 400W laser and installed SigmaLabs thermal monitoring system is excellent for production of parts with a high level of geometric complexity or with small scale features that require the high resolution provided by the 70 nm laser spot size.

OMAX 1515 WATERJET FOR CUTTING MATERIAL UP TO 6” THICK

The OMAX Waterjet uses abrasive particles and water pressure to cut material to different sizes and shapes. It can cut a multitude of material, up to 6 inches thick, from soft plastics, glass type of material, aluminum, carbon fiber, steel, titanium, hardened steel, and even armor plating.

FENN 2HI/4HI REVERSING ROLLING MILL

The rolling mill at the CAVS Steel Research Center enables researchers to hot and cold roll various metal alloys including Advanced High Strength Steels (AHSS) using a maximum of 850,000 pound of mill separation force. Combining 2-high work rolls of 12-inch diameter and 4-high work rolls of 3.75-inch diameter along with 14-inch roll face width, the machine allows for hot rolling of ingots from 3-inch thickness down to 0.15-inch and cold rolling plates from 0.15-inch thickness down to 0.055-inch.



NIKON XT H 225ST COMPUTED TOMOGRAPHY X-RAY SYSTEM

The Nikon XT H 225ST X-ray computed tomography (CT) system provides a 225 kV microfocus X-ray source with a 3 µm focal spot size. This system enables researchers to perform non-destructive testing (NDT) for the evaluation of the internal and external structures of material samples.

CAVS ASSOCIATE DIRECTOR CREATES ATHLETIC ENGINEERING PROGRAM TO HELP ATHLETES IMPROVE PERFORMANCE

BY PHILIP ALLISON | PHOTOGRAPHY BY MEGAN BEAN

Ask most Mississippi State football fans to rank their all-time favorite Bulldog wins and the 1996 victory over Alabama is likely to be high on the list. For Reuben Burch, an assistant professor of industrial and systems engineering in the Bagley College of Engineering, it's also a big reason why he ultimately chose to attend Mississippi State as a student.

A native of Montevallo, Alabama, Burch had grown up as an Auburn fan. His father had been on Auburn's track & field team, and he figured it was the school for him. But when he started looking at colleges, his dad, then an Alabama Power chief engineer, mentioned that the best young engineers at the company were Mississippi State graduates.

"I came to Starkville on a recruiting visit the weekend of the Alabama game in 1996," Burch said. "The energy of that game and the friendliness of the fans was special and something I decided that I wanted to be a part of. It's been only Mississippi State ever since."

Burch was a walk-on fullback for the Bulldogs from 1997-2001, playing for teams that won the 1998 SEC Western Division title and reached three-straight bowl games. He graduated with a bachelor's degree in computer engineering in 2002.

After more than a decade in private industry and after earning his Ph.D. in industrial and systems engineering through MSU's online program in 2014, Burch joined the university's ISE faculty in 2016. He also serves as an associate director at the Center for Advanced Vehicular Systems (CAVS) and is a faculty research fellow at the National Strategic Planning and Analysis Research Center, or NSPARC.

"Athletics is open to sharing data with the academic side of the university, and because we're a top research school, we can take advantage of the research capabilities that already exist here. We believe we're one of the first schools in the country to have an athletics-academics partnership like this. We want it to be mutually beneficial for everyone involved."

Since his return to campus, and with his history as a Bulldog athlete, Burch has helped create the Athlete Engineering research program. The multi-disciplinary team includes faculty and staff from such on-campus areas as engineering, athletics, textiles, kinesiology and sociology, as well as researchers from CAVS and NSPARC.

Put simply, the group's goal is to use data to help coaches and athletes improve their performance. The work includes developing unique wearable sensors that can capture lab-quality data on a field or court. In the hopes of reducing injuries, one study looked at how athletes land after they jump. Another used motion-capture to study the mechanics behind the swings of MSU softball players.

"The stars have somewhat aligned for this collaboration," Burch said. "Athletics is open to sharing data with the academic side of the university, and because we're a top research school, we can take advantage of the research capabilities that already exist here. We believe we're one of the first schools in the country to have an athletics-academics partnership like this. We want it to be mutually beneficial for everyone involved."

Burch also hopes the Athlete Engineering team can offer some long-term benefits to current Bulldogs.

"Having played college sports, getting out of bed these days is a little bit of an adventure," said Burch, explaining injuries he received years ago. "Hopefully this research can help give current student-athletes a chance to not have to go through that."

MSU'S CAVS RESEARCHERS, EMCC'S COMMUNIVERSITY PARTNER TO STUDY WEARABLE TECHNOLOGY IN INDUSTRY SETTINGS

BY JAMES CARSKADON | PHOTOGRAPHY BY AMANDA MEELER AND SUBMITTED BY EMCC

Mississippi State University CAVS Researchers and East Mississippi Community College are working together to understand the barriers to, and potential benefits of, wearable technology in industry settings.

A team from MSU with representation from the university's James Worth Bagley College of Engineering, National Strategic Planning and Analysis Research Center, and Center for Advanced Vehicular Systems is working with EMCC Communiversity Director Courtney Taylor on the National Science Foundation-funded project. With $120,000 in funding, the team will conduct several focus groups to better understand how various industry stakeholders perceive wearable technology. This technology includes sensors that are worn by a user and transmit data about their movements and other physiological indicators such as heart rate.

The project builds on similar work that was conducted by MSU's Athlete Engineering research team, which focused on how strength and conditioning coaches perceive wearable technology in sports settings. Reuben Burch, associate director of human factors and athlete engineering at MSU's Center for Advanced Vehicular Systems, said the team will be using the technology acceptance model to study potential benefits and drawbacks in industrial settings.

"With the industrial athlete, the biggest stigma is that 'big brother' is watching," Burch said. "How are employers and managers going to use this data? Some companies say that they don't see a way to overcome this stigma. Others acknowledge it might be tricky but value the potential efficiencies that could come from it. Culturally, you have a wider variety of perceptions of wearables in industry than you do in sports, where they have been more commonly used and accepted."

Taylor, who works closely with Golden Triangle industry leaders as part of her role at EMCC, said wearable technology has proven useful for contact tracing during the COVID-19 pandemic, something few would have been talking about just a year ago.

"In the industrial setting, as COVID is proving, we really don't know where tomorrow is going to take us," Taylor said. "This gives us the opportunity to work with local industry partners to look at this technology and find out what people are truly saying about it instead of just assuming people are going to be scared and anxious about it. It also helps industry understand what challenges they are going to face."

The researchers primarily will be focusing on areas such as manufacturing, logistics, and warehousing. One commonality with many jobs in these sectors is repetitive motion, which can create muscular skeletal disorders, Burch said. Companies can use wearable technology to train personnel to perform a task in a way that reduces injury risk, which keeps employees on the job.

As wearable technologies generate data, MSU is also developing data analysis tools that can help users of the new technology make the most out of their investment. John Ball, associate professor and Robert D. Guyton Chair in MSU's Department of Electrical and Computer Engineering, an investigator on the NSF grant, said the team also can develop hardware to gather information from wearables.

"The most important thing is we provide data analysis tools," Ball said. "We can take the data, analyze it, transform it and put it into actionable results. Instead of getting raw data streams, we can give you information on how risky a movement is."

NSPARC will assist in developing and carrying out the focus group sessions using the center's facilities. Shane Warren, research project manager at NSPARC, said the focus groups will include a wide range of people who would potentially interact with wearables, from human resources personnel, purchasing decision makers, and employees wearing the devices.

Lesley Strawderman, professor and International Paper Chair in MSU's Department of Industrial and Systems Engineering, is serving as a co-principal investigator on the grant, along with Burch, Ball, and Taylor.

For more on MSU's Athlete Engineering research group, visit http://www.cavs.msstate.edu/research/athlete_engineering.php.

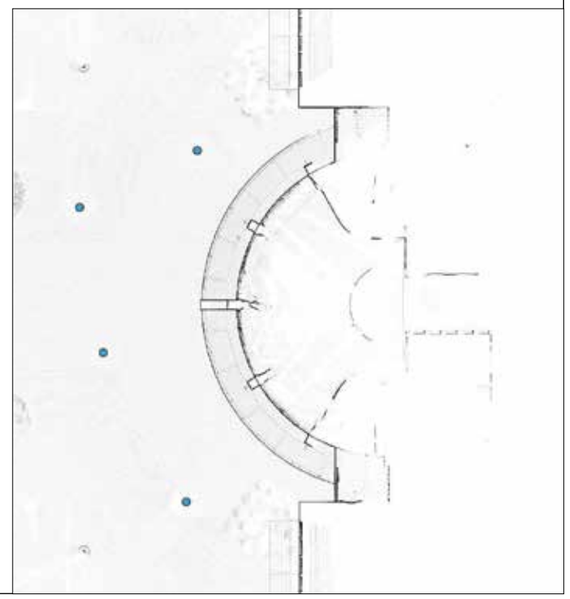
LASER ROOM SCANNING TO OPTIMIZE FACILITY LAYOUT

BY JONATHAN CURTIS AND EMILY WALL

Laser room scanning allows us to collect dimensional data of manufacturing plants much more efficiently, accurately, and thoroughly than we could have ever done with conventional measurement tools. In just a few hours, we can collect more information now than we could have previously done in several days. This allows us to more quickly shift our focus to solving layout related problems that would help clients achieve better flow and productivity.

2020 HIGHLIGHTS

- Raytheon - Created 3D scans of part of the facility in Forest, MS to assist in a process improvement / simulation project.
- Toyota - Created 3D scans of the majority of the Blue Springs plant to assist in the development of ALC Virtual Production Line system and simulation.
- Navistar Defense. – Created 3D scans of the West Point facility to provide an updated CAD model of the entire plant.
- Thrifty Building Supply – Created 3D scans of the facility in Olive Branch, MS to generate an As-Is CAD layout along with alternate layouts to improve flow.

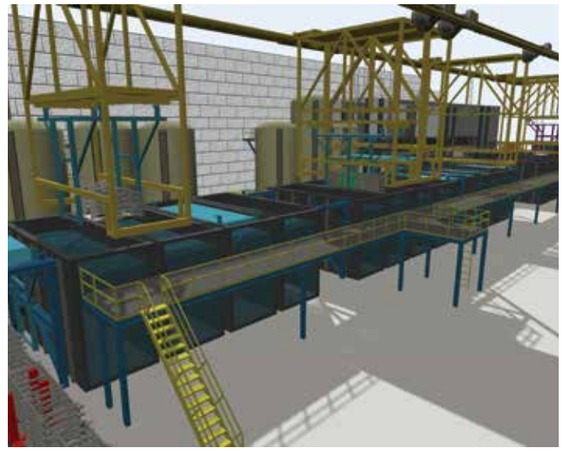


IMPROVING ORGANIZATIONAL PERFORMANCE THROUGH SIMULATION MODELING

BY TRAVIS HILL, ADAM COLLINS AND CHASE SAUNDERS

Simulation modeling and analysis involves developing a virtual and dynamic representation of a system. Typically these could be a manufacturing, service or logistics systems. Simulation provides an effective means to understand a system's behavior and allows experimentation of the system without disrupting the real system. Simulation is used to evaluate potential physical and logical changes to a system. These could include changes to the layout, production schedules, product mixes, equipment, personnel, system rules and much more. Simulation's ultimate goal is to improve organizational performance through the following:

- enabling sophisticated "what if" analysis,
- effectively dealing with complexity (interdependencies + variability + dynamics),
- reducing analysis costs and being less disruptive than experimenting with the real system,
- and forcing attention to detail, improving understanding of the system and improving communication by requiring many groups to work together to develop a representative system.



2020 HIGHLIGHTS

- Nissan Tire Room Simulation Analysis. The purpose of the simulation was to evaluate the Tire room's key equipment and various production plans. The result of the simulation analysis was the identification of bottlenecks preventing system from achieving desired throughput for final production plan evaluated. Reported economic impact of $50 million.
- Toyota ALC Virtual Production Line. Helped develop ALC Virtual Production Line system and simulation. Primarily focused on the simulation for the plant's three main shops (Body, Paint and Assembly) at Toyota's Mississippi facility and aided in the development of the live Unity-based system. This system and simulation is meant be used on a daily basis to visualize vehicle positions in the absence of sensor data and to simulate near-term future conditions so Toyota can make better training opportunity, maintenance and overtime decisions when issues arise.

"The MEP.ms Center at CAVS-E, through projects like ours, links small manufacturers with cutting-edge technology developed by leading experts housed within our public universities and local extension services. Certainly, in the realm of engineering, the MEP.ms Center at CAVS-E provides a cost-effective means of gaining access to resources, such as advanced engineering tools that smaller manufacturing companies, like Systems Electro-Coating, do not have internally. At the end of the day, these resources help us build the human capital within our local organizations and communities."
- Toni Cooley, president, Mississippi Manufacturers Association

CAVS-E IN ACTION: SIX SIGMA CERTIFICATION

BY JUDY JOHNSON

CAVS-E delivers Six Sigma Certification courses to help participants develop data-based problem-solving methods targeting substantial gains for their respective organizations. Both Green Belt and Black Belt courses are offered, and teach participants how to maximize and sustain business success by reducing the cost of quality, increasing process efficiency, and providing a structure for continuous improvement. Six Sigma can be applied to almost any industry such as manufacturing of all types, healthcare, food production and transportation.

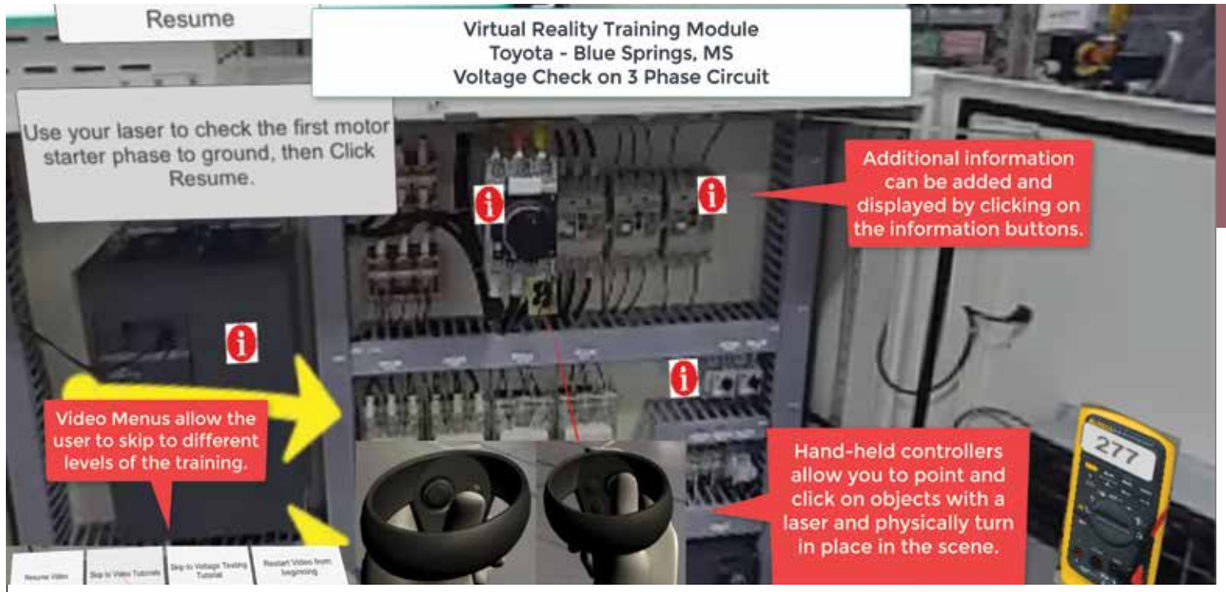
Six Sigma is a highly-disciplined process that helps companies focus on continuously improving customer satisfaction and profit. The strategies used in Six Sigma are propelled by an understanding of customer needs, a systematic use of data, and careful attention to improving business processes. Variation is the culprit behind many product defects and process inefficiencies. Six Sigma strategies are focused on improving the quality of the output of a process by identifying and removing the root causes of variation.

By identifying and reducing variation in business activities, Six Sigma methods become a change within the organization that improves processes and the quality of products and services delivered to customers. Applying Six Sigma processes helps to reduce errors, customer complaints, production time, schedule delays, and cost overruns. Six Sigma strategies define, measure, analyze, improve, and control processes. The success of Six Sigma initiatives depends on its implementation by team members within an organization and can be applied to maximize labor efficiency, reduce inventory, and reduce lead-time, to name just a few benefits. Certified Six Sigma professionals should have a clear understanding of how current practices impact the business and be able to use statistical tools to decrease costs, increase revenue, and improve processes.

Six Sigma certification is given a "Belt" title that corresponds to the participant's level of experience and depth of study. CAVS-E participants can earn either a Green Belt or Black Belt. The Green Belt receives instruction in the basic use of statistical data analysis, with an emphasis on team problem-solving techniques. Black Belts should be able to lead teams and are knowledgeable of the use of more advanced statistical data analysis, designed experiments, and project management. Green Belts must have a minimum of $25K financial impact from their projects, and Black Belts must impact their businesses by $100K or more. The averages for projects implemented during CAVS-E training workshops are approximately $75K and $300K for Green Belts and for Black Belts respectively.

CAVS-E uses the Six Sigma DMAIC (define, measure, analyze, improve, control) process in its certification, which is an improvement methodology for existing processes that do not meet customer and business standards. CAVS-E's Six Sigma Green Belt and Black Belt Certifications consist of 11 days of scheduled training during a five-month period. Participants are required to implement techniques and tools and receive consulting support to assist with the successful completion of their projects.

"Through the efforts of the MSU-CAVS team our ability to increase production of generators for the intermodal market has more than doubled. From the lean manufacturing principles that MSU-CAVS implemented along with time studies, the length of our assembly line was reduced and with fewer units being on the line each day. Our units produced per day increased, the employees were happier and certain customers requested that we cut back on our weekly shipping volume as we became more efficient."
- Steve Duke, General Manager, Taylor Power



INDUSTRY TRAINING GAINS BENEFITS FROM VIRTUAL REALITY

BY EMILY WALL

Virtual reality's goals are to provide a method for individuals to observe and/or practice a process for the intent of learning. Benefits of VR include lower costs of training individuals when compared to on the line training and the ability to do training and see processes that otherwise would be unsafe if performed in the real world by unexperienced individuals.

2020 HIGHLIGHTS

- Toyota Paint Inspection VR training – developed VR training system to help new hires become familiar with the process steps.
- Toyota Maintenance VR training – developed VR training system to help maintenance personnel review safety features and process steps for troubleshooting electrical panels
- Yokohama first inspection VR training – developed VR training system to help new hires become familiar with the process steps.
- Yokohama Tire Building VR training - developed VR training system to help new hires become familiar with the process steps and included complicated 3-D models with added animations to recreate the moving machinery around the individuals to further emulate the real world.

TMMMS VIRTUAL

YOKOHAMA

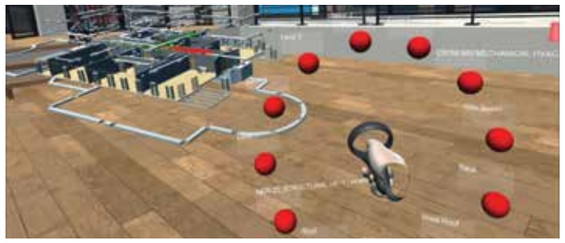
"Virtual Reality in our training systems has the potential to enhance employee engagement during training while improving overall quality and performance."
- Justin Herman, TPM/TPS Manager, Yokohama Tire

SYNTHETIC COLLABORATION ENVIRONMENT FOR IMMERSIVE RESEARCH

BY REED MOSHER AND T.C. FALLS

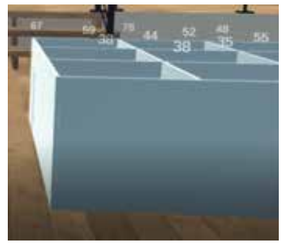
The Synthetic Collaboration Environment for Immersive Research (SCEIR) is a Virtual Reality (VR) software application to facilitate remote meetings and conduct research in a shared virtual environment. Originally developed for the US Army Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi, the SCEIR application serves as a testbed for exploring user experiences, multi-user interactions, building information modelling (BIM), and digital twinning in VR. This prototype seeks to determine if remote meetings, design reviews, and shared data dashboards can be improved by incorporating VR.

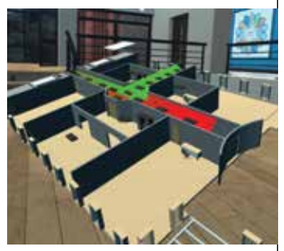
The image above shows a user inspecting the outside of a building model while the image below shows the user inspecting the interior of the same model. In the below image, the outside walls have been toggled off and some internal elements have been toggled on. The user interface for controlling these interactions is one area of interest for research using this application. In this case, the user swipes over to the red spheres which represent different actions. When the user's hand interacts with the sphere, that triggers an action, such as, toggling visual elements of the active building model. However, other interface schemes have been incorporated into the application and can be tested against each other to collect data to improve user experiences in VR.



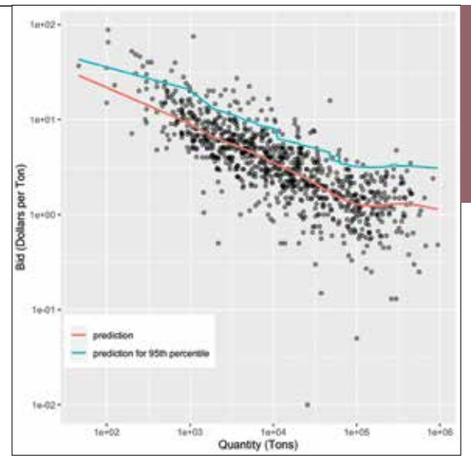
Another human factors aspect of this project is to determine the best way to input data within VR environments. The SCEIR application has incorporated speech-to-text by using Google Voice pictured below. The same service used by Android cell phone users. There are other methods for inputting data, such as, a VR version of an on-screen keyboard, contextual actions, and other research groups have even incorporated sign language detection within VR applications. However, in many ways these methods do not perform better than a traditional physical keyboard. Improving data input controls within VR applications is still an active area of research that also can be explored using SCEIR.

Combining disparate data sources and models is yet another focus of this project. VR may also be advantageous when communicating sensor data and the results of simulations to users during discussions that involve 3D geometry. Many factories and buildings use sophisticated data systems for controlling machinery and processes. These are often reported through individual applications depending on who set up the system. Some organizations collect and store data generated by these systems in centralized databases and provide readouts of the data to web applications in the form of dashboards. This can take the form of raw data, calculated values, projections, and simulations. In the image below and to the left, a user observes the raw data counts of doors opening over a specified time period generated a simulation of people walking through the area. The counters appear above their respective doors in the visible section of the building. In the image below to the right, a user observes a summary visualization of calculated values in the form of a heatmap that describes movement within a hallway. High trafficked areas are red and low trafficked areas are green.





Consider that traditional dashboards are often provided in the form of dashboards within web applications. These web dashboards are certainly an improvement over displays that might have been limited to non-networked physical locations in the past. However, by removing data from its sources this has added a level of abstraction that may prevent non-experts within an organization from truly understanding their data sets. By integrating dashboards into VR applications, such as SCEIR, these abstractions and the subsequent cognitive loads imposed on the users may be reduced by displaying data directly over their sources in the form of digital replicas. This research seeks to determine if VR can remedy this situation and improve communications between stakeholders. In the image below, two users are discussing a combined door access counter along with the previously described heatmap.



ISER CREATES INVENTIVE AUTOMATED INTELLIGENCE TOOL FOR SELECTING BEST ECONOMICALLY FEASIBLE SOLUTIONS

WRITTEN BY T.C. FALLS, JAMES WARREN AND DIANE GODWIN

The Institute for Systems Engineering Research has built a systematic cost assessment tool to aid the Mississippi Department of Transportation in creating and maintaining expenditure estimates with increased accuracy. MDOT continually evaluates construction projects to include in their work program based on a project's cost, performance or value over its lifetime. Administrators have a menu of infrastructure projects to assess, and this system gives them the ability to pair a project with an estimated cost that raises the success rate of delivering a project on time and within budget.

The system has two main applications that can be utilized for a host of other purposes. For instance, the modeling tool creates cost table graphic visualizations that will adapt with existing MDOT estimate processes. The system also generates input for decision tree analysis to aid in selecting the most economically feasible solutions for Mississippi's transportation infrastructure. Additional advantages include the options of giving multiple users access to leverage this tool, as well as creating and saving a variety of customized projects that are correlated to specific cost assessments.

"The tool presents an interface for generating models that can then be used for selecting pay items of interest. Models are then used to predict the cost of selected pay items expected in a specified year," said David Allen, an MSU research engineer who helped design the system, "First, a set of pay items is selected. Next, each pay item is provided a specific quantity and model year. Once the selection set is created the tool returns an estimate and saves the selection as a project file. The estimate can then be exported to different users or applications within the department."

Although the typical user will only interact with the front-end menu-driven interface, the backend of the system leans heavily on data science processes. The unseen workflow of the tool consists of pre-processing historical data through an importing, cleaning and augmenting procedure. After this set of cleaned historical data is integrated into the tool, a modeling process commences.

"Several machine learning models are trained and tested for each pay item using an automated process that selects the models which produce the best data fit for each pay item," said Jonathan Storey, an MSU engineer, who helped refine the system's automated intelligence. "The models are purposely constructed to help quantify the uncertainty of each prediction allowing the user to understand the range of possible outcomes."

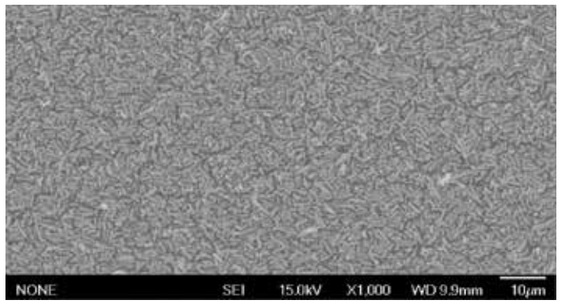
One of the tool's strengths is its ability to couple the UI with a solid data science background. However, the system's ability to consume new data and adjust to new construction techniques might be an even greater advantage. As more historical data is gathered, new models need to be generated and existing estimates need to be updated. The architecture of the tool allows for these steps to take place as seamlessly as possible. The result of these features is a user-friendly, cost estimating system that adjusts and allows decision-makers to identify trends in construction costs.

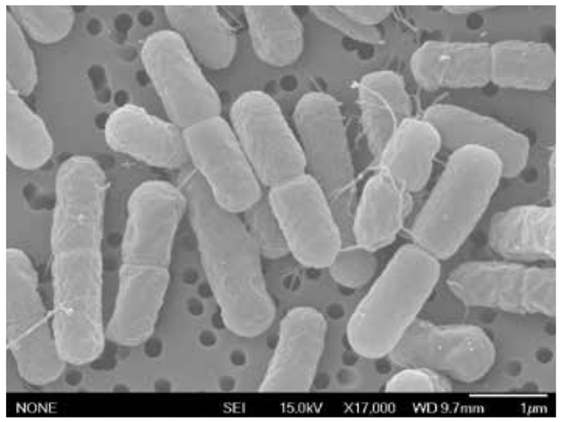
In the future MDOT can utilize this tool to more quickly generate accurate and reliable cost estimates with greater accuracy and confidence. ISER hopes that the decision-making process will be bolstered and streamlined as the cost estimating system is integrated into MDOT's workflow.

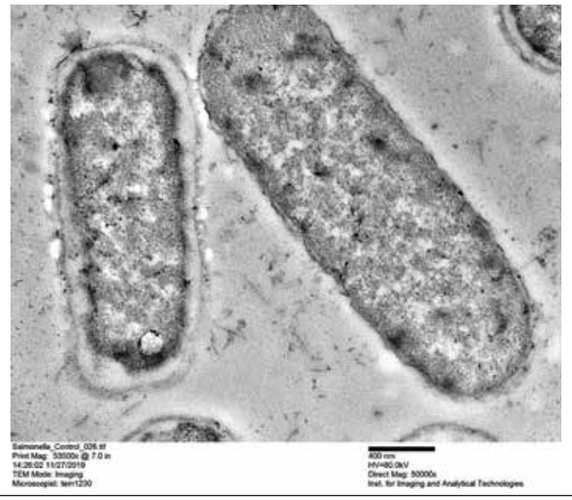
I2AT HELPS RESEARCHERS READ THE SCIENCE OF IMAGES

WRITTEN BY DIANE GODWIN

Scientific image samples are recognized as some of the most difficult to analyze because of the precision accuracy needed to read and analyze the minuscule details within them. That is why the availability and access to imaging science technology and imaging modality approaches are important in advancing research. The Institute for Imaging & Analytical Technologies provides next-generation imaging technologies and instrument instructors to support internal and external research teams by operating equipment or offering access to reliable, high-quality tools that improve scientific outcomes.







"Our expertise is imaging science. We offer specialized, high-precision imaging instrumentation for the biopharma, pharma, life sciences, forensics, food, and environmental research areas within the university and the outside community," Director of I2AT, Zach Rowland said. "We can image and/or analyze samples or researchers can operate the equipment and ask us to collaborate on their findings. Our scientific collaborations include helping researchers with manufacturing chemical and material analysis to simple imaging describing the form of various structures within biological organisms."

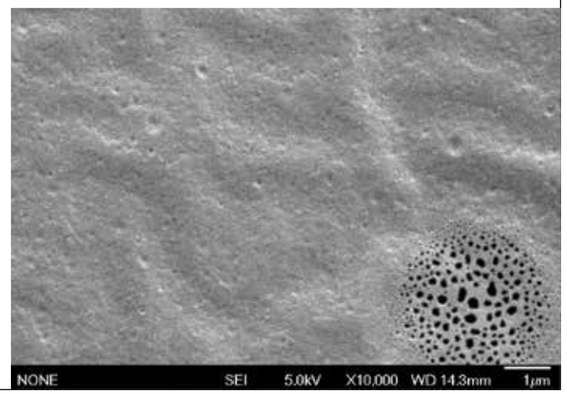
Rowland explained his teams' biotechnology research collaborations, like the above mentioned, focus on imaging and analysis that assess treatments and coatings that could be used for food preservation—imaging that can help improve food edibility, consistency and shelf life.

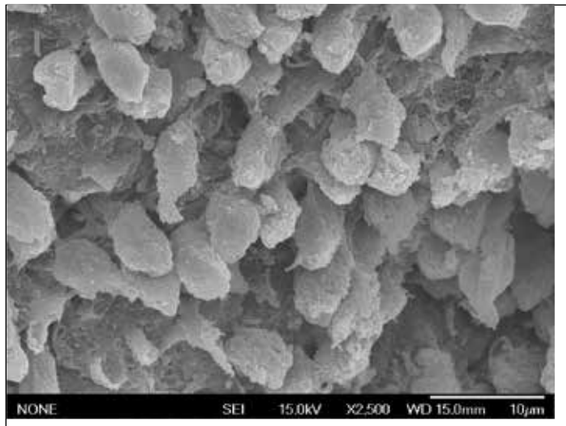
Other scientific inquiries have been imaged that are coupled with bacterial colony counts to visualize and quantify the reduction in the number of harmful bacteria present on food items. For instance, analyzing if a chemical treatment or a physical barrier reduces the number of harmful bacteria on pork or produce.

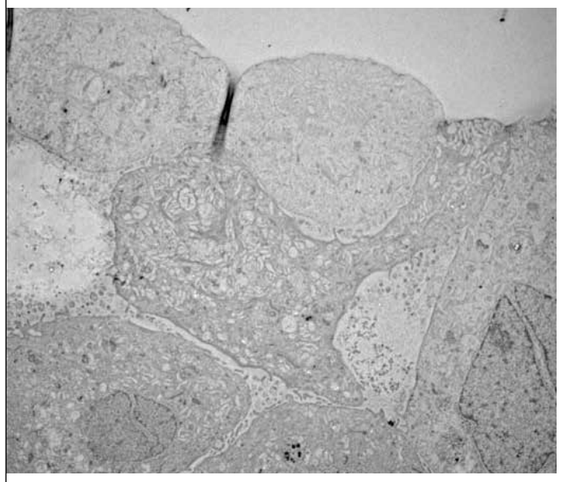
"In the study contributing to the processing of pork, the effect of an acetic acid bath on the number of surviving salmonella bacteria was visualized with a scanning electron microscope (SEM) and a transmission electron microscope (TEM)," Rooban Venkatesh K. G. Thirumalai, an I2AT assistant research professor said. "In a similar study a physical barrier, produced by a coating of chitosan, is thought to reduce the ability of bacteria to proliferate on the surface of produce after harvesting but before consumption. Both treatments are intended to be used to reduce harmful bacteria introduced to the food items during packaging and shipping. "

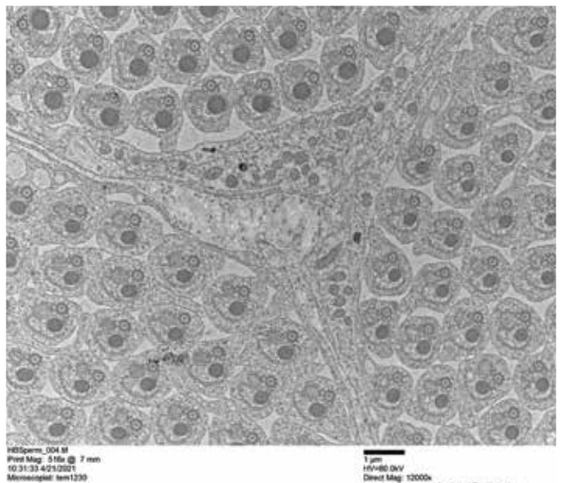
Another area of research is concentrated on infectious diseases. Collaborations with the College of Veterinary Medicine Research team include conducting advanced studies investigating an array of diseases and injuries that affect both people and animals. Research endeavors include projects related to infectious diseases, cell and molecular biology and veterinary clinical sciences.

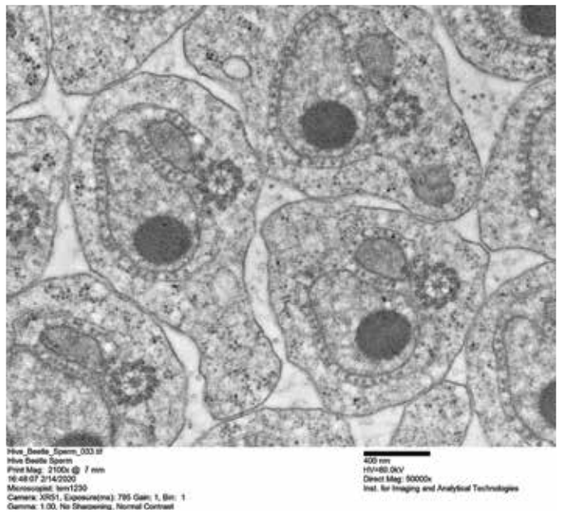
"Some of the most complex and challenging projects are those that examine the interactions between host cell types and bacterial or











viral infectious agents," Iwei Chu, an I2AT senior research engineer said. "In a recent study, we collaborated with researchers at the school of veterinary medicine to investigate the relationship of an infectious bacteria and the epithelial lining of the bladder within a feline model."

More specimens under the scanning electron and transmission electron microscopy technology include the study and imaging of insects. This scientific imagery can serve as the basis for developments in biological and chemical pest control, food and fiber production and storage, pharmaceuticals epidemiology, biological diversity, and a variety of other fields of science.

"We put the insects under the SEM and TEM to describe the sperm of the small hive beetle, Aethina tumid. Small hive beetles are invasive honeybee pests. This work can help develop solutions to prevent reproduction of small hive beetles," Orion Rivers, I2AT senior research associate explained. "Small structures such as the internal organelles within sperm are quintessential TEM samples. The same techniques also can shed light on the physiology of much larger organisms."

In addition, Orion and his colleagues helped researchers study images of alligator gars. These types of studies help to monitor the health of the aquatic environment and to understand human health.

"The alligator gar, Atractosteus spatula can survive in fresh and brackish water environments. During a recent study we imaged small changes that occur in the gills of the alligator gar which allow for its survival in a wide range of salinities," Orion said. (Figures 3 & 4)." The alligator gar population is on the decline and MSU researchers are studying their aquatic habitat to help them survive."

I2AT works to make every researcher a better scientist by providing cutting-edge instrumentation technology for discoveries that are reliable, robust, scalable and shareable. They strive in making efforts to advance science and the positive contributions Mississippi State researchers make in medicine, chemistry, biology, zoology, astronomy, physics, earth science and astrophysics.

MSU TEAMS COMPETE IN NATIONAL BOWIE KNIFE COMPETITION

WRITTEN BY AMANDA MEELER

Two teams of Mechanical Engineering students from Mississippi State University, led by graduate students at the Center for Advanced Vehicular Systems, participated in the Steel Founders' Society of America second annual Cast in Steel competition.

The competition challenged universities to design, cast, and sharpen a Bowie knife that was to be performance tested with edge retention and sharpness tests. Ultimately, 14 universities competed with 18 knives submitted for competition.

Ben Abbot, two-time winner of History Channel's "Forged in Fire" and current judge on the show, made his second appearance as a guest judge for the Cast in Steel competition.

While neither MSU team won the grand prize, team two was awarded the "Most Period Correct Handle," following in last year's footsteps of winning the "Most Historically Accurate" award during the 2019 Viking Axe competition.

Both MSU knives were cast at Southern Cast Products in Meridian, Mississippi, and measured at approximately 15 inches in total length. Team one's handle was hand-shaped from hickory and fixed by dual brass pins, while team two's knife featured a desert ironwood handle with a classic 6-pin coffin handle.

Members of team one includes graduate students William Williams and Josiah Phillips, and undergraduate students Katarina Kushla and Ben Nelson. Team two members include graduate students Blake Stewart and David Salley, and undergraduate students Will Nye and Garrett Phelps. Hongjoo Rhee served as a faculty adviser for both teams.

TEAM 1

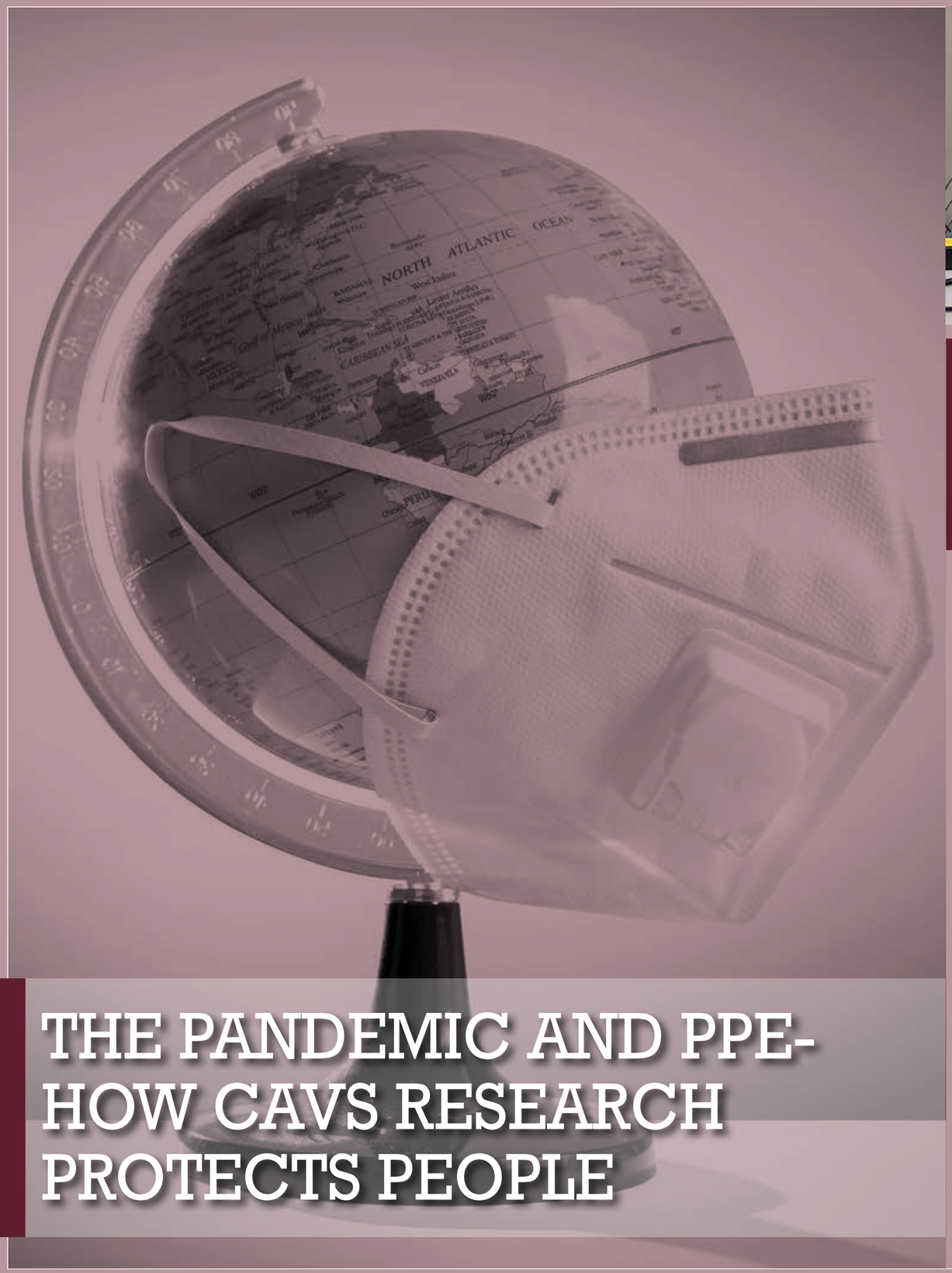
William Williams, Josiah Phillips, Katarina Kushla, and Ben Nelson

TEAM 2

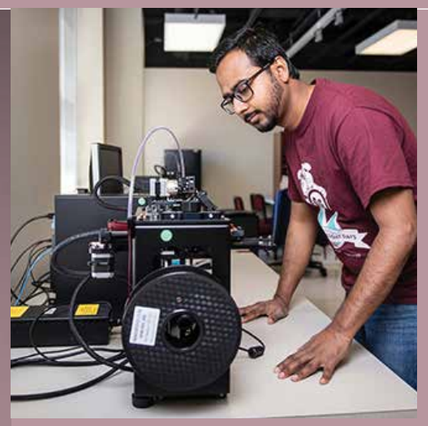
Blake Stewart, David Salley, Will Nye, and Garrett Phelps

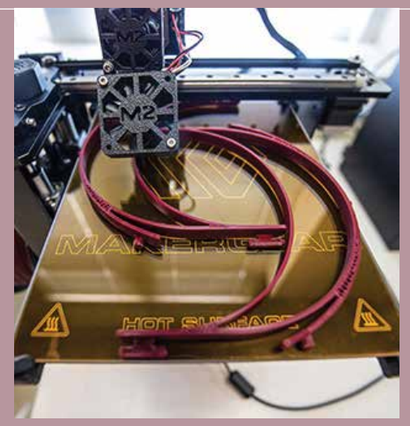
To view a full list of award winners from annual Cast in Steel Competition, visit www.sfsa.org/castinsteel.

For more information on the Steel Founders' Society of America, visit www.sfsa.org.



THE PANDEMIC AND PPE- HOW CAVS RESEARCH PROTECTS PEOPLE





CAVS RESEARCHERS USE 3D PRINTERS TO PRODUCE FACE SHIELDS FOR MERIDIAN MEDICAL PERSONNEL

WRITTEN BY PHILIP ALLISON | PHOTOGRAPHY BY LOGAN KIRKLAND

With personal protective equipment in short supply nationwide, a team of engineers and researchers at Mississippi State University is turning to an unlikely combination of 3D printers and office supplies to aid medical personnel tackling COVID-19.

The team, led by faculty from MSU's Bagley College of Engineering and researchers at the university's Center for Advanced Vehicular Systems, is producing face shields by combining 3D-printed head bands with transparent plastic sheets and elastic bands generally found at office supply stores.

The head band for each face shield takes approximately two and a half hours to print. Using 10 different 3D printers, the team is producing approximately 250 shields per week using polylactic acid filament. The first batch was donated this week with over 100 going to both Rush Foundation Hospital and Anderson Regional Medical Center in Meridian, where they are being used by medical professionals caring for patients with coronavirus.

"We are in complete awe of the outpouring of support and donations we've received from residents and community businesses," said Rush Health Systems Chief Executive Officer Larkin Kennedy. "The donation of these face masks from Mississippi State University helps ensure our front-line staff remains safe while caring for patients."

Face shields are generally used in conjunction with surgical masks and protect the eyes, nose and mouth from splashes and sprays. The MSU team developed two prototypes before working with Kennedy to determine the best option for the Rush Foundation Hospital medical staff.

Working on the project are Linkan Bian, who holds the Thomas B. and Terri L. Nusz Professorship in industrial and systems engineering; Steve Elder, professor of agricultural and biological engineering; Wenmeng Tian, assistant professor of industrial and systems engineering; Tyler Hannis, research engineer at CAVS; and Abdullah Al Mamun, an industrial and systems engineering Ph.D. student from Bangladesh.

Bian said other university employees also have expressed interest in contributing to the project, including faculty and staff from both MSU's College of Business and Mitchell Memorial Library.

"This has been a tremendous team effort so far," Bian said. "We would not be able to move at our current pace without the efforts of Steve, Wenmeng and Tyler. We've also been contacted by others on campus who have 3D printing capacity, and they want to know how they can help. It is really encouraging."

The project came about thanks in large part to research partnerships developed as part of Mississippi State's Faculty Research Advisory Committee. When hospitals began to face shortages of personal protective equipment, Bian, a past chair of the group, contacted Carlton Young, professor of healthcare administration at Mississippi State's Meridian campus and MSU-Meridian's committee representative, to ask how he could help. Young connected Bian to Kennedy to launch the project.

"Dr. Bian reached out to me and said there was a group at Mississippi State that was willing to 3D print face shields for the hospitals in Meridian. They are now producing hundreds of them," Young said. "Their expertise, public spirit and passion truly embody the heart of Mississippi State and our mission to serve the people of Mississippi."

The Bagley College of Engineering is online at www.bagley.msstate.edu and can be found on Facebook, Twitter, Instagram and YouTube at @msuengineering.

CAVS FACULTY AND STAFF HELP MSU ENGINEERING STUDENTS DESIGN MASK DISINFECTANT BOX FOR METRO AMBULANCE IN MERIDIAN

WRITTEN BY JAMES CARSKADON | PHOTOGRAPHY BY LISA SOLLIE

Emergency medical technicians and paramedics at Metro Ambulance Service have a new, fast way to disinfect their masks courtesy of a device designed and built by Mississippi State students.

A team from MSU delivered the device, a toolbox outfitted with ultraviolet lights, to Metro Ambulance this past week. As EMTs and paramedics complete their shift, they will be able to sanitize their masks in approximately 30 minutes, extending the lifespan of their personal protective equipment. The apparatus can be used to disinfect cloth, surgical and N-95 masks.

"This device will allow us to refurbish our masks the medics wear and have them sanitized," said Clayton Cobler. Metro Ambulance Service director. "With that peace of mind, they can put them on, go back out and still be protected. This saves money because we can re-use the N-95 masks. We don't have to trash them after every shift and get new ones."

"We have designed this to be affordable, portable and effective. I think this is an incredible opportunity to help our healthcare providers by giving them something that can help keep them safe while they're on the front lines."

The first disinfectant box was built at MSU's Center for Advanced Vehicular Systems in April after the university's John C. Longest Student Health Center requested it amid a national shortage of personal protective equipment. Within two weeks, the device was designed, built and delivered by students in MSU's Bagley College of Engineering with support from faculty and staff at CAVS. The students built another device for the Mississippi Veterans Home in Kosciusko.

MSU has worked to make the technology publicly available through its Office of Technology Management. The university joined the COVID-19 Technology Access Framework, a consortium of institutions dedicated to providing fast and royalty-free access to technologies that can be used fight the pandemic.

"We have designed this to be affordable, portable and effective," said Ryden Smith, a second-year master's student in mechanical engineering who built the device. "I think this is an incredible opportunity to help our healthcare providers by giving them something that can help keep them safe while they're on the front lines."

To download the design plans for the box, which can be built using readily-available items, visit www.cavs.msstate.edu/covid-19.php.

CAVS RESEARCHERS AND MSU ENGINEERING STUDENTS WORK TOGETHER TO CREATE STERILIZER FOR PERSONAL PROTECTIVE EQUIPMENT

WRITTEN BY JAMES CARSKADON | PHOTOGRAPHY BY LOGAN KIRKLAND

Mississippi State mechanical engineering students have turned a conventional truck toolbox into a device that will sterilize face masks for the university's John C. Longest Student Health Center staff.

A team of two students, under the leadership of researchers at MSU's Center for Advanced Vehicular Systems, built and tested the device before delivering it to the health center on Monday [April 13]. Built using low-cost materials, the device can sterilize 15-20 masks in minutes, filling a need for the health center during the COVID-19 pandemic and a nationwide shortage of masks.

"It's a great application of what we learn in school because there's not always a standard solution," said Ryden Smith, a mechanical engineering graduate student from Tuscaloosa, Alabama. "I've been really honored with the opportunity to work on this and help our healthcare providers."

Working with Smith on the project is Wesley Cameron, a senior mechanical engineering major from Richton. He said the team looked at established healthcare sterilization protocols and studies on UV light's effects on N95 masks to design the device and determine best practices.

Dr. Cliff Story, MSU director of University Health Services, reached out to campus officials to see if someone at the university could build a sterilization device to help the center get more use out of its masks amid a nationwide shortage.

"We didn't really have a way to sanitize masks other than to put them in a paper bag and store them for about three weeks, assuming that the virus would die during that time," Story said. "Adding this sterilization process to the storage solution only makes us more confident in our supply. It's awesome that the team at CAVS was able to build this. I'm really excited about this, as are the other doctors in the clinic."

The students at CAVS worked under the direction of Associate Director Hongjoo Rhee's research team and were encouraged and aided by CAVS staff including Purchasing Coordinator Andrea Hemmingway Oakley, Research Engineer Jennie Maddox and Assistant Professor of Mechanical Engineering Wil Whittington.

Whittington explained that while using UV light to sanitize medical gear is not new, large hospitals often have a single room dedicated to UV sterilization. Portable UV sterilizers are available, but they cost hundreds of dollars and are much smaller than the device his students made using a toolbox.

"There are a lot of smaller health facilities like the Longest Student Health Center and nursing homes that don't have the real estate to dedicate an entire room to this, so having something that can be put in a room but is still large enough to handle a large volume of masks can be helpful," Whittington said. "We talked about retrofitting a closet for this, but the students came up with the idea of retrofitting a toolbox, which can just be placed in a room without having to change a room to provide the aluminum reflectivity you need."

The CAVS team will work with health center staff this week to determine protocols and best practices for using the device. They plan to share the design specifications so other health care centers can have similar devices made and extend the lifespan of their personal protective equipment.

For more on MSU's James Worth Bagley College of Engineering, visit www.bagley.msstate.edu.

MSU CAVS-EXTENSION HELPS MISSISSIPPI MANUFACTURERS ADDRESS SHORTAGE OF ISOLATION GOWNS FOR HOSPITALS

WRITTEN BY JAMES CARSKADON

With a team led by Mississippi State's Center for Advanced Vehicular Systems-Extension, Mississippi manufacturers and suppliers have come together to produce isolation gowns to help some of the state's hospitals in need.

As the disposable gowns became more difficult to obtain during the COVID-19 pandemic, several hospitals in the state reached out to CAVS-E this summer to express their concerns. At the request of the hospitals, CAVS-E personnel identified furniture manufacturers with the capabilities of making the gowns, as well as primary material suppliers. CAVS-E worked with the hospitals and manufacturers to fine-tune the design of the isolation gowns to meet the needs of each facility, which included OCH Regional Medical Center in Starkville, Anderson Regional Medical Center in Meridian and South Central Regional Medical Center in Laurel.

"Since its founding, CAVS-E has been a tremendous asset for Mississippi's manufacturing base and has a long track record of helping companies improve their production processes," said MSU Interim Vice President for Research and Economic Development Julie Jordan. "This experience, as well as the team's detailed knowledge of manufacturing capabilities in Mississippi, has CAVS-E well-positioned to help companies in our state meet the evolving needs of healthcare providers during a time when personal protective equipment has been in short supply."

Isolation gowns are sanitary, personal protective equipment used by medical personnel when they enter a room with a patient who has an infectious disease, such as COVID-19. Procedures for isolation gowns are much like those for disposable gloves, where a fresh gown must be used each time the medical staff enters a different patient's room. Small hospitals can go through more than 100 of these gowns each day.

"Since its founding, CAVS-E has been a tremendous asset for Mississippi's manufacturing base and has a long track record of helping companies improve their production processes."

The CAVS-E effort was carried out by Lean Healthcare Deployment Coordinator Susan Moore, Project Manager John Moore, and Project Coordinator Debbie Miller. Furniture manufacturers, many of which have in-house cut-and-sew operations in their plants—including Bauhaus, Corinthian Furniture and Max Home—were quick to respond to the need. Materials suppliers such as Mississippi Polymers, a manufacturer of thin-gauged flexible films, and DAF Products, a manufacturer of emergency response fabrics, were identified as companies that could provide the gown material.

"This is an excellent example of what CAVS-E does," said CAVS-E Director Glenn Dennis. "Debbie contacted people in the furniture industry about different materials and designs. John and Susan sent several samples to the hospitals for their input, which took several design iterations, but they knew it was important and did not stop until the hospitals were satisfied. I am really proud of what this team did. They did not do this for the publicity, but they saw friends that were hurting, wanted to help, and they did."

CAVS-E offers a Lean Healthcare Certificate program to healthcare organizations in the state that helps them improve the cost, quality and speed of delivery of healthcare services. For more information about this program, or to learn more about other programs and services offered by CAVS-E, visit www.cavse.msstate.edu.

FINANCIAL HIGHLIGHTS

CAVS-R • CAVS-E • ISER • I2AT

TOTAL CAVS PROPOSALS 2017-2020

2017	$129,658,763
2018	$29,803,120
2019	$35,833,495
2020	$159,133,105

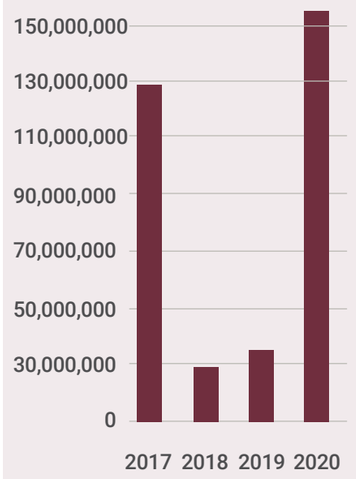
TOTAL CAVS AWARDS 2017-2020

2017	$19,613,004
2018	$25,448,355
2019	$33,686,980
2020	$34,674,692

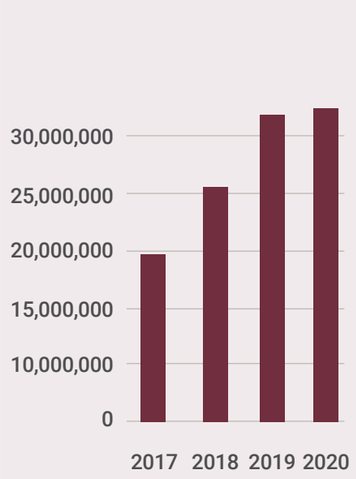
TOTAL CAVS RESEARCH EXPENDITURES 2017-2020

2017	$24,891,284
2018	$25,802,557
2019	*$31,844,198
2020	*$29,976,106

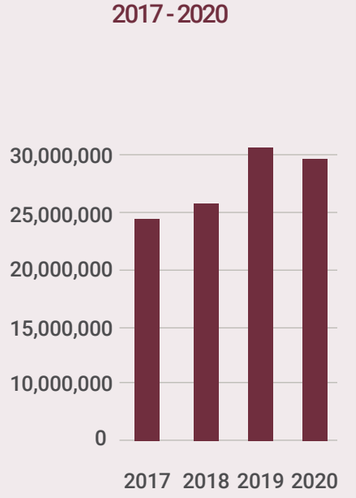
TOTAL CAVS PROPOSALS 2017 - 2020



TOTAL CAVS AWARDS 2017 - 2020



TOTAL CAVS RESEARCH EXPENDITURES 2017 - 2020

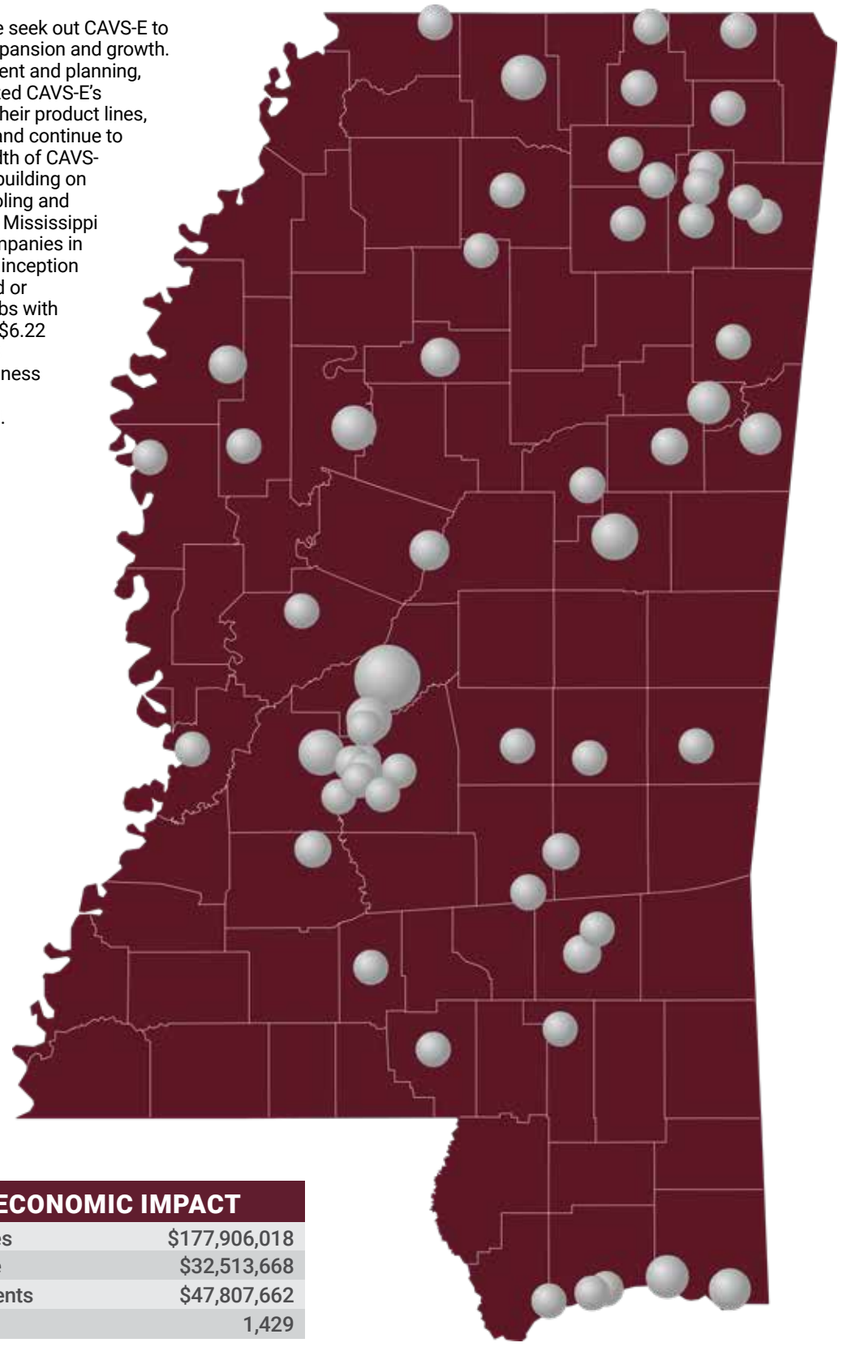


*Does not include state appropriation dollars

ECONOMIC IMPACT

The following map illustrates the economic impact of CAVS-E on companies throughout the state over the last four years, 2017 – 2020.

Companies across the state seek out CAVS-E to identify opportunities for expansion and growth. Through strategy development and planning, these companies have utilized CAVS-E's resources to help diversify their product lines, broaden their supply base, and continue to create more jobs. The breadth of CAVS-E's impact is felt from ship building on the Mississippi coast, to tooling and appliance companies in the Mississippi Delta, and to aerospace companies in North Mississippi. Since its inception in 2003, CAVS-E has created or retained more than 6,054 jobs with a total economic impact of $6.22 billion, signifying how CAVS Extension can assist in business improvements that lead to future growth in Mississippi.



2017 - 2020 ECONOMIC IMPACT	
Increased/Retained Sales	$177,906,018
Cost Savings/Avoidance	$32,513,668
Total Company Investments	$47,807,662
Jobs Created	1,429

RESEARCH ACCOMPLISHMENTS

John Ball, the MSU electrical and computer engineering Robert D. Guyton Chair, and a team of graduate students, Jackson Cornelius and Blake Brockner, now with CFD Research Corporation, won the 2020 IEEE International Conference's best industry paper award, Prognostics and Health Management: "Estimating and Leveraging Uncertainties in Deep Learning for Remaining Useful Life Prediction in Mechanical Systems."

Cindy Bethel, a computer Science and engineering professor in MSU's College of Engineering, has been named as one of the "World's 50 Most Renowned Women in Robotics" by Analytics Insight magazine. Bethel, also has been elected to serve on the Computing Research Association's board of directors. The CRA is a national organization that works to further innovation by joining with industry, government and academia to strengthen research.

Emily McCabe, a former graduate student in mechanical engineering, was selected as the recipient of the distinguished Leonard P. Gollobin scholarship by the I/ITSEC Annual Post Graduate Scholarships and Conference. McCabe was a GRA in ME. She studied the physical simulation and characterization of novel additive manufacturing methods. The MSU alumna was one of just two students nationwide to be selected for the Gollobin scholarship.

Lesley Strawderman, the International Paper Chair for MSU's industrial and systems engineering, received the 2020 Outstanding Mid-Career Teaching Award from the Southeastern Section of the American Society for Engineering Education. The award recognizes faculty who have made exceptional contributions to engineering education through outstanding classroom performance.

Linkan Bian, who holds the Thomas B. and Terri L. Nusz Endowed Associate Professorship in MSU's industrial and systems engineering department, will serve as president-elect for the Quality Control and Reliability Engineering division of the Institute of Industrial & Systems Engineers for 2020-2021. He will take the reins as president in 2021-2022.

Yucheng Liu, the MSU Jack Hatcher Chair in Engineering Entrepreneurship, is receiving the 2020 Forest R. McFarland Award from SAE International. The McFarland Award is presented annually to Society of Automotive Engineer members who have made outstanding contributions to SAE Engineering events through planning, development and dissemination of technical information via meetings, conferences and professional development programs.

Reed Mosher, director emeritus of the U.S. Army Engineer Research and Development Center's Information Technology Laboratory, was named director of the Institute for Systems Engineering Research, housed in Vicksburg at ERDC. Mosher spent 40 years at the ERDC before retiring. ISER is a collaborative effort between the ERDC and MSU.

Like Li, an MSU assistant mechanical and engineering professor, is part of a nationwide team awarded a $2.5 million grant from the US Department of Energy Efficiency and Renewable Energy office. Li is collaborating with researchers at Michigan and Oregon State and Purdue University Northwest to develop a low-cost, zero-emission solid-state fuel that can efficiently store solar energy through high-temperature thermochemical reactions.

U.S. ARMY ERDC INDUCTS INSTITUTE OF SYSTEMS ENGINEERING RESEARCH DIRECTOR INTO DISTINGUISHED GALLERY

WRITTEN BY MARY MARGARET EDNEY, U.S. ARMY ENGINEERING RESEARCH AND DEVELOPMENT CENTER

The U.S. Army Engineering Research and Development Center (ERDC) inducts Reed Mosher, Director of ISER at Mississippi State University, into the Waterways Experiment Station (WES) Gallery of Distinguished Civilian Employees. Mosher joins the ranks of more than 100 former employees whose significant career achievements left a lasting impression on both ERDC and the nation.

Mosher served as a director of laboratories at the ERDC, pioneered technologies that proved to be lifesaving for American Soldiers; and left behind a remarkable legacy when he retired from federal service.

Each year, the ERDC inducts new members into the gallery, the highest honor bestowed to those who have worked at WES in Vicksburg.

Mosher, who spent 40 years as a federal employee, retired as director of the Information Technology Laboratory (ITL) in 2018. Under his leadership, the lab's staff grew by 108 percent, becoming the second largest ERDC laboratory. He also oversaw the construction of a 66,000 square-foot expansion to the laboratory, and his vision for a new secure computing facility is currently under construction and scheduled for completion later this year.

Before his ITL role, Mosher served as the lead technical director for military engineering in the Geotechnical and Structures Laboratory, where he also was directly involved with assessments after some of the world's most notorious attacks and bombings, including the Oklahoma City in 1995, the U.S. Embassies in Africa in 1998 and the September 11, 2001 attack on the Pentagon. He was instrumental in developing new technologies designed to protect soldiers in Iraq and Afghanistan from rockets, mortars and other explosives.

Even after retirement, Mosher is still involved with the ERDC as the director of the Mississippi State University Institute for Systems Engineering Research, a partnership initiative with the ERDC.

CAVS 2020 TOP TWEETS

Center for Advanced Vehicular Systems - CAVS @CAVS_MSSTATE

The captain is calling...

Welcome to @HailStateFB, @Coach_Leach. 🐾
#HailState

Jan 9

Center for Advanced Vehicular Systems - CAVS
@CAVS_MSSTATE

As a member of the COVID-19 Technology Access Framework. CAVS and @msstate have released a comprehensive tutorial for constructing our student-designed UV Light Disinfectant.

May 19

Center for Advanced Vehicular Systems - CAVS
@CAVS_MSSTATE

It might look a little different this year, but we're ready for a @HailStateFB weekend!!

Happy #MaroonFriday and #HailState! @HailStateMascot @HailState

Oct 2

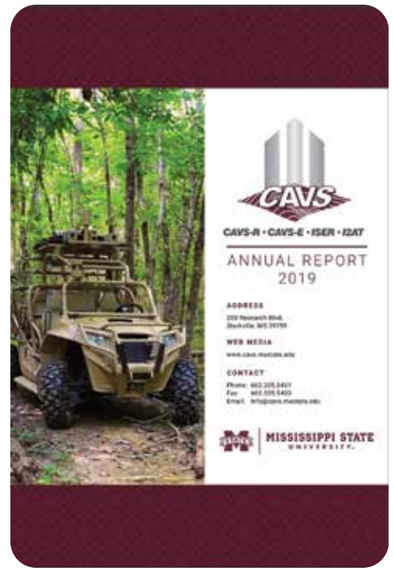
Center for Advanced Vehicular Systems - CAVS
@CAVS_MSSTATE

CAVS has added a new member to its leadership team. Dr. Tonya Stone, a @MSUEngineering researcher & faculty member, has been appointed to the role of Associate Director of Computational Engineering Mechanics. Congratulations @DrTonyaStone!

Oct 19

Center for Advanced Vehicular Systems - CAVS
@CAVS_MSSTATE

We are pleased to release our 2019 Annual Report! Take a second to learn about some of the exciting work our researchers and faculty are doing. #weringtrue
cavs.msstate.edu/annualreports...



Oct 30

WE INVITE YOU TO FOLLOW US ON SOCIAL MEDIA!

Are you on Facebook, LinkedIn, Instagram or Twitter? If so, give us a follow to stay up-to-date on research taking place at the Center for Advanced Vehicular Systems!

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MISSISSIPPI STATE UNIVERSITY™

CENTER FOR ADVANCED VEHICULAR SYSTEMS

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