

RESEARCH, SUPPORT AND ECONOMIC DRIVE: 15 YEARS IN, CAVS CONTINUES TO HELP MISSISSIPPI MANUFACTURING THRIVE

By James Carskadon, Photos by Russ Houston & Beth Wynn

In 2001, Mississippi officials saw a chance to secure the state's first automotive manufacturing plant—a major investment from Nissan that would create billions of dollars in economic impact.

They turned to the state's leading research university to help make it a reality.

The results of their efforts became Mississippi State University's Center for Advanced Vehicular Systems, which was created with a two-fold mission—conduct world-class research in areas relevant to the manufacturing sector and, through CAVS Extension, provide direct support to manufacturers like Nissan and their supply chain.

Now, 15 years after CAVS opened in Starkville and CAVS Extension opened in Canton—Nissan's Mississippi home—the center continues to make a significant impact by bringing faculty and grants to Mississippi State, adding jobs to the Mississippi economy and solving complex issues with internationally recognized research.

BRINGING JOBS TO MISSISSIPPI

Since its inception, CAVS has worked to remain relevant to Mississippi industry. It has capitalized on its automotive focus to expand its reach throughout the state, according to Clay Walden, executive director of the center.

“So many of our country's manufacturing concepts came out of the automotive industry. If you're relevant to the automotive sector, you can leverage that in a lot of different ways,” Walden said.

“Although we were started as part of the incentive package for Nissan, we knew we would not be successful if all we did was work for Nissan,” he continued. “The first director, Don Trotter, was very passionate about that and Nissan was supportive of our mission to support all aspects of the manufacturing supply chain. For CAVS Extension, working with Nissan's suppliers became important early on because typically those companies don't have the same

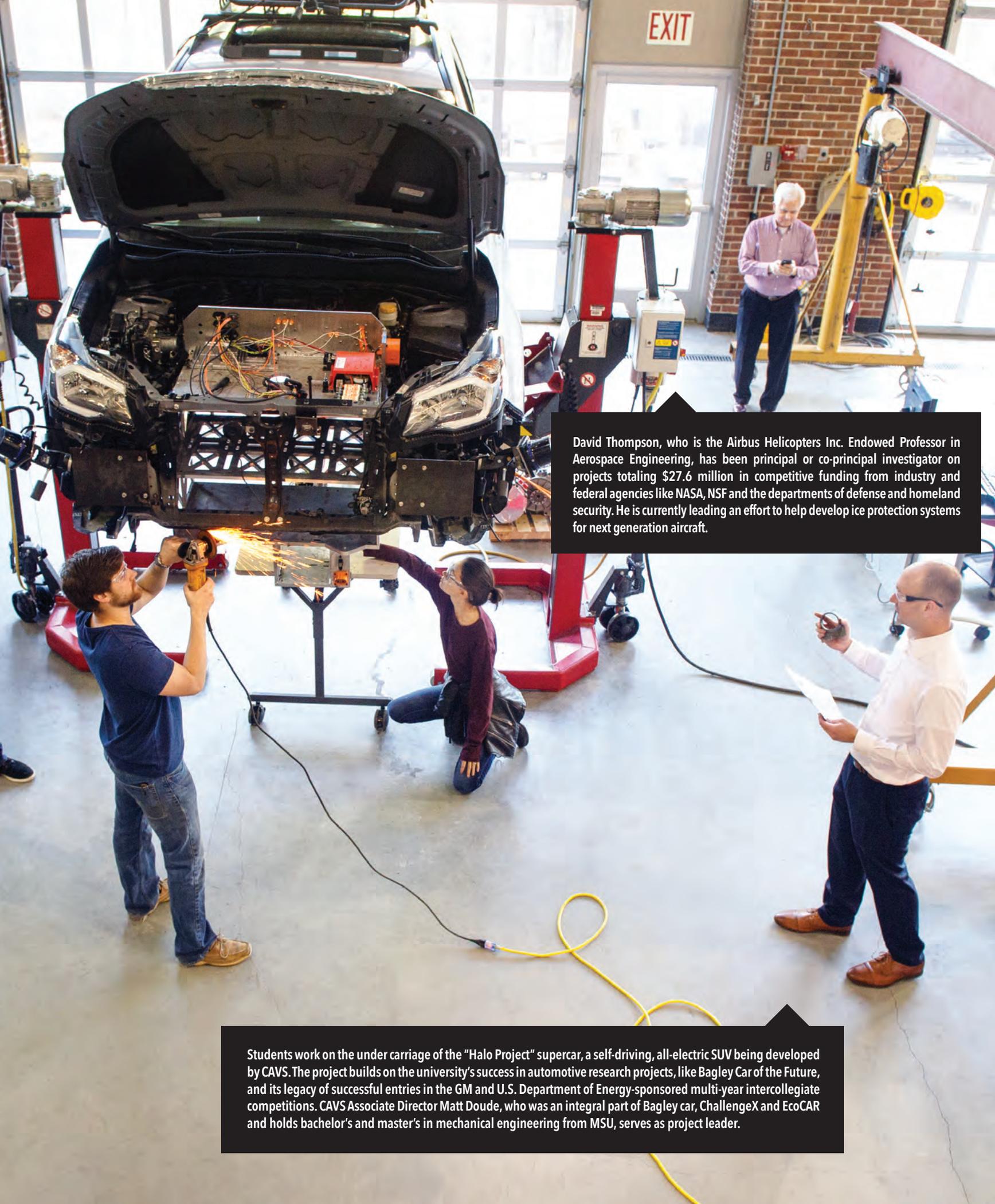


technical and engineering resources as the larger companies.”

That strategy has helped CAVS become a key part of Mississippi's economic development efforts. When Yokohama Tire officials came to tour what would become the site of their new plant in West Point in 2013, state officials pitched the company on Mississippi in a CAVS

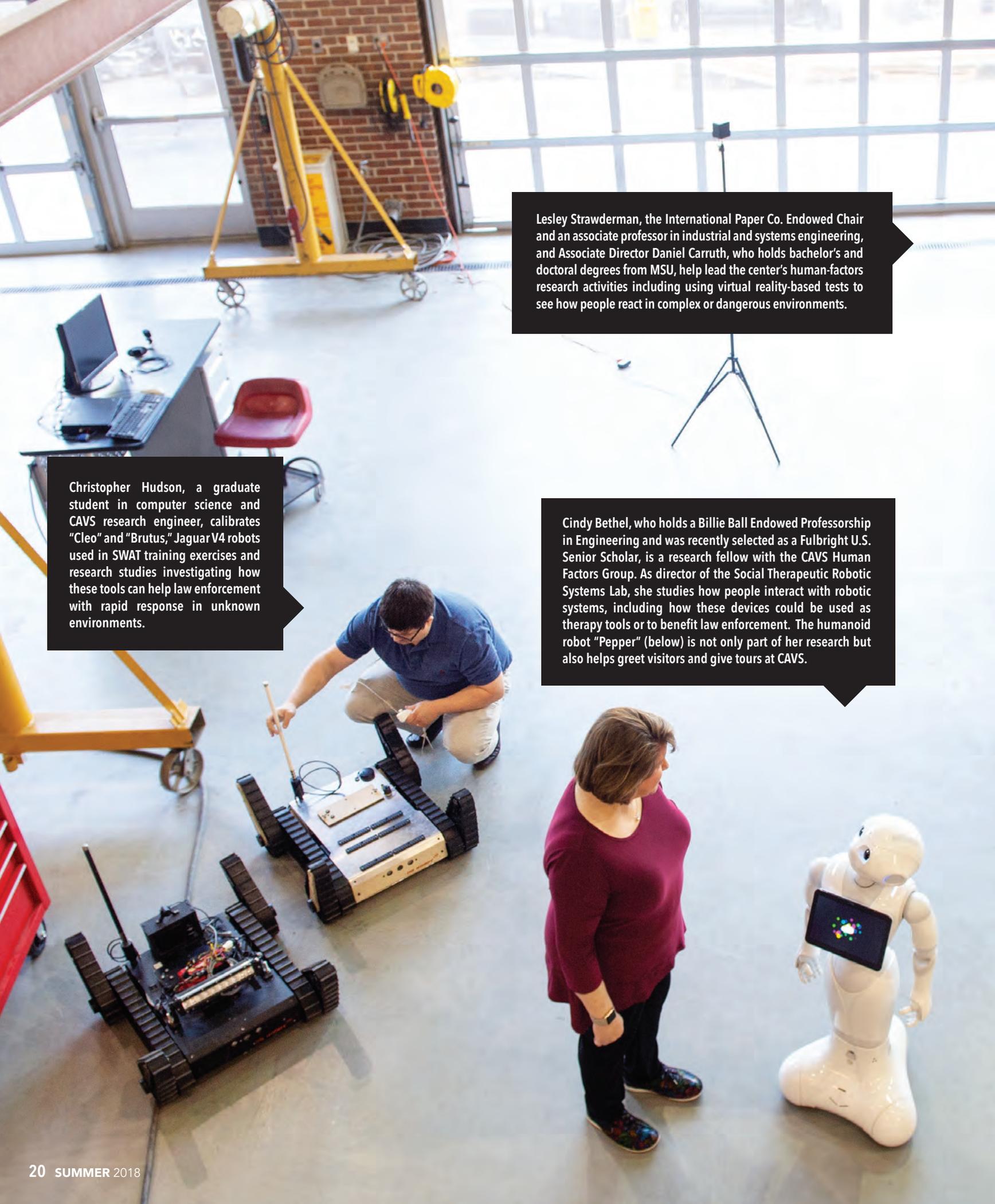
conference room. The center has been involved in several other industrial recruitment efforts. Just the outreach work of CAVS Extension has had nearly a \$6 billion economic impact and created or retained 4,600 jobs.

“MSU's Center for Advanced Vehicular Systems is a unique advantage, which allows our state to grow this technologically intensive



David Thompson, who is the Airbus Helicopters Inc. Endowed Professor in Aerospace Engineering, has been principal or co-principal investigator on projects totaling \$27.6 million in competitive funding from industry and federal agencies like NASA, NSF and the departments of defense and homeland security. He is currently leading an effort to help develop ice protection systems for next generation aircraft.

Students work on the under carriage of the "Halo Project" supercar, a self-driving, all-electric SUV being developed by CAVS. The project builds on the university's success in automotive research projects, like Bagley Car of the Future, and its legacy of successful entries in the GM and U.S. Department of Energy-sponsored multi-year intercollegiate competitions. CAVS Associate Director Matt Doude, who was an integral part of Bagley car, ChallengeX and EcoCAR and holds bachelor's and master's in mechanical engineering from MSU, serves as project leader.



Lesley Strawderman, the International Paper Co. Endowed Chair and an associate professor in industrial and systems engineering, and Associate Director Daniel Carruth, who holds bachelor's and doctoral degrees from MSU, help lead the center's human-factors research activities including using virtual reality-based tests to see how people react in complex or dangerous environments.

Christopher Hudson, a graduate student in computer science and CAVS research engineer, calibrates "Cleo" and "Brutus," Jaguar V4 robots used in SWAT training exercises and research studies investigating how these tools can help law enforcement with rapid response in unknown environments.

Cindy Bethel, who holds a Billie Ball Endowed Professorship in Engineering and was recently selected as a Fulbright U.S. Senior Scholar, is a research fellow with the CAVS Human Factors Group. As director of the Social Therapeutic Robotic Systems Lab, she studies how people interact with robotic systems, including how these devices could be used as therapy tools or to benefit law enforcement. The humanoid robot "Pepper" (below) is not only part of her research but also helps greet visitors and give tours at CAVS.



Shuchisnigdha Deb, a CAVS and industrial and systems engineering postdoctoral associate, and Karl Smink, a graduate student in computer science, run a virtual reality simulation to test how pedestrians respond to autonomous vehicles. This study is part of a larger transportation safety research effort and is among several projects underway in the CAVS Human Factors group.

industry sector. CAVS's commitment to helping the state's manufacturers by focusing on their needs and developing specialized workforce training courses gives Mississippi's manufacturers the tools needed to achieve long-term success," said Glenn McCullough Jr., executive director of the Mississippi Development Authority. "CAVS Extension also plays a vital role in giving advanced vehicular systems companies a workforce advantage, which enables them to win in today's global economy."

The center has supported all eight, new model launches at the Nissan plant in Canton and assisted with the rebuilding of Ingalls' shipyard after Hurricane Katrina. However, one project stands out to Walden, who led CAVS Extension before moving into his new role with CAVS in Starkville last year.

When the U.S. military needed to produce more mine-resistant ambush protected, or MRAP, vehicles, Navistar Defense in West Point was chosen as the contractor. CAVS and CAVS Extension helped design a plant that

could efficiently produce the protective vehicles needed to keep U.S. troops safe in war zones. The plant went on to produce approximately 15,000 vehicles, becoming the highest-volume production facility for MRAP vehicles in the country. In addition to providing a major benefit to the military, the plant also provided a major economic boost to West Point and the Golden Triangle area.

"Every vehicle they shipped saved somebody's life," Walden said. "We received letters from the military units about how

their groups survived attacks. Years later, we taught somebody in one of our classes who was in an MRAP and survived a blast. That just floors you. The secretary of the Navy at the time came to the MRAP plant and said it was the best example of industrial mobilization since WWII."

CONDUCTING CUTTING-EDGE RESEARCH

Although CAVS has developed a reputation for strong automotive research, the backbone of much of the center's work lies in computer modeling and simulation, which is why CAVS is under the High Performance Computing Collaboratory at MSU. The high-end computer simulation is supported by empirical experimentation that takes place at CAVS, bringing together the accuracy of real-world testing with the efficiency of using a computer model to study many variables at once.

"I look at each of our research areas, and while they are very diverse—from human factors to materials—it's sort of in our DNA to have modeling simulation and empirical testing and evaluation," Walden said. "The richness you get when you combine those two has allowed us to solve big, complex numerical problems."

Since CAVS opened 15 years ago, the center has received approximately \$125 million in external research funding. The funding has come from federal partners such as the Department of Defense and Department of Energy, as well as corporate partners that see the benefit of the



(CLOCKWISE FROM FRONT LEFT) Engineering graduate students Hamed Bakhtiari, biomedical; Cory Krivanec, mechanical; and Luke Peterson work with Mark Horstemeyer, who in addition to being the center's chief technical officer is also the CAVS Endowed Chair in Computational Solid Mechanics and a Giles Distinguished Professor, to test a magnesium alloy using the center's high pressure, high strain-rate Hopkinson bars. With applications toward developing more crash-resistant vehicles and stronger armor, projects like this have received funding from units including the Army Research Lab in Baltimore, Maryland, and ERDC in Vicksburg.

Linkan Bian, an assistant professor in industrial and systems engineering, and Hayley Doude, a research engineer who earned bachelor's, master's and doctoral degrees from MSU, discuss an upcoming presentation on the additive manufacturing capabilities of CAVS. Mississippi State is one of the few universities in the nation with a Laser Engineered Net Shaping machine equipped with a thermal monitoring system. It also has a selective laser melting machine and multiple polymer additive manufacturing systems. Not only are these machines useful in sponsored-research, they have also been used to "print" state-of-the-art parts for automobiles being developed at CAVS. Much of the equipment was procured through funding from the Army Research Lab.



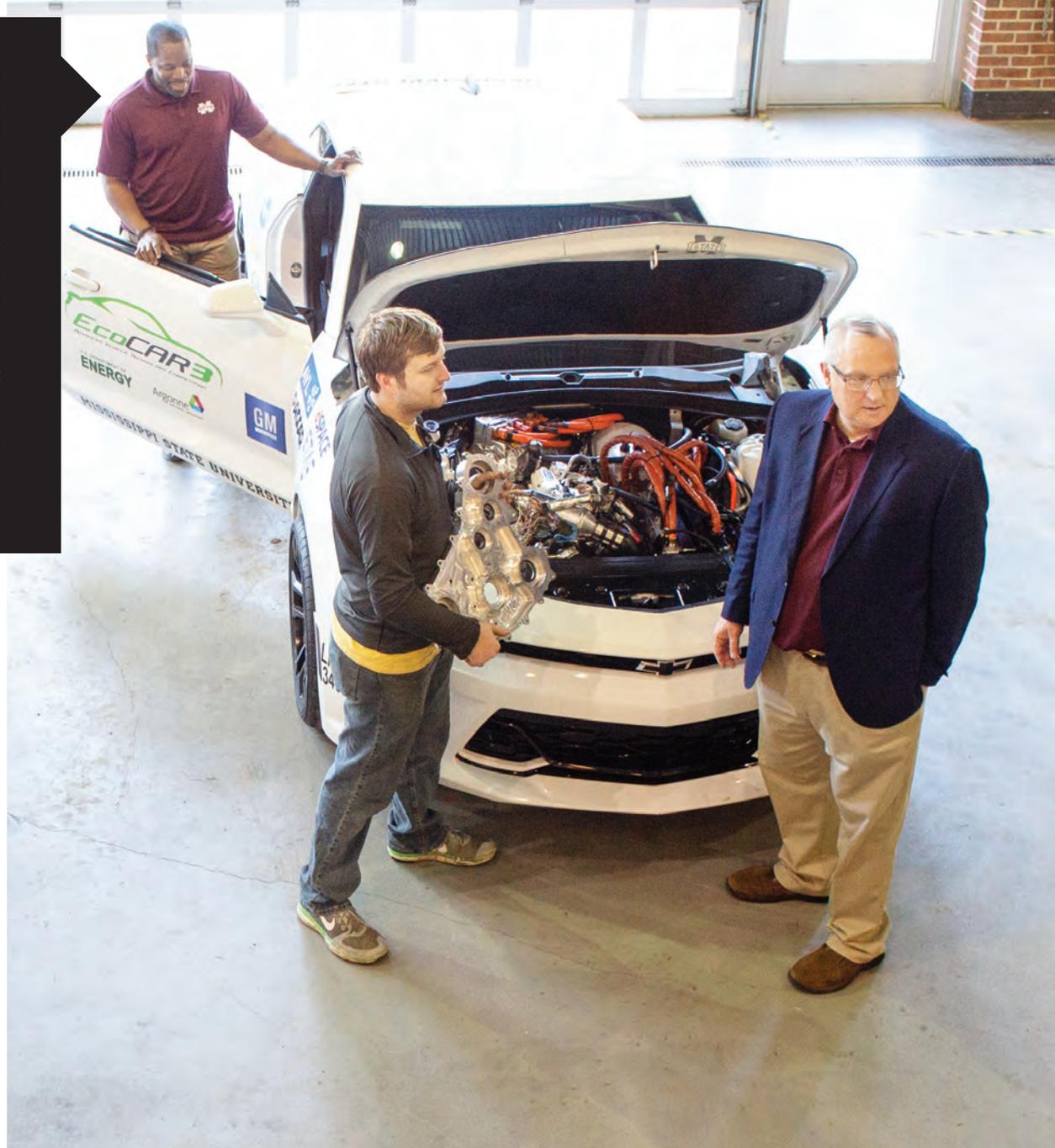


(L-R) Michael Gibson, an alumnus who recently returned to Mississippi State as a research engineer, and Pedro Mago, the PACCAR Endowed Chair and head of the Department of Mechanical Engineering, make plans for the Dynamometer Testing Laboratory. Located in a building adjacent to the main CAVS facility, the space already houses chassis and electric-motor testing beds, as well as a PACCAR-donated diesel engine for study, and will be adding emissions testing capabilities to facilitate the research of new faculty member Andrea Strzelec.

Hongjoo Rhee, an associate research professor, and Haitham El Kadiri, the Coleman and Whiteside Endowed Professor in Mechanical Engineering, oversee steel hot rolling on the recently installed reversing rolling mill capable of hot or cold rolling a variety of steel alloys and other metallic materials. Located near Eckies pond on MSU's main campus, the steel research facility contains equipment that covers the full range of steel production from a small-scale blast furnace to casting to final heat treatments. Work in this facility is funded by Army Research Lab, U.S. Army Engineer Research and Development Center (ERDC) and various steel companies including SDI Columbus.



Byron Williams, a Jack Hatcher Engineering Entrepreneurship Chair and associate professor of computer science and engineering, serves with Randy Follett, an associate professor of electrical and computer engineering (not pictured), as co-adviser of Mississippi State's EcoCAR 3 team. Now ending its final year of competition, EcoCAR 3 is the latest in MSU's long and successful history in Advanced Vehicular Technology Competitions including ChallengeX, EcoCaR and EcoCAR 2. Sponsored by GM and the U.S. Department of Energy, the AVTC are considered North America's premier collegiate automotive engineering competitions. Mississippi State has earned four first-place overall finishes since 2007 in the invitation-only challenges.



center's high-end research. CAVS also works closely with the U.S. Army Engineering Research and Development Center in Vicksburg.

Roger King, who led CAVS from 2009 until his retirement in 2017, placed an emphasis on international partnerships and funding. Those efforts resulted in research partnerships in the United Kingdom, Korea and Japan, among other countries. Additionally, the center's work for the Department of Defense showed organizations like NATO that MSU was capable of completing large defense research projects.

"If you want to say we're doing world-class research, then the rest of the world better be funding your research," King said. "The international partnerships take a lot of effort, but they help the university become a global university."

By being proactive and identifying key personnel and equipment needs, CAVS has built up internationally recognized expertise in additive manufacturing, computational fluid dynamics, human factors and other areas. King also emphasized working with the university's academic faculty, which helped the university bring in expertise in diverse areas.

IMPACTING MISSISSIPPI STATE UNIVERSITY

In addition to having a significant impact on the state of Mississippi, CAVS provides tangible benefits to Mississippi State University, starting with elevating its research portfolio.

Over the last 10 years, CAVS has employed approximately 2,000 graduate and undergraduate students through its research

programs. MSU's engineering students, as well as those in other disciplines, have excelled in student competitions such as ChallengeX and EcoCar. The students also have had the opportunity to work on projects like "Car of the Future" or the new "Halo" project, an all-electric, self-driving SUV. Because of these opportunities, MSU becomes more competitive for students interested in certain engineering fields, Walden said.

"Our graduates are in management levels at PACCAR,

A man with a beard and glasses, wearing a grey t-shirt and dark pants, stands in a workshop. He is holding a large, circular, black mechanical part, possibly a brake rotor, in front of him. The workshop has shelves with various tools and equipment in the background.

CAVS Director Clay Walden is given a tour by team members Vance Hudson, a mechanical engineering junior, and Matt Bilson, mechanical engineering graduate student, of MSU's EcoCAR 3 entry as it is prepared for the final phase of the four-year challenge. The invitation-only field of 16 North American universities was tasked with redesigning a Chevrolet Camaro using emerging automotive technologies, while still maintaining the iconic car's performance.

Ford and General Motors," Walden said. "We have our graduates everywhere. While CAVS does not have a primary education focus, we certainly provide an opportunity to greatly enrich educational experiences through working on our research projects. That's very important to us."

In addition to attracting students, CAVS also helps MSU bring in high-quality faculty researchers, which enhances the reputation of the center and the academic departments in which they teach.

"We are regularly helping support startup packages for new hires," Walden said. "We're glad to do that because it keeps bringing in new thoughts, new perspectives and new challenges to our organizations. When we're asked to be involved in some of those hires, we're very happy to assist. I believe that it makes Mississippi State a more competitive place."

By retaining a substantial, diversified research portfolio, CAVS also helps MSU maintain its standing as one of the nation's top 100 research institutions, all while solving global challenges and working to meet local industry needs.

"CAVS is one of the premier multidisciplinary research centers at MSU and is a great example of how we can bring faculty from across the entire university to address global challenges with cutting-edge research, capitalizing on all of the strengths of a major land-grant university," said David Shaw, MSU's vice president for research and economic development. "CAVS is the embodiment of MSU's commitment to making a difference in the lives of Mississippians through research and economic development efforts that support industry and federal research partners."

LOOKING TO THE FUTURE

In taking the reins of CAVS, Walden accepted the task of keeping CAVS prepared for the future.

Although CAVS has invested approximately \$20 million in equipment since it opened, the center will continue to make strategic infrastructure investments that will allow CAVS to be competitive for research funding, Walden said. Additionally, Walden said he hopes to bring in personnel that will keep the center moving forward.

CAVS will focus its research on areas that are growth oriented and relevant to Mississippi. An emerging focus is autonomous mobility, both within automotive and aerial systems. For example, human factors researchers at CAVS are using virtual reality to test pedestrian reactions to autonomous vehicles.

"Semi-autonomy will be big in the future," Walden said. "Ninety percent of accidents are human error. What happens if an advancement in that field cuts that by two-thirds? A very minor thing could have a big effect on safety and crash reductions. I think it's an exciting time to be in the vehicular industry and it's an exciting time at Mississippi State and for what we can do at CAVS. I'm convinced we have a niche role to play in some of these future technologies."

As Mississippi, and the Golden Triangle in particular, continue to grow its manufacturing base, Walden is hopeful CAVS and MSU can help recruit more research and development activities to the region, providing an additional boost to the economy.

"There have been studies that show the level of innovation increases when the design and development activities happen close to the manufacturing activities," Walden said. "We want to continue to work with the Mississippi Development Authority and other economic agencies around the state to help recruit advanced manufacturers, as well as we try to recruit the R&D activities that will be moving into our region. We certainly see this area around Starkville as a hub connecting R&D and manufacturing. That's some of the exciting opportunities that we have." ■