

CWICAR

CLEMSON UNIVERSITY INTERNATIONAL CENTER FOR AUTOMOTIVE RESEARCH

2013 ANNUAL REPORT



FROM THE EXECUTIVE DIRECTOR

After almost 33 years in the auto industry, I was asked to become the new executive director for CU-ICAR on April 1, 2013. My attraction to CU-ICAR was driven by several factors. First of all, there was the very “idea” of a partnership between industry and academia, at the center of a thriving automotive cluster in Upstate South Carolina. Was the notion of a research community, dedicated to automotive innovation, even possible? More importantly, was it making a difference for industry and the people of South Carolina?

Secondly, there was the establishment of the CU-ICAR campus-based Campbell Graduate Engineering Center focused on the highest order of graduate and doctoral education and research in automotive engineering. Amazing. Revolutionary.

Here’s what I’ve discovered:

What is CU-ICAR? CU-ICAR is the result of visionary leadership. It is *an idea* that is working to

develop new leaders in automotive engineering. It is *an idea* that is advancing the state of the art in automotive technology. It has built its foundation on *people* and the necessity of relationships to foster new ideas and build lasting relationships. The result is that CU-ICAR is *a critical brand* for economic development in the state, the region and for the automotive industry. CU-ICAR is still in its infancy, a startup organization of sorts that will take its next step in maturity. With a rejuvenated automotive industry, CU-ICAR’s future is very bright!

What’s next for CU-ICAR? Our primary goal will continue to be to conduct research that is leading-edge and relevant to the global automotive industry. We will expand our global network to bring new ideas and new partners to our site. We will be viewing ourselves through an “enterprise” lens. In what areas should we focus and grow? How can we nurture our distinctiveness? How can we improve? We want to define our long-term

vision, establish a corresponding business plan and organize around this plan.

CU-ICAR has turned out to be all I had expected and so much more. I am grateful for the foundation laid by so many thoughtful pioneers. The need for innovation in transportation has never been greater. The need for automotive engineering leaders, globally, is at an all-time high. We are up to the challenge, and we will continue to “raise the bar.”

Sincerely,
Fred Cartwright
Executive Director
CU-ICAR



MOVING FORWARD

The original vision of the CU-ICAR concept was to be the world's finest research and education center for automotive engineering and motorsports. We have taken this vision to heart and are striving to reach those heights. As a consequence, faculty and students are engaged in cutting-edge research to solve some of the most challenging problems of the industry, and our graduate programs are considered to be some of the most innovative worldwide.

The automotive engineering program is growing, with 18 faculty and more than 190 students enrolled this academic year. We expect two new faculty to join our ranks in August, and based on the number of applications and acceptances, we are certain to see a larger student body. Our research portfolio and funding continue to grow. Research spans the areas of advanced powertrains, manufacturing and materials, systems integration, vehicle performance, human-machine interface and connected vehicles. We are studying advanced and highly efficient engine concepts that utilize a

multitude of fuels, developing technologies that increase vehicle electrification and efficiency, developing and utilizing advanced materials and processes that can reduce vehicle weight and decrease the cost of manufacture, identifying opportunities and technologies to reduce energy consumption in factories, and addressing issues of safety by designing improved human-machine interfaces and vehicle-to-vehicle communication. Research is sponsored by major OEMs and federal agencies such as the U.S. Department of Energy and the National Science Foundation. Our research efforts are making a difference in moving the U.S. toward a more sustainable future.

The CU-ICAR educational programs continue to garner national and international attention as we strive to produce a workforce that satisfies industry needs. Our programs have been featured at conferences in Beijing, China, and San Diego, Calif., and at the SAE World Congress in Detroit, Mich. More importantly, our graduates are in great

demand in industry. We now have the distinction of having graduated the first male and female Ph.D.s in automotive engineering in the U.S.

The Department of Automotive Engineering is proud of these accomplishments and grateful for the incessant support received. We are fortunate to be located in Greenville, and the support of the community here is terrific. We are fortunate to have the commitment and support of the Clemson University administration and faculty colleagues on the main campus. Finally, we are lucky to have a great faculty, students and staff who are committed to making this the best program it can be.

Sincerely,
Imtiaz Haque
**Founding Chair, Department of
Automotive Engineering and Executive
Director, Carroll A. Campbell Jr. Graduate
Engineering Center**

2013 ANNUAL REPORT

Welcome to the 2013 CU-ICAR Annual Report! It has been another exciting year at Clemson University's International Center for Automotive Research. This report describes our continued growth over this past fiscal year and shares some of this past year's highlights.

One of **our proudest** accomplishments is the continued **emphasis**, and exemplary recognition of, our focus on collaboration with industry. CU-ICAR is not typical in any way, and our **distinct** commitment to working with a wide range of industrial partners is one way in which we set ourselves apart from others.

In the last 12 months alone, we have won recognition for **"improving the competitiveness of the automotive industry"** from prestigious organizations such as the State Science and Technology Institute (page 30), and we have been praised by the U.S. Department of Commerce for our industry-academia collaboration business model (page 31). **Read on to learn more about what sets CU-ICAR apart.**

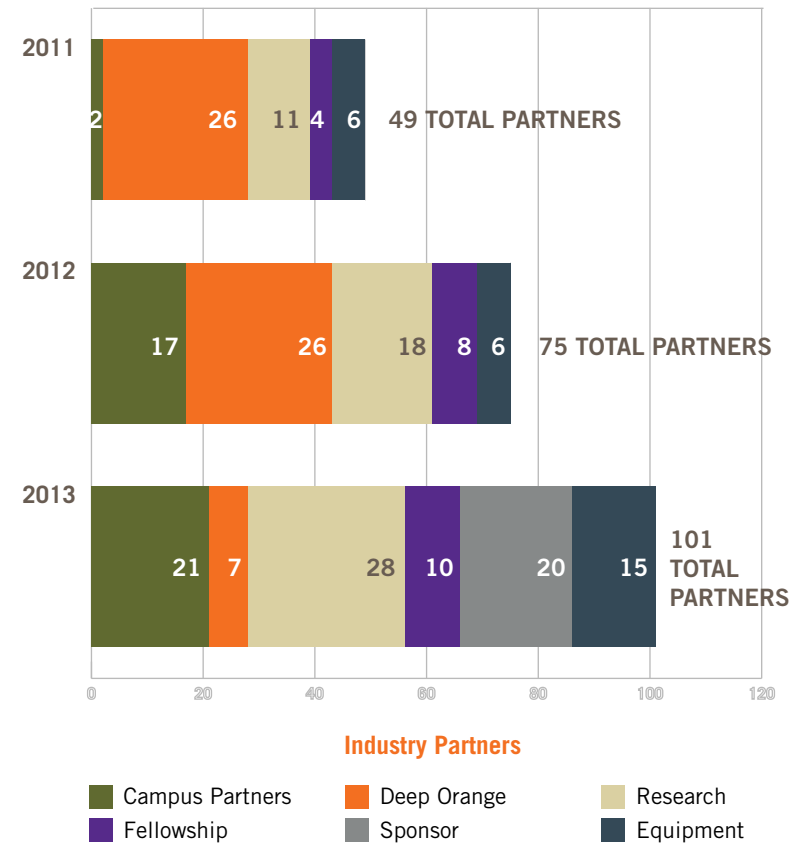


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EDUCATION

AUTOMOTIVE ENGINEERING CURRICULUM PREPARES THE ENGINEER OF THE FUTURE

Much has been written about the need to reinvent engineering education to make it more responsive to the needs of industry. In 2008, the American Society of Mechanical Engineers (ASME) Center for Education began to look at the issue of workforce readiness for early-career engineers. This grew into the VISION 2030 project that seeks to address the question of what changes are needed in the current education system to prepare engineers for the needs of industry. The work of the task force shows that there is a notable disconnect between the skills being taught in many engineering programs and the needs of industry. In November 2012, an article was published detailing 15 key knowledge areas, skills and abilities that young engineers must have to succeed and recommendations for curriculum changes to address these needs. In particular, noted amongst these critical areas are

practical experience, communication, engineering codes and standards, critical thinking and project management.

Through its partnership with industry, Clemson University's CU-ICAR is at the forefront of this change. The University's automotive engineering curriculum embodies all the recommendations of the ASME VISION 2030 report. Through CU-ICAR's Deep Orange vehicle prototype project, students conduct research, analyze data, build, test and operate in industry-supported projects that mirror the workplace. They develop much-needed skills including leadership, problem-solving, communication and conflict resolution while sharpening their technical abilities. The program engages senior engineers from industry to teach some of its classes, again bringing an industry perspective into the

classroom. Those not participating in the Deep Orange project are required to complete a six-month industry internship. This lengthy internship period allows students to go beyond surface tasks and really become part of a productive team. At the conclusion of their internship period, students have the skills and practical experience that employers are looking for.

The uniqueness of the Department of Automotive Engineering and its programs has drawn international attention. As such, it has been featured at the 2012 International Mechanical Engineering Education Summit (Beijing, China), the 2013 International Mechanical Engineering Education Leadership Summit (San Diego, Calif.) and the SAE 2013 World Congress (Detroit, Mich.).





ALUMNI HIGHLIGHTS

Clemson recruits top talent from around the globe. The best and the brightest students from more than 15 countries have come to CU-ICAR to receive an exceptional education. Our professors are world-class leaders in the automotive field. The global economy is no secret to our campus. Approximately 93 percent of our alumni are gainfully employed in the automotive industry. Of these, currently 36 percent have stayed in South Carolina and make this state their home.

Inaugural Alumni Reunion

CU-ICAR had the pleasure of holding its first alumni event on May 17, 2013. Our alumni are gainfully employed in key positions within the automotive industry and are excellent ambassadors of our program around the world. To date, CU-ICAR's Department of Automotive Engineering has awarded 123 master's and doctoral degrees.

The event began as Fred Cartwright, executive director of CU-ICAR, welcomed the alumni to campus and discussed his new role. The alumni took a tour of CU-ICAR's new testing facilities, were

able to test drive the simulator in the Creative Car Laboratory and learned about future construction on campus. The tour was followed by a reception where alumni caught up with professors, colleagues and friends.

The alumni event continued at the 2013 BMW Charity Pro-Am where they were invited to watch the competition from a skybox on the 18th hole of Thornblade Country Club. The event was a great opportunity for alumni to see the progress CU-ICAR has made and share their experiences after graduation.

Clemson Graduates the Nation's First Female Ph.D. in Automotive Engineering

In December 2012, Clemson alumna Ala Qattawi made history as the first woman in the country to earn a Ph.D. in automotive engineering.

Before beginning her doctoral studies at Clemson, Qattawi studied industrial engineering at the Jordan University of Science and Technology and graduated at the top of her class. Qattawi's love of



math and science conquered whatever doubts she might have felt about going into a male-dominated field. She acknowledges that there are few female role models for aspiring automotive engineers and hopes her accomplishments will inspire others.

"Ala Qattawi's accomplishment is exemplary of the tradition CU-ICAR has in being first to deliver exceptional talent at the Ph.D. level to the automotive industry," said Imtiaz Haque, Ph.D., executive director of the Carroll A. Campbell Graduate Engineering Center (CGEC) and chair of the Department of Automotive Engineering. "It shows our passion and commitment to professionally developing women with outstanding capabilities for today's and tomorrow's talent pool."

NEW FACULTY



Mark Hoffman (Research Assistant Professor) joined the automotive engineering faculty at Clemson in January 2013 as an assistant research professor. He earned an M.S. and a Ph.D. in mechanical engineering

from the University of Michigan by characterizing the combustion chamber deposits formed during Homogeneous Charge Compression Ignition operation and the burden those deposits place on the control system of a multi-mode engine. Before joining the Department of Automotive Engineering faculty, Prof. Hoffman served as a research fellow in the W.E. Lay Automotive Laboratory and an engineering teaching consultant with the Center for Research on Learning and Teaching at the University of Michigan. His primary research interests are in advanced combustion, vehicle electrification and sustainable energy systems.



Andrej Ivanco (Research Assistant Professor) received his master's degree in control engineering from the Czech Technical University in Prague in 2005. He continued his education as a Ph.D.

student at the University of Orleans, where he further developed the concept of the hybrid pneumatic engine with the support from the French government. After graduation in 2009, he joined the University of Michigan as a research fellow and for two years pursued multiple projects relative to hybrid vehicle system design and optimization. As of 2013, Prof. Ivanco contributes to the clean transportation sector as an assistant research professor in Clemson's Department of Automotive Engineering.



David Smith (Assistant Professor) joined the CU-ICAR faculty in September 2012. He received his B.S. in computer information systems in 2002 from Clemson. He received an M.S. in computing

in 2005 and a Ph.D. in 2009 from Queen's University in Kingston, Ontario, Canada. Prior to joining the CU-ICAR faculty, Prof. Smith had a successful career as a software development consultant. From 2002 to 2006, he worked as defense contractor in the Washington, D.C., area developing large-scale enterprise software systems to support Department of Defense intelligence activities. In 2008, he became a graduate researcher at the BMW Information Technology Research Center on the CU-ICAR campus. From 2009 to 2012, he worked in the motorsports industry developing a variety of software tools for NASCAR and Formula One organizations. Prof. Smith's research interests lie at the intersection of software development, vehicle design and human-computer interaction.

NEW FACULTY FOR FALL 2013

For the fall 2013 semester, two new faculty will join the outstanding roster of professors in the Department of Automotive Engineering. Both come to CU-ICAR with exceptional experience in strategic automotive fields. Their expertise is sure to complement the existing capabilities of our world-class faculty.



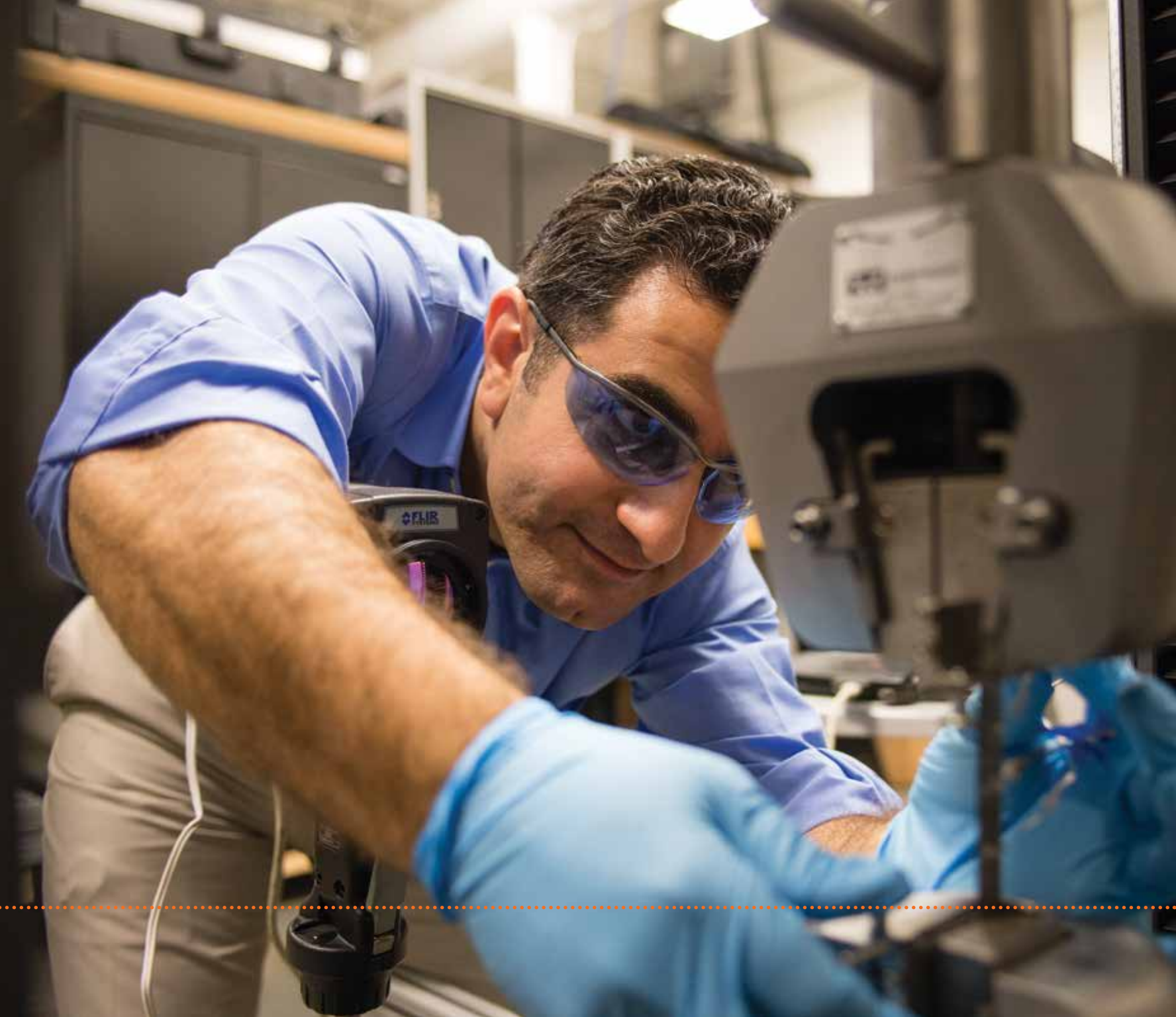
Simona Onori, Ph.D.
Energy management in hybrid electric vehicles
Research Scientist, CAR
Lecturer, Department of Mechanical and Aerospace Engineering
The Ohio State University

Simona Onori is a research scientist and adjunct fellow at the Center for Automotive Research (CAR) and lecturer in the Department of Mechanical and Aerospace Engineering at The Ohio State University. She received her laurea degree in computer science engineering from University of Rome Tor Vergata (Italy), her M.S. in electrical and computer engineering from University of New Mexico (Albuquerque, N.M.) and her Ph.D. in control engineering from University of Rome Tor Vergata. She joined OSU in October 2007 as a postdoctoral fellow. Her research is in the broad area of control system theory and applications, focusing on model-based control design in advanced propulsion systems, energy management control and optimization in hybrid vehicles; model-based fault diagnosis for automotive system applications; aging, characterization, modeling and identification of advanced batteries; prognosis and damage degradation modeling and estimation in complex systems.



Srikanth Pilla, Ph.D.
Assistant Scientist,
Wisconsin Institute for Discovery, University of Wisconsin-Madison
Srikanth Pilla previously served as assistant scientist at the Wisconsin Institute

for Discovery, University of Wisconsin-Madison. Prior to that, he was a materials scientist at SuGanit Biorenewables Inc. in Toledo, Ohio. He received his postdoctoral training in the Department of Civil and Environmental Engineering at Stanford University, his Ph.D. from the University of Wisconsin-Milwaukee, his M.S.M.E. from the University of Toledo and his B.S.M.E. from JNT University in India. He worked as a visiting research scientist at S.C. Johnson & Son in 2006. He is interested in understanding and integrating the chemistry of materials and the physics of the manufacturing processes to engineer and develop unique and hybrid methods and mechanisms to be used in a variety of applications such as automotive, packaging, civil and construction, and other mechanical and chemical engineering-related applications. During his Ph.D. studies, Pilla developed novel biobased and biodegradable composites and foams for automotive and civil engineering and packaging applications.



Laine Mears
with acting dean
Martine LaBerge



STUDENT AND FACULTY AWARDS

- **Fadi Abu-Farha, Ph.D.**, Assistant Professor of Automotive Engineering
“Integrated Materials-Mechanics-Manufacturing Approach to Hot Blank–Cold Die (HB-CD) Forming of Lightweight Alloy Sheets,” NSF CAREER Award, March 2013
- **Fadi Abu-Farha, Ph.D.**, Assistant Professor of Automotive Engineering, and **Justin Milner**, doctoral student
“Friction Stir Back Extrusion (FSBE) of Lightweight Alloys,” Best Poster Award — Young Professional Technical Division Poster Contest/Light Metals Division
- **Beshah Ayalew, Ph.D.**, and **Justin Sill '12, Ph.D.**, vehicle dynamics/powertrain R&D engineer at Tesla Motors
“Vehicle Stability Control Through Predictive and Optimal Tire Saturation Management,” ASME-DETC2012-71182, Best AVT Student Paper Award, 14th *International Conference on Advanced Vehicle Technologies*
- **David Bodde, D.B.A.**, Professor of Automotive Engineering
Invited member, National Academies Committee analyzing the deployment of electric vehicles
- **Johnell Brooks, Ph.D.**, Assistant Professor of Automotive Engineering
Institute for Advancement of Health Care Scholar
- **Zoran Filipi, Ph.D.**, Timken Chair in Vehicle Design and Development
“Improving the Predictiveness of the Quasi-D Combustion Model for Spark Ignition Engines with Flexible Intake System,” 2012 Springer Award for the most cited article in the *International Journal of Automotive Technology*
- **Laine Mears, Ph.D.**, Associate Professor of Automotive Engineering
Clemson University College of Engineering and Science McQueen Quattlebaum Faculty Achievement Award
- **Laine Mears, Ph.D.**, **Wes Salandro '12, Ph.D.**, quality engineer at BMW, and **Christina Bunget, Ph.D.**, former postdoctoral at CU-ICAR
“A Thermal Approach for Determining Electroplastic Characteristics,” SAGE Best Paper Prize in 2012

LEADING THE PACK IN MOTORSPORTS

Clemson University is poised to lead the pack in motorsports education. With history that spans nearly two decades, Clemson motorsports boasts more than 50 graduates who are working at every level of the industry and in every series, both in the U.S. and abroad.

Two notable motorsports alumni are Greg Erwin, who serves as a crew chief for Penske Racing, and Mike Nelson, who is in his sixth season as Penske Racing South's vice president of operations. In his role, Mike oversees multiple teams, including the 2012 NASCAR Sprint Cup Series Champion Brad Keselowski.



LEADING THE PACK IN MOTORSPORTS



Brooks Institute

At the center of the motorsports program is the Clemson University Brooks Institute for Motorsports. Founded in 1994 by Clemson alumnus Robert H. Brooks, the institute was a way to memorialize NASCAR driver Alan Kulwicki, Mark Brooks, Dan Duncan and Charlie Campbell, who perished in a plane crash in 1993.

The institute is focused on giving Clemson students experience in all aspects of the motorsports industry with primary interests in business, communications, engineering, marketing and sports science. Given this focus and its fit with the mission of the Department of Automotive Engineering, the Brooks Institute for Motorsports was moved under the auspices of the Department of Automotive Engineering in the second half of 2012. The institute is under the leadership of automotive engineering assistant professor Robert Prucka, Ph.D.

This has been a successful year for the institute as it works toward achieving its strategic goals of creating student experiences in motorsports, positioning Clemson University as the top motorsports research and education university in the world and using the excitement of racing to expose the next-generation workforce to STEM careers.



Driving SCIENCE

The greatest strides may have been made in the institute's efforts to use racing to expose the next-generation workforce to STEM careers. Through its support of Driving SCIENCE, the institute is making STEM education fun for both teachers and students. With classes that take place at NASCAR tracks, the Driving SCIENCE curriculum is fast-paced and stimulating. The program exposes diverse communities to the best practices in STEM education and develops an awareness of STEM careers that link to motorsports. In this, its first year, Driving SCIENCE provided professional development for 125 teachers from 21 school districts in eight states impacting 18,750 students.

The work is paying off with special recognition. The American Society of Engineering Education's (ASEE) Corporate Member Council (CMC) awards committee selected Driving SCIENCE as one of the 2013 winners of the ASEE CMC Excellence in Engineering Collaboration Award. The Driving SCIENCE program also received the annual DuPont Collaboratory Partnership Award, which recognizes organizations that partner with the DuPont Office of Education to advance science education. Driving SCIENCE is also anticipating growth in the coming year and is expanding to offer more opportunities and even more track venues.



DEEP ORANGE

In an exceptionally industry-focused program for teaching automotive engineering, CU-ICAR students, led by Paul Venhovens, Ph.D., the BMW Chair in Systems Integration, work with numerous automotive companies in an open-innovation and proof-of-concept platform to develop, integrate, showcase and verify new innovations and technologies in a full-vehicle working product. The use of industry-relevant teaching and mentoring methods provides a close alignment of academic and industry practices that the automotive industry will face in the years to come.

"The students at CU-ICAR represent tomorrow's engineering leaders who will need to combine deep knowledge of a particular field with the breadth to place it in context," Prof. Venhovens said. "Deep Orange 3 is evidence of that."

Deep Orange runs the course of two academic years in parallel with Clemson's two-year master's

program in automotive engineering. The vehicle product development program provides students with experience in financial and market analysis, vehicle design, development, prototyping and production planning, and gives them an opportunity to work with numerous automotive industry partners to develop next-generation vehicle concepts.





Deep Orange Partners



John Waraniak, vice president of vehicle technology for the Specialty Equipment Market Association (SEMA), also a CU-ICAR partner, said the Deep Orange project demonstrates Clemson's vision to develop CU-ICAR as the world's premier automotive, performance aftermarket and motorsports research and education facility. "Deep Orange encourages open innovation, entrepreneurship and creativity," Waraniak said. "Next-generation vehicle enthusiasts want the fastest and coolest cars, as well as the smartest cars. For this alone, CU-ICAR and SEMA make an obvious partnership."

Built by Students, Powered by Mazda

Deep Orange 3, the third-generation Deep Orange vehicle prototype designed and engineered by Clemson's automotive engineering students, is a completely new vehicle, inside and out. Deep Orange 3 was created in partnership with Mazda North American Operations and the Art Center College of Design in Pasadena, Calif. The students had free rein to push the boundaries of conventional design and engineering.

The concept chassis was unveiled at the 2012 Specialty Equipment Market Association (SEMA) show. The annual show attracts more than 120,000 attendees and more than 2,000 exhibitors to the Las Vegas Convention Center. The completed styling vehicle model will be unveiled for the first time in Traverse City, Mich., in August 2013 at the CAR Managers Briefing Seminars, one of the automotive industry's premier events.

Deep Orange 3 features breakthrough technology and earns its name "The Next-Big-Thing" (NBT). The concept features the following innovations:

Powertrain: The NBT's unique hybrid powertrain automatically chooses front-, rear- or all-wheel-drive and unites a downsized internal combustion engine with clean efficient electric drive to create a Through-the-Road Hybrid AWD system. It provides the solution to the efficiency-versus-sportiness debate delivering driving pleasure while providing great efficiency and low carbon footprint.

Body-in-White: Lightweighting is made affordable via a load-bearing structure based on innovative sheet-folding technology patented by Industrial Origami®. It allows the use of light-gauge material folded into

complex, high-load-bearing structures, formed with simple, low-cost fixtures at the point of assembly. Capital-intensive hydraulic press lines and stamping are technologies of yesteryears.

Interior: This features a distinctive 3+3 seating configuration in a sports car architecture all packaged in an exterior design created by students at the Art Center College of Design. The design not only provides solutions to the efficiency-vs.-sportiness debate, but also delivers driving pleasure, practicality and flexibility in a setting where everyone enjoys the ride.

DEEP ORANGE
CLEMSON UNIVERSITY





RESEARCH

RESEARCH AND SPONSORED PROGRAMS AWARDS RECEIVED IN FISCAL YEAR 2013

\$4,419,494.95

Total research and sponsored program awards received for faculty affiliated with the Department of Automotive Engineering

24 total

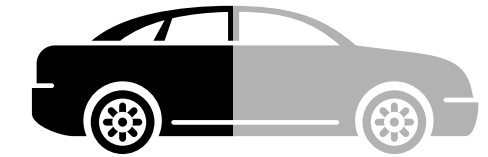
Project counts

13

Sponsored by nonprofits/government/ education (54%)

11

Sponsored by industry (46%)



46%

Most significant to note is that in the current CU-ICAR research portfolio, 46 percent of the research is sponsored by automotive companies. This is a significantly high ratio of private sector vs. public sector funding for an academic institution. It exemplifies our focus on adding value to the automotive industry.

RESEARCH

CU-ICAR's research portfolio is driven, as is our philosophy, by industry needs. We continuously analyze the market and survey industry partners, industry leaders and automotive companies to determine their technology and R&D focus. Based on that knowledge, today the research clusters and "technology identity" of CU-ICAR are centered in seven areas.





GRAND OPENING OF COMPONENT TESTING LAB

Another example of our strong industry focus is the addition of new infrastructure dedicated to serving a key identified industry need — namely for testing of interior components. In September 2012, the University opened the Component Testing Laboratory in the Center for Emerging Technologies. This state-of-the-art facility provides the infrastructure for Tier 1 automotive suppliers to test their interior components under a wide array of parameters, complementing existing full-vehicle testing and systems integration research at CU-ICAR.

Initial testing services include advanced solar simulation, environmental/climate testing and shaker/vibration testing. The laboratory has two chambers. Chamber 1 comprises a vibration chamber, which features temperature and humidity control and a shaker system, which can accommodate vertical and lateral vibration testing.

The second chamber, the only one of its kind for commercial use in the U.S., features a walk-in solar chamber for OEM climate solar simulation tests and a solar array with solar simulation that

can simulate in-vehicle conditions of components commonly exposed to solar irradiation inside the cockpit. The solar chamber provides accelerated aging simulation of components.

Always with an emphasis on education, the testing laboratory will enable CU-ICAR students and faculty to identify potential areas of research with existing and new public-private partners. Further, the facility is designed to help CU-ICAR's partners become more competitive in the marketplace. Companies can test components locally rather than send them to overseas facilities.



James F. Barker, president of Clemson University, and Josef Kerscher, president of BMW Manufacturing Co., cut the ribbon to officially open the Component Testing Laboratory.



SPOTLIGHT ON RESEARCH

Creative Car Lab

The newest addition to the Center for Emerging Technology is the Creative Car Laboratory at CU-ICAR. The lab provides an innovative approach to vehicle cockpit design and development. The lab applies tools and techniques from the information technology and digital media industries to automotive interior design. The goal is to create an environment that fosters creativity and multidisciplinary collaboration for the interior design of vehicles of the future.

The centerpiece of the lab is a custom-built multifunctional driving simulator. The simulator is designed from the ground up for reconfigurability and iterative design. The lab provides a rich infrastructure for rapid prototyping of physical cockpit components, which can be easily integrated into the simulator. Several simulator software packages are supported for a wide range of vehicle simulations and driving scenarios.

GATE Center

In 2011, Clemson's automotive engineering program received a \$1 million competitive award from the Department of Energy's Graduate Automotive Technology Education (GATE) division. These funds are devoted to building a center for research and education in sustainable vehicle systems.

Currently there are 37 students following the GATE curriculum within Clemson's Department of Automotive Engineering. These 37 students were selected through a competitive application process. In addition to having a 3.5 GPA and exceptional GRE scores, applicants had to write an essay or research plan and submit multiple letters of recommendation. Students who are accepted to the program are called GATE Fellows. They follow a specific curriculum that includes courses on engine combustion and emissions, alternative energy sources, hybrid vehicle powertrain control and automotive control system design.

Completing this track will provide GATE Fellows with a specific set of expertise:

- Modeling and experimental tools for advanced powertrain concepts including hybrid and electric vehicles, advanced engines and transmissions
- Controls and systems integration
- Component and system diagnostics and reliability
- Lightweight design and manufacturing

The curriculum will provide a broader perspective for the GATE Fellows by connecting technical solutions to life-cycle impact, market viability, resource economics and public policy issues. Fellows completing the research and education program under this track will receive a Certificate of Excellence in Sustainable Vehicle Systems.

SPOTLIGHT ON RESEARCH



Advanced Materials and Manufacturing

Fadi Abu-Farha, Ph.D., joined CU-ICAR in January 2012 as an assistant professor of automotive engineering. His research activities have been targeting greater utilization of lightweight materials in the transportation sector. Lightweighting is considered one of the most effective means to reduce fuel consumption levels in future vehicles, and the lightweighting research group at CU-ICAR

performs a wide range of research activities in pursuit of lightweight vehicular structures. The students test and characterize existing lightweight metallic materials to understand their structure and behavior, process them to favorably alter their behavior and ultimately develop cost-effective energy-efficient sustainable manufacturing techniques that are particularly suitable for forming these materials into lightweight components.

Research projects include developing hot blank — cold die (HB-CD) of lightweight alloy sheets to form magnesium and aluminum alloy sheet components that meet automotive standards. Another area of research involves processing bulk lightweight materials through friction stir forming (FSF). Prof. Abu-Farha targets the defense and aerospace sector with the strength enhancement of titanium alloy sheets by accumulative roll bonding (ARB), a process that is used to refine the grain structure of selected titanium alloy sheets by almost 100 times.

SPOTLIGHT ON RESEARCH

“CU-ICAR is a key development partner focused with EcoDual on meeting our customer needs, both today and in the future. By accelerating our next-generation product development, we will continue to bring market-leading solutions to our customers. The partnership with CU-ICAR provides the expertise and world-class development facilities that will better enable the success of our efforts. We are excited about this collaboration.”

Mike Donoughe
President and CEO of EcoDual Inc.



EcoDual Inc.

CU-ICAR and EcoDual Inc. have joined resources to research and develop a commercially viable compressed natural gas engine system for heavy-duty trucks. Specifically, they will focus on converting diesel engines already on the road to natural gas operation and reduction of exhaust emissions. “We expect to see a significant uptake in the use of natural gas for heavy-duty vehicles in the immediate future, driven by the projected low prices of this fuel compared to diesel,” said Zoran Filipi, Timken Endowed Chair in Vehicle System Design at CU-ICAR.



ECONOMIC DEVELOPMENT

INDUSTRY PARTNERSHIPS

CU-ICAR's worldwide reputation is a result of successful partnerships with leaders in the industry. By leveraging Clemson's extensive network, we are able to build bridges and open doors to new opportunities. Our students, research, economy and campus all reap the benefits of strategic partnerships.

In the past three years, CU-ICAR has seen amazing growth. Successful collaborations with key organizations are driving us to achieve our mission to be the premier automotive and motorsports research and educational center in the world.

CU-ICAR has continued to welcome new companies to the campus this year. The Center for Emerging Technologies building, opened in May 2012, is now fully leased. Two international companies who have joined our exceptional roster of world-class companies on the campus are featured next.



Tigges USA Inc.

Founded in 1925, Tigges is recognized worldwide as a leader and innovator in the manufacture of precision tight-tolerance custom fasteners and connecting elements. Tigges offers four production technologies under one roof: cold forming, CNC machining, grinding and hot forging. Metals used include stainless steel, titanium, aluminum, specialty alloys and high-temperature steel. Tigges makes custom and critical connection devices for leading manufacturers in diverse industries including automotive, motorsport, off-road, heavy equipment, offshore, marine, aerospace, gas and oil wells, mining, lighting, medical devices and many more industries that use connecting elements requiring function and precision.



In-Tech Automotive Engineering

Founded in 2002 and privately held, this is a "car-fascinated company" that is committed to ongoing training and development of associates to keep the company on the leading edge of automotive development. The company serves global automakers and system suppliers and manufacturers of electronic components for the automotive industry. The company specializes in quality analysis and project management in the development, integration, testing and fault analysis of automotive electronics systems.

State Science and Technology Institute Award

CU-ICAR has garnered another prestigious award. Six organizations were named winners of the State Science and Technology Institute (SSTI) 2012 Excellence Award for investing in science, technology and innovation to grow their local and regional economies. For its role in regional economic development, SSTI recognized CU-ICAR with its Excellence in Tech-Based Economic Development Award for Improving Competitiveness of Existing Industries.

SSTI president and CEO Dan Berglund said CU-ICAR exemplifies a comprehensive, strategic initiative that connects a research university, key industry partners and government at all levels to increase the competitiveness of a key regional industry and develop the workforce necessary to support it.

“CU-ICAR is a program that applies best practices in a consistent and intelligent manner and has yielded the measurable and meaningful results to prove it,” Berglund said.

SSTI is a national nonprofit organization that leads, supports and strengthens efforts to improve state and regional economies through science, technology and innovation.



BEST PRACTICE FOR INDUSTRY-EDUCATION COLLABORATION

CU-ICAR received recognition in a 2013 U.S. Department of Commerce report entitled “The Innovative and Entrepreneurial University: Higher Education, Innovation and Entrepreneurship in Focus.” The Department of Commerce’s Office of Innovation and Entrepreneurship spoke directly to colleges and universities around the country to understand how they are promoting innovation and entrepreneurship. The Department of Commerce is focused on nurturing innovation, developing advanced manufacturing in the U.S. and increasing exports to the world. Innovation is a priority for the agency because it helps American industry, universities and research institutes develop the next generation of technologies and increase the number of high-growth American startups.

Out of 131 research universities, CU-ICAR was named one of four best practices for facilitating university-industry collaboration. The report states that CU-ICAR’s “focus on applied education and direct engagement with industry leaders includes cutting-edge curriculum development and research capabilities focused on current trends and related issues in the automotive industry.”

The report also stated that as federal resources become limited, universities are seeking broader channels of support for technology development and commercialization efforts, particularly from the business community. Further, universities with specific strengths in the areas of manufacturing or energy research have established long-term partnerships with large corporations. These relationships allow students and faculty to engage in cutting-edge research while helping solve industry problems.



CAMPUS PARTNERS



EQUIPMENT PARTNERS



FELLOWSHIP PARTNERS



PIONEER/FOUNDING PARTNERS



RESEARCH PARTNERS



MAGNET VENUE



SAE Natural Gas Symposium

Each year, industry events draw leaders and innovators to CU-ICAR's campus. One such event was the 2013 Society of Automotive Engineers (SAE) Natural Gas Symposium.

The symposium, which examines the feasibility of natural gas as an alternative fuel, opened with a high-level overview session providing natural gas production forecasts, infrastructure development, government initiatives and technology trends. CU-ICAR's Zoran Filipi, Ph.D., who helped organize the conference, said the increased use of natural gas for transportation is the most cost-effective way to utilize the vast quantity of newly discovered domestic reserves.

"The industry is poised to unlock the full potential of this technology, including the possibilities to make engines run cleaner," Filipi said. The conference offered the perspectives of manufacturers, fuel-system suppliers, infrastructure providers and fleet owners. Topics included the development of natural gas fuel systems, engine-conversion technologies, home fueling options and fleet business cases.

International Para-cycling Event

Representatives from the U.S. Handcycling Federation, U.S. Olympic Committee, Greenville Health System, Greenville County and the city of Greenville were joined at CU-ICAR by Joe Berenyi, an American gold, silver and bronze medalist from the London Paralympic Games; Alex Zanardi, an Italian gold medalist from the London Paralympic Games; Hans-Peter Durst, a German silver medalist from the London Paralympic Games; and Aaron Trent, an American silver and bronze medalist from the 2009 UCI Para-cycling Track World Championships and member of the Roger C. Peace Para-cycling Team, to kick off the 2013 Greenville Para-Cycling Open, which took place at the Millennium Campus in Greenville.

Greenville has been selected to host the UCI Para-Cycling Road World Championships in September 2014. This event is projected to include more than 450 athletes and 200 coaches and staff from over 45 countries. The Para-Cycling Road World Championships have not been hosted by an American city since Colorado Springs, Colo., in 1998. The economic impact and exposure for the Upstate will be significant — an estimated \$4.5 million for the local economy. CU-ICAR looks forward to hosting these amazing athletes once again!

2013 Clemson Day at the Statehouse

The Deep Orange vehicle made a special trip to Columbia for the 2013 Clemson Day at the Statehouse. Clemson board members, alumni and friends gathered together on April 10 to thank the South Carolina Legislature for their service to our state. The all-day celebration included guest speakers Chairman David Wilkins, President James F. Barker, Student Body President Kaley Seawright and Clemson Head Football Coach Dabo Swinney. Deep Orange's presence at Clemson Day provided a unique opportunity for lawmakers to gain insight into Clemson research capabilities. The vehicle was positioned directly outside of the Statehouse allowing the South Carolina Legislature to interact with the prototype and learn more about the Department of Automotive Engineering's outstanding curriculum.



CU-ICAR is actively pursuing a solution to increase diversity in the workforce. Many companies have discovered that workforce diversity contributes to product innovation and global competence. Diversity fosters openness, engagement, creativity and new ways of approaching problems. Engineering innovation, the key to global competitiveness and corporate survival for many industrial firms, can be the essential byproduct of a diverse workplace. Together, we can work toward a goal of inclusiveness that enables us to attract and retain a talented workforce.

Southern Automotive Women's Forum Open House

According to a study by the Society of Women Engineers, only 20 percent of bachelor's degrees in engineering and technology are awarded to women. At CU-ICAR, we recognize this imbalance and work to increase interest in the field of engineering. It is important to introduce students to the challenges and rewards of engineering. We strive to inspire them to consider a career in engineering by introducing them to leaders in the industry and creating excitement around the topic.

On May 13, 2013, the Southern Automotive Women's Forum (SAWF) and CU-ICAR hosted

its Third Annual Open House at the CGEC. More than 150 young women from Greenville County middle schools attended. The girls were greeted by Suzanne Dickerson (CU-ICAR) and Cherie McCain (BMW MC) and learned about the purpose of SAWF. SAWF's primary objective is to provide academic scholarships for young women who are interested in engineering and to support development of the next generation of women. Gemma Parker (Draexlmaier) shared her experiences in the automotive industry and discussed the many opportunities for careers in science, technology, engineering and mathematics (STEM) fields. The day concluded with an activity led by Serita Acker of Clemson's WISE program.

Pictured from the left: Tassilo Wirth, global diversity manager, BMW Group; Josef Kerscher, president, BMW Manufacturing Co.; and Randall Trigg, procurement manager and diversity champion, BMW Manufacturing Co.

BMW Minority Supplier Diversity Event

CU-ICAR was once again a proud sponsor of the BMW Tier 1 Supplier Diversity Conference. Earlier this year, BMW Manufacturing hosted more than 1,000 businesses owned by women and minorities, introducing them to over 100 of the company's Tier 1 suppliers at the second annual Matchmaker Conference. This full-day event included matchmaking, face-to-face networking and exchange in a business opportunity trade-fair environment where small businesses could make valuable new connections. As an event sponsor, CU-ICAR provided campus tours to all attendees and displayed among BMW's Tier 1 suppliers at the networking trade show.



LOOKING FORWARD

The 2013-2014 academic year will bring exciting opportunities and new ventures. New research facilities, campus development and faculty will drive CU-ICAR to be the premier automotive and motorsports research and education facility in the world. Read ahead to learn about the upcoming additions to CU-ICAR.

Advanced Powertrain Laboratory

The future of transportation will be shaped by our ability to address major challenges related to energy security, impact on the environment, global market forces and consumer adoption patterns. Solutions for sustainable transportation will require considering a diverse set of energy sources, carriers and powertrain architectures. Therefore, the Department of Automotive Engineering has identified advanced powertrains as a strategic direction and set very ambitious goals for research in this area.

Zoran Filipi, Ph.D., the new Timken Endowed Chair in Vehicle System Design, is working with the automotive engineering faculty to fulfill the



strategic goals. Efforts so far have resulted in more than \$2.4 million of new extramurally funded research over a 12-month period. Further growth requires expansion of the experimental facilities, and plans have been developed for renovating 2,000 square feet of space in the CGEC and upgrading the infrastructure for a state-of-the-art Advanced Powertrain Laboratory (APT).

APT will provide unique flexibility for combining in-depth research and powertrain system integration. In addition to experiments with fully instrumented IC engines, batteries, supercapacitors and electric motors, APT will ultimately enable integration of the real hardware and virtual components to create an emulated

vehicle environment. Application of advanced diagnostics will allow unique insights under realistic operating conditions and ultimately create a new paradigm for powertrain system design and optimization.

Figures above illustrate the layout of the new facility, with two state-of-the-art powertrain test-cells, a smaller reconfigurable space in the middle and the new infrastructure behind CGEC, including the power transformer, HVAC system, intake air and exhaust systems, and a new fuel farm. A natural gas system will enable combustion research in the test-cell, as well as an outside dispenser for refueling of prototype vehicles.

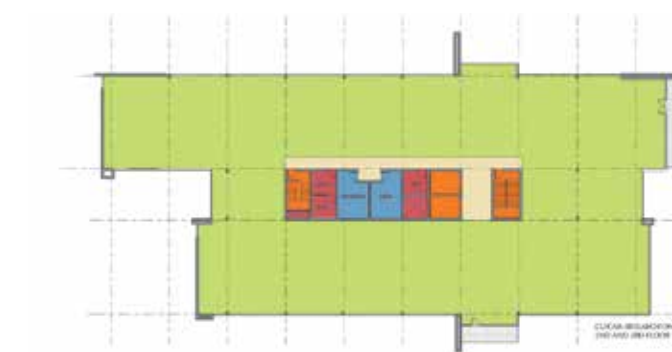


ONE RESEARCH DRIVE

One Research Drive is the sixth and final building in CU-ICAR's Technology Neighborhood I and will be located adjacent to the BMW Information Technology Resource Center. The multi-tenant facility will also house classroom and laboratory space for Clemson's Department of Automotive Engineering. One Research Drive boasts over 70,000 square feet of rentable space spread over four floors. For information about rentable space at One Research Drive, scan here.



Ground Floor
Rentable Space: 14,500 sf



2nd and 3rd Floor
Rentable Space: 21,500 sf



4th Floor
Rentable Space: 12,900 sf



FAREWELL AND THANKS TO CLEMSON PRESIDENT JAMES F. BARKER, FAIA

After nearly 14 years serving as the 14th president of his alma mater, on April 13, 2013, Clemson University President James F. Barker announced plans to retire from that position and return to the classroom.

A 1970 Clemson graduate, Barker was named president in 1999 with a mandate to lead Clemson into the top ranks of American universities. At his inaugural address in April 2000, he said, "I am convinced that there is no university in America stronger than Clemson when we are 'One Clemson.' A united Clemson is unstoppable." For his leadership, Barker has received the Order of the Palmetto, South Carolina's highest civilian honor, and has been awarded honorary doctorates from the Medical University of South Carolina, South Carolina State University and Mars Hill College.

During Barker's presidency, Clemson has added more than 57,000 alumni; set records for student SAT scores, retention and graduation rates; launched the Academic Success Center and raised nearly \$900 million in private funding since 1999. Research expenditures surpassed the \$100-million-a-year mark, and almost 3 million square feet of space has been completed, constructed or designed, including projects on and off campus.

"Jim Barker's presidency has been marked with many milestones. Clemson University's academic quality and national prominence have soared. The creation of CU-ICAR is among the most exceptional accomplishments of any university in the world during the past 10 years. Jim personally led the team to create CU-ICAR. He led the shaping of key private sector relationships and the overall design of the concept. It was a game-changing accomplishment for Clemson University and very much part of Jim's legacy."

John W. Kelly, Ph.D.
Vice President for Economic Development at Clemson University
Executive Director,
Clemson University Restoration Institute



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Scan here to visit
CU-ICAR.com.

