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THE 2016 ANNUAL REPORT
FOCUSES ON HOW CU-ICAR IS

POWERING THE FUTURE OF MOBILITY

by producing world-class engineering leaders; pioneering crucial industry research; and fueling economic growth by connecting, supporting, and catalyzing knowledge-based innovation enterprises.

Each section of this report highlights how our students, faculty, and partnerships are driving innovation and contributing in meaningful ways to the automotive industry, our economic prosperity, and our communities.

We hope you enjoy this glimpse into CU-ICAR's influential and far-reaching impact, and our role in building a bright and exciting future.



FREDERICK
CARTWRIGHT
Executive Director

FOREWORD BY
CU-ICAR'S EXECUTIVE DIRECTOR

FREDERICK CARTWRIGHT



The secret of change is to focus all of your energy
not on fighting the old, but on building the new.”

— SOCRATES

Considering that quote, CU-ICAR has spent a good portion of this fiscal year working on a revised Master Plan. Our first Master Plan, developed in 2004, served as a tool for programmatic, academic, business and physical development of the campus. It established an organizational development framework of five Technology Neighborhoods. In 2007, the Master Plan was updated to reflect rapid growth of the campus and to better address strategic projects and adjacent property developments.

Much has happened since that first Master Plan, not only in this organization, but in the automotive industry and the world as a whole. Think about it: the smartphone has become practically ubiquitous, by extension serving as a first step toward smart “things” in the world around us. Thanks to social media, global connectedness has been explosive. The global economy suffered the worst recession since the Great Depression. The automotive industry very nearly reached the brink of extinction.

What do these events have to do with CU-ICAR? Quite simply, everything. The world we knew in 2004 is not the same world we now live in. Industries have changed, new companies have emerged and vehicles continue to get smarter and more connected. The context for the creation of CU-ICAR today is no longer what it was then. As the world has changed, so must we. Our CU-ICAR Master Plan Advisory Committee has wrestled with these changes from October 2015 through June 2016. The committee’s diligent efforts have resulted in a plan we call “CU-ICAR Forward,” curated by key stakeholders in industry, the university and the government.

The new CU-ICAR Forward plan addresses the changes that have occurred in our context and purpose over the last 10-plus years. Our narrative in 2004 referred to a narrow definition of the term “automotive.” Now, the technological impact of research, education

and economic development has opened new avenues in the spheres of mobility, ranging from clean propulsion to revolutionary manufacturing. Increasingly digital and automated manufacturing will significantly increase manufacturing efficiency and quality, all while lowering cost. Fortunately, we have a head start in the area of sustainable mobility and manufacturing by way of our partnership with Greenville Technical College; born of this union is the Center for Manufacturing Innovation, which will offer advanced manufacturing certificate programs. Additionally, we will continue to develop our own capability in talent and research related to smart, connected vehicles.

All the aforementioned considered, there is still much to do. The automotive industry is in dire need of software engineers. Our Automotive Engineering program will grow in order to focus on this need. In response to the innovation required by the broader mobility industry, we must examine more home-grown solutions by establishing a mobility incubator. This is all on our radar as CU-ICAR looks to grow and evolve.

Simon Sinek, author of “Start with Why,” posits that “we spend most of our time explaining the ‘what’ and ‘how’ of our ideas, while most ideas get spread because of the ‘why.’” Why does CU-ICAR exist, then? To fuel the development of the knowledge-based economy in South Carolina. This was reaffirmed during our planning process, and will serve as the measuring stick for all we do and all we plan to do.

We aspire to be innovative leaders in mobility. We aspire to continue producing the next generation of leaders in the mobility industry. We aspire to help establish knowledge-based businesses here at CU-ICAR and across South Carolina. It seems only appropriate that CU-ICAR be driving this change.

I am very fortunate to have been at the helm of the Automotive Engineering Department during yet another banner year. Our program is expanding in every aspect—increased number of graduates, increased number of student applications, increased faculty research productivity and awards, and more. The department is also investing in critical new partnerships and programs which will provide the means for continued success in the future. More than expanding, the department continues to improve on its core mission to provide the top notch talent for the automotive industry and impactful research leading the way to sustainable transportation and a new age of personal mobility.

All key indicators attest to the fact that we have realized the original vision to create a world-class, multi-disciplinary program focused on automotive industry. We aimed high two years ago and set specific goals with aspirational peers in mind. I am extremely proud of our faculty and students for achieving these ambitious targets. Now is the time to aim even higher, with the help of our partners and new faculty that joined during the past year!

Our graduates have earned high praise from employers, and over time became true ambassadors of the Automotive Engineering program. Carmakers and Tier 1 suppliers in S.C., the nation, and abroad visit us annually to recruit, and we maintain full placement of our graduates in competitive industry jobs. The pool of applicants to our program reached 600 this year, and we admitted 76 M.S. and 6 Ph.D. students. It is with pleasure and pride that I can report almost 20 percent of females in our program. As we start looking towards the impending 10-year anniversary, we are excited about 336 M.S. students graduated so far, and another 36 Ph.D.'s. The most recent project, Deep Orange 6,



Our program is expanding in every aspect — increased number of graduates and student applications, increased faculty research productivity and awards, and more.”

—ZORAN FILIPI

was unveiled on the world stage at the SAE World Congress in Detroit, and received wide praise and acclaim, starting with the Toyota Motor Corporation Chairman of the Board of Directors Takeshi Uchiyamada.

Automotive Engineering faculty are on the forefront of research that addresses challenges imposed by the fuel efficiency and greenhouse gas regulation, societal concerns and consumer expectations. The research sponsors include National Science Foundation, U.S. Department of Energy and U.S. Department of Defense, and a large group of industry partners led by key South Carolina players BMW, Michelin and Bosch, and a plethora of other global powerhouses such as Fiat Chrysler Automobiles, General Motors R&D, Honda, BorgWarner, ThyssenKrupp and JTEKT-Koyo. It has been another banner year in terms of research productivity, with \$4.14M of research expenditures. We started the new chapter in our relationship with Automotive Engineering's founding partner BMW after becoming one of only eight strategic partners: MIT and Georgia Tech being the only others from U.S. As a result, the door is not open to our faculty to start collaboration with a multitude of R&D groups in FIZ-Munich. Our faculty received major national and international awards, and you will find more info on the key accomplishments in the body of this report.

The future looks bright and even more exciting. I am happy to welcome a newly appointed endowed Chair, the Michelin Endowed Chair in Vehicle Automation, Dr. Venkat Krovi. Dr. Krovi came to us from the University at Buffalo with impeccable record as a researcher and scholar in robotics. He will lead the major expansion of Automotive Engineering in the area of autonomous driving and mobility transformation, accompanied by recently hired Assistant Professor Dr. Yunyi Jia. I look forward to working with Drs. Krovi and Jia on elevating Clemson's stake in the future of automation.



DOCTOR
ZORAN FILIPI
Chair & Executive Director

FOREWORD BY

DR. ZORAN FILIPI

CHAIR & EXECUTIVE DIRECTOR,
AUTOMOTIVE ENGINEERING
TIMKEN ENDOWED CHAIR IN
VEHICLE SYSTEM DESIGN

EDUCATION

The Department of Automotive Engineering's (AuE) cutting-edge M.S. and Ph.D. programs have continued to receive national & international recognition, resulting in a record number of applicants for a limited number of spots.

Our programs' focus on industry needs continue to produce highly sought-after graduates who go on to represent CU-ICAR at major carmakers, Tier 1 suppliers, and non-traditional players in the automotive industry.

The pool of applicants reached 600 this year, and we admitted 76 M.S. and 6 Ph.D. students. Through August 2017, AuE has graduated a total of 410 outstanding students (359 M.S. and 51 Ph.D.) who will become the next generation of leaders in the broader mobility industry.



410 Degrees Awarded in Automotive Engineering through FY2016:
309 M.S.
38 Ph.D.



Top Employers After Graduation

1. Ford Motor Company
2. Fiat Chrysler Automobiles
3. BMW Group
4. Honda R&D Americas
5. Cummins, Inc.



Top Employing States After Graduation:

- 44% Michigan
- 21% South Carolina
- 5% California
- 5% Ohio
- 5% International
- 20% Other



CHANDLER COOK FOR

TESLA MOTORS

Electrification in the automotive industry has exploded in pace and popularity. At the forefront of this essential facet of future mobility is none other than Tesla Motors, the innovative, disruptive and even controversial company piloted by eccentric founder Elon Musk.

Be it the original Roadster, ubiquitous Model S luxury sedan, gullwing-doored Model X SUV or feverishly anticipated entry-level Model 3, Tesla Motors enjoys rampant, Apple-like speculation surrounding its next move. Graduate student Chandler Cook enjoys a first-hand glimpse into what working for the innovative company is like.

Cook is an industrial engineering intern focusing on Powertrain components, battery pack lines and optimization at Tesla's Giga factory in Nevada. "CU-ICAR provided a much needed stepping stone for me to grow as an individual and a problem solver before entering the automotive industry. The program gave me the opportunity to bolster my technical skills from my mechanical engineering background with a plethora of leadership and group work opportunities," Cook said. "These communication skills gained, along with the chance to build knowledge from two MBA courses, an automotive project management course and a moderate focus on automotive branding and target markets, gave me the confidence and perspective I needed to succeed and spring forward into and out of my internship roles at Tesla Motors."

Tesla will hopefully become home for Cook, who added that he does not intend on applying outside of the company. "The business culture is extremely collaborative, encouraging, insightful, exhilarating, and fast-paced. I am convinced that there is no other place like Tesla."

SKYLAR STAMEY FOR

MCLAREN APPLIED TECHNOLOGIES

Graduate student Skylar Stamey interns in Development Engineering at McLaren Applied Technologies. His focus is developing models for data and control-driven high performance electronic solutions, and many of the products he supports are used by a major American motorsports series, including the Digital Dash and Engine Control Unit.

"CU-ICAR exposed me to highly advanced technology topics and trends in the automotive industry that apply directly to high performance electronic solutions and motorsport. The hands-on knowledge from engine laboratory sessions applied directly to the theory and practicality used to develop Engine Control Units," Stamey said. "Implementing various sensors and analyzing the resulting data at CU-ICAR gave me a basis of understanding of the high performance data systems used in motorsport. The systems thinking required for the Deep Orange program gave me a strong appreciation for all of the stakeholders in an automotive product. This appreciation is universal, even transcending the electronics and motorsport solutions fields."

As the first intern hired by McLaren Applied Technologies' U.S. office, Stamey made a measurable impact. So much so, in fact, that he has been offered a full-time position upon graduation. "In the future, I hope to be a part of cutting edge electro-mechanical solutions for critical industries, and I can do just that at McLaren Applied Technologies. McLaren's race-bred will to win and constantly innovate is woven into every project they undertake, and I am proud to be a part of the company."



CU-ICAR exposed me to highly advanced technology topics and trends in the automotive industry that apply directly to high performance electronic solutions and motorsport."

—SKYLAR STAMEY

FELLOWSHIPS

Graduate fellowships help Clemson recruit and develop exceptional engineers who are passionate about shaping the future of the automotive industry. CU-ICAR's fellowship partners have direct communication with our top automotive engineers and are helping diversify and grow the talent pool.

DEEP ORANGE AWARD FOR EXCELLENCE

Melvin Babbs
William Copley
Aaishwary Kulkarni
Pratiksha Shelke
Rohan Shrivastava
Roshan Subburaj
Dheemanth Uppalapati

BMW M.S. FELLOWSHIP

John Cleland
David Nguyen
Alex Van Nest

DRAEXLMAIER FELLOWSHIP

Kartik Bagga
Breno Schwambach Costa
Bhoomika Narasimhan
Yang Yang

BOSCH FELLOWSHIP IN AUTOMOTIVE ENGINEERING

Lauren Mims

BRIDGESTONE FELLOWSHIP

Matthew Dwyer
Vinicius Ribeiro Leao

CLEMSON UNIVERSITY R. C. EDWARDS

Brandt Ruszkiewicz

COOPER STANDARD FELLOWSHIP

Ting Zheng

FEV FELLOWSHIP

Robert Blankenship

FULBRIGHT SCHOLAR

Juan Gutierrez Aguilar

JTEKT FELLOWSHIP

Kyle Mattinson

KLOKWERKS/PROFORMA IMPACT BUSINESS FELLOWSHIP

Veera Aditya Yerra

MAZDA/GATE FELLOWSHIP

Vasanthilakshmi Karri
Shailer Lawton
Michael O'Neal

SAFETY-KLEEN FELLOWSHIP

Mitchell Beckman

PLASTIC OMNIUM FELLOWSHIP

Yu-On Kan

SAGE FELLOWSHIP

Robert Knizek

STÄUBLI FELLOWSHIP

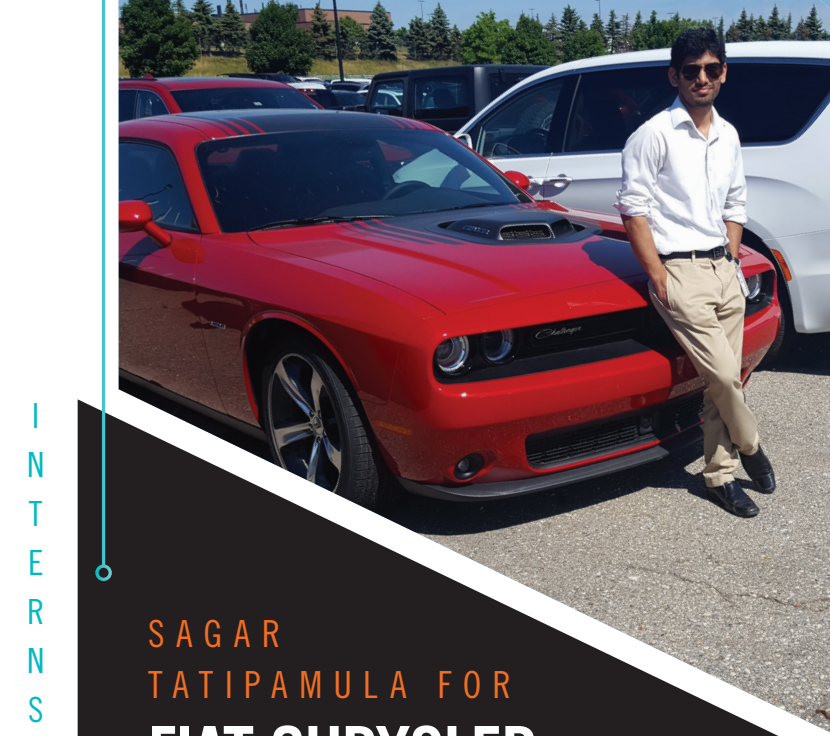
Shruti Kizhakkal

PH.D. STUDENT OF THE YEAR

Satadru Dey

M.S. STUDENT OF THE YEAR

Vasileios Bardis



SAGAR TATIPAMULA FOR FIAT CHRYSLER AUTOMOBILES

As a Powertrain Controls Intern at Fiat Chrysler Automobiles, Sagar Tatipamula has a real-world venue to apply knowledge gained at CU-ICAR. Working mostly on 8-Speed and 9-Speed automatic transmission diagnostic, Sagar has a measurable impact on an indispensable part found in millions of FCA vehicles worldwide.

"CU-ICAR offers a strong blend of industry-oriented courses in automotive engineering that prepare us diligently for the professional world," Tatipamula said. "The major transformation I've seen in myself has been in my approach, and patience for, digging deep into a problem. I believe the first step to tackling a problem is understanding both it and the objective behind the exercise. CU-ICAR has prepared me for exactly that, immersing me in projects that had a well-defined objective and current-day relevancy to automotive industry challenges. It hasn't just helped me at FCA, it's helped me everywhere."

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VANSANTHI KARRI FOR MAZDA GATE



The Graduate Automotive Technology Education (GATE) program was introduced at CU-ICAR in 2011 through a \$1 Million competitive award from the Department of Energy. The program acts as an initiative towards sustainable mobility solutions.

It provides 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. Renowned worldwide for their driver-focused cars and engineering focus, Mazda is a chief sponsor of the program at CU-ICAR. A true Mazda enthusiast, Vasanthi Karri was ecstatic to receive support from the Japanese automotive giant to pursue her dreams through graduate study at CU-ICAR.

“The support from Mazda helped me on focus on my education and research without having to fret much about my finances, as they are a consistent worry of international students,” Karri said. “Mazda is one of the foremost players in the manufacturing of driver’s cars. The brand is well-known for its stylish and powerful vehicles. They consider human factors in the design of the vehicles, placing importance on the driver experience. As an automotive engineer, the Miata has always been my dream ride. With this scholarship, I felt a little closer to my dream.”

Karri will continue her graduate studies as a member of the Deep Orange project vehicle team.

SIMONA ONORI

NAMED AN EMERGING LEADER IN ENERGY

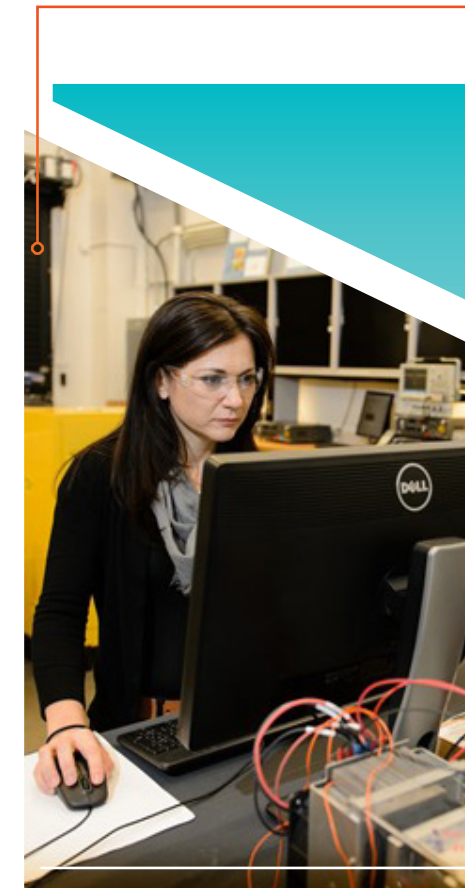
The 2016 Carolinas Energy Summit brought cause for celebration at CU-ICAR, as Assistant Professor of Automotive Engineering Simona Onori was bestowed a Carolinas Energy Leadership Award. E4 Carolinas, a trade association for energy companies in North and South Carolina, annually collaborates with the *Charlotte Business Journal* to produce the Carolinas Energy Leadership Awards. Onori was honored for her research in extending the lifespan of hybrid vehicle batteries, work that has resulted in global recognition.

“It’s an honor to be recognized as an emerging leader in a region where there is so much talent,” Onori said. She previously won an InnoVision Sustainability award, an honor that recognizes some of South Carolina’s top technological advancements. Her main research focus is in developing new technologies to make automotive systems more efficient; this includes fundamental research, supported by experimental work on aftertreatment systems, lithium-ion batteries for electric vehicles and waste heat-recovery systems. The main questions she investigates deal with how to operate systems more efficiently and make them last longer or being able detect when they fail.

“She is driven by an overarching goal of achieving sustainable transportation and highly deserving of the emerging leaders award,” said Dr. Zoran Filipi, Chair of Automotive Engineering. “Simona’s efforts contribute significantly to the growth of the research enterprise at the Clemson University International Center for Automotive Research.”

Not content to rest on her laurels in South Carolina, Onori has been invited to share her knowledge at higher education institutions from China to Germany. Onori is currently a visiting professor in the mechanical and energy engineering department at the University of Orleans in France. Onori’s research has been sponsored by Honda R&D Americas, Johnson Controls, Chrysler Fiat Automobile, Borg Warner and the National Science Foundation.

“Dr. Onori’s work is part of the reason why Clemson University has established itself as a worldwide leader in clean-energy research,” said Anand Gramopadhye, dean of the College of Engineering and Science. “She has accomplished much in a short time in South Carolina. This is a richly deserved award.”



BMW FELLOW

DAVID NGUYEN

Whether it be through its Information Technology Research Center or its continuous involvement in educational programs, CU-ICAR founding partner BMW continues to serve as an invaluable resource, ally and proponent of the campus through every avenue.

Perhaps most illustrative of this partnership is BMW Manufacturing Company's (BMW MC) continued commitment to CU-ICAR's Automotive Engineering students through fellowships at the firm's Spartanburg SUV plant. Through these fellowships, which make up just one facet of BMW's educational commitment to CU-ICAR and other local education networks, CU-ICAR students gain valuable knowledge, tuition support and the formation of a long-term relationship with the company. Graduate Automotive Engineering student David Nguyen has experienced this first hand, bridging his education and one of the world's most storied automotive brands.

Nguyen currently fellows in the Department of Quality Management. His main focus, an onboarding training program, allows newly hired associates to learn about and get familiar with the process of assembling a BMW vehicle. The Spartanburg plant, known worldwide as the main source of SUV production for BMW, assembles everything from the compact and athletic X3 to the outrageous, 567-horsepower X6 M Sports Activity Coupe. "Vehicle production on the assembly line is a strenuous job, and the health of associates is important because it affects the

quality of work they do while on-shift," said Nguyen. "This new training program allows associates to adapt to the vigorous and demanding work environment in both mind and body. A well-trained associate has the potential to mitigate the amount of defects present in BMW's products, ultimately yielding the highest quality vehicle for the customer."

Through BMW's commitment to him, Nguyen was able to worry less about finances and maintain razor-sharp focus on his education. "In addition, the BMW Fellowship has allowed me to expand my automotive network during my first year at CU-ICAR. I have met many influential people at BMW MC and have learned so much about the projects they are involved in. They have helped me understand the many intricate aspects that go into manufacturing a vehicle. Between the people I've met and the new interest for manufacturing they inspired, I decided to switch my concentration from advanced powertrains to manufacturing and materials. I wanted to explore this newfound interest through real-world experience, and the BMW Fellowship helped me do just that with a future co-op position at BMW MC."

As he looks to the future, Nguyen has noted BMW's commitment to its goals with no signs of slowing down. "BMW is just as dedicated to giving back to the community, environment, and academia as it is to providing premium high quality vehicles to its customers. Those who lead BMW want the best for their employees and are willing to devote resources to satisfy their needs. BMW has given me the opportunity to pursue my goal of impacting the automotive industry, and in evolving the company so that it continues to be an industry leader."

“

BMW has given me the opportunity to pursue my goal of impacting the automotive industry, and in evolving the company so that it continues to be an industry leader.”

— DAVID NGUYEN



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RESEARCH



CU-ICAR's research portfolio and philosophy are driven by industry needs.

We continuously analyze the market and survey industry partners, industry leaders, and automotive companies to determine their technology and R&D focuses. Based on that knowledge, today the research clusters and technology identity of CU-ICAR are focused on the following seven areas: Advanced Powertrain, Connected Vehicles, Advanced Materials, Manufacturing, Human Factors, Vehicle Performance, Systems Integration.

FISCAL 2016 STATS

59
Total
Projects

2/3
of all research
expenditures
funded by industry

\$4.1M
in research
expenditures &
sponsored programs
received by the
Department
of Automotive
Engineering

\$26.5M
in research
expenditures
since FY2011



DEEP ORANGE

UNVEILING & BACKGROUND

6

In an age of social media and ride sharing, Generation Z has abruptly about-faced regarding their feelings of personal car ownership.

The rise of services like Uber and Lyft, coupled with Generation Z's engrossment in social media, have shaken the automotive landscape, and the impact they have will continue to grow. Graduate students on CU-ICAR's Deep Orange project team sought to address the connected, collective mindset of a Generation Z buyer with the uBox, or Deep Orange 6. The uBox is the sixth concept car in the Deep Orange series, a collaboration between graduate automotive engineering students at Clemson University, transportation design students at ArtCenter College of Design and industry partners such as Toyota and Sage Automotive.

"It has been widely reported that Gen Z is less interested in vehicle ownership," said Jeff Makarewicz, senior vice president of Vehicle, Quality, & Safety Engineering at Toyota Motor North America. "As such, the future of the automotive industry is about to be redefined."

Mark Benton, Clemson's student team leader, wanted a hands-on graduate engineering experience after receiving an industrial design

degree from Auburn University. He got that and much more while leading the Deep Orange team. "I think part of the growing and learning process is being able to compromise between the different teams," Benton said. Being part of a multidisciplinary team taught Benton and the other students how to integrate different personalities, interests and engineering goals. "Toyota was fantastic, from the local dealership to meetings with vice presidents all the way up, every single person treated us like professional colleagues," Benton said. "They asked tough questions, they were respectful and they were very generous with their time. Allowing us to put their brand on the product has meant the world to me and our team."

After in-depth market research, 18 CU-ICAR graduate automotive engineering students and two ArtCenter graduate transportation systems and design students worked together to create the uBox with a distinctive look, but with conveniences for urban living for the active entrepreneur. The uBox was unveiled at the Society for Automotive Engineers' 2016 World Congress in Detroit, Michigan.

CU-ICAR RESEARCHER HEADS TO OAK RIDGE

Born and raised in Colombia, South America, Jackeline Rios-Torres understood at a young age that learning was the best way to succeed in life.

The first in her family to earn a bachelor's degree and, subsequently, earn a doctoral degree, Rios-Torres made it her mission to positively impact the world around her. Formerly a researcher at CU-ICAR, Rios-Torres followed her interest in automotive technologies all the way to Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee.

"My research experience at CU-ICAR helped to increase my interest for new automotive technologies. At CU-ICAR, I worked to find new ways to optimize the energy consumption of hybrid-electric vehicles and develop eco-driving systems that help drivers improve their 'green' driving skills; these efforts aimed to reduce the amount of energy consumed by vehicles," Rios-Torres explained. "Furthermore, I had the opportunity to work in cooperation with different research groups and professors, and to share experiences with exceptional women who were also pursuing their graduate studies in the automotive field."

"As part of my research, I was doing a literature search and found a paper related to Driver Assistance Systems written by Dr. Andreas Malikopoulos, a R&D staff member, and Alvin M. Weinberg Fellow with the Energy & Transportation Science Division at ORNL." Later on, Malikopoulos became Rios-Torres' mentor. "I contacted him to ask about his published work, and after a few conference calls, he invited me to apply to the Advanced Short-Term Research Opportunity (ASTRO) program at ORNL. The ASTRO program is focused on professionals that are working beyond their Master's degrees, and offers the opportunity to conduct short-term research in areas that are relevant for ORNL

and the U.S. Department of Energy missions." As a participant of the ASTRO program, Rios-Torres began working on one of Malikopoulos' laboratory-directed research and development projects related to connected and automated vehicles.

After Rios-Torres completed her journey in the ASTRO program, she applied for, and was selected as, a Eugene P. Wigner Postdoctoral Fellow. She currently holds a full-time position in the Energy and Transportation Science Division at ORNL and works on expanding her previous research by studying the implications of interaction between autonomous and non-autonomous vehicles, as well as integration of different vehicle technologies. This includes, but is not limited to, battery electric vehicles, hybrid electric vehicles and so on.

"While I was a research assistant at CU-ICAR, I had the opportunity to work on a number of projects in collaboration with different research groups and professors. Such interactions were essential to gain a wider view of my research and to increase my interest in the automotive area. They motivated me to seek new and exciting information, and to continue growing professionally. I got the opportunity to meet great classmates that later became great friends, with whom I interacted and had valuable discussions related to our research. We also shared motivational conversations to support each other in the challenging process. I had the support of CU-ICAR professors and staff, encouraging me to continue working towards my goal of being among the first group of women to graduate from the Ph.D. program in Automotive Engineering. For that, I am forever thankful."



JACKELINE RIOS-TORRES

AS ONE DOOR CLOSSES, A LIGHTER DOOR OPENS

Gone are the days of the heavy, gas guzzling land yachts that used to enjoy ubiquity on American roads. As the automotive industry has adjusted and innovated following the 2008 recession, focus on lightweight vehicles and superior fuel economy has all but engulfed the focus of OEMs and suppliers not only in the United States, but worldwide.

A team led by Clemson University began a \$5.81 million research project aimed at developing an ultra-lightweight door expected to help automakers in their race to meet federal fuel economy standards, which require OEM fleets to average 54.5 miles per gallon by 2025.

Researchers have begun utilizing carbon-fiber-reinforced thermoplastic composites to fabricate a driver's side front-door assembly in partnership with Honda. The technology could also be used to create other parts of the vehicle and hit the market by 2022. The goal is to reduce the door's weight by 42.5 percent. Researchers are mandated to keep the cost increase down to \$5 for every pound of weight saved; a cross-disciplinary team of faculty members from Clemson's mechanical engineering and automotive engineering departments have come together for the research.

Srikanth Pilla, an assistant professor of automotive engineering, is the principal investigator on the project. The co-principal investigators are Melur "Ram" Ramasubramanian, D. W. Reynolds Distinguished Professor of Mechanical Engineering and department chair; Paul Venhovens, the BMW Endowed Chair in Automotive Systems Integration; and Gang Li, an associate professor of mechanical engineering. "Of course, as we hit these weight and cost targets, we're going to be careful to not

compromise on functional or safety requirements," Pilla said. "It's possible we could exceed those requirements, even as we make the door lighter. We're going to do this in collaboration with the University of Delaware and industry. This project is particularly exciting because we have a commercialization plan. Honda has clearly expressed a strong interest to take full or partial technologies and put them into vehicles that will come in 2022 and beyond."

Several public and private sources are providing funding for the research. The largest portion comes from the U.S. Department of Energy, which has announced it is contributing \$2.25 million. Private industry contributed the rest.

Dr. Zoran Filipi, CU-ICAR automotive engineering chair, said the research that Pilla and his team are doing will help connect CU-ICAR's labs with the road. "Not only will we help the auto industry meet a critical deadline, but we will also be educating the next generation of automotive engineers," he said. "We're creating the model to transform U.S. automotive engineering competitiveness."

Project managers across the many teams and entities involved met in January for a kick-off meeting. The team's goal for November of 2016 was to narrow down the multiple potential designs to just one.

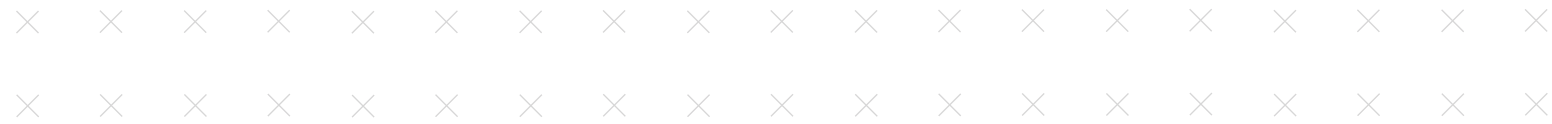
ECONOMIC DEVELOPMENT

We strive to be the premier automotive research, education and innovation enterprise in the world. This is no small task and requires the long-term commitment of talent and resources from multiple stakeholders. As Henry Ford once said, “Before everything else, getting ready is the secret of success.” CU-ICAR has been getting ready.

The launch of a successful Automotive Engineering program, contributions in key areas of research and completion of Technology Neighborhood I have been our first steps. We have built a strong foundation, upon which we can expect even greater success. Quoting from our Master Plan, CU-ICAR is about “people—students, faculty, scientists, technologists, visitors and friends,” all coming to a campus designed to “bring people together” and provide “spaces for people to meet, talk, plan and celebrate.” CU-ICAR was initially conceived to “be a shining technology city” with each Neighborhood “a dense urban cluster of buildings” focused on bringing people together. These ingredients make up a recipe for an international icon, one that our many partners can be proud of.

CU-ICAR MASTER PLAN UPDATE

2016



CU-ICAR was initially conceived to “be a shining technology city” with each neighborhood “a dense urban cluster of buildings” focused on bringing people together to foster innovation, collaboration, and a global perspective.

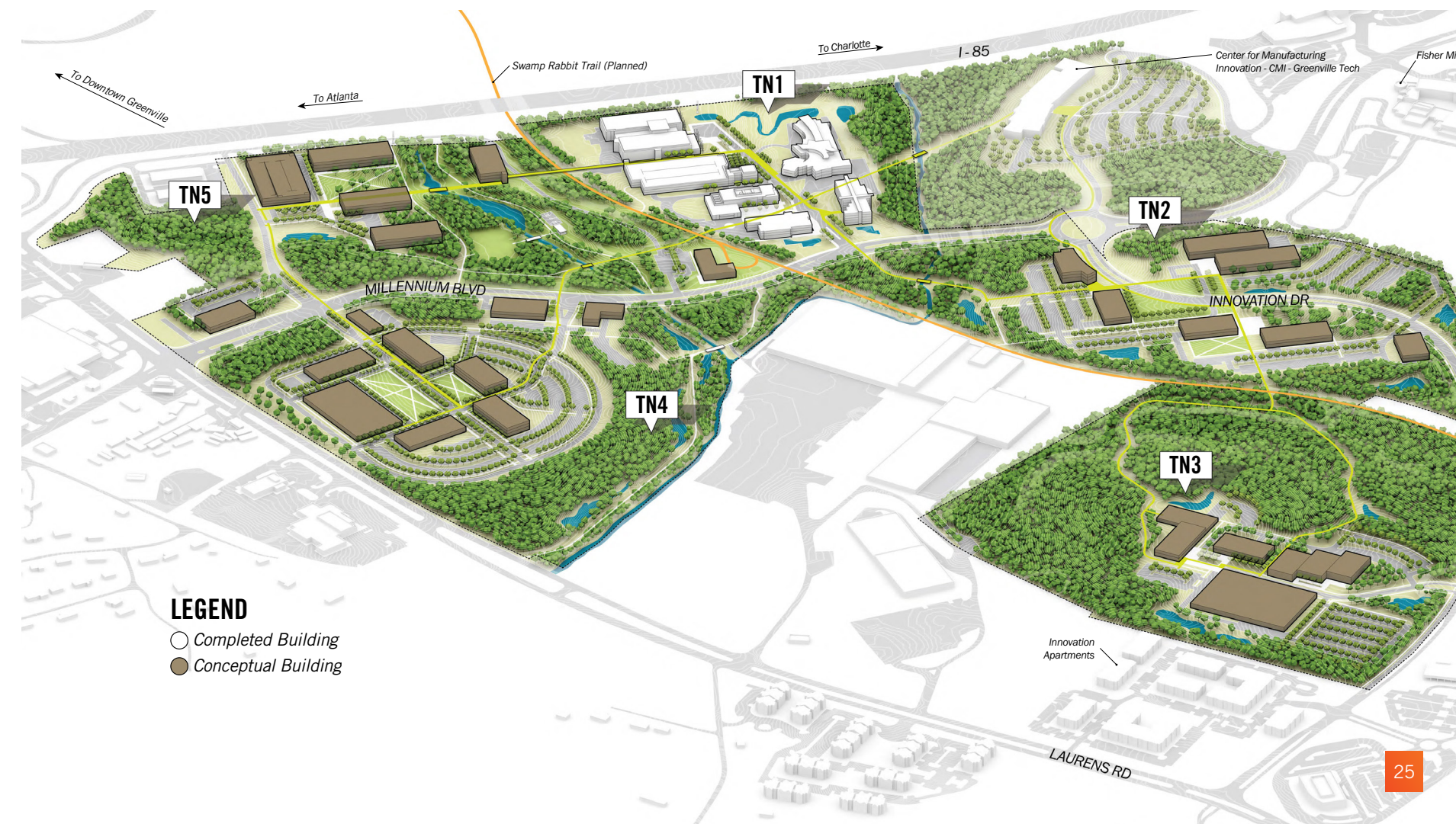
After more than a decade, many aspects of the original master plan have been successfully implemented, resulting in an award-winning campus that represents more than \$250 million in investment dollars, 439 automotive engineering degrees, and six buildings totaling 448,000 gross square feet.

However, the world today is not the same world we knew in 2004. As we acknowledge the changing needs of the global automotive industry, we recognized the need to revisit the vision, goals, strategic partnerships and physical plan for the next phase of development at CU-ICAR. The 2016 CU-ICAR Master Plan Update builds upon the concepts and vision of the original master plan and its 2007 update to maintain the CU-ICAR image as an advanced research and technology community of industry, government, and university partners that will attract top talent to Greenville and the campus.

CU-ICAR engaged with private sector advisors, industry experts, and university faculty to assess the enterprise today, take stock of trends

in the automotive industry, benchmark against similar enterprises, and produce a strategic master plan that accounted for dramatic changes at the intersection of technology, the automotive sector, and workforce.

The master plan update includes plans to create five distinct multi-use, cross-disciplinary neighborhoods with the intent of fostering greater collaboration and innovation by positioning academics, research, industry, suppliers, and entrepreneurs in close proximity. The physical master plan builds on previous concepts of five Technology neighborhoods surrounded by a green preservation zone of wooded slopes and streams, linked by a continuous network of roadways, pedestrian paths, and bike trails. Alongside physical neighborhoods and infrastructure, the plan highlights opportunities to further grow research expertise in sustainable mobility and advanced manufacturing, continue producing an increasing number of world-class engineering talent, and work to build the local entrepreneurial ecosystem by connecting, supporting, and growing innovative enterprises.



LEGEND

- Completed Building
- Conceptual Building

CENTER FOR MANUFACTURING INNOVATION

In partnership with Greenville Technical College, Upstate advanced manufacturers, Greenville County Council and other government bodies, CU-ICAR moved forward with the Center for Manufacturing Innovation (CMI). The goal for the CMI is to increase the number of skilled workers for manufacturing in South Carolina, an attempt to close the skills gap that has hampered many Upstate employers in trades such as CNC machining and robotics usage.

“The Center for Manufacturing Innovation is another great example of the partnership between Clemson and Greenville Tech,” said Clemson University President James P. Clements. “This center has the potential to transform manufacturing education in the Upstate, which will make a huge difference that will eventually be felt across South Carolina, and I am thankful for all of the people who worked to make this happen.”

Located at the Millennium Campus adjacent to CU-ICAR Technology Neighborhood 1, the CMI will offer education specifically designed to meet industry needs and will include dual credit programs in partnership with Greenville County Schools. These programs will allow a student with an associate’s degree to gain a bachelor’s degree, as well as immerse the student in workforce training and certificate programs that increase the qualifications of a manufacturing employee. Manufacturing is the Greenville area’s most lucrative economic asset, with nearly all annual capital investment in the area resulting from manufacturing.

“This one-stop-shop for manufacturing industries in the Upstate will offer a unique environment for educating the manufacturing workforce of the future. This showcase for the careers and

technology of modern manufacturing will also excite younger students and career-changers about the rewarding professions available in manufacturing. Furthermore, this new center will drive economic development by attracting new industries to the region and engaging with existing local industries, helping them grow and prosper,” added David Clayton, Executive Director of the CMI and Assistant Vice President of Greenville Technical College.

“Our Center for Manufacturing Innovation represents a game-changing approach to education,” said Keith Miller, president of Greenville Technical College. “We will close the skills gap by creating the skills needed for new employees and improving the skills of the current workforce. And we will fully integrate education from the K-12 system to the two-year college to the four-year university level, working together to better meet the needs of manufacturers in order to advance our economy.”

Since the previous fiscal year, the CMI and its purpose have continued to take shape. The building, nearing completion, will soon host students, faculty and visitors, all with the express intention of innovating in manufacturing skill sets for the Greenville area and beyond.



This one-stop-shop for manufacturing industries in the Upstate will offer a unique environment for educating the manufacturing workforce of the future.

— DAVID CLAYTON
Executive Director of the CMI
& Assistant Vice President of
Greenville Technical College.

JTEKT GROWS AT CU-ICAR

November 2015 brought news of an expansion of global component supplier JTEKT's existing facility at CU-ICAR, in which the company named the location its North American Headquarters. The expansion included a \$1.75 Million buildout project and the addition of 27 new professional positions.

"The goal for CU-ICAR is to provide a dynamic environment where global leaders in the automotive industry can be located together and work together, and it is exciting to see JTEKT call the CU-ICAR campus home," Clemson University President James P. Clements said at a news conference at the CU-ICAR campus. "It's a win for Clemson students, faculty and staff; it's a win for JTEKT; and it's a win for South Carolina's economy."

JTEKT, formed in 2006 through a merger of bearings manufacturer Koyo Seiko and machine tool manufacturer Toyoda Machine Works, employs more than 44,000 people worldwide, and more than 7,000 in North America. It supplies JTEKT-brand automotive steering and driveline components, Koyo-brand bearings and Toyoda-brand machine tools.

To lend insight to the brand's global reach, JTEKT is part of the Toyota Group; while most consumers associate Toyota solely with the company's wildly popular automobiles, the Toyota Group encompasses dozens of companies that operate both in and out of the automotive industry. JTEKT, consisting of the Koyo and Toyoda Machine Tools brands, serves as an integral part of that global network.

"Our operational headquarters in Greenville County and CU-ICAR will provide an efficient base to support our extensive footprint in North America," said JTEKT Chief Operating Officer Mike Davidson. "The availability of professional and technical talent, proximity to the majority of our production facilities and the quality of life in the Upstate makes this a great move for our organization."

South Carolina Governor Nikki Haley also added that "JTEKT North America has been a fantastic partner to South Carolina, and we're excited that they have decided to build this operation headquarters at Clemson's ICAR facility. These 27 new jobs really will make a difference in the lives of South Carolinians, and that's a real reason to celebrate."



“
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— NIKKI HALEY, *Former Governor of South Carolina*



HANNOVER MESSE

WHERE GLOBAL INDUSTRY GATHERS

From April 24 through 29, 2016, CU-ICAR joined the U.S. delegation to Hannover Messe. Occurring yearly in Hannover, Germany, the event is the world's biggest industrial trade show. The 2016 exhibition hosted more than 5,200 exhibitions and over 190,000 visitors.

For the first time in the fair's history, the United States was selected as the Partner Country, a status that provided the 390-plus businesses and organizations in the U.S. delegation an unprecedented opportunity to be prominently featured throughout the event. President Obama participated in this year's event, themed "Integrated Industry-Discover Solutions." Widely discussed across many exhibitions and industries was the school of thought surrounding "Industry 4.0," which encompasses digitized factories and an industrial "internet of things."

"The U.S. business community and the Department of Commerce have a clear message for the world: the United States is open for business," added Former U.S. Secretary of Commerce Penny Pritzker, who also accompanied the delegation.

Clemson exhibited in the Research and Technology Pavilion, one of several pavilions at the exhibition.

"The integration between foreign and domestic investments was a central theme for this year's exhibition. The purpose of our participation at Hannover Messe was to play a role in foreign direct investment in the U.S., and South Carolina specifically. We achieved this in close concert with the U.S. and S.C. Departments of Commerce," said Frederick Cartwright, CU-ICAR Executive Director.

"Commerce Secretary Pritzker personally invited Clemson University to be part of the U.S. delegation, one of only around a dozen universities that were invited to attend," added Rob Krulac, CU-ICAR Business Development. "For Clemson, this was a chance to highlight our alignment with industry and gain university recognition on a global stage."

SC AUTO WEEK **ALL GIRLS AUTO KNOW**



Held from February 21-27, 2016, South Carolina Auto Week brought together the Palmetto State's original equipment manufacturers (OEMs), suppliers and innovative industry personnel for a week focused on the vibrant automotive community from Greenville to Charleston and back.

The week's festivities included a variety of student programs, industry events, and public activities held in various cities and towns across South Carolina. Integral to the week's success is its founding organization, the South Carolina Automotive Council (SCAC); a unifying organization for the automotive industry across the state, the SCAC is made up of members connected to OEM, supplier and other firms.

A highlight of the 2016 SC Auto Week was formed in partnership with the Southern Automotive Women's Forum (SAWF), founded in 2009. As the Forum entered its sixth year during fiscal year 2016, its dual missions focus on promoting education and scholarships, as well as personal and professional advancement of women in the automotive industry within the Southeastern United States, has been continuously realized. The organization pursues its missions through building STEM (science, technology, engineering and mathematics) awareness, sponsoring scholarships and events such as All Girls AUTO Know. The day-long All Girls AUTO Know event at CU-ICAR's AT&T Auditorium is coordinated twice a year with Greenville, Spartanburg, Union, Anderson County and private schools across the upstate. Seven All Girls AUTO Know events have taken place thus far, in partnership with many organizations, including but not limited to CU-ICAR, BMW and the SCAC. The SAWF hosted an All Girls AUTO Know event during SC Auto Week with sessions taking place at CU-ICAR; around 300 middle-school-age girls, parents, teachers and counselors visited CU-ICAR to attend a half-day STEM awareness event. They also took part in a hands-on STEM activity focused on automotive technologies.

CU-ICAR continued its commitment to STEM education and awareness for underrepresented groups locally, statewide and internationally through programs like All Girls AUTO Know. South Carolina Automotive Council Executive Director Catherine Hayes added that "it's important for any adult to realize that engaging in a hands on activity is critical to making an impact on these young women."

ENGINEERING ENCOUNTERS

As a prospective graduate student or business partner, it would be difficult to visit CU-ICAR's modern, innovative technology neighborhoods and not be enamored. What about younger students who may be future great STEM minds and not yet know it? Graduate students Lauren Mims and Abe Pleta considered this question, and born of that curiosity was Engineering Encounters.

"Engineering Encounters is a way for K-12 students to get a day-in-the-life experience of being a student here at CU-ICAR," said Lauren Mims. "The students get to learn about what CU-ICAR is, what the working environment is like and what it means to be an engineer. They also get an introduction to the automotive industry and all the possibilities that the industry has to offer."

"I organized the lab experience with two other Ph.D. students, Matthew Krugh and Aditya Yerra, to give a hands-on immersive experience in the lab space of CU-ICAR. From CNC machining to 3D printing, design and virtual reality, the students were exposed to the various aspects of what goes on in automotive engineering," said Pleta.

During an Engineering Encounters campus visit, students engage in an interactive tour of different labs. They have an opportunity to witness

first-hand the innovations in manufacturing and engineering being researched at CU-ICAR, and even engage in a Deep Orange mini-project in which they work as a team on a vehicle-based challenge. Mims, along with Becky Cornwell of the STEM Centers of South Carolina, developed the Deep Orange challenges to include constraints, team roles, supply lists and scheduling.

"The highlight for me was during the first Engineering Encounter, where a lower income group of students visited. Seeing some of their eyes light up when they understood that they could become an engineer, a designer, a leader and rise above what they thought was possible for their futures was incredibly rewarding," added Pleta. "We aided in igniting their spirit, and they started to understand that by taking their courses step by step, they too could be the next leader in the automotive industry."



NISSAN'S JOSÉ MUÑOZ

TALKS
CU-ICAR,
AUTONOMOUS
TECHNOLOGY
AND THE
DYNAMISM
OF THE
INDUSTRY

The modern day automotive industry brings along with it a nature of globalism almost unparalleled by any other industry.

While many firms bear strong national ties to their country of origin, the parts and networks that come together to form their product have roots in just about every corner of the world. A firm that beautifully illustrates this concept of globalism is the Renault-Nissan Alliance. CU-ICAR was privileged to host a key member of the group's Nissan Motor Company: Executive Vice President José Muñoz. Mr. Muñoz visited CU-ICAR in the late fall of 2015 to tour the campus and engage in a forum with around 100 students.

Muñoz discussed a number of topics with students, ranging from the future of mobility to educational advice and beyond. On autonomous vehicles, Muñoz said that "One in two people born today will live to 100. They might not be able to drive but they still need mobility. There is a huge need, and huge marketability." He also highlighted Nissan's commitment to that technology in 2016 and beyond, and added that the biggest challenge regarding autonomous vehicles will be to develop policy that keeps up with the technology.

Muñoz gave further insight to how tech sector players like Google, Uber and Apple will carve out their place in the automotive world. "When you get new players in the industry you get more know-how, more pioneers, more elements in the supply chain that helps the whole industry to develop faster."

"If you want to be successful, follow your instructors' directions, work hard, never give up and be humble," Muñoz said. "Sometimes when you are a student you are thinking of doing something else, you don't see the connection with the outside world. Only the best will be considered. There are many competitors."

The visit by an Executive Vice President of one of the world's largest car makers "shows how connected CU-ICAR is to the U.S. and global auto industry," said Chandler Cook, president of the CU-ICAR Student Association. "It shows that (industry leaders) want to see what our students are doing, understand the talent we have and how we can contribute."



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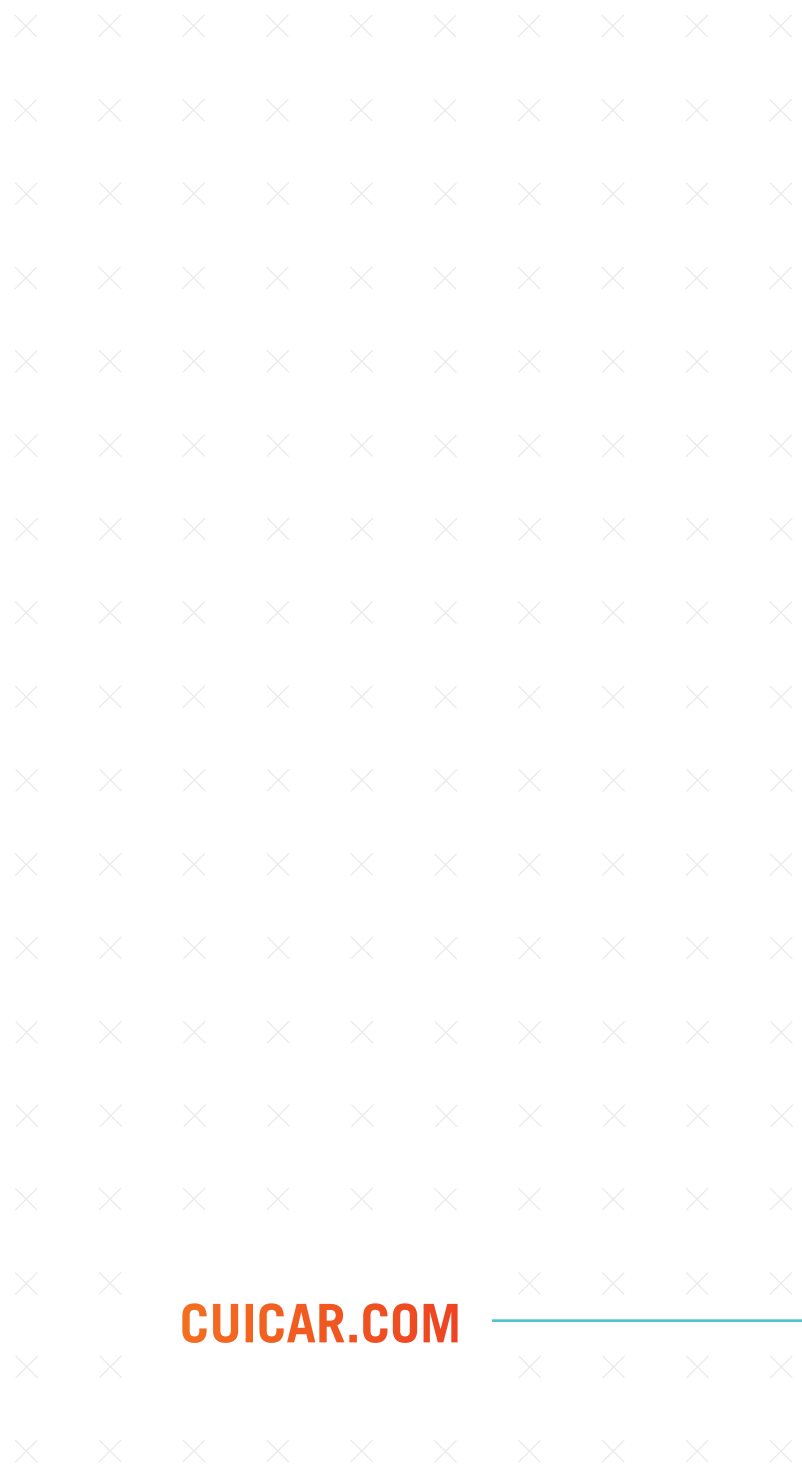
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