



CICEP

INNOVATION AND ECONOMIC PROSPERITY UNIVERSITIES
AWARDS PROGRAM

CASE
STUDY
2015

IEP CATEGORY • TALENT

**Building Next Generation
Engineering Talent at the Clemson
University International Center for
Automotive Research (CU-ICAR)**

AT CU-ICAR, TALENT IS PART OF AN ECONOMIC DEVELOPMENT ECOSYSTEM. CU-ICAR provides an example of a national best practice for public-private partnership focused on talent development aligned with industry research and education.¹ The \$250+ million innovation campus—founded in collaboration with Clemson University Foundation, BMW, Michelin, Timken, the state of SC and others—launched the first graduate program in automotive engineering (AuE) in the US in 2007 as a direct response to industry needs.² CU-ICAR’s business model includes industry partnerships through the AuE graduate programs and a core economic development mission supported by CU-ICAR’s Partnership Office. The Partnership Office is charged with making connections between automotive companies within CU-ICAR and SC’s automotive cluster. Twelve different partnership models exist to promote interaction with the campus, linking automotive companies to Clemson students, faculty and research expertise, and providing resources to connect industry throughout the region.³



Student demo at CU-ICAR

The need for MS and PhD programs in Automotive Engineering was originally identified by BMW Manufacturing and reiterated by Michelin and Timken, all major employers and investors in SC. These companies have since made significant monetary commitments to the program.⁴ Clemson’s Department of Automotive Engineering (AuE), is housed in the College of Engineering and Science and offers MS and PhD programs in Automotive Engineering focused on Systems Integration. This program is also part of the College’s national commitment to meet Grand Challenges through innovation and relevance.⁵

AuE faculty are internationally recognized experts in Advanced Powertrains, Manufacturing and Materials, Vehicular Electronics, Vehicle-to-Vehicle and Vehicle-Infrastructure Integration, Vehicle Systems Integration and Vehicle Performance, including Human Factors and Human Machine Interface (HMI).

1. The Association of University Research Parks (AURP), an international organization representing university-related research parks, presented CU-ICAR with its Emerging Research/Science Park Award in 2009. Web: <http://newsstand.clemson.edu/mediarelations/cu-icar-recognized-as-top-emerging-technology-research-center/> ; For its role in regional economic development, the State Science and Technology Institute (SSTI) recognized CU-ICAR with its Excellence in Tech-Based Economic Development award for improving competitiveness of existing industries. Web: <http://newsstand.clemson.edu/mediarelations/technology-institute-awards-cu-icar-economic-development-excellence-award/> ; Named one of seven US Department of Energy GATE Centers of excellence

2. Department of Automotive Engineering, “Points of Pride”. Web. <http://www.clemson.edu/ces/departments/automotive-engineering/about/points-of-pride.html> April 21, 2015.

3. Dickerson, Suzanne. CU-ICAR: 10 Business Models. May 2009. Web: (http://CU-ICAR.com/wp-content/uploads/2013/01/CU-ICAR_business_models2012.pdf) April 20, 2015.

4. BMW provided \$25M, matched by the State through the Centers for Economic Excellence program, resulting in an endowment of \$31M.

5. <http://pratt.duke.edu/sites/pratt.duke.edu/files/Grand-Challenge-MOU-Signed-2015.02.pdf>

CAR cultivates engineering leaders with deep knowledge of a particular technical field, the ability to work in multi-disciplinary teams and a strong, holistic understanding of product development.

Students collaborate with cross-functional teams and learn to handle complex organizational functions and work with colleagues with differing perspectives. They are trained to understand systems, cultural, societal and political forces, are expected to tackle complex problems and are encouraged to be thoughtful about the impact of their work and product. A key element of this is the vehicle prototyping program known as the Deep Orange Initiative.

DEEP ORANGE INITIATIVE. Each year, AuE students develop a unique prototype vehicle with a specific market focus and technical objectives. Deep Orange participants create and manufacture the vehicle prototype in partnership with industry sponsors, giving students the chance to gain comprehensive technical knowledge as well as valuable “soft skills” including collaboration, conflict resolution, and creativity. Industry partners (entrepreneurs, suppliers, and OEMs) are offered a neutral open-innovation and proof-of-concept platform to develop, integrate, showcase and verify new innovations and technologies in a full-vehicle working product. Knowledge gained feeds directly back to both industry and academia.

The use of industry-relevant teaching and mentoring methods aligns academic and industry practices and prepares students to address the future challenges of the automotive industry. Deep Orange also supports the growing industry cluster in



CU-ICAR Research Areas



Deep Orange 5, the fifth generation of CU-ICAR's concept vehicle program

Deep Orange 5 is designed for generations Y and Z (young adults) who will live in mega cities in 2020. “Deep Orange 5 is about creating a better value proposition for young adults that have little money to spare, less interest in vehicle ownership than previous generations, yet need a personal mobility solution that aligns with their complex lifestyle,” said Paul Venhovens, BMW Endowed Chair in Automotive Systems Integration in the department of automotive engineering at CU-ICAR.

Janet Goings, Associate Director of Research and Development at General Motors, said, “Our experience working with these students was exceptional. They came up with creative and innovative ideas for their defined target consumers. We were very impressed with their holistic approach and final result of this accelerated product development process.”



TOYOTA RAV4
Vehicle and Owner Profile (Gen Y and Z)

Market Profile	Owner Profile
• Project area: USA, USA	• Age: 24
• Projected for 12 months	• Gender: Executive/Professional
• Sales: 100,000 units/year	• Income: Mid-to-High Income/Upper
	• Education: 4th-6th
	• Household Income: Middle
	• Marital Status: Single/Divorced
	• Location: USA, Europe, Asia, South America
	• Occupation: Health Care Professional
	• Education: Higher College Degree



GRAND CHALLENGE ▲
Each project addresses a real-world grand challenge related to sustainable mobility (examples: youth mobility, aging drivers, urbanization). It requires the students to understand societal trends and future legislation.

MARKET ANALYSES ▲
As part of the curriculum, market analyses are conducted to create a better understanding of the psychographics and demographics of the target audience.

PERSONAS ▲
One or more fictional characters are constructed to represent a specific future market segment. The personas will guide all decisions about the product concepts, services and interaction.

INSPIRATION ▲
The design and engineering students often take inspirations from architecture and fashion and other non-automotive domains as an inspiration source to develop their vehicle concepts.

MONTHS 24-23

MONTHS 22-21

MONTHS 20-19

MONTHS 18-17



BENCHMARKING ▲
At CU-ICAR, students have access to full-scale testing facilities to benchmarking vehicles providing them with data critical to the development of next-generation vehicles.

SYNTHESIZING MIND ▲
Students are trained to sort through data, identify similarities and produce a big picture. They need to convey to others what is important and what needs to be done next.

MANUFACTURING INNOVATIONS ▲
Students are encouraged to explore and implement disruptive technologies. An example is using lighter gauge material folded into complex, innovative, high load-bearing structures, formed with simple, low cost fixtures, at the point of assembly.

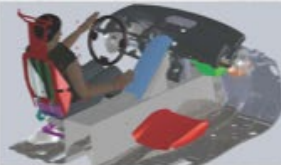
SELF-EXPLORATION ▲
To facilitate deep understanding of a new concept and tools, students are given the opportunity to discover and try different ideas to acquire the knowledge intuitively.

MONTH 16

MONTH 15

MONTH 14

MONTH 13



ART IN ENGINEERING ▲
Emphasizing arts as part of the engineering education is a key to creativity which is an essential component of, and spurs innovation.

DIGITAL MOCK-UPS ▲
3D computer software is used to represent the concept in a virtual world. It allows for a great number of design iterations in a short amount of time and minimizes the number of physical prototypes.

USABILITY TESTING ▲
Paper prototypes are often used to obtain feedback from external end-users to identify problems and guide the design. The process is repeated until end-users find the design satisfying and easy to use.

PROTOTYPING ▲
After reaching an acceptable level of maturity of design, a scale mock-up built out of cardboard or similar material is constructed in order to test the manufacturability of the structure.

MONTH 12

MONTH 11

MONTH 10

MONTH 9



TEAMWORK ▲
During the entire project, the students learn to be tolerant of differences and respect ideas, opinions and values of others. The strength of each member is the team.

IMPLEMENTATION ▲
The built-phase of the vehicle concept allows the students to implement the skills and knowledge that they have gained throughout their program of study.

SYSTEMS INTEGRATION ▲
The design and manufacture of future vehicles requires the integrated application of concepts in disciplines ranging from engineering and information technology to business and human factors.

GRADUATION AND MARKETING ▲
After project completion and graduation, the graduates are involved in showcasing the project outcomes at major venues such as the SEMA Show and LA Auto Show.

MONTHS 8-7

MONTHS 6-5

MONTHS 4-3

MONTHS 2-1 SOP

INDUSTRY COLLABORATION ▼
The project is an open-collaboration initiative allowing industry partners to work with students implementing, exploring and showcasing novel ideas.

INNOVATIONS ▼
Being free of legacies, the students are encouraged to explore and implement disruptive technologies. Examples include additive manufacturing and/or low cost, low investment technologies.

COMPONENT TESTING ▼
Subsystems and components are tested and calibrated before they are assembled into the vehicle concept.

FULL VEHICLE VALIDATION ▼
In the last phase of the project, the functionality of the vehicle prototype is validated against the targets that were defined in the strategic planning phase.



Deep Orange Process

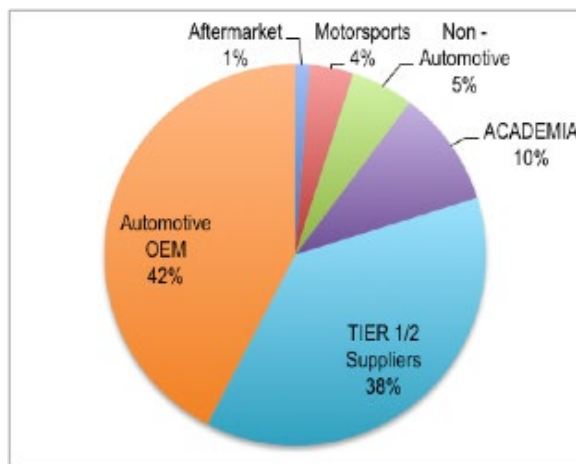
the southeast, connecting startups and medium sized companies with multinational OEMs like Toyota, Mazda, General Motors and BMW—all of which have sponsored Deep Orange. **Deep Orange 5**, the latest iteration of the project, was sponsored by General Motors and revealed at the GM world headquarters in Detroit in conjunction with the Society of Engineers (SAE) International World Congress. The value of this program for students and private sector partners has resulted in a recurring state funding allocation of \$750,000.

THE CENTER FOR MANUFACTURING INNOVATION (CMI) is a facility and academic collaboration between CU-ICAR and Greenville Technical College focused on developing the pipeline of next-generation advanced manufacturing production and engineering technicians. Top AuE graduate students will research and investigate new manufacturing methods and approaches, working alongside advanced technical college students to organically “cross-pollinate” ideas, while also linking local high schools, recruiting programs and bridge programs to allow a student to move from associate’s to bachelor’s degrees. This represents a new model of education designed not to retroactively bridge the “valley of death” between laboratory research and commercialization, but rather to fill in the valley as technologies evolve. As a result, newly developed manufacturing processes and systems will be more practical and implementable, and there will be a trained workforce ready to support emerging technologies and approaches. Currently under construction at CU-ICAR, CMI has received strong support from manufacturing leaders such as BMW, Michelin, GE, Bosch Rexroth, ADEX Machining Technologies, League Manufacturing, JTEKT Koyo, and others.



CMI rendering

TALENT OUTCOMES AT CU-ICAR. Since launching in 2007, the AuE MS and PhD programs have received national and international recognition, resulting in a record number of applicants. The growth in the graduate program has been immense, averaging about 200-210 students annually. For Fall 2015, 203 students from 18 different countries were registered for the AuE program (65 PhD and 138 MS students). Through May of 2015, AuE graduated a total of 28 PhD and 229 MS students, 95% of which are employed in the automotive industry, predominantly



Employers of AuE Graduates (2015)

Top 5 Employers of Clemson Automotive Engineering Graduates

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

in South Carolina and Michigan. Alumni have gone to work for Ford, Fiat Chrysler, General Motors, Toyota, Honda, Audi, Volvo, Mercedes-Benz, Daimler, BMW, Michelin, Tesla, Goodyear, Navistar, Caterpillar, Mitsubishi, Bosch, Cummins, John Deere and Magna, among others.