

# Clemson University International Center for Automotive Research (CU-ICAR)

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## Summary

CU-ICAR is a 250-acre advanced technology research campus located in Greenville, South Carolina, 45 miles from the main Clemson campus in Anderson, South Carolina. CU-ICAR is also home to several embedded labs. An embedded lab is a satellite research location of a company or companies located on or near a university campus with the primary objective of facilitating a collaborative industry-university relationship.

Since the location of BMW in the Greenville-Spartanburg area in 1994, CU-ICAR has progressed from an idea by Clemson faculty to build a wind tunnel to a full-scale automotive research center. This center uses the latest available industry technology and leverages Clemson faculty research and student capabilities, especially appropriate given that Clemson has one of the nation's only Ph.D. programs in automotive engineering,

CU-ICAR has not only provided a skilled workforce for the auto industry through its industry-specific programs, but it has helped spur jobs and investment in the greater Greenville-Spartanburg region. As an embedded lab within Clemson University, CU-ICAR provides automotive testing facilities, engineering talent, and on-site collaboration between faculty, staff, and students. This case study shows how CU-ICAR has helped strengthen the automotive cluster in the Greenville-Spartanburg region through partnerships forged between industry, state government, and academia.

## Background

Over the last two decades, the greater Greenville area has transformed its economy from a large textile industry presence to a diversified concentration of automotive-related industries, becoming a hub of automotive research and development in the southeastern United States. The developing "core auto cluster" is located in the Upstate region, along the Interstate 85 corridor. It primarily comprises five counties-- Anderson, Greenville, Spartanburg, Cherokee, and York—and is centered on the Greenville-Spartanburg area.

As of June 2012, the South Carolina unemployment rate was 9.4 percent, down from 10.5 percent in June 2011. Although unemployment in the Spartanburg metropolitan statistical area (MSA) remains at 10.4 percent, the Greenville MSA boasts one of the lowest unemployment rates in the state, at 8.6

percent, in part a reflection of the concentration of automobile-related opportunities.<sup>1</sup> The manufacturing sector in South Carolina has continued to grow, adding 7,400 jobs (or 3.43 percent) from June 2011 to June 2012. Manufacturing is the largest sector in South Carolina, representing 11 percent of employment. As of 2012, manufacturing has 849 establishments in the Greenville MSA, employing 37,879 workers.<sup>2</sup>

In 1994, BMW located its U.S. manufacturing plant in Greer, South Carolina, on a high-visibility site along the I-85 corridor between Greenville and Spartanburg. The location was chosen for several reasons: (1) a technically trained workforce, (2) rail infrastructure, (3) proximity to the ports of Charleston and Savannah, (4) proximity to BMW's target market, (5) location of two-thirds of the U.S. motorsports racing teams along the I-85 corridor between Atlanta, Georgia and Charlotte, North Carolina and (6) the inclusion of state and local incentives (including tax credits, abatements, job training allowances, and infrastructure improvements). BMW's location has resulted in an investment of \$4.6 billion in South Carolina.<sup>3</sup> According to a recent economic impact study, BMW has a multiplier effect of 4.3 meaning that for every one job created by BMW, another 4.3 jobs are created for suppliers and related industries.<sup>4</sup>

In early 2000, Clemson's dean of the College of Engineering, Thomas Keinath, approached BMW to be an investment partner in constructing a commercial wind tunnel, the objective of which was to commercialize university research in mechanical engineering related to the auto industry. BMW already had a multimillion-dollar commercial wind tunnel (which can cost \$41 million to construct)<sup>5</sup> in Germany, but discussions between BMW and Clemson continued. BMW was particularly interested in building a local technically trained workforce that could support its operations and future growth, as well as build the capacity for its suppliers to locate nearby. In particular, BMW needed engineers with advanced automotive degrees not currently offered in the United States – these would differ from the traditional mechanical engineering degree, for which Clemson already had an established program, and focus solely on the needs of the automotive industry.

From these discussions came the Clemson University International Center for Automotive Research (CU-ICAR), which broke ground on its first facility, the BMW Information Technology Research Center, in 2003. This center is completely occupied by BMW, where company engineers and Clemson students collaborate to address challenges that face automotive information technology.

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<sup>1</sup> South Carolina Department of Employment and Workforce, Labor Market Information. Source: <http://www.dew.sc.gov/about-lmi.asp>.

<sup>2</sup> South Carolina Works Industry Profile data. Source: <http://jobs.scworks.org/>.

<sup>3</sup> Source: Greenville Economic Development Corporation: <http://www.greenvilleeconomicdevelopment.com/automotive.php>

<sup>4</sup> BMW in South Carolina: *The Economic Impact of a Leading Sustainable Enterprise*. University of South Carolina Moore School of Business. September 11, 2008.

<sup>5</sup> "CU-ICAR wind tunnel viable, but not essential" Clemson University newsroom, October 27, 2006. Source: <http://www.clemson.edu/newsroom/articles/2006/october/windtunnel.php5>

## Organization & Funding

The CU-ICAR facility used an initial \$40 million investment from the South Carolina Department of Commerce to the university (which originated from BMW's tax credits earned from job creation and capital investment). The South Carolina General Assembly adopted the Research University Infrastructure Bond Act in 2004, which granted Clemson a \$70 million award for research infrastructure and facility construction.<sup>6</sup> With \$10 million in matching Centers of Economic Excellence funds from the state, CU-ICAR then secured endowed-chair positions from BMW and Michelin, at \$5 million each, which began the program. Today, CU-ICAR has four endowed-chair positions under Founding Chair and Executive Director Imtiaz Haque. The endowed-chair positions are courtesy of industry partners Timkin, Michelin, and BMW (which has two endowed chairs). The Carroll A. Campbell Jr. Graduate Engineering Center was completed in 2007, and houses the graduate automotive engineering and research programs at Clemson. Funding includes \$50 million from public partnerships and \$200 million from private partnerships. Partner companies have access to the research facilities at no cost.

CU-ICAR is a physical campus of Clemson University, organized under the university's Office of Economic Development and reporting to the Office of the President. The Clemson University Real Estate Foundation (CUREF) is a 501c(3) organization that plays an integral role in the planning and development of the 30,000 university-owned acres across the state, including the 250-acre CU-ICAR property. John Boyette, who has managed CUREF since 2004, has served as interim director of CU-ICAR since December 2011. Suzanne Dickerson, who manages business development for CU-ICAR, regularly interfaces with local economic development groups, the City of Greenville, the state Department of Commerce, and the Upstate Alliance.

## Operation

Three key aspects of CU-ICAR are: (1) its design, (2) joint university-industry research, and (3) practice-based instruction.

**Facility Design.** CU-ICAR was developed with a focus on foreign direct investment. Clemson University President and former architecture professor Jim Barker realized that CU-ICAR's physical design would be crucial in drawing international attention, including the construction of LEED-certified buildings and implementing restrictions and covenants on building construction. The center's design created a collaborative environment, facilitating dialogue and interaction between researchers and industry professionals.<sup>7</sup> Clemson University and CUREF designed a master plan that sectioned the campus into five "traditional neighborhood" phases of development. Phase 1, comprising CU-ICAR's five existing buildings, is nearly complete as of late 2012. As CU-ICAR develops, funds from leases will help move CU-ICAR operations to a self-sustaining funding model.

As of late 2012, CU-ICAR is currently composed of five main buildings:

<sup>6</sup> Non-government matching funds were required to receive funding. Phone interview with John Boyette, July 23<sup>rd</sup>, 2012.

<sup>7</sup> Understanding Research, Science, and Technology Parks: Global Best Practices. National Research Council (U.S.). Committee on Comparative Innovation Policy: Best Practice for the 21st Century, National Research Council, (2009), p. 87.

- **Auto Park and Innovation Place** – Parking facility and central gathering place at CU-ICAR.
- **BMW Information Technology Research Center (ITRC)** – Research and development extension of BMW.
- **The Carroll A. Campbell Jr. Graduate Engineering Center** – Central location for postgraduate studies in automotive engineering.
- **Koyo Bearings/JTEKT Group Collaboration 3 Building** – Koyo Bearings' location for needle bearing design and technology development.
- **Center for Emerging Technologies (CET)** – CU-ICAR's 60,000-square-foot business incubator and startup space and world headquarters for Sage Automotive Interiors.

These buildings house some of the world's most advanced, automotive equipment research and development technology available to Clemson students, including a road simulation and climate test chamber, drive-on vehicle coordinate measurements, an engine performance facility, and machine shop. The services provided by these facilities are offered at a deep discount to industry (partners have use of these facilities at no cost). The sharing of facilities between students and industry further builds the collaborative environment at CU-ICAR.

**Joint University-Industry Research.** CU-ICAR is unique in that professors and graduate students are routinely engaged in research that will benefit the automotive industry, which primarily sponsors the research projects. The Michelin Tweel is one of the more high-profile research projects at CU-ICAR. Faculty and students in the advanced powertrain systems area of research are developing the Tweel, an airless tire that uses a "hub and spoke design," combined with a flexible wheel, to enable more efficient tire performance.<sup>8</sup> Application of the technology is being tested on the NASA lunar wheel. A CU-ICAR graduate team is also collaborating with DiMora Motorcar to develop a new suspension technology that will enable enhanced stability at high vehicular speeds. These types of industry applications further advancements in the auto industry, while providing a synergistic environment for industry and academia.

**Practice-Based Instruction.** The annual Deep Orange program at CU-ICAR provides a studio learning experience for students. The program takes a vehicle from concept to a full-scale, market-ready prototype. CU-ICAR faculty and more than 20 industry partners are involved in this program. Deep Orange allows students to understand issues, including geographic, social, political, and financial matters faced by the automotive industry's original equipment manufacturers (OEMs) and suppliers, an experience not typically gained until after the students have entered the workforce. Deep Orange also allows the industry partners to glean a fresh perspective on vehicle design using the latest available technology at CU-ICAR.

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<sup>8</sup> Michelin. "Michelin Lets the Air Out of Future Tire Innovation," 2005. Source: <http://michelinmedia.com/news/michelin-lets-the-air-out-of-future-tire-innovation/>

## Results to Date

Since its launch, CU-ICAR has expanded from two to 19 on-site partners in five constructed buildings totaling 760,000 constructed square feet. CU-ICAR's newest building, the Center for Emerging Technologies (CET), is a 60,000-square-foot center that provides office, administrative, and laboratory space for the transportation, technology, and energy sectors.<sup>9</sup> Funded in part by a \$3 million grant from the federal Economic Development Administration, the CET will provide office space for companies that want to be close to the OEMs and suppliers but do not wish to lease an entire building. Already 87 percent leased, the new center will complete the link at Clemson between laboratory research and the marketplace, and will attract \$11 million of new investment to the university.

Since its inception in 2003, CU-ICAR has generated more than \$230 million in public and private investments, created some 775 jobs, placed hundreds of Clemson automotive engineering and systems engineering graduates in related industry careers, and helped attract thousands more jobs from CU-ICAR's partner companies and affiliates.

The Greenville area now has more OEMs and first-tier suppliers than Detroit.<sup>10</sup> Overall, international companies employ 107,000 people and have invested more than \$37.3 billion in South Carolina since 1960.<sup>11</sup> BMW alone generates more than \$4 billion in exports, primarily through the Port of Charleston. Nearly two dozen international companies are located at or near CU-ICAR, and the international impact is even greater when considering companies that not only work directly with ICAR, but also those that work with their industry partners to leverage ICAR research. Automotive research through partnership is at the core of CU-ICAR's mission. To date, CU-ICAR has received more than \$130 million in research contributions through various public and private partnerships. Several new research initiatives are on the horizon at CU-ICAR.

Job generation is perhaps CU-ICAR's greatest accomplishment. The synergy of companies and university research has helped to create more than 10,000 jobs in the greater Greenville area.<sup>12</sup> Some of the most recent examples include:

- Bridgestone tire factory in Sumter County that will have 1,600 jobs
- Bridgestone's new 1.5 million-square-foot plant in Aiken County that will have 850 jobs
- ZF Industries in nearby Laurens County that will have 1,600 jobs
- 50 percent increase in production at the BMW facility
- Michelin's expansion of Proterra<sup>13</sup> (a startup zero-emissions bus company)

<sup>9</sup> Source: <http://www.clemson.edu/media-relations/3779>

<sup>10</sup> Using a 500-mile radius around Clemson and Detroit, Michigan. Source: Understanding Research, Science, and Technology Parks: Global Best Practices. National Research Council (U.S.). Committee on Comparative Innovation Policy: Best Practice for the 21st Century, National Research Council, p. 88

<sup>11</sup> "South Carolina Draws International Companies" Bill Lewis. Source: <http://businessclimate.com/south-carolina-economic-development/south-carolina-draws-international-companies>. Accessed July 25, 2012.

<sup>12</sup> Source: Greenville Area Development Corporation, accessed online July 29, 2012. <http://www.greenvilleeconomicdevelopment.com/automotive.php>

In addition, a new American Titanium Works mill, which will be built in nearby Laurens County, will locate research at CU-ICAR with a \$500 million investment. Auto supplier Bosch is expanding its operations in nearby Dorchester County with an investment of \$125 million, creating approximately 300 new jobs. CU-ICAR also is talking with three more major prospects about partnerships.

CU-ICAR had more than 200 students apply to the graduate program in 2012.<sup>14</sup> Of the average 100 students in the program each year, 100 percent are placed in related industry jobs.<sup>15</sup> Many of those jobs are retained in South Carolina, as 44 percent remain in the state. The United States retains 90 percent of the ICAR jobs that leave the state, with only 10 percent going overseas. CU-ICAR's partners, including Staubli Corporation, BMW, Automation Engineering Corporation, Altair, and the Mazda Corporate Foundation, have also contributed to scholarships and fellowships for outstanding CU-ICAR students. Building on CU-ICAR's automotive focus, five technical colleges have collaborated to offer automotive engineering-related programs in the Upstate region of South Carolina. The South Carolina Technical College System's Division of Economic Development and Workforce Competitiveness also offers a complementary training program, ReadySC, that provides free pre-employment training to new and expanding companies that create permanent, high-quality jobs in the state's industry clusters.

## Lessons Learned

Several factors have contributed to CU-ICAR's success. CU-ICAR has a critical mass of companies drawn to the campus from initial partnerships with BMW, Michelin, and Timkin. Word travels fast in the industry, and companies that look to build relationships with a company like Michelin would likely want to be located nearby. The access to considerable resources in one place functions much like a city center for the industry. These companies range from established manufacturers to startups, and CU-ICAR provides the work environment for companies in various stages of their life cycle. CU-ICAR listened to what the industry wanted and created the academic niche on the research side and in the job market for the auto industry's future workers.

The CU-ICAR model is replicable around state research universities and target industry clusters. South Carolina is currently replicating the model with the aerospace industry cluster in Charleston, with Boeing and Clemson as partners. Research at Clemson's Advanced Materials Center in Anderson is primarily focused on the auto industry, but there is also crossover in aerospace. In partnership with Clemson, the South Carolina Research Authority built an Applied Research Innovation Center adjacent to the Charleston International Airport where startup companies will bring new advanced materials to the aerospace market.<sup>16</sup>

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<sup>13</sup> Phone Interview with John Boyette, July 23, 2012. The South Carolina Department of Commerce ranked Proterra its top economic development achievement of 2010. Source: 2010 – 2011 CU-ICAR Annual Report, accessed online: [http://media.clemson.edu/cuicar/CUICAR\\_10\\_11\\_Report\\_Print.pdf](http://media.clemson.edu/cuicar/CUICAR_10_11_Report_Print.pdf)

<sup>14</sup> Phone Interview with John Boyette, July 23, 2012.

<sup>15</sup> In 2010, there were 107 graduate students and nine faculty members in the program. Source: 2010 – 2011 CU-ICAR Annual Report p. 13, accessed online: [http://media.clemson.edu/cuicar/CUICAR\\_10\\_11\\_Report\\_Print.pdf](http://media.clemson.edu/cuicar/CUICAR_10_11_Report_Print.pdf)

<sup>16</sup> South Carolina Research Authority. Source: [http://www.scra.org/scra\\_applied\\_research\\_center.html](http://www.scra.org/scra_applied_research_center.html)

Clemson took a risk by placing its bets on the auto industry, but it has resulted in a program that benefits the university, companies in the auto industry, and the state. Through these partnerships, CU-ICAR has become a premier research and development facility for the industry, as well as a place where the auto industry's future workforce can gain valuable hands-on skills. While CU-ICAR's beginnings can be traced to BMW's decision to locate in South Carolina, its success in attracting additional foreign direct investment has been generated by the university's willingness to reach out, listen, and respond to the needs of potential partners for the betterment of economic development in the state.

## Milestones

Year	Milestone
1992	BMW chooses a site along I-85 in Greer, South Carolina for its U.S. manufacturing plant.
1994	BMW opens its manufacturing plant.
2000	Clemson University's dean of engineering approaches BMW to explore the possibility of an industry-university partnership for constructing a commercial wind tunnel.
2003	BMW Information Technology Research Center launched.
2004	South Carolina General Assembly adopts the Research University Infrastructure Bond Act, allocating \$217 million across three state research institutions, including \$70 million to Clemson.
2006	CU-ICAR officially opens.
2007	Carroll A. Campbell Jr. Graduate Engineering Center building within CU-ICAR opens.
2008	BMW announces a second assembly plant, a \$750 million investment that includes a 300,000-square-foot addition and a 1.2 million-square-foot flexible assembly second plant.
2010	Clemson University creates the Department of Automotive Engineering, diverging from the Department of Mechanical Engineering; program staff includes 11 professors as of 2012.
2011	CU-ICAR's newest building, the Center for Emerging Technologies, opens.
2011	BMW announces a \$100 million investment in its Upstate assembly plant.

## References

CU-ICAR website: <http://www.cuicar.com/>

Deep Orange website: <http://www.cuicardeeorange.com/>

### Interview with John Boyette

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