Developing Engineering Talent for the Automotive Industry: A Case Study

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Executive Director and Founding Chair
Department of Automotive Engineering
Clemson University

- South Carolina’s Land-Grant University
- Focused on Engineering and Agriculture
- Founded 1889
- 19,000 + students
Located in the Heart of Automotive Manufacturing in South Eastern United States of America

More than 1,000 Automotive Assemblers & Suppliers are within a 500-mile radius of CU-ICAR location.

Source: Upstate Alliance
Clemson University International Center for Automotive Research

250 Acres

Academic Programs in each sector surrounded by industry

$220 Million in investments

The Campus

250 Acres

Bus Rapid Transit (BRT)

Millennium Blvd.

Timken Technology Center

Campbell Graduate Engineering Center

Innovation Place

BMW ITRC

Interstate 85

Laurens Road

Innovation Drive

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The Idea: An NAS Top 5 Global Best Practice

I. EDUCATION
Top-10 exceptional graduate curriculum in automotive engineering

II. RESEARCH
Breakthrough applied research conducted in world-class labs

III. ECONOMIC DEVELOPMENT
Award-winning 250-acre technology research campus

IV. MAGNET VENUE
Hot spot for regional, national and global automotive and manufacturing events
How? A Public/Private Partnership

CLEMSON UNIVERSITY

SOUTH CAROLINA DEPARTMENT OF COMMERCE/LOCAL AND REGIONAL ECONOMIC DEVELOPMENT PARTNERS

PRIVATE SECTOR

Companies with a strategic interest in automotive/motorsports research, development, education or advanced manufacturing
Faculty Structure

| BMW Chair in Manufacturing | BMW Chair in Systems Integration | Timken Chair in Design and Development | Michelin Chair in Vehicular Electronics |

Other Faculty, Adjunct Faculty, Post-doctoral Students, Visiting Professors
Cutting Edge Graduate Programs targeted to the Auto Industry

MS in Automotive Engineering
Started August 2007
– 42 credits (30 Engineering, 6 business, 6 internship)

Ph.D. in Automotive Engineering
– Started August 2006
– First program in US
– First Ph.D. graduate in US
– Required technical and business minors

• Graduates to Date: 11 PhDs and 92 MS
• Current Enrollment: 192 students
A Central Theme: Systems Integration

- Vehicle Infrastructure
- Energy Infrastructure
- Transportation Infrastructure
- Information Infrastructure
- Human-Machine Interface
- Human Operator
Research Areas

- Advanced Powertrains
- Manufacturing and Materials
- Vehicular Electronics and IT
- Vehicle – Infrastructure Integration
- Vehicle Platform Integration
- Vehicle Performance
- Human-Vehicle Interface
The Educational Challenge

- The design, manufacture and effectiveness of modern road transportation require the integrated application of concepts in disciplines ranging from engineering and information technology to business and behavioral sciences.

- Challenges and opportunities arise from advances in enabling technologies amid the myriad of often conflicting and ever-changing public regulations and policies.

- The rate of market change has increased dramatically challenging product development speed and innovation cycles. It is increasingly difficult to forecast and integrate future product requirements into new products and services.

The industry is in dire need of a workforce that can master/lead this process.
Preparing the 21st Century Automotive Engineer

• Tomorrow’s engineering leader will need to combine deep knowledge of a particular field with the breadth to place it in context.

• They will need to collaborate with many other industries as well as with colleagues whose perspectives are shaped by radically different experiences.

• They will need to understand systems, cultural, societal and political forces, will need to tackle complex problems, and will need to be thoughtful about the lifecycles of their work and production.

Adaptation from “5 Minds for the Future” by Prof. Howard Gardner
Creating the Educational Program

- Extensive input from industry
  - OEMs
  - 20 tier-one, tier two suppliers

- Sustained input through an industry advisory board

- Engaging qualified industry professionals for teaching

- Required industry internship programs

- Feedback and continuous improvement
Creating the Engineer of Tomorrow: Our Philosophy

- **Immerse** students in a setting that resembles the daily business of their future work environment at an automotive OEM or supplier.

- Set up a 2-year **capstone project** where study meets the (future) workplace addressing a practical, real world challenge using the skills and knowledge that students have gained throughout their program of study.

- Give the students **hands-on experience** with vehicle design, development, prototyping and production planning from their first day in the automotive engineering program until graduation.

- Establish a close **collaboration** between the **industrial and academic sectors**.

- Focus on **leapfrogging** the latest vehicle technologies by eliminating the constraints and legacy issues that have pervaded the automotive industry.
Combining both Academic and Industry Aspects

The industry participation is crucial and serves multiple purposes:

• Provide realistic problems and challenges that address current and future (industry) issues,
• Give access to new innovations, materials, technologies and processes,
• Mentor students during regularly scheduled meetings.
• Provide critical feedback on the (intermediate) results of the various tasks and recommend different approaches,
• Provide crucial background information on subject matter often not accessible in an academic setting, and
• Fund the overall program.
Linking Research, Development, Education & Collaboration

**Research**
- Market/Value Assessment
- PhD Students
  - Emphasis on idea generation and securing Intellectual Property.

**Development**
- Internal Concepts
  - "THE GATEWAY"
- Validation
  - "THE GATEWAY"
- MS Students
  - Emphasis on maturing, integration & realization.
  - Showcase technology.

**Faculty Oversight**
- Industry Participation
- Industry Mentoring

**External Industry Concepts**
- Proven Concepts and Methods
- Proven People

**Industry Participation**
- PhD Students
  - Faculty Oversight
The Importance of Creativity in Engineering Education: Collaboration with the Arts Center
“I was blown away by the tremendous possibilities and designs out there in the world that you can draw into the automobile production”

“It helped us understand that, aesthetics is also the responsibility of automotive engineers and not just artists”

“This workshop was one of the most constructive learning experiences I’ve ever been involved in”

“I was amazed by the kind of things I could imagine or infer from simple pictures”

“Helped us think ‘outside the box’!”
Deep Orange: A Vehicle Prototyping Program for Education and Research

Market Analyses
Start: Day 1

Annual new Prototype Vehicle releases from two-year Development Cycles

An integral feature of MS/PhD Research & Education Programs

Product Design & System Integration
Day 193

Validation
End: Day 712

Manufacturing
Day 523
Automotive Engineering (MS) Curriculum

Semester 1
- AuE 880 Product Design Overview
- AuE 881 Automotive Systems & Functions
- AuE 833 Manufacturing Overview
- AuE 835 Vehicle U/E Systems & Functions

Semester 2
- AuE 816 Combustion & Emissions
- AuE 847 Suspension Design
- AuE 850 Stability & Safety Systems
- AuE 887 Vehicle Testing
- AuE 817 Alternative Energy
- AuE 882 Integration Concepts & Architectures, Methods

Internship

Semester 3
- AuE 849 Chassis & Body Design
- AuE 827 Vehicle Control Systems
- AuE 828 Driveline Dynamics
- AuE 877 Lightweight Engineering
- AuE 893 Advanced Engines
- AuE 883 Applied Systems Integration
- AuE 826 Diagnostics & Prognostics
- AuE 886 Vehicle NVH
- AuE 853 Vehicle Crashworthiness
- AuE 867 Manufacturing Process
- AuE 893 Quality Systems
- AuE 832 Development

Industry Mentoring

Under Development
Automotive Engineering MS Curriculum

DELIVERABLE:
Every student to produce an evidence book documenting all integration steps and including all quality documents that any OEM would require for technology acceptance.
Incorporating Market Changes

**Gen-Y Cool**
- Affordable
- Efficient
- Connective
- Customizable
- Modular Design
- Low RR-tires
- Integrated Electric Drive
- No paint shop
- New Joining Technologies

**Future Family Vehicle**
- Efficient (CAFE)
- Affordable
- Safety
- Interior/cargo capacity
- Lightweight engineering
- Low-Cost AWD
- ...

**Scalable Dual Use Vehicles**
- Reconfigurable
- Lightweight and Low-cost
- Adapts for changing combat environments
- Fuel-flexible propulsion
- Platform architecture
- New joining technologies
- Rapid/compact manufacturing
- Titanium-based lightweight armor
- ...

Annual, evolving Showcases for Focus Areas, CU-ICAR/Partner innovations, and Supplier technologies
Involving Industry
The Infrastructure

• Unique facilities/capabilities

  – Access to Michelin Laurens Proving Ground
  – In-house Test Cells at CGEC
  – Capabilities for test planning, instrumentation, data acquisition and reduction
  – Engineering Services
Example: Generation-Y Concept Vehicle
Pilot Project Chronology

- **Pilot Project Start**: April 2009
- **Donor Vehicle Benchmarking**: August 2009
- **Design/Engineering Convergence**: March 2010
- **Simulation**: August 2010
- **Paint Shop**: June 2010
- **Graduation**: August 2010
- **SEMA 2010**: November 2010
- **LA Auto Show 2010**: November 2010
Create Desirability for Generation Y (Why Buy?)

Seamless integration of Smartphone based on open source architecture

Emissions-free driving and best in class fuel economy

Safe and comfy seating

Great styling

Source: Adam Stubblefield, Trevor Turner, Clemson University, January 2009
Deep Orange 1 Industry Partners
Major Deep Orange 1 Features

Extended Range Electric Powertrain concept with full functional, geometrical and production integration incorporating competing properties such as energy efficiency, performance, noise, vibrations, safety, and durability.

Electric Energy Storage System with enclosure engineered on the basis of Industrial Origami innovation, a low-cost, low investment metal forming innovation.

Novel seating concept that achieves both lighter seating system while improving occupant safety. Seat attachment architecture based on mounting the seat’s backrest to both roof and floor of the vehicle.

Open-architecture Android based infotainment integration relying solely on a portable Smartphone device in combination with a cloud storage concept. Top quality audio integration.
Deep Orange Deliverables: CU-ICAR

- Range Extended Electric Vehicle
- Energy Storage and Traction Motor
- Smartphone Integration with HMI
- Roof Suspended Seating Concept
- Origami-Style Battery Enclosure
- Final Assembly
Deep Orange Deliverables: Art Center College of Design

Exterior Design Model (1:1 scale)

Interior Buck (1:1 scale)
Creativity
Making Design Features Work
Holistic View on Geometry, Functions and Materials
Systems Integration (Energy Storage System)
Struggling with Engineering Alternatives
Design for Safety and Durability

Failure stress = 450 N/mm²
Design for Assembly
Packaging: Reality Check
Mechanical Engineers Overcome Electrical Challenges
Industry Partners: Learning from the Masters
Theory vs Practice

Leadership

Collaborative Learning

Problem Solving

Putting it all together
Documentation

Full project description on about 1000 pages
At the End of the Day: Professional Validation
SEMA Las Vegas, November 2010
Los Angeles Auto Show, November 2010
Demand for Alumni

“There is a war for talent in our industry,” Original Equipment Supplier Association president and CEO Neil De Koker said at the 2012 Automotive News World Congress in Detroit.

The primary issues of skills and workforce flexibility are key to sustainable success in the automotive industry. Both OEMs and suppliers will have to plan for a future that requires ever more-skilled workers from design to production. Tomorrow’s engineers will need to understand systems, tackle complex problems and be cognizant of the life cycle impact of their work and production, all while understanding cultural, societal and political forces.

CU-ICAR is meeting that demand today.

Contributing to automotive companies such as ...
Thank you!