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Use of Advanced Vehicle Technology Competitions to Engage, Educate, and Retain Collegiate Students in the Hybrid Vehicle Field

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Abstract

For over two decades the Argonne National Laboratory has coordinated a series of Advanced Vehicle Technology (ATV) competitions, co-sponsored by the Department of Energy, to engage, educate, and retain college students for the automotive and associated technology sectors. The previous competition, Challenge X, challenged 17 North American Universities to design, build, and test a hybrid powertrain using alternative fuels for a 2005 Chevrolet Equinox to decrease well-to-wheels petroleum usage and emissions production while maintaining stock performance, utility, and safety. The current competition, EcoCAR, repeats the challenge for a 2009 Saturn Vue. This paper provides a background on the AVT competitions and emphasizes the scope of impact they have had on engaging, educating, and retaining students in the hybrid vehicle field. Examples of engagement, education, and retention are provided by an EcoCAR participating university and two competition sponsors which are reinforced with student testimonials.

Keywords: alternative fuel, HEV, modelling, simulation

1 Introduction

For the last 21 years, the Department of Energy (DOE) has co-sponsored Advanced Vehicle Technology (AVT) competitions with organizational support provided by Argonne National Laboratory (ANL). They began as a series of Alternative Fuel (AF) competitions in 1989 challenging student teams to reconfigure a production vehicle to run on methanol (1989-90), natural gas (1991-93), propane (1996-97), and ethanol (1998-99). A hybrid electric vehicle (HEV) track was initiated in 1993 with three years of the Hybrid Electric Vehicle Challenge with Ford, Saturn, and Chrysler sponsoring each yearlong competition. Four years of FutureCar followed with joint support from the Big Three through the Partnership for a New Generation of Vehicles (PNGV) challenging students to triple the fuel economy of a 1995 Dodge Intrepid, a 1996 Chevrolet Lumina, or a 1996 Ford Taurus to over 80 mpge. The competition goals ramped up substantially in 2000 with the first FutureTruck competition co-sponsored by General Motors. Fifteen top North American colleges were challenged to design and implement hybrid electric powertrains to decrease the pump-to-wheels petroleum consumption and the well-to-wheels

emissions production without sacrificing performance, utility, and safety. The second FutureTruck competition was co-sponsored by Ford Motor Company, providing a Ford Explorer platform, with fifteen North American schools challenged to meet the same rigorous competition goals including well-to-wheels petroleum consumption and a requirement to use alternative fuels.

The fourth version of the competition, Challenge X, was co-sponsored by General Motors with the previous competition expectation level elevated to that of a production vehicle design process to redesign a 2005 Chevrolet Equinox. Seventeen North American schools were selected to follow the GM Global Vehicle Development Process (GVDP) which emphasized component and system modeling during year one, a working mule vehicle for year two, and a prototype vehicle for year three. The competition was extended to a fourth year with a focus on durability and outreach with east and west coast road rallies serving as the culminating event. Technical events in mathematical modeling, virtual instrumentation, and use of embedded silicon complemented the legacy dynamic vehicle events.

The current competition, EcoCAR, again challenges seventeen North American schools to redesign a 2009 Saturn Vue again following the GM GVDP. A greater emphasis on model-based system design (MBSD), software-in-the-loop (SIL), and hardware-in-the-loop (HIL) is evident in the current first year of completion with the mule and prototype vehicle requirements yet to be determined.

The goal of these 21 years of AVT competitions has been to accelerate the development and demonstration of technologies of interest to DOE and the automotive industry, help prepare the market to accept advanced vehicle technologies, and ***to provide the automotive industry with a new generation of engineering leaders with highly desirable experience***. More than 11,000 students from over 85 schools have participated in the 13 distinct AVT competitions, resulting in a tremendous impact in the automotive and manufacturing field [1].

2 AVT Challenge X Highlights

To exemplify the breadth and depth of student engagement, education, and retention through AVT competitions, yearly summaries of the Challenge X competition, in the form of internet press releases through ANL, are presented. Participating schools included include Michigan Technological University; Mississippi State University, The Ohio State University; Pennsylvania State University; Rose-Hulman Institute of Technology, San Diego State University, Texas Tech University; University of Akron; University of California, Davis; University of Michigan; University of Tennessee; University of Texas at Austin, University of Tulsa, University of Waterloo, University of Wisconsin-Madison; Virginia Tech; and West Virginia University.

2.1 Challenge X : Year 1

The University of Waterloo won first place in Year One of the Challenge X: Crossover to Sustainability competition at the General Motors University in Auburn Hills, Mich. Challenge X is a three-year-long competition to minimize energy consumption and reduce emissions of hybrid vehicles while maintaining performance. The Canadian team's winning design integrated a nickel-metal hydride battery with a hydrogen fuel cell.

The competition, sponsored chiefly by General Motors Corporation (GM) and the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy FreedomCAR and Vehicle Technologies Program through Argonne, challenged 17 universities in the United States and Canada to simulate a design for a hybrid vehicle in one year. Each school met GM's requirements and is working to integrate their unique drive systems into a 2005 Chevrolet Equinox. Designs ranged from reformulated gasoline hybrids to hydrogen fuel-cell hybrids. The University of Akron took second place with a biodiesel hybrid built from a 1.9-liter Volkswagen engine. In third place was Ohio State University with a biodeisel hybrid design using a Fiat engine.

"The impressive applied technologies that I have seen have come from students' creativity and design, said Steve Gurski, lead technical coordinator of the Challenge X program at Argonne.

The competition is meant to simulate the real-world vehicle design process, beginning with computer modeling, then integration of a design into a vehicle before testing and refinement. Argonne's Powertrain System Analysis Toolkit (PSAT) was integral in the simulations used to determine feasibility of students' drivetrain systems. PSAT is a previous winner of *R&D Magazine's* "100 most technologically significant new products award.

"General Motors views this program as a way to cultivate new engineers capable of getting the most energy output from 'well to wheels,' the term for the amount of energy required to extract, refine and burn fuel, said Bob Larsen, director of Argonne's Center for Transportation Research.
The collaborative effort that GM is making involves the U.S. and Canadian governments as well as a host of industry sponsors including BP, Michelin, LG subsidiary Ballard Power Systems and 30 other sponsors.
Challenge X follows in the footsteps of FutureTruck, another DOE- and Argonne-sponsored competition, in its multiyear approach. "In past," Gurski said, "students had one year to make significant improvements on the vehicles once the competition was over. What we expect to see in three years of refinement is some fantastic vehicles. [2]

2.2 Challenge X : Year 2

A student team from Virginia Polytechnic Institute and State University won the second-year *Challenge X: Crossover to Sustainable Mobility*, a three-year engineering competition designed to improve the fuel efficiency and reduce the environmental impact of a 2005 Chevrolet Equinox. The Virginia Tech team developed and built a hybrid version of the Equinox that uses two electric motors and runs on E85, a fuel blend containing 85 percent ethanol and 15 percent gasoline. The Virginia Tech vehicle also exhibited the best braking and handling, the lowest tailpipe emissions, and the lowest petroleum usage. The U.S. Department of Energy (DOE) and General Motors Corporation (GM) are the lead sponsors for Challenge X, in which 17 teams of North American engineering students are participating. Argonne manages the competition every year.
Other teams that placed at the top in the competition include University of Wisconsin-Madison (second place), Mississippi State University (third place), Ohio State University (fourth place), Pennsylvania State University (fifth place), and University of Tennessee (sixth place).
Like Virginia Tech, most of the teams in this year's competition used a combination of hybrid technology and alternative fuels, filling their tanks with E85, B20 (a diesel blend containing 20 percent biodiesel), or hydrogen. For example, the University of Wisconsin-Madison students designed a through-the-road parallel biodiesel electric hybrid with a diesel 1.9-L turbo-charged engine. The Mississippi State University team developed a split-parallel, through-the-road hybrid electric vehicle that runs on B20 biodiesel.
Deviating from the pack was the University of Waterloo, which employed a hydrogen fuel cell. While Virginia Tech and most other teams drew on a nickel-metal-hydride battery for their power supplies pack (the same type used in today's hybrids), the University of Akron also added ultracapacitors, and West Virginia University's power supply came from ultracapacitors alone. Two teams employed lithium-ion battery packs, while the University of Michigan-Ann Arbor forsook electrical storage, and instead employed a hydraulic system to store the vehicle's mechanical energy.
The first year of Challenge X, which began in 2004, focused on vehicle simulation and modeling and subsystem development and testing. In years two and three, students integrate their advanced powertrains and subsystems into the Chevy Equinox. The final competition will be held at the end of the 2007 academic year.
"The demonstration of performance and realization of vehicle designs in this year of Challenge X was phenomenal," says Argonne's Steve Gurski, Lead Technical Coordinator – Challenge X. "Testing in record temperatures in the Phoenix area challenged the student teams to their limits, and they were able to rise to the occasion. Year two of Challenge X utilized cutting-edge vehicle testing technologies such as on-road emissions that will be the basis of future competition emissions testing. If the fantastic results of year two are any indication, year three of Challenge X will be truly spectacular." [2]

2.3 Challenge X : Year 3

The third year of the four-year, Argonne-managed Challenge X collegiate engineering competition came to a close on June 7, 2007, with Mississippi State University taking top honors. Staff and engineers from Argonne National Laboratory have managed Challenge X and its predecessor competitions since the Department of Energy (DOE) first began holding them in the early 1990s.
In the current year's competition, the Mississippi State team was among 17 universities from across North America that have re-engineered a 2005 Chevrolet Equinox crossover SUV using advanced propulsion technologies that increase fuel efficiency and reduce environmental impact, yet retain its consumer appeal.
The Mississippi State team designed a through-the-road parallel hybrid electric vehicle with a 1.9-liter

GM direct injection turbo diesel engine fueled by B20 biodiesel. It achieved a 48% increase in fuel economy over the production vehicle. The second place vehicle, engineered by students at the University of Wisconsin-Madison, is also a through-the-road parallel biodiesel electric hybrid design with a 1.9-liter GM diesel turbocharged engine that runs on B20. Virginia Tech was awarded third place overall with a split parallel hybrid architecture that runs on E85 ethanol with a 2.3-liter turbo spark ignition engine.

"Developing more energy-efficient and 'greener' automotive technologies has become a global priority," said John F. Mizroch, Principal Deputy Assistant Secretary, U. S. Department of Energy's Office of Energy Efficiency and Renewable Energy. "Students competing in Challenge X are on a quest to deliver environmentally friendly, functional and fuel efficient vehicles that consumers want to buy."

Larry Burns, vice president of GM Research and Development and Strategic Planning, said advanced powertrain technologies and alternative fuels play a key role in GM's overall strategy to help decrease the nation's dependence on petroleum and reduce greenhouse gas emissions. "The vehicles developed by the Challenge X teams are right in line with GM's strategy and thinking," said Burns. "The real-world training you have gained though this program has given you invaluable engineering experience that has made you very marketable to the industry. In fact, GM has already hired 40 students from the first two years of the competition, and we intend to extend several offers at the conclusion of this year's program."

Other Challenge X sponsors, including Caterpillar, National Instruments, Freescale Semiconductor, Johnson Controls, and MotoTron, also have hired students out of the program.

Challenge X is a unique engineering competition that is providing 17 university teams from across North America the opportunity to follow the GM Global Vehicle Development process and develop advanced propulsion technology solutions that will increase energy efficiency and reduce environmental impact. The teams are using a variety of alternative fuels including biodiesel (B20), ethanol (E85), reformulated gasoline and hydrogen.

Here are some additional highlights of the Challenge X vehicles:

- Twelve teams are using biodiesel fuel (B20).
- The University of Waterloo has a dedicated hydrogen fuel cell for its primary propulsion source, and as a result, their vehicle emits zero emissions from the tailpipe. The team is using compressed hydrogen.
- Three teams — Pennsylvania State University, Texas Tech University and the University of Tulsa — are using hydrogen as a supplementary or secondary propulsion source. Penn State is injecting hydrogen into their vehicle's diesel engine as an emissions abatement strategy. The Texas Tech and Tulsa teams are using hydrogen to power auxiliary systems or their vehicles.
- The University of California at Davis is the only team to use plug-in hybrid technology for the energy source within their Challenge X vehicle. Their vehicle has an all-electric range on battery power.
- The University of Michigan Challenge X team has developed a hydraulic hybrid, which stores pressurized fluid in large tanks from which the vehicle can extract or store energy much like a battery electric hybrid stores energy recovered from regenerative braking. Their vehicle also uses the electrical energy to propel the vehicle on electric-only power.
- Two teams, Ohio State University and Virginia Tech, are using belt alternator/starter technology for an electric performance assist in their vehicles.
- West Virginia University and the University of Akron are using ultracapacitors to source high levels of power for short periods of time and still recapture energy from braking Ultracapacitors are more robust than batteries and can source more energy in operations, but cannot store as much energy as a traditional battery.
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The first year of the Challenge X program, which began in 2004, focused on vehicle simulation and modeling and subsystem development and testing. In years two and three, students have been integrating their advanced powertrains and subsystems into the Chevrolet Equinox. In the fourth year, students will focus on customer acceptability and over-the-road reliability and

durability of their advanced propulsion systems with real-world evaluation outside of the laboratory and proving ground environment.[2]

3 Rose-Hulman Involvement

Rose-Hulman Institute of Technology (RHIT) is a private, undergraduate college of engineering, science and mathematics located in Terre Haute, Indiana. Ranked number one in undergraduate engineering education for the last ten years in a row, ***RHIT is focused on cultivating the next generation of engineers and scientists through rigorous academics and experiential learning***. RHIT participated in Challenge X and has continued on to EcoCAR with the vision of engaging, educating, and retaining engineers in the advanced transportation and sustainable mobility fields. [3]

3.1 RHIT : Engagement

Over the last five years of AVT involvement, over 90 students have been involved with the Challenge X and EcoCAR teams. The team used numerous outreach activities to attract students to Rose-Hulman including radio and TV interviews, visits to high schools, and serving as a focal point for campus visits. As a result, 17% of this year's freshman class of 520 students cited Challenge X as being the reason they came to Rose-Hulman

3.2 RHIT : Education

Rose-Hulman has embraced the model-based system design philosophy and partnered with Freescale, The MathWorks, and Mototron to develop a revolutionary MBSD laboratory at a cost of $675,000. Two courses, introductory and advanced, have been developed and are the two core courses for the Advanced Transportation Certificate.

The introductory course focuses on a simple electric genset with a light bulb load. Keeping the physics simple allows students to focus on the MBSD process. They begin with simple physical models and control strategies, developed as software in the loop (SIL) using products from The MathWorks including Matlab, Simulink, and Stateflow. Using automatic code generation, a real-time target is created and explored via xPC. The controller is then, again using auto-code generation, placed on the Freescale development target and connected to the physical system. Students then perform verification and validation of the models and controller.

The advanced course builds upon the modeling skills developed in the introductory course. A series electric vehicle serves as the more complex system with a substantially more complicated controller. The system is developed in software, targeted to xPC, and then to the Freescale development board as in the previous course. Two Mototron production controllers are then employed with one housing the plant model, the other the controller. CAN communication is established between the two and a physical PRNDL, accelerator, and brake (breadboard switches and knobs) is used to verify the controller. The software side of this course has been successfully packaged as a two-day technical short course.

A third course, Introduction to Hybrid Vehicle Modeling, is currently under development.

3.3 RHIT : Retention

The RHIT CX team has had four alumni go directly into hybrid vehicles with General Motors. Students have also joined Caterpillar, Cummins, Delphi, NAVSEA-Crane, Rockwell-Collins, and Southwest Research Institute working in advanced vehicle technology areas.

4 Freescale Involvement

4.1 Freescale : Engagement

Freescale provides an unparalleled portfolio of power management solutions, microprocessors, microcontrollers, sensors, radio frequency semiconductors, analog and mixed signal circuits and software technologies which are embedded in products used around the world. Freescale's rich history of embedded solutions goes back more than 50 years when they were a part of Motorola. Today, as an independent company, Freescale is headquartered in Austin, Texas, operates in more than 30 countries with 24,000 employees. The Freescale University Program provides educators and students with the resources needed to succeed in classroom environments. ***Freescale's goal is to ensure universities have the latest technologies prominently used in industry*** by offering hardware kits, software development tools, easy to find references to textbooks, courseware, and technical information. Freescale has also served as a platinum level sponsor of the Challenge X and EcoCAR AVT competitions as well as supporting twelve University Partner Labs in North America of which Rose-Hulman is one. [4]

4.2 Freescale : Education

The partnership between RHIT and Freescale in developing the Model-Based System Design Lab will be tremendous. For RHIT, students will be given the opportunity to become proficient on Freescale technologies and be highly marketable to industry. For Freescale, the lab can be used for industry customer training and at the same time provide RHIT students and faculty to the same training and access to industry.

4.3 Freescale : Retention

Freescale will continue to build our relationship with Rose-Hulman Institute of Technology by supplying semiconductor development tools that keep the Model-based Systems Design Laboratory up-to-date with the latest technology innovations from Freescale.

5 The MathWorks Involvement

The MathWorks is the leading developer of mathematical computing software. MATLAB, the language of technical computing, is a programming environment for algorithm development, data analysis, visualization, and numeric computation. Simulink is a graphical environment for simulation and Model-Based Design of multi-domain dynamic and embedded systems. Engineers and scientists worldwide rely on these product families to accelerate the pace of discovery, innovation, and development in automotive, aerospace, electronics, financial services, biotech-pharmaceutical, and other industries. ***MathWorks products are also fundamental teaching and research tools in the world's universities and learning institutions***. Founded in 1984, The MathWorks employs more than 2100 people in 15 countries, with headquarters in Natick, Massachusetts, USA.[5]

5.1 The MathWorks : Engagement

Student competitions provide a unique opportunity for industry and academic institutions to collaborate in encouraging engineering students to bridge the gap between theory and practice while addressing industry-specific needs. By sponsoring EcoCAR, The MathWorks is able to recruit from and encourage an enthusiastic pool of engineering graduates with hands-on experience and enhanced skills and knowledge. By mentoring and training contestants, makers of engineering tools can cultivate longtime champions of their products.

5.2 The MathWorks : Education

While previous student engineering competitions focused primarily on hardware modifications, EcoCAR includes a unique focus on modeling and simulation, as well as subsystem development and testing. In today's society, green technologies and industries are garnering more attention and financial backing, and EcoCAR focuses on developing students and technologies that will advance this field. The goal of the competition is to reduce the environmental impact of vehicles by minimizing the vehicle's fuel consumption and reducing its emissions while retaining the vehicle's performance, safety and consumer appeal. With green technologies poised to be the fastest-growing industry in the nation, EcoCAR is an important opportunity for The MathWorks to test and demonstrate how these tools can be used in this field.

5.3 The MathWorks : Retention

Through its support of EcoCAR, The MathWorks provides a group of Senior Automotive Consultants who serve as mentors to each team, providing expertise and product support through all three years of the competition. In addition, The MathWorks will donate more than $1 million in software, funding, and training to the EcoCAR teams. By sponsoring EcoCAR, The MathWorks realizes its mission of support for math and science educational endeavors, fostering growth opportunities for those who will make contributions and discoveries now and in the future.

6 Student Biographies

Following are three biographies from students who participated in ANL coordinated ATV competitions who have entered the HEV field and continue to contribute to the advancements of those technologies and support the competitions from which they matriculated. These testimonials have collected from ANL and are available for public dissemination.

6.1 Cindy Svestka

After earning a Bachelor’s degree in Mechanical Engineering from Utah State University in 1998 and participating in student vehicle competitions while in college, Cindy Svestka went to work at Argonne National Laboratory on the Advanced Technology Vehicle Competition program, in which EcoCAR is the latest project.

After two years at Argonne, Cindy joined the General Motors team in 2000. Cindy spent her first four years at GM in the Fuel System Group and eventually taking on the role of lead design engineer on the launch of the Ethanol (E85) flex-fuel systems for the full-size Pick-up and SUV applications. In 2004, Cindy took over responsibility for the Energy and Drive Quality performance of the Chevrolet HHR. After seeing that program successfully through its launch, Cindy joined GM's Hybrid vehicle group where she worked on meeting fuel economy and vehicle performance targets for the 2009 Saturn Vue Two-Mode Hybrid program.

Cindy completed a Master's of Science in Engineering from Purdue University in 2006. In August of 2007, Cindy took on the role of Executive Technical Assistant and Business Process Manager for GM's Powertrain/Vehicle Integration group.

Throughout her time at GM, Cindy has remained active in supporting the ATVC program, supporting the 2001 FutureTruck competition and serving as the GM Technical Lead for Challenge X in 2005 and 2006. She continues to support these programs as a member of the Steering Committee for EcoCAR: The NeXt Challenge.

6.2 Forrest Jehlik

In his junior year of studies at the University of California-Riverside, Forrest Jehlik was approached by one of his professors and asked if he would be interested in leading a student team to develop a propane powered vehicle for student competitions. Forrest, an environmental engineering student who had grown up riding motorcycles and working and restoring classic cars had no choice in the answer- it was simply in his blood.

Following the 1997 Propane Vehicle Challenge, Forrest returned his senior year to head the 1998 Ethanol Vehicle Challenge team, where he slept little and learned the true value of a pot of coffee. In between finals and exams and labs, the amazing experiences Forrest had with the Advanced Vehicle Technology Competitions (AVTC's) took that Southern California student through Texas, Chicago, Detroit, and on to Washington DC, where he was given the opportunity to speak at the then newly opened Ronald Reagan center in front of the 1998 Clean Cities Conference. Although always interested in cars and engines, this experience cemented his future and passions in transportation and the automotive industry.

Following his undergraduate experiences, Forrest received his graduate degree in Mechanical Engineering from the University of Wisconsin-Madison, completing his thesis at Engine Research Center. He then worked five years at General Motors in both research and development and powertrain, even spending some time in Italy through a joint engine research program. At GM, he ultimately served to develop an advanced diesel combustion system, a production version slated for the new 4.5L Duramax engine. That work lead to numerous patents and publications. Following his GM tenure, he was hired by Argonne National Laboratory as the Technical Coordinator of the Advanced Vehicle Technology Competitions in July of 2005, bringing him close to the roots that started his career, where he served to technically support Challenge-X. He has since moved to Argonne National Laboratory's Advanced Powertrain Research Facility (APRF) where he studies and benchmarks advanced powertrain and alternative fueled vehicles, and has centered his passion and energy in displacing petroleum, eventually leading to a fully domestic, and sustainable, future for individual transportation.

Forrest readily acknowledges those years in the challenges as the most formative and directive years of his life: "It was through those competitions that I found my calling. They gave me a chance, and believed I could make a change, so I did my best. It was the first time I was looked at as a leader, and realized I was part of something much bigger and that I could serve to make this world a better place for future generations."

6.3 Brandon Talbert

As an undergraduate at Penn State, Brandon was looking all over campus to get involved with things that interested him. He was told as a freshman that the best way to end up in a career he loves is to get involved in an extracurricular activity in college and then pursue an associated career. One evening while out with a few friends, he met the team leader from Challenge X and was told all about the competition. Brandon had a nascent interest in hybrid vehicles and clean energy and thought this could be an exciting opportunity.

Starting in year one, Brandon began working with his team to promote hybrid vehicles, the competition, and its sponsors throughout the campus and to local news media. As the years continued, they worked with other sustainable

groups around campus to promote the ideals of sustainable living. They worked with local media to promulgate the mission of Challenge X and the interests of its sponsors to create the automotive engineers and technologies of the future right here on their campus.

After graduating with a Bachelor's degree in Communications from Penn State, Brandon was hired by Sentech, Inc. as a communications analyst for the U. S. Department of Energy's Vehicle Technologies Program. At the DOE, Brandon manages communications and web development. He works with engineers to promote the research and development pursued at the DOE's national laboratories regarding advanced vehicle technologies. He also manages logistics and planning for outreach and events for the Program. On top of his other duties, Brandon helps with logistics, planning, and judging for EcoCAR: The NeXt challenge, which is the successor to Challenge X.

Brandon feels that without his experience at Penn State in Challenge X, he never would have found a career which appeals to his interests, as has happened, "Challenge X really gave me the focus and the experience I needed to land a job which interests me as much as my current job does. Everyday I learn something new about advanced vehicles and it's really a lot of fun being involved with the future of automotive technologies."

References

[1] ANL Transportation Technology R&D Center, http://www.transportation.anl.gov/competitions/index.html, accessed on 2009-03-04

[2] ANL Transportation Technology R&D Center, , http://www.transportation.anl.gov/competitions/index.html, accessed on 2009 03 06

[3] Rose-Hulman Institute of Technology, http://www.rose-hulman.edu, accessed on 2009-02-03

[4] Freescale, http://www.freescale.com, accessed on 2009-04-01

[5] The Mathworks, http://www.mathworks.com, accessed on 2009-04-02

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Marc Herniter is a Professor at Rose-Hulman Institute of Technology (Ph.D., Electrical Engineering, University of Michigan, Ann Arbor, 1989); Dr. Herniter's primary research interests are in the fields of power electronics, hybrid vehicles, and alternative energy systems. He has worked on power electronic systems that range in power levels from 1500 W to 200 KW.

Kristen De La Rosa is the Director of the Advanced Vehicle Technology Competition program at Argonne National Laboratory where she has managed more than eighteen collegiate automotive engineering competitions since 1996. Ms. De La Rosa is responsible for establishing government/industry/academic partnerships to support cutting-edge engineering education activities including a $75M collaboration of more than three dozen organizations to support ***EcoCAR: The NeXt Challenge*** competition series.