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News From Argonne's Transportation Technology R&D Center

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FutureTruck Student Engineering Competition Finishes Strong

Challenge X: New Three-Year Competition Set to Take Center Stage

On June 9–17, 2004, at Ford's Michigan Proving Ground, 15 teams of college students from the United States and Canada participated in the final year of one of the most successful of the DOE/industry student competitions — FutureTruck, a unique five-year college-level automotive engineering competition. For the second year in a row, one or more of the student teams succeeded in reengineering a conventional sport utility vehicle into a lower-emissions vehicle, with at least 25% higher fuel economy, without compromising the performance, utility, and safety that consumers demand. The strong finish of the FutureTruck competition sets the stage for a new three-year competition, called "Challenge X: Crossover to Sustainability," to implement advanced technologies in vehicles. *Page 2*

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Argonne "Engineers" Unique Collaboration between the United States and China

In 2003, China became the largest oil-consuming country after the United States. Argonne and the China Automotive Technology and Research Center (CATARC) of the People's Republic of China signed a groundbreaking memorandum of understanding (MOU) on March 9, 2004, to help solve energy problems associated with China's rapid transportation growth. The MOU will officially make it possible for Argonne and CATARC to exchange information that will promote the commercialization of energy-efficient vehicle technologies and clean transportation fuels in China. *Page 4*

TTRDC Facilities Offer a Broad Spectrum of Research Opportunities

TransForum has published many articles describing projects carried out at Argonne's various transportation research facilities. This article provides descriptions of some of these facilities — all in one place — as a resource for our readers. With its world-class facilities and over 30 years of transportation research experience, Argonne's Transportation Technology R&D Center offers a one-stop resource for automobile, truck, and locomotive research, as well as a gateway to the other national laboratories. *Page 5*

FutureTruck Student Engineering Competition Finishes Strong

Challenge X: New Three-Year Competition Set to Take Center Stage

When it was first conceived in the late 1990s, the plan was a bold one: bring together the vast resources of government, industry, and academia in a partnership to develop advanced vehicle technologies addressing one of the world's primary sources of energy consumption. At the heart of the effort would be teams of college students designing and implementing innovative new automotive systems with the help of both donated and purchased products, components, and software from corporate sponsors.

On June 9–17, 2004, at Ford's Michigan Proving Ground, 15 teams of college students from the United States and Canada participated in the final year of one of the most successful of these partnerships — FutureTruck, a unique five-year college-level automotive engineering competition. For the second year in a row, one or more of the student teams succeeded in reengineering a conventional sport utility vehicle (SUV) into a lower-emissions vehicle, with at least 25% higher fuel economy, without compromising the performance, utility, and safety that consumers demand. Ford, along with the U.S. Department of Energy (DOE), was the headline sponsor of the competition during 2002–2004, while General Motors headlined the first two years (1999–2001).

Why ask college students to help find ways of reducing SUVs' energy consumption and emissions? One of the best reasons is that students have yet to learn all of the "rules of the trade," which means they aren't as likely to be bound by those rules. Students are usually eager to push the technology envelope and think outside the gear box. Unfortunately, few programs encourage and reward this sort of creative problem solving. That's one area where DOE's student engineering competitions have proven extremely valuable.

"In addition to reengineering the vehicles, we also wanted to help reengineer tomorrow's engineers," said Kristen De La Rosa, FutureTruck Project Manager. "One of our primary goals was to help develop a new generation of automotive engineers with a greater passion for, and understanding of, the environmental and energy-related issues involved in designing and producing automobiles." De La Rosa added that up to 60% of the students in the competitions take jobs in the automotive industry upon graduation and that Ford alone has hired over 200 of these young engineers.

This year, after enduring site-wide power outages, torrential rains, and a muddy morass of an off-road course, the University of Wisconsin-Madison (UW) again took first place. The UW vehicle achieved a 33% increase in on-road fuel economy and a 50% reduction in greenhouse gas emissions with respect to the stock Explorer that Ford donated to each FutureTruck team.

The students had a third year to work on their Ford vehicles, which gave them a chance to really enhance system performance and robustness. Wisconsin's winning vehicle, a parallel hybrid, used an advanced 1.8-liter diesel engine with a sophisticated multiple catalyst system that achieved ultra-low emission vehicle (ULEV) emissions standards — a remarkable accomplishment for any vehicle, let alone an SUV, and only one of a handful of times it has been accomplished in over a decade of DOE vehicle competitions. Wisconsin's Explorer delivered over 25 mpg (gas equivalent) using biodiesel in mixed city and highway on-road driving and came within 0.4 seconds of the stock vehicle's acceleration performance on a 1/4-mile track from a standing start. Despite the addition of a nickel-metal hydride battery pack and an electric motor, the student-built aluminum frame helped reduce overall vehicle weight by more than 200 pounds.

Pennsylvania State claimed second place with its innovative diesel-emission-reduction system in a parallel hybrid configuration that used a 2.5-liter diesel engine with an AC induction electric motor. Third place went to Georgia Tech, which employed a powerful through-the-road parallel hybrid-electric powertrain that would be easy to install as a factory option. All in all, the FutureTruck competition prototype vehicles displayed a remarkable level of technical sophistication and proved that light-duty trucks, such as pickups, vans, and SUVs, could be made substantially more fuel efficient and environmentally friendly.

"Light-duty trucks today comprise 54% of all auto sales, and these larger vehicles have historically been less fuel efficient than passenger cars," said Bob Larsen, director of Argonne's Center for Transportation Research, which manages FutureTruck. "We knew we could have a proportionately greater positive impact by tackling the fuel consumption and environmental issues associated with light-duty trucks — so we partnered first with GM and then with Ford to work on two of the top-selling SUVs, the Suburban and the Explorer." While the teams don't have to take into account all of the same safety, reliability, and cost factors that go into designing a production

vehicle, the student engineering experience does give everyone a better understanding of some potential solutions for achieving increased fuel economy and lower emissions, Larsen added.

The success of FutureTruck has attracted the attention of other nations, which have shown interest in using the competition as a model for their own student engineering events.

Challenge X: Crossover to Sustainability

DOE plans to follow FutureTruck with a new three-year competition called "Challenge X: Crossover to Sustainability." General Motors Corporation is cosponsoring the new competition, and 17 teams from across North America have been selected to participate.

Participating teams are challenged to reengineer a GM crossover sport utility vehicle to minimize energy consumption, emissions, and greenhouse gases while maintaining or exceeding the vehicle's existing utility and performance. Year 1 will focus on modeling and simulating the vehicle powertrain and vehicle subsystems selected by each school. Years 2 and 3 will require teams to develop and integrate their advanced powertrain and subsystems into the donated GM crossover vehicle. At the conclusion of each competition year, teams will come together to compete against each other while undergoing extensive judging and evaluation.

Teams will follow a real-world approach modeled after GM's Global Vehicle Development Process. This process gives students valuable experience in real-world engineering practices, resource allocation, and meeting deadlines. While previous student engineering competitions focused primarily on hardware modifications, Challenge X includes a unique focus on modeling and simulation, as well as subsystem development and testing. Because the technical focus of the competition is broadened to include more aspects of the entire vehicle development process, the university teams will have a greater opportunity to expand their learning and refine their vehicle solutions.

Visit: *www.challengeX.org* for more information.

Argonne "Engineers" Unique Collaboration between the United States and China

China's growth in transportation has been explosive in recent years. In fact, in 2003, China became the next largest oil-consuming country, second only to the United States. To help solve problems associated with this rapid growth, Argonne and the China Automotive Technology and Research Center (CATARC) of the People's Republic of China signed a groundbreaking memorandum of understanding (MOU) on March 9, 2004.

The MOU will officially make it possible for Argonne and CATARC to exchange information that will promote the commercialization of energy-efficient vehicle technologies and clean transportation fuels in China. This unique Argonne-CATARC partnership will benefit the people of China as well as the United States. According to Larry Johnson, Director of Argonne's Transportation Technology Research and Development Center (TTRDC), "This collaboration is very important because China's a rapidly developing country. In 10 years, China's gone from exporting oil to importing 30% of its oil now. We think it's important for China to have the best understanding of the most energy-efficient technologies in transportation."

Argonne and DOE will benefit from the partnership because their research strengths and areas of focus — including policy analysis and technology R&D — parallel those of CATARC. In particular, Argonne is looking forward to working with CATARC because of its leading role in the Chinese auto industry, especially in standardization. The benefits of the partnership, however, go far beyond any one country's borders.

For example, oil consumption and emissions are global concerns. Because China is now becoming a major oil importer, the world oil market faces additional strain. If, however, China can improve vehicle efficiencies, it will use less oil and thereby diminish the strain on the world oil market. The MOU will help China find ways to improve vehicle efficiency. The MOU will also address the environmental concerns associated with greenhouse gas emissions in China. Said Argonne's Michael Wang, Manager of the Systems Assessment Section in the Energy Systems Division's Center for Transportation Research, "greenhouse gas emissions are a global issue, and so we expect that by improving vehicle efficiency, we can decrease those emissions in China as well as in the U.S." Wang also expects that the experience of the Chinese in improving auto efficiency can help the U.S. auto industry improve efficiency.

Improving fuel efficiency is just one of many challenges facing China. Imagine the cultural, economic, and environmental challenges posed by rapid economic growth in such an extensive and ancient country. For example, because annual income in China has grown, more people need — and can own— cars, which increases the distances people are willing to drive. But rapid growth is not necessarily all good: aged automotive technology and a higher number of vehicles on China's roads are increasing not only oil consumption, but pollution and congestion as well — particularly in China's mega-size cities.

As a result of explosive growth and rapid change, the Chinese auto industry is scrambling to catch up to European and American automotive, environmental, and safety standards. In fact, "for the first time in 50 years," said Zhao Hang, president of CATARC, "China has proposed fuel economy standards." The MOU will enable Argonne to work with CATARC to advance its knowledge and understanding of the interrelationships among performance, fuel consumption, emissions, and safety of motor vehicles.

Establishing standards is just one goal: meeting them is a larger-scale goal, given the burgeoning Chinese automotive industry (which is partly fueled by major manufacturers outside of China, like General Motors). According to Zhao, "we expect to see 30% annual growth in auto production in China." In fact, last year, China produced 4.3 million vehicles — in 2004, Zhao expects to produce more than 5 million vehicles.

And if those numbers aren't impressive enough, consider this: according to Wang, in 2003, China consumed 5.5 million

CATARC was established in 1985 as a scientific research institute focusing on automotive safety, emissions control, energy conservation, and science and technology research. CATARC is supported by the state and affiliated with the China National Automotive Industry Corporation. The award-winning organization has become China's leading automotive research organization.

barrels of oil per day (~30% of that was imported), but in 2020, China is expected to consume 10.2 million barrels of oil per day, 60% of which will be imported. "By comparison, total oil use in the United States today is about 20 million barrels per day," said Wang. The potential for congestion, pollution, and crowded highways is very significant, given that outlook.

On the bright side, however, China is ideally prepared to adopt alternative vehicles because it must establish infrastructure to handle the demands of future transportation — regardless of the source of fuel. Again, the MOU provides the means to help China explore alternative vehicles. Explained Johnson, "We have been working on electric vehicles, hybrids, and fuel cell vehicle technology for many years; we have developed capabilities that we think can be helpful to China and specifically to CATARC."

China's transformation to a major oil consumer is well under way — and has progressed rapidly. Now that the paper infrastructure between Argonne and CATARC is in place, Argonne expects China to continue to move quickly in developing improved automotive and environmental control technology. "Don't be surprised," said Johnson, "if China is someday meeting some fairly impressive standards in terms of renewable energy and automotive technology." The world will be watching.

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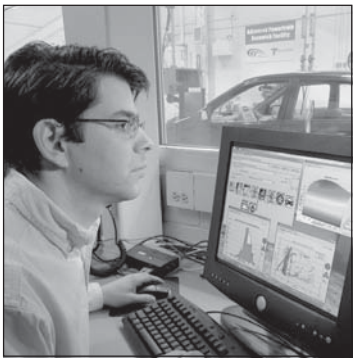
TTRDC Facilities Offer a Broad Spectrum of Research Opportunities



Previous issues of TransForum have focused on the projects carried out at Argonne's various transportation research facilities. In this issue, we describe the world-class facilities that make the TTRDC a one-stop resource for automobile, truck, and locomotive research.

Advanced Powertrain Research Facility (APRF)

The APRF is a multi-dynamometer vehicle and component test facility for testing conventional and hybrid vehicle propulsion systems and vehicles (2- or 4-wheel drive), using a variety of fuels (including hydrogen), in a precise laboratory environment. The facility has state-of-the-art performance and emissions measurement equipment that can be used to assess powertrain technology for light- and medium-duty propulsion systems. Component, subsystem, and vehicle test facilities support hardware-in-the-loop (HIL) testing, control system development, and technology validation. The facility serves as the vehicle systems validation center for DOE's FreedomCAR and Vehicle Technologies (FCVT) program. Components/subsystems can be interchanged for standardized assessment in the modular APRF.

Argonne's APRF is the only facility in North America that combines the best available emissions instrumentation with such a wide range of fuels. Also, the APRF's experienced staff have tested more hybrid vehicle designs than has any other public-sector group.

Battery Test Facility

In 1976, DOE established Argonne's Battery Test Facility to conduct independent evaluations on advanced batteries for transportation applications. The computer-based test facility, which has been used to test over 4,000 cells and batteries, can test small cells to full-size (500-volt, 500-ampere) batteries and can test to any profile over a wide range of temperatures. Some of the battery technologies that have been tested for transportation applications include lithium-polymer, lithium-ion, nickel-metal hydride, and lead-acid. The facility is capable of running over 120 separate tests simultaneously. Researchers at the facility focus on the testing and evaluation of high-energy batteries for electric vehicle applications, conducting performance and life tests on electric vehicle battery deliverables and benchmark testing of advanced batteries.

Advanced Lithium Battery R&D Laboratory

Argonne's Advanced Lithium Battery R&D Laboratory, the major facility employed in the FCVT near-term R&D program, contains a comprehensive, unique array of equipment used in the development of more stable lithium cell chemistries. Extensive facilities include controlled environments for handling sensitive materials and a variety of analytical equipment.

Engine Research Facility/Heavy-Duty Truck Engine Test Cell

Engineers are using Argonne's Engine Research Facility to study in-cylinder combustion phenomena under realistic operating conditions to find ways to increase fuel efficiency and reduce harmful emissions. The test cells are equipped with single-cylinder versions of modern electronically controlled auto and truck engines, along with state-of-the-art gaseous and particulate emissions measurement instruments. Argonne researchers are also linking the fuel spray characterization being performed at the Advanced Photon Source to efficiency and emissions reduction characteristics of combustion by conducting controlled engine experiments.

Engineers will use a single-cylinder engine dynamometer facility to evaluate the efficiency of directly injecting hydrogen in internal combustion engines and conduct component and system development. This facility, with a special highly accurate fuel measurement system and other sophisticated equipment, will enable visualization of combustion phenomena at high speeds and loads.

High-Performance Computing Research Facility

Argonne's High-Performance Computing Research Facility will enable researchers to adapt their expertise to next-generation vehicle design. Argonne provides computational facilities and technical support for state-of-the-art computer-aided engineering (CAE) software and hardware systems for the transportation industry. Transportation-related studies at the facility have included crash analysis, underhood thermal management, and aerodynamic drag of truck-trailer combinations. The heart of Argonne's high-performance computing capabilities is Jazz, a system that offers sustained speeds of 1.1 teraflops. Transportation-related modeling studies also take advantage of Argonne's CAVE immersive virtual reality environment.

Tribology Laboratory

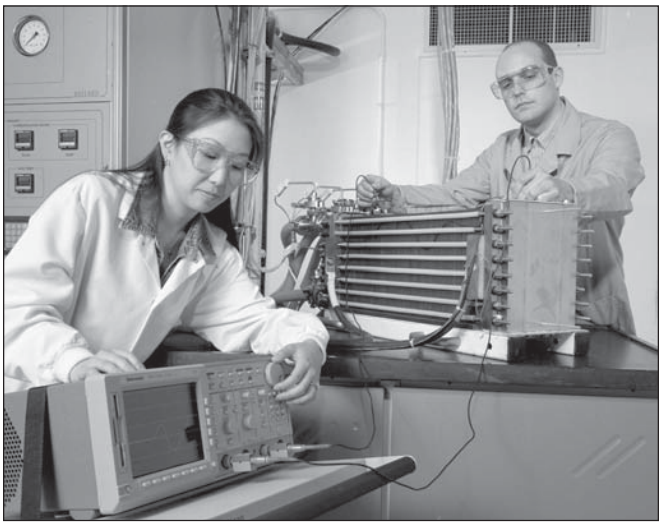
Engineers use the Tribology Laboratory to conduct research on advanced tribological systems for use in aggressive environments. Here, they develop high-performance (near-frictionless carbon) coatings and assess their friction and wear properties for components in advanced engines and fuel cell compressor/expanders, evaluate solid lubricants, and assess how fuel and lubricant additives interact with surfaces. The laboratory is equipped with a full range of coating development, friction and wear testing, and characterization facilities.

Selective Continuous Recycling of Automotive Parts (SCRAP) Facility

Argonne has two major facilities for the recycling of automotive shredder residue. The first is a large-scale shredder residue separations pilot plant, which consists of a mechanical separation facility and a plastics separation facility. The second facility is the six-stage plastics separation/recovery plant. The new pilot plant is the first continuous, multistage plastics separation plant of its kind. The new recycling process works for just about all mixtures of plastics generated by industry. In full operation, it can recover up to five products from a single waste stream. The pilot plant will be used to demonstrate the feasibility of recovering specific polymers from the shredder residue plastics.

Fuel Cell Test Facility

Commissioned in 1999, Argonne's Fuel Cell Test Facility (FCTF) serves as a site for DOE, other government agencies, fuel cell developers, and U.S. automakers to conduct independent evaluation of fuel cell technologies. The facility is being modified to handle systems up to ~105 kW (a small SUV). The FCTF has been used to test hydrogen- and simulated-reformate-fueled stacks of up to 30 kW. It has also been used to test complete gasoline-powered systems of up to 50 kW. In addition to testing complete systems, the FCTF has been used to evaluate components and subsystems. Through standardized tests and test conditions, Argonne provides its sponsors with direct comparative data on the performance, operational characteristics, and durability of fuel cells.



Advanced Photon Source

Teams of Argonne researchers are using high-brilliance x-rays from the Advanced Photon Source (APS) — a unique user facility dedicated to producing the world's brightest synchrotron x-rays for research — to shine a piercing new light on the fluid dynamics and chemistry of fuel spray behavior, particulate formation, and combustion processes. The team is using APS x-rays to obtain never-before-possible quantitative data on the structure and behavior of gasoline and diesel sprays. The x-ray adsorption techniques fill a critical gap in our knowledge of spray behavior and dynamics. Work is proceeding to determine the feasibility of an x-ray-transparent engine.

Additional transportation research facilities at Argonne include the laser applications lab for welding, glazing, and heat treatment; sensor labs for controlling engine performance and emissions; and labs for advanced materials (metals, ceramics, and composites) fabrication and testing.

CTR Reorganization Reflects Changing Research Emphasis

Argonne's Center for Transportation Research (CTR) was recently reorganized. The former Technology Assessment section has been divided into two — the Technology Analysis section led by **Dan Santini** and the Systems Assessment section headed by **Michael Wang**. The reorganization will allow Technology Analysis researchers to focus more closely on their individual projects. For Systems Assessment research, the change reflects the growing importance of hydrogen infrastructure development and planning and an increased emphasis on life-cycle analysis of advanced vehicle technologies and new transportation fuels. The two sections will interact closely to develop analytical capabilities and information that will help the nation make choices of effective technology options to meet societal goals of oil use and emission reductions.

Don Hillebrand

In addition to these changes, CTR's Vehicle Systems and Fuels section — which includes the Advanced Powertrain Research Facility, hardware in the loop (HIL) research, the Powertrain System Analysis Toolkit (PSAT) modeling work, and the benchmarking of advanced technology vehicles — has been renamed Vehicle Systems. **Don Hillebrand**, who recently joined CTR, manages this section. Don's skills and experience in engineering, government affairs, regulatory affairs, research, and the European Commission will serve the Laboratory well. Since 1998, he has worked for DaimlerChrysler as Manager, Technology Management; Manager of Research Policy; and Manager of Technical and Regulatory Affairs. Prior to his employment at DaimlerChrysler, he acted as Senior Policy Advisor for the White House Office of Science and Technology Policy, Executive Branch Fellow for the American Association of the Advancement of Science, and in various engineering positions for Chrysler. Don's patent, *Self-Restoring Energy Absorber Bumper Mount*, generated $45 million in cost savings and was applied to most Chrysler passenger cars in the period 1988–1992. He has a doctoral degree in systems engineering, a masters degree in mechanical engineering/CFD, and a bachelors degree in mechanical engineering from Oakland University.

Argonne Transportation Software Wins R&D 100 Award

This year, four technologies developed or co-developed at Argonne have been recognized with R&D 100 Awards, which highlight some of the best products and technologies newly available for commercial use from around the world. One of the Argonne winners was the Powertrain System Analysis Toolkit (PSAT), which allows vehicle designers to develop realistic hybrid and powertrain control systems and assess performance of components. Developed by Argonne CTR engineers **Aymeric Rousseau, Phillip Sharer,** and **Sylvain Pagerit** (all of the Energy Systems Division), the computer simulation provides accurate performance, fuel economy, and emissions simulations, allowing automotive and truck manufacturers and their suppliers to select appropriate advanced technologies and bring them more quickly to the market in improved hybrid vehicle systems. PSAT was released in 2003 and licensed not only to industry, but also to universities to develop designs for student competitions. This is the 41st year the technology awards have been given by *R&D Magazine* to recognize the "100 most technologically significant new products" from the entries the magazine receives.

PUTTING ARGONNE'S RESOURCES TO WORK FOR YOU

Industrial technology development is an important way for the national laboratories to transfer the benefits of publicly funded research to industry to help strengthen the nation's technology base. The stories highlighted in this issue of *TransForum* represent some of the ways Argonne works with the transportation industry to improve processes, create products and markets, and lead the way to cost-effective transportation solutions, which in turn lead to a healthier economic future.

By working with Argonne through various types of cost-sharing arrangements, companies can jump-start their efforts to develop the next generation of transportation technologies without shouldering the often-prohibitive cost of initial R&D alone. Argonne has participated in dozens of these partnerships and has even been involved in helping to launch startup companies based on the products and technologies developed here.

If working with world-class scientists and engineers, having access to state-of-the-art user facilities and resources, and leveraging your company's own capabilities sound like good business opportunities to you, please contact our Office of Technology Transfer and see how we can put our resources to work for you.

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