FutureDrive

Volume 4, Number 2 **DOE/Industry Competitions Advancing Automotive Technology** Spring 1998

TECHNOLOGY FEATURE

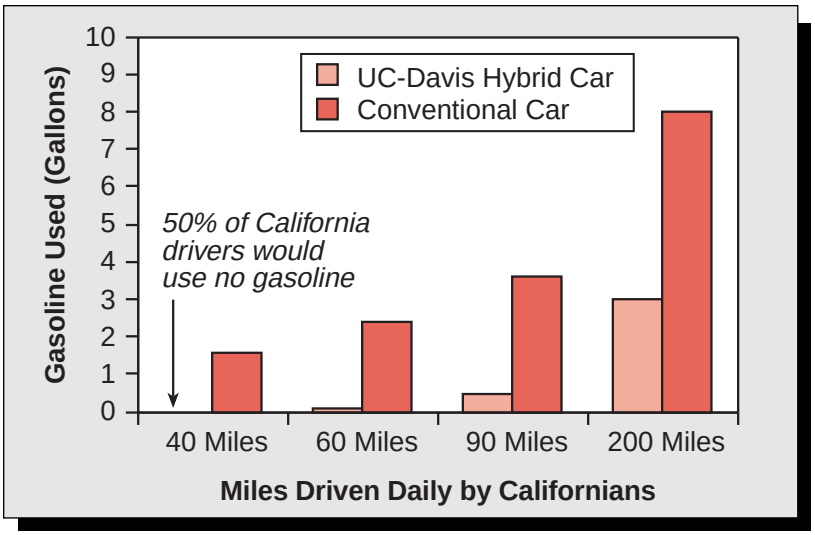
Sixty Miles on a Teacup of Gas

Not all things in California are big. A hybrid electric vehicle built in Davis is a big car with a *tiny* thirst. Driving it, a typical commuter could go 60 miles in the city on just a teacupful of gas—and 1,000 miles on the highway on a single charge. Meet "Joule," a fully equipped Taurus modified by students at the University of California-Davis.

In the 1997 FutureCar Challenge, Joule won first place overall, first place for energy efficiency, and five other top awards. The Davis team used a charge-depletion parallel hybrid configuration with an advanced nickel-metal hydride battery.

UC-Davis is pushing its hybrid design even farther for the 1998 FutureCar Challenge. And an ultra-light all-aluminum chassis makes this year's UC-Davis FutureCar 600 pounds lighter than last year's.

The as-yet-unnamed Davis entry has an 18-kilowatt-hour nickel-metal hydride battery that is smaller, lighter, and more powerful than any prototype hydride system before it. It could, by itself, carry the car 80 miles.



The 3-cylinder, 660-cubic-centimeter engine (about 40 cubic inches, or one-quarter the size of a conventional Taurus engine) has a peak horsepower of 40 but operates mostly at 12-14 horsepower, its most efficient range. The computer control program to manage the power flow uses a conventional engine processor, which contributes to the relative inexpensiveness of the design.

The UC-Davis control strategy reflects a shift in perspective from individual vehicles to *fleet* performance in emissions and efficiency. The team learned that half of all Californians drive 40 miles or less a day, while only 5% drive more than 100 miles a day.

(continued on page 4)

"Joule" at a Partnership for a New Generation of Vehicles Symposium in July 1997. Joining the UC-Davis team is Shelley Launey, Manager of Vehicle Competitions for the U.S. Department of Energy.

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FUTUREDRIVE
Volume 4, Number 2, Spring 1998

Purpose
To inform past, present, and potential sponsors, participants, organizers, volunteers, and others interested in DOE-sponsored vehicle competitions about the plans for and the results of the competitions.

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DOE Opens a New GATE

We have seen commercial products, system improvements, remarkable automotive performance, and an incomparable generation of new automotive engineers emerge from student vehicle competitions. Now the U.S. Department of Energy is announcing a new program directly related to the successes of college and university competitions.

GATE—the Graduate Automotive Technology Education program—is the DOE's Office of Transportation Technology's latest initiative. GATE will build on the spinoff successes of student vehicle competitions like those described in FutureDrive. And in time, vehicle competitions will benefit from GATE.

We like to think of GATE as the "gateway" to the automobile of the future.

GATE will give talented engineering students the opportunity to focus their graduate educations on one of the critical areas of automotive technology development that are of particular interest to DOE: fuel cells, advanced materials, hybrid drivetrains and control systems, direct-injection engines, or advanced energy storage systems.

In May, DOE will issue a solicitation inviting universities and colleges with accredited engineering programs to propose how they would establish a Center of Excellence in one of these five technology areas. The Centers will be largely designed for graduate students, although schools must also provide ways for interested undergraduates to benefit. Once the Centers are established, DOE will fund a limited number of fellowships at each university or college, beginning in the 1999-2000 academic year.

GATE is designed to help equip this country's most talented engineering students with the tools they need to bring the vehicles of the future into production. It also offers rich possibilities for partnerships among industry, government, and academia. Fuel cell companies, for instance, often have difficulty hiring new engineers with relevant experience. These companies could provide research topics to the GATE university, offer internships for students, arrange for guest lectures, provide funding, share facilities and equipment, and, of course, hire students as they graduate from the program.

Similar relationships are expected to develop in the other specified technologies, as well. Who knows? Some of the advances pioneered in the Centers of Excellence might find their first applications in the FutureCars of the next millennium before being put into production.

Has there ever been a better win-win scenario?

Shelley Launey
Manager of Vehicle Competitions
DOE Office of Transportation Technologies

UW-Madison's HEV a Paradigm of Design Excellence

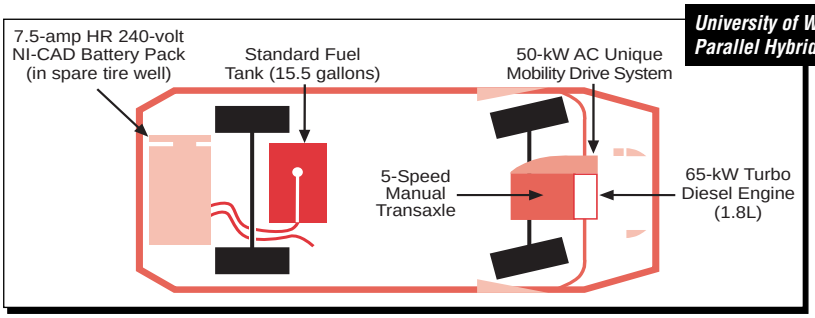
The University of Wisconsin-Madison's "Team Paradigm" wants to be the FutureCar team that other schools strive to equal. That's a tough challenge, whether you're looking at UW's vehicle performance or team character and spirit. Last year Team Paradigm finished first in the FutureCar endurance event and third overall, with a converted Dodge Intrepid it named "FutureCow" in honor of one of Wisconsin's main claims to fame.

The goal for 1998 is to bring a road-ready parallel hybrid electric vehicle to the competition, which is no small undertaking. Their strategy is to keep the car light and as simple as possible, says team leader Jonathan Erdmer.

The team's entry, a 1994 aluminum-intensive Mercury Sable, will have an international twist: it will be powered by a prototype direct-injection diesel engine, a production version of which will be installed in one of Ford's European models, the Mondeo.

According to faculty advisor Glenn Bower, "Part of the challenge this year is in retrofitting—trying to install parts engineered for a Mercury Mystique into a Sable. Not all of the components fit nicely from the start."

Team Paradigm used a number of advanced technologies in its HEV, including regenerative braking, to maximize fuel economy and reduce emissions. Emission control strategies include exhaust aftertreatment, exhaust gas recirculation, and modified fuel injection timing. All operating data will be logged and diagnostic information gathered by a removable laptop computer. Ford's prototype 1.8-liter 4-cylinder, 4-stroke diesel is transversely mounted—an engineering strategy that's unique in this year's competition.



University of Wisconsin's Parallel Hybrid Design

What's behind Team Paradigm's success? Teamwork, strong faculty support, and a great vehicle. "Our team consists mainly of undergraduate mechanical and electrical engineers, but we also have students from the business school, industrial engineering, computer sciences, and journalism," says Team Leader Erdmer.

Last year, a journalism major created videotapes showing a typical week of team activities, including individual student work, steering committee meetings, and team seminars. The video has been used to recruit new students, equipment donors, and sponsors.

Team Paradigm's participation in FutureCar brings a wealth of opportunities for the students, the community, and industry. "Working with industrial partners gives students a much better perspective on what the real world is like," observes Bower.

The team is working with a Madison-area business on vibration control. Bower notes that exhaust aftertreatment is an area in which industry's involvement could yield far-reaching benefits in finding ways to control emissions.

"We're trying to get an industrial partner for each of the engineering areas. Once companies find out what we're trying to accomplish, they're very supportive because everyone benefits," says Bower.

Team member Amanda Jo Pertzborn agrees: "I've had the opportunity to learn about technologies that will have an important place in the future of the automotive industry."

The University of Wisconsin-Madison has one of the most highly regarded diesel engine research programs in the world, attracting top engineering students from around the world. Both DOE and the U.S. Department of Defense support the program financially.

Kevin Brown

1998 Team Paradigm

(continued from page 1)

"We designed our car so the average person can do all their driving on battery power," says UC-Davis faculty advisor Andrew Frank. Thus, for the first 40 miles the car runs only on its Ovonics nickel-metal hydride battery pack.

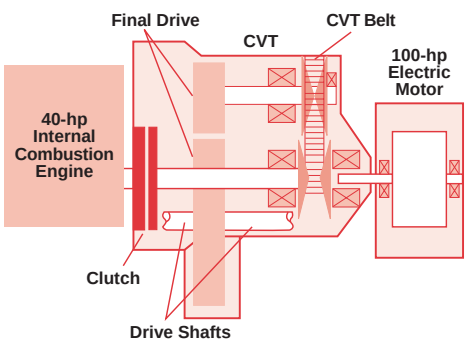
Beyond 40 miles, it begins to draw gradually on its motorcycle-sized three-cylinder gasoline engine. With this scheme, even the 200-miles-a-day marathon commuter could still get cleaner operation and much higher fuel efficiency than in a conventional vehicle. Major car companies have shown interest in the concept.

"We start to bring in the gasoline a little at a time," says Frank. "So if you go 40 miles a day in the city, you use no gas at all. If you go 60 miles a day, you use maybe a cupful of gas; 90 miles, you might use half a gallon; 200 miles, 3 gallons."

Because only a small percentage of drivers would routinely go far enough to use gallons of gasoline, the net result would be vastly lower emissions and fuel use overall, across the driving population.

"Assume a fleet of vehicles with driving patterns representative of California as a whole," says Frank. "A fleet of 1,000 Tauruses using our design and control strategy would use only 3% of the gas used by a conventional fleet."

Jane Andrew



The UC-Davis Parallel Hybrid Powertrain

SPONSOR PROFILE

Illinois Agency Helps Get EVC Up and Running

EVC Participants from the Illinois Institute of Technology

What Illinois agency can advise travelers about the best Chinese restaurant on Chicago's north side, fund a project to turn 3,100 used tires into an all-weather running track, *and* help bring together some of the most promising engineering students in the country to showcase cars that burn a fuel made from corn? The Illinois Department of Commerce and Community Affairs (DCCA), co-sponsor of the first Ethanol Vehicle Challenge, is involved in all these programs and dozens more designed to promote "Better Business and Better Living" in Illinois.

DCCA is working with the U.S. Department of Energy, General Motors Corporation, and other sponsors on the first alternative fuels competition that focuses on corn-derived ethanol as the primary fuel. Selected colleges and universities from the United States and Canada have been given a Chevrolet Malibu sedan to convert to dedicated E-85 operation. The competition will begin May 25 at GM's testing facility in Milford, Michigan.

Sponsoring the EVC makes sense for DCCA, says David Rose, a Mechanical Engineer with DCCA's Bureau of Energy and Recycling. The competition will promote the use of clean-burning ethanol, which helps Illinois' environment as well as its economy. At the same time, the EVC will help educate the public about ethanol. Illinois leads the nation in ethanol production and ranks second in corn yield—many of DCCA's energy programs promote the use of ethanol as an alternative fuel.

DCCA's ethanol programs are designed to stimulate economic growth in both industrial and rural Illinois communities. The agency, which has a $20.2 million budget for energy conservation programs, also funds research to reduce ethanol production costs. Right now DCCA is:

- Planning a state-of-the-art ethanol pilot plant
- Teaming with DOE to develop a multi-fuel reformer for fuel cell vehicles
- Testing and demonstrating flexible fuel vehicles
- Adding to the number of commercial E-85 refueling stations in Illinois
- Offering rebates to fleet operators who purchase E-85 vehicles
- Planning an exposition about ethanol for this year's Illinois State Fair

DCCA's interest in promoting ethanol use was instrumental in giving the EVC its start. Thus far, the agency has provided several grants for the program, including one for a participant workshop at Argonne National Laboratory. Two other grants have gone to the University of Illinois–Chicago and the Illinois Institute of Technology to help them participate in the EVC.

To find out more about this Illinois agency and its efforts to promote the use of alternative fuels, check out the DCCA homepage at http://www.commerce.state.il.us/

Mary Fitzpatrick

New Advanced Powertrain Test Facility a Valuable Tool for HEV Researchers

The U.S. Department of Energy opened the Advanced Powertrain Test Facility at Argonne National Laboratory near Chicago last January. The one-of-a-kind facility will provide independent verification and modeling support for DOE alternative-fuel vehicle programs and will eventually be open to industry.

Argonne researchers are currently using the facility's 190-horsepower engine dynamometer to evaluate and "map" hybrid electric vehicle components and systems (including a series HEV engine from Michigan Tech and an alternator from Cedarville College that were used in recent competitions). An Argonne-designed computer control system simulates the performance of the components and systems with different aerodynamics under a wide range of driving and road conditions. The resulting database of operating parameters and road conditions will be a tool for configuring hybrid combinations that are both efficient and powerful.

Working with Argonne's National Battery Test Laboratory and Fuel Cell Testing Facility, researchers will be able to investigate HEV battery cycle life, in-use efficiency, and performance limitations in a real HEV propulsion system. The Advanced Powertrain Test Facility is the newest addition to Argonne's Transportation Technology Research and Development Center.

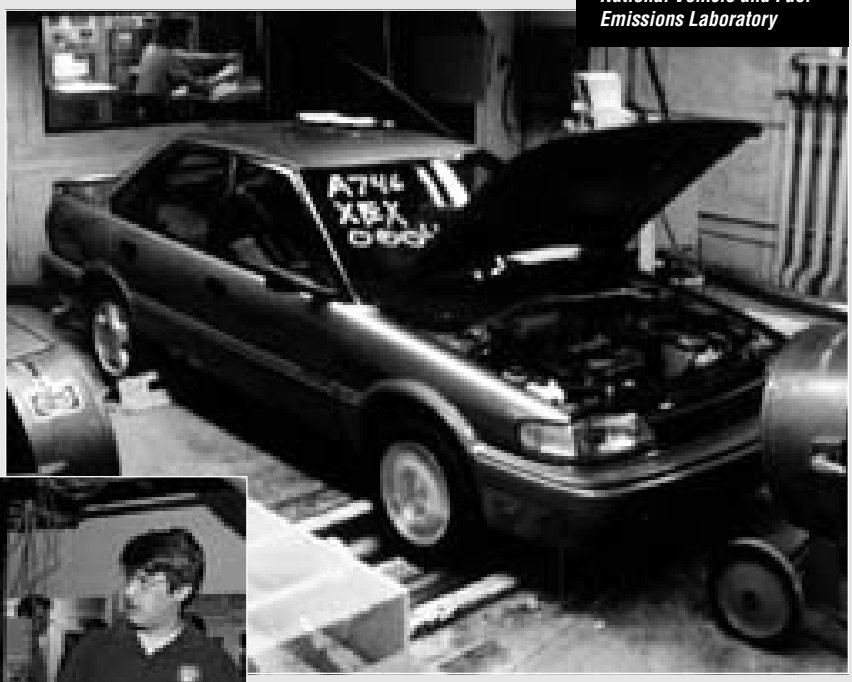
Again in 1998, FutureCar Entries Will Be Tested by the Experts

Access to government and industry testing facilities is one of the perks that make alternative-fuel vehicle competitions a meaningful challenge for university engineering students. The U.S. Environmental Protection Agency will make its National Vehicle and Fuel Emissions Laboratory (NVFEL) in Ann Arbor, Mich., available for several events in the FutureCar Challenge again this year. Additional emissions and energy economy trials will be held at Chrysler's state-of-the-art facility in Auburn Hills, Mich.

NVFEL recently made several changes in its equipment to adapt to U.S. automakers' dramatic advances in fuel economy and emissions control. The laboratory's emissions-testing equipment has been readied for Tier II of the Clean Air Act, when car pollution-control devices will be expected to maintain ultra-low emissions for 10 years or 100,000 miles. NVFEL has also partially converted its chassis dynamometers from dual-roll water brake to single-roll electric, to allow simulation of high-speed, high-acceleration driving. This type of driving is much more common, with America's increasing reliance on urban expressways.

NVFEL conducts the largest portion of the federal government's testing programs to control air pollution from motor vehicles. One of its principal roles is vehicle certification, testing the compliance of new vehicle models with federal emissions and fuel economy standards.

Cathy Kaicher



Dynamometer at the EPA National Vehicle and Fuel Emissions Laboratory

Richard Gonzales, left, professor of electrical engineering at the University of Purdue-Calumet, learns about the new Advanced Powertrain Test Facility from Argonne Research Engineer Carlos Buitrago.

Nothing Could Be Finer
Enterprising High School Students Spark EV Fervor in Rural Carolina

Before it became the first high school in the nation to organize an EV rally, Northampton County High School-East had already put the small town of Conway, North Carolina, on the map. The school was consistently producing the EV teams to beat, winning competition after competition around the country. In the process, its pace-setting young students were showing that kids from disadvantaged areas can come out on top.

North Carolina Power Company helped set NCHS-East on the road to success back in 1993 when it gave the school $2,500 to design its first electric vehicle. The end product, Shocker, won the 1994 Richmond EV Grand Prix. It ran the full course, 68 miles, on a single charge.

NCHS-East teams went on to build Shockers II and III and to win more events, like the esteemed APS Electrics, in which they beat out 37 other teams. The school gained national press coverage and was featured in a program aired on PBS. It won DOE's Otter Award for environmental efforts, the first public school to do so.

Fueled by these achievements, two NCHS-East teachers, Harold Miller (auto shop) and Eric Ryan (physics), joined to teach a class in EV technology. And, noticing a sparsity of EV events in the fall—the time of the school year when enthusiasm and the learning curve are highest, Miller says—they came up with the notion of starting their own EV rally. They convinced the North Carolina Department of Environmental Health and Natural Resources to fund their efforts, and the North Carolina International Electric Vehicle Rally was born. This year the event will be held October 2 and 3.

The rally is open to anyone with an EV, whether the car is powered by a fuel cell, solar panel, or battery. There are separate divisions for professionals, the public, college students, and high school students. Vehicles can drive with or without bypass contactors, letting participants really "burn some rubber." Who says learning can't be fun?

"Every year our rally gets bigger and better," says Miller. "This year a team from Canada is coming down to participate. And we're adding a middle school competition that will give younger kids a chance to join in.

"A focus on cross-curricular activities is what makes the rally such a unique event," he adds.

Simply designing and driving a car is not enough. Students win points for environmental service, giving their teachers a ride in their EVs, and giving short talks in towns along the rally's course. They also get points for writing press releases.

Just about everybody gets involved in the friendly competition. Last year a state policeman bragged that his Ford Crown Victoria could beat an EV in acceleration speed. After trying five times, he never won.

Organizers will be happy to work with anyone who would like to participate this year, supplying information and financial help if needed. They've reserved lots of motel rooms. Interested parties should call NCHS-East at 919-585-0627.

Marita Moniger

Electrathon Competitions

Sponsored by various regional and local organizations, most Electrathons are aimed at high schools but will accept all applicants that meet the rules. Students build lightweight vehicles powered by 64 pounds of lead-acid batteries. The winner travels the farthest in one hour.

May 16 / Cedar Rapids, IA
May 23 / Springport, MI
May 30 / Ottawa, Ontario
June 6 / Marne, MI / Regional
July 13–15 / Marne, MI / National
September 26 / Springport, MI

- *Iowa event contact:*
  Matt Lorenzen
  Ph: (319) 273-6912
  E-mail: electrathon@uni.edu
- *Michigan events contact:*
  Jim Nicolas
  Ph: (616) 837-9753
- *Ontario event contact:*
  EVCO, Box 4044, Station E
  Ottawa, Ontario K1S5B1

Ethanol Vehicle Challenge

Sponsored by DOE, GM, and Natural Resources Canada. Fourteen teams of college students from the U.S. and Canada will convert 1997 Chevrolet Malibus to run on E-85 fuel. The goal is to improve fuel economy, lower exhaust emissions, and provide excellent cold-startability while maintaining performance and drivability. After testing at GM's Milford Proving Ground, the cars will embark on a road rally to Washington, DC, for exhibition at the Clean Cities Conference.

May 25–June 2 / GM Milford Proving Ground, MI, and Washington, DC

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EV Rally
North Carolina International Electric Vehicle Rally

(See article on page 6.)

October 2 and 3, 1998
Northampton County, NC

- *Contact:*
  Harold Miller
  Northampton County High School – East
  Conway, NC
  Ph: (919) 585-0627

ABB University Spec Series

Electric Vehicle Technology Competitions, Ltd., sponsors the ABB University Spec Series, in which 13 teams are awarded points for a series of races. The first, the Indy Electric Classic, was held in August 1997. Next, the APS Electrics took place March 6-8 in Phoenix. Other events in the series are:

Indy Electric Classic
May 16 / Indianapolis, IN

Cleveland Electric Formula Classic
July 11 / Cleveland, OH

Tustin Thunder
July 17–19 / Tustin, CA

- *Contact:*
  Mike Shaw, Phoenix, AZ
  Ph: (602) 256-2599
  Fax: (602) 256-2606
  E-mail: info@evrace.com
- *Web site:*
  http://www.evrace.com

FutureCar Challenge

Annual competition sponsored by DOE and USCAR (representing Chrysler, Ford, and GM) gives students from more than a dozen universities the opportunity to convert a Dodge Intrepid, Chevrolet Lumina, or aluminum-bodied Ford Taurus into a car of the future with up to three times the fuel efficiency and the same performance, utility, and safety as today's vehicles. Students select advanced technologies and varying fuels for meeting the 80-mpg goal.

June 3–10 / Auburn Hills, MI

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- *Web site:*
  http://www.uscar.org/futurecar/

Junior Solar Sprints

DOE program open to 6th, 7th, and 8th graders. Participants receive a kit with a photovoltaic panel and motor and must design and build a model vehicle that will compete in a 20-meter, wire-guided race. Interested parties are welcome to start their own regional competitions. A sponsor is sought for a national event.

- *Web site:*
  http://www.nrel.gov/business/education/SprintWeb/

Colorado Junior Solar Sprint
May 16 / Golden, CO

- *Contact:*
  Linda Lung
  National Renewable Energy Laboratory, Golden, CO
  Ph: (800) 639-3649
  E-mail: linda_lung@nrel.gov

(continued)

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Formula SAE

College students design and build formula-style racing cars. Restrictions are placed on the car frame and engine to test participants' creativity. Four-cycle engines up to 610 cc can be turbocharged or supercharged. Cars are judged in three categories: static inspection and engineering design, solo performance trials, and track endurance. Formula SAE cars compete in two classes: gasoline and methanol. Sponsored by the Society for Automotive Engineers, the methanol class is also sponsored by DOE.

May 27–31 / Pontiac, MI

- *Contact:*
  Tony Androsky
  Ph: (412) 772-8535
  E-mail: androsky@sae.org
- *Web site:*
  http://www.sae.org/STUDENTS/student.htm

SAE Supermileage

University teams develop and build a single-person vehicle with the goal of setting a world fuel economy record. Engines are donated by Briggs & Stratton.

June 12–13 / Kalamazoo, MI

- *Contact:*
  Fred Kinney
  Transmission Div., Eaton Corp.
  Kalamazoo, MI
  Ph: (616) 342-3314
  Fax: (616) 383-5508
  E-mail: fredriclkinney@eaton.com
- *Web site:*
  http://www.sae.org/STUDENTS/student.htm

10th Annual American Tour de Sol

Seven-day, 350-mile road rally for electric, hybrid electric, or solar-assisted electric sedans, utility vehicles, mass transit vehicles, and motorcycles. Free public events featured in communities along the way. Open to a fixed number of manufacturers, students, or hobbyists. A two-day conference sponsored by NESEA and SAE opens the tour in New York City. DOE is the title sponsor.

May 8–14 / New York City to Washington, DC

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  E-mail: nhazard@nesea.org
- *Web site:*
  http://www.nesea.org/98ATDS/98atds_home.html

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DOE/Industry Competitions Advancing Automotive Technology

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