

members of his team will be interning this summer at the GM assembly plant in Janesville, Wisconsin.

In addition to supplying the vehicles, GM put up \$10 000 in seed money and up to \$25 000 worth of additional production parts, including the GM engine of its choice, to each team. Ten teams, including the top three scorers, opted for a 1.9-liter direct-injection turbodiesel, which ironically isn't available in the US market. Universities were required to match the seed funding, grant release time of one course per semester for a faculty adviser, and provide an auto shop and computer lab. Institutions also committed to granting course credits to at least a core subgroup of the team members.

A Canadian entry, from the University of Waterloo, was the only vehicle with hydrogen fuel-cell propulsion. A major challenge was to get the cell, which was made for stationary applications, to fit under the car's hood, explained Charles Hua, a chemical engineering graduate student. Although it was the only zero-emissions vehicle in the competition, its range was limited to 150 miles per tank by a contest rule that restricted the liquid hydrogen storage to 5000 pounds per square inch, half the pressure that is currently practical. There's also the matter of finding hydrogen fuel, although Hua said he knows of at least two filling stations in Ontario.

A belt-driven motor paired with a flexible-fuel engine was the Texas Tech University entry. To reduce the load on

the engine, the eleventh place team fitted a small fuel-cell and hydrogen tank in the trunk to power the lights, air conditioning, and other electric accessories. Team member Stephen Barrett explained that hydrogen can be injected to boost engine combustion under full acceleration conditions. Barrett has already landed a job with National Instruments Corp, a contest sponsor; his work on the vehicle's electronics package won a \$700 prize from NI, which supplies electronic control equipment to automakers and others.

Hydraulic drive

Arguably the most exotic drive train was a hydraulic hybrid system designed and built by last-place finisher University of Michigan. Its engine does not supply power directly but drives a pump that pressurizes hydraulic fluid in two onboard "accumulator" tanks. That stored energy is used to drive hydraulic motors turning the front and rear axles. The drive system requires no battery or transmission, explained team member Javier Somoza, who said that he'd "definitely" be looking for a career in hybrid propulsion R&D once he's completed his master's in mechanical engineering.

Teams were initially instructed to follow the development process GM uses when introducing a new model. After a year of modeling, simulation, and testing of the selected drive trains, teams were given two years to integrate them into their vehicles. The final year was devoted to ensuring customer ac-

ceptability and proving vehicle reliability in real-world conditions. Teams were graded periodically on their progress, their outreach efforts, and metrics such as acceleration, emissions, and fuel economy. More esoteric criteria included "well-to-wheel" greenhouse gas emissions reductions, well-to-wheel petroleum use, and "dynamic consumer acceptability."

Awards totaling \$79 500 were doled out to top-ranking competitors in various categories. As first overall, MSU won \$7000.

A 300-mile road rally from New York to Washington, DC, marked the end of the road for Challenge X, but DOE, GM, and Natural Resources Canada have already selected the 17 teams for a three-year contest that kicks off this fall. Argonne National Laboratory, which managed Challenge X, will also manage the new program, in which Saturn SUVs will be reengineered to meet California's tough zero-emissions standard. Most of the schools from Challenge X, including the top three finishers, will be back.

David Kramer

Experiments, jobs cut at DOE labs

During a trip to Washington, DC, this spring, Pushpalatha Bhat told Barack Obama's Senate staff that they need to apply the Democratic presidential candidate's "Yes we can" attitude to reverse the budget cuts that were levied late last year on physics. "That's his motto," says Bhat. "And I challenged them that we need 'the audacity of hope'—the title of Obama's book. We can't afford to lose that. We need to fund science and education. They are the basic building blocks for advanced civilization. And we need to regain credibility and standing on the world stage."

Fermilab, where Bhat has been an experimental physicist for 20 years, is cutting 200 positions, or more than 10% of its workforce. "Morale is low," she says. "Very smart young people that I know have recently left the field because they are discouraged about what's happening to the lab." Fermilab's budget for fiscal year 2008 is \$320 million, or \$52 million less than expected and \$24 million less than in 2007 (see PHYSICS TODAY, April 2008, page 37).

Fermilab may have been hardest hit, but many Department of Energy labs are reeling from budget cuts. SLAC, at Stanford University, with a high-energy physics budget of \$95 million,



MARK FINKENSTADT/GM

Matthew Doude, leader of the Mississippi State University Challenge X team, shows the winning vehicle to General Motors vice president for environment and energy **Beth Lowery** (left) and US Energy Secretary **Samuel Bodman**.

came up more than 20% short of its anticipated amount, which forced the lab to prematurely close the B factory, stop work on the International Linear Collider (ILC), reduce the hours of operation of its synchrotron light source, and cut 15% of its workforce, or about 225 jobs. As part of a 7%, \$39 million cut from FY 2007 levels in Argonne National Laboratory's budget, DOE directed the lab to shut its Intense Pulsed Neutron Source a year early, which resulted in 44 people losing their jobs. Other labs, including the weapons labs, also suffered losses. Lawrence Livermore National Laboratory, for example, laid off 440 employees in May and, as of press time, expected to slash 100 more jobs at the end of June. That's on top of layoffs and voluntary departures earlier this year and other recent job cuts. In total, LLNL is down nearly 2000 employees from two years ago. This year's cuts are "unprecedented," says Fermilab director Pier Oddone, "other than the SSC [Superconducting Super Collider], which was more catastrophic."

In high-energy physics, Oddone says, "the biggest impact of the cuts is on all the future projects." Funding for the ILC and superconducting RF research—for Project X, which would produce neutrinos, muons, and kaons and is seen as a less costly way to do important science if the ILC is delayed (see *PHYSICS TODAY*, October 2007, page 30)—was slashed by 75%, but since that came about a quarter into the fiscal year, work in those areas has ground to a standstill. NOvA, the neutrino experiment slated to be the lab's largest facility after the Tevatron turns off, got zeroed out just when construction was to begin.

Stopping capital investments in those projects wasn't enough to fit the slimmed-down budget, so Fermilab introduced furloughs and is cutting jobs. Since February all Fermilab employees have had to take a week of unpaid leave every two months. "We saved about \$12 million that way," Oddone says. The furloughs lasted only four months, thanks to a \$5 million anonymous gift to the University of Chicago that will be used at Fermilab. Morale took "a big step up" with the 27 May announcement, says Fermilab press officer Judy Jackson. "It was palpable. You could tell by the noise level in the cafeteria."

The budget cuts undermine Fermilab's ambitions to host the ILC, Oddone says. "Even participating in a signifi-

cant way is more difficult. It's not only the cuts that hurt, but the fact that ITER [the international fusion energy reactor] was not funded. Again we get egg on our face. The question [international partners have] will always be 'How can we trust you?'"

On a more positive note, Oddone points to the 29 May Particle Physics Project Prioritization Panel report, whose recommendations support keeping the US in a leadership role in particle physics. "We are getting a lot of support. It gives

a lot of hope," says Oddone.

"After the cuts there was mobilization of the science community to make a better case with the Congress, and even the congressional words have been very supportive of science. Things can change when a new administration comes in," he adds. "I think it's directorial disease, but I am optimistic about the future."

Toni Feder

US stellarator aborted

"The magnets look crazy—like they were hit by a truck—but the particles see an almost symmetric magnetic field," Stewart Prager, a plasma physicist at the University of Wisconsin-Madison and chair of the Fusion Energy Sciences Advisory Committee, talking about the National Compact Stellarator Experiment, which the US Department of Energy (DOE) announced on 22 May would be terminated midconstruction due to cost and schedule overruns.

In 2002 when the NCSX was planned for the Princeton Plasma Physics Laboratory (PPPL), the cost was estimated at around \$75 million and startup was

planned for 2007. By the time the project was approved in 2004, the cost had climbed to \$96 million. About \$92 million has gone into the machine so far, but a review this spring put the tab at \$170 million and the start date at 2013. Moreover, the review, by DOE's Office of Science, concluded that "the bottoms-up estimate is yet to achieve acceptable credibility due to design maturity, integration complexity, evolving experience base, and risk events excluded from analysis."

In a statement, DOE undersecretary for science Raymond Orbach said that concentrating on the National Spherical Torus Experiment "better positions PPPL to remain a center of excellence for fusion energy and plasma sciences, and thereby to compete for new areas of leadership in the future fusion program." Tokamaks like the NSTX and stellarators both use magnetic fields to confine plasmas, but in tokamaks symmetry makes the field two dimensional, whereas in stellarators the field is three dimensional. Tokamaks are better at confining plasmas, and stellarators are better at sustaining them. The idea of the NCSX was to get both advantages by creating a field that is quasi-symmetric (see the news story in *PHYSICS TODAY*, June 2002, page 21, and the article by Richard Hazeltine and Stewart Prager in July 2002, page 30).

Says A. J. Stewart Smith, dean of research at Princeton University, which runs PPPL for DOE, "It turned out that this complex device, with large forces and very tight tolerance requirements, was more difficult to assemble than had originally been estimated." PPPL will complete two NCSX coil systems that would be expensive to restart, will store the major components of the machine, and, at DOE's request, will document engineering solutions. These measures, says Smith, "will be of critical value if another device of this type is undertaken in the future."

The NCSX "was a creative experi-



Oddone



ELEANOR STARKMAN, PPPL

The vacuum vessel (segment shown) and other parts of the canceled stellarator at the Princeton Plasma Physics Laboratory have strange shapes to create quasi-symmetry for the plasma particles.