issues & events

Passenger jets collect data for research on climate change and pollution

Next time you settle in for a long flight, consider that instruments for sampling the outside air for atmospheric research may also be on board.

Two air-quality and climate-change research projects in Europe are joining forces, with the aims of securing long-term funding and expanding their data gathering to global coverage. MOZAIC (Measurements of Ozone and Water Vapour by Airbus In-service Aircraft) and CARIBIC (Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container) fly instruments on commercial jets to collect air samples and perform in-flight measurements.

Starting in September, the two projects will share management, funding, and data. And while they will maintain separate research thrusts, they will also take on a monitoring role for climate forecasting. A third research effort along the same lines is run out of Japan.

Global access

Since the mid-1990s MOZAIC and CARIBIC—and the predecessor to the current Japanese project, CONTRAIL (Comprehensive Observation Network for Trace Gases by Airliner)—have been hitching rides for their instruments in the cargoes of commercial jets. NASA ran a similar project in the 1970s, and weather services use commercial aircraft to gather pressure, temperature, and wind data, but not generally for research. Among the things the current experiments measure are ozone, water vapor, carbon monoxide, carbon dioxide, reactive nitrogen species, and aerosols. In the case of CONTRAIL, "the main purpose is to understand the global carbon cycle," says the project's coordinator, Toshinobu Machida of Japan's National Institute for Environmental Studies. Data from all three are used in climate-change and pollution studies. Other uses include validating satellite measurements and guiding computer models of various atmospheric chemical and physical processes.

"Wherever we fly, we get information that is otherwise not available," says CARIBIC coordinator Carl Brenninkmeijer of the Max Planck Institute for Chemistry in Mainz, Germany. "It's impossible to get all this information by means of satellite—the resolution is too coarse—or from ground stations." And flying instruments on passenger jets is cheaper and offers more frequent flights and wider global coverage than would be feasible with dedicated research planes.

LUFTHANSA

UDO KRÖNER/LUFTHANSA

The air inlet system on the belly of the Lufthansa jet that takes data for CARIBIC is roughly 30 cm tall and has three intake probes, one each for water vapor and ice crystals, trace gases, and aerosols. MOZAIC's instruments, such as this module (below) for measuring nitrogen oxide, fly continuously and are swapped out every six weeks for servicing.

Commercial airliners cruise at roughly the altitude of the tropopause, which, at 8–16 km depending on latitude and season, is the transition region between the troposphere and the stratosphere. "The tropopause is the barrier for exchange of chemicals such as chlorofluorocarbons, water vapor, and ozone," says Andreas Volz-Thomas, the chemist at Research Center Jülich who is coordinating IAGOS (In-service Aircraft for a Global Observing System), as both the new incarnation of MOZAIC and the umbrella for MOZAIC and CARIBIC are called. "It is the most climate-sensitive region, and changes in its dynamics may well influence ozone at Earth's surface."

With instruments for 15 experiments that sample more than 40 different gases, the CARIBIC cargo weighs 1.5 metric tons. Once a month project members haul it to the Frankfurt airport, where Lufthansa workers install it in an airplane with a built-in air inlet system. When the plane returns—from Toronto; Houston, Texas; Santiago, Chile; Chennai, India; or wherever—"we bring the mobile laboratory back to the institute, like a Trojan horse," says Brenninkmeijer. "We get data, air samples, aerosol samples. These are analyzed, and a month later we repeat the whole sequence."

In flight, "we have a rigorous system where we repeatedly sample at regular intervals," adds Brenninkmeijer, "and we are working on an air collector that is triggered by pollution plumes so that we can quickly take an air sample of that particular air mass for detailed analysis."

MOZAIC, by contrast, sports fewer instruments—its load is only about 150 kg—but flies on several planes, all the time. Every six weeks the MOZAIC team collects a storage disk of data from each plane.

"We have less instrumentation than CARIBIC, but we do a lot of measurements," says Research Center Jülich's Herman Smit, who is responsible for MOZAIC's water-vapor measurements. "Since 1994 we have collected data from more than 28 000 long-haul flights from which we get detailed information on the seasonal variation and geographical distribution of substances that influence air quality and climate."

As MOZAIC enters a new phase as part of IAGOS, better, lighter-weight instruments are key, says Volz-Thomas. The aim is to reduce the total instrument weight to 100 kg while also expanding the measurement capabilities. "We have to keep transport costs at a limit acceptable to airlines—so far they have carried our instruments for free, and we hope they continue." The first IAGOS instruments are slated to fly next year. The aim is to raise enough funding to fly instruments on 20 planes within 10 years.

For its part, CONTRAIL combines air sampling and continuous measurement. Air samples are collected on twice-monthly flights between Tokyo and Australia and other equipment monitors CO_2 continuously. The project uses five planes.

The three projects have different scientific emphases and "also have quite different flight routes," says MOZAIC coordinator Jean-Pierre Cammas of the CNRS Laboratoire d'Aérologie in Toulouse, France, which along with Jülich and France's national weather service is one of the project's main science partners. "The projects are complementary."

Blue skies research

Examples of CARIBIC research include using mercury measurements in three-dimensional global atmospheric transport models, characterizing aerosols in the upper troposphere and lower stratosphere, and deducing vertical profiles of gases from scattered light. "We have three tiny telescopes built into the pylon. We let in light, not air," says Ulrich Platt of the University of Heidelberg. "The advantage of spectroscopy is that you can see the unknown. We are looking in the near-UV at 300–400 nm." One highlight, he adds, "was finding precursors to OH [hydroxyl] radicals, which provide self-cleaning of the atmosphere. We have found that thunderstorms might contribute a lot to self-cleaning of the atmosphere."

In the aerosol intake, air is slowed from about 250 m/s to a few m/s so the particles don't smash into the walls of the collection tube. Nuclear physicist Bengt Martinsson of the University of Lund, Sweden, and colleagues analyze samples using transmission electron microscopy, particle-induced x-ray emission, and other methods to identify and quantify aerosols. "The picture emerges of little transport of particulate matter from low altitudes by deep convective systems," says Martinsson. Instead, he adds, aerosols in the upper troposphere are produced from gaseous precursors that have been transported up from lower altitudes.

Among MOZAIC's most important findings so far, says Cammas, is the presence of ice supersaturation. "The upper atmosphere is much wetter than we thought. It's quite important for the formation of cirrus clouds and the formation of contrails by aircraft. Contrails can generate other cirrus clouds, which could impact climate." MOZAIC also discovered high summertime levels of nitric oxide over the eastern coast of the US, says Volz-Thomas, and ozone levels depend on NO. "There is NO from automobile exhaust, brought up by convection. A lot comes from lightning, too, and there is NO from aircraft." Because of the incomplete vertical transport description in models, he adds, "the impact of aircraft on ozone is at least disputable."

Indeed, says Volz-Thomas, a big debate at the moment is whether it's true that "because of their additional effect on ozone, methane, and cloudiness, aircraft emissions influence climate three times more than the same amount of CO_2 emitted from a ground-based power plant." In a new emissions trading scheme, the European Commission (EC) plans to apply charges based on that assumption. "Airlines want to know if the factor of three is correct. Our data will help answer this."

Seeking sustainability

"We are trying to get IAGOS to be a global, sustainable infrastructure with long-term funding," says Volz-Thomas. "If you want to look at trends, you need 30 years or so of continuous record keeping. But funding agencies usually want to see something sexy, something new." IAGOS leaders put the cost of modifying aircraft, building new instruments, and running the project at about $10 million a year.

Making a united case for funding is one reason CARIBIC has teamed up with MOZAIC. Says Volz-Thomas, "We hope IAGOS will be an important part of the in situ infrastructure for the atmospheric part of GMES"—Global Monitoring for Environment and Security, a new European service expected to go online around 2012—"and GMES could help fund IAGOS." Gathering data with commercial airliners "is turning into a combination of research and monitoring climate," adds Cammas.

Starting in September, IAGOS has EC funding for four years to get countries to sign on to the project. "The main objectives are to prepare the legal and organizational framework for IAGOS and to raise funds for operating it over a long time," Volz-Thomas says. Potential sources of money are participating institutions, national funds, and, via GMES, the EC, he adds. "Will they consider this project important enough?"

Toni Feder

DOE urged to proceed more deliberately with global plan to expand nuclear power

Critics of the Global Nuclear Energy Partnership say the Department of Energy is rushing to commercialize unproven technologies.

In March the UK became the 21st country to sign a nonbinding "statement of principles" that attempts to address the conflicting Global Nuclear Energy Partnership goals of spreading nuclear energy generation throughout the world while preventing the spread of technologies needed to manufacture and recycle nuclear fuel to nations that don't already possess them. Signatories to the GNEP include the nuclear haves Russia, China, Japan, and France, have-nots like Senegal, Jordan, and Ghana, and nations that have relied on other countries for their nuclear fuel, including the former Soviet satellites Hungary, Bulgaria, and Lithuania.

Many experts believe that a vast expansion of nuclear power is the only plausible option for meeting the anticipated explosion in electricity demand from the developing world while mitigating global warming. According to one widely accepted computer model, the Mini Climate Change Assessment Model, stabilization of atmospheric carbon dioxide concentrations at 550 ppm—a level that many climate scientists fear is still too high—will require as many as 4000 new nuclear reactors, said Victor Reis, a senior adviser at DOE. "This is an area where the US can provide some serious leadership," Reis recently told an audience at the American Association for the Advancement of Science.

But the GNEP's opponents argue that the program's adoption will increase the risk of proliferation of fissile materials that could be fashioned into a nuclear explosive. They charge that the program can't be justified on economics and say it will add to the environmental problems resulting from the use of nuclear energy by creating new waste streams.

Reactors and nuclear fuel

Unveiled in 2006 by President Bush, the GNEP envisions the US and other nuclear powers supplying aspiring nuclear nations with both advanced reactors and the nuclear fuel for them. For their part, recipient nations would agree to return their spent fuel to its nation of origin and pledge not to develop uranium-enrichment or spent-fuel reprocessing capabilities of their own. The US and other fuel-supplying nations would reprocess the spent fuel and recycle its plutonium into fresh fuel.

The GNEP blueprint includes R&D and construction of a reprocessing and fuel-fabrication facility and a fast neutron "burner" reactor that would transmute the long-lived actinides from spent fuel as it generates electricity. Together, the two technologies could so reduce the amount of waste needing storage that the Yucca Mountain dump in Nevada will suffice for the rest of the century. But achieving that goal would require deploying 40 to 75 advanced fast reactors.

DOE's implementation strategy for the GNEP calls for the formation of a government–industry partnership by the end of this year to proceed with detailed design and planning to build the two technologies at a commercial scale. According to the plan, construction would proceed as soon as final designs can be validated. But it is unlikely that the agency's schedule will be met; last year Congress slashed DOE's $405 million GNEP request to $179 million and expressly prohibited construction, technology demonstration, or commercialization activities, saying the technologies were not ready for deployment. The agency has requested $301.5 million for the Advanced Fuel Cycle Initiative, the GNEP's technology component, for fiscal year 2009, but lawmakers are widely expected to put off action on appropriations bills until after the November elections.

Immature technologies

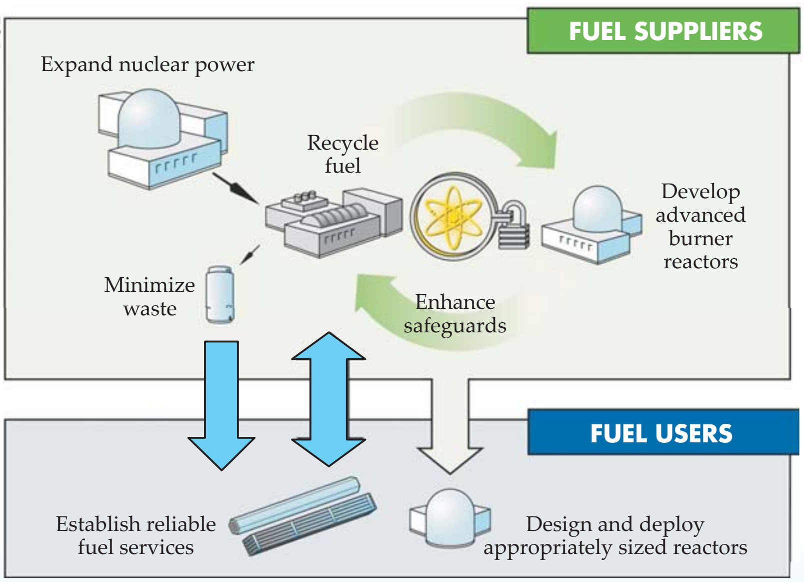
Two groups of outside reviewers also have urged DOE to apply the brakes to the GNEP. The Government Accountability Office warned in a May report that moving to construction too rapidly will "likely require using unproven evolutions of existing technologies" and ultimately limit their usefulness for nuclear waste reduction and proliferation prevention. A National Research Council review completed late in 2007 reached the similar conclusion that the GNEP technologies are immature. The NRC committee recommended that DOE continue with R&D, but said the agency could do more to revitalize nuclear power in the near term by focusing on assisting domestic utilities with the licensing and construction of advanced light-water reactors. Thomas Cochran, senior scientist with the Natural Resources Defense Council and a GNEP opponent, advised the nuclear industry to place highest priority on enacting a cap on US carbon emissions. A charge of $40–$60 per metric ton of carbon dioxide emissions likely will be needed for nuclear energy to compete with fossil-fuel generation, he told the House Committee on Science and Technology in April. Cochran said the GNEP "would be a disaster for international security and a multinational economic boondoggle of staggering proportions."

Robert Fri, chair of the NRC review panel, told a House hearing in April that the GNEP's accelerated deployment strategy "will create significant technical and financial risks by prematurely narrowing technical options." Although DOE argues that building the facilities sooner rather than later will save time and money, "just the opposite is likely to be true," Fri warned.

Defending the GNEP, Idaho National Laboratory director John Grossenbacher told the same hearing that "waiting until someone determines the economics are right to begin investing in alternate and advanced technologies tends to produce the kind of crises the world faces today, with oil prices well over $100 a barrel."

Officials at DOE are continuing to assess the feasibility and projected costs of building the GNEP facilities. In March four industry consortia received follow-on awards from the department totaling $18.3 million to study the fuel-recycling and fabrication plant and the burner reactor. Preliminary designs and cost and schedule estimates that those consortia prepared under earlier contracts were released this spring. By one estimate, the cost of the fuel-recycling and fabrication facility alone would be $16.6 billion, and it could be operating as early as 2023. An initial burner reactor could be built by 2025, although one study suggests it's likely to be

DOE



The Global Nuclear Energy Partnership plan by the Bush administration would promote more widespread use of nuclear power abroad by having the world's major nuclear powers supply reactors and fuel to developing nations. Those nations would return their spent fuel to the country of origin for recycling into new fuel.

mid-century before commercial versions are in operation.

Reprocessing revival?

No feature of the GNEP is more controversial than reprocessing, a technology that the US forswore for civilian use in the late 1970s out of concern that reprocessed plutonium could be stolen or diverted for weapons purposes. Princeton University professor Frank von Hippel, a longtime opponent of a closed nuclear fuel cycle, told a May roundtable discussion at the Carnegie Endowment for International Peace that nearly all nations that have acquired reprocessing capabilities—Pakistan, Brazil, and India among them—started nuclear weapons programs. South Korea, a GNEP member, recently declared its intention to develop a reprocessing capability. The GNEP does not require its members to renounce reprocessing, acknowledged Carter Savage, DOE associate deputy assistant secretary for nuclear energy. On the other hand, he added, GNEP members have no obligation to provide their reprocessing technology or know-how to the South Koreans.

Environmental and antinuclear activists are skeptical of public pledges by DOE to not deploy a reprocessing technology that yields weapons-usable plutonium, as does the plutonium–uranium extraction process that is used by France and the UK. But it isn't clear what chemical separation process will be used, and the experts don't agree on the extent to which various alternatives will serve as a barrier to proliferation.

Critics of the GNEP also argue that reprocessing can't be justified economically. A dozen European nations have stopped buying reprocessing services from France, the UK, and Russia, von Hippel said, because they found that storing their spent fuel after a single pass through the reactors is less costly. But Alan Hanson, executive vice president of Areva, the French nuclear conglomerate that operates La Hague reprocessing complex, countered that the economics will vary with the price of uranium, which has fluctuated between $31 and $138 per pound in recent years. Reprocessing adds about 6% to electricity rates in France, which has the lowest rates in Europe, he said. "We know exactly what it costs to reprocess, but nobody has even the slightest idea what it will cost to store spent fuel," Hanson told the May roundtable.

Indeed, storage costs can't be estimated as long as the already decades-long delay with building the Yucca Mountain site drags on. But even if the repository is completed—not before 2020, according to DOE—it will have only enough room for spent fuel that is generated through the year 2010 (see PHYSICS TODAY, June 2008, page 28). Without reprocessing, DOE warns, a second repository will need to be built to accommodate the growing quantities of spent fuel that will result from a revitalized US nuclear industry, let alone material that will be shipped back to the US under the GNEP. **David Kramer**

Social networks link interdisciplinary scientists

Analysis of social networks has become a many-body problem, attracting physicists and uniting once-divergent disciplines.

Ten years ago newly hired mathematical physicist Jennifer Chayes told her boss, Microsoft Corp founder Bill Gates, about new methods, derived from the phase-transition theory of spin glasses, to solve constraint-satisfaction problems in social and other networks. She warned him, however, that they "would take 100 years to pay off."

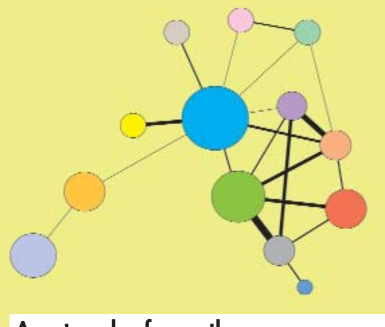
Chayes, who cofounded Microsoft's theory group with her husband and fellow physicist, Christian Borgs, recently contacted Gates to say, "I can't believe it, Bill. It has only taken 10 years to pay off."

Now, as director of Microsoft's new research laboratory in Cambridge, Massachusetts, Chayes will assemble and lead groups of social, computer, and physical scientists to model and design online social networks. Microsoft Research New England is the company's sixth research lab and the first with the mission of bringing together social and computer scientists to work on algorithms for social computing applications. More than just message boards, online social network applications such as Facebook, MySpace, and LinkedIn have become popular venues for advertising and search companies; industry analysts speculate that the new Microsoft lab and the company's bid for internet rival Yahoo Inc point to the urgency that the software giant is placing on competing online. Microsoft Research New England is expected to open this summer, just less than a year after it was first proposed, says mathematician Henry Cohn, a founding member of the new lab. "One of the advantages of industry is that when there is a compelling case for something, it can get done quickly."

Use of the Web has surged with the popularity of so-called Web 2.0 applications, which allow users to generate content and form communities. Several physicists, including Chayes, saw opportunities in the late 1990s to apply statistical mechanics principles to analyze complex networks like the Web. Peter Norvig, director of research at Google Inc, says the online search and advertising company employs "well over 100 people with one or more degrees in physics" to work on mathematical problems. "The reason I think that physicists do so well [in network theory] is that we are used to dealing with very large systems with lots of similar and interacting entities," says Chayes. "In the case of the World Wide Web, for example, there are on the order of 100 billion static webpages and even more dynamically generated webpages."

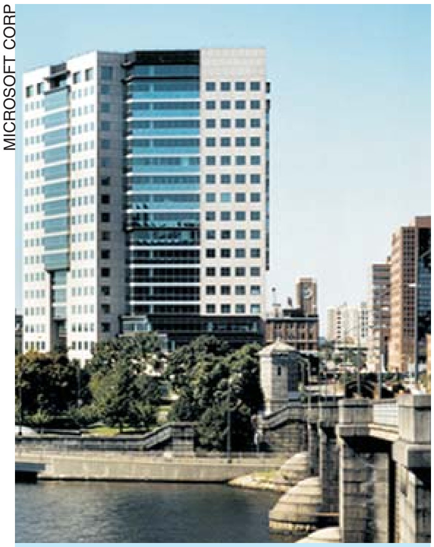
Highly connected hubs

Researchers studying self-organizing social networks look at how links are formed between individuals, whether some individuals or nodes are better connected than others, and the collective action or behavior of the entire network. In the past social scientists relied on surveys and questionnaires, but on the Web "social behavior is self-documenting—it leaves traces behind," says Microsoft research sociologist Marc Smith, who studies and designs improvements for



MARK NEWMAN

A network of coauthors among physicists who had published papers on networks as of 2003 shows the formation of discrete communities, denoted by colored nodes; the size of nodes corresponds to the size of the community. The thickness of the links connecting the nodes is proportional to the number of pairs of collaborators between communities.


MICROSOFT CORP

Microsoft Research New England will be housed in this building near the MIT campus.

social online applications.

Duncan Watts, director of the human social dynamics group at Yahoo Research, is using Friend Sense, an application he wrote for Facebook that queries users' political attitudes and how well they know their friends. Watts, who holds a bachelor's degree in physics and is also a Columbia University sociology professor, may be best known for showing that so-called small-world networks can be characterized by a small path length between nodes (related to the six degrees of separation) and a large degree of clustering among nodes (see PHYSICS TODAY, September 1998, page 17). For example, Bernardo Huberman, a physicist and director of the social computing group at Hewlett-Packard Co labs, recently scoured 362 million messages, minus the identifying information, of 4.2 million Facebook users and found that college students cluster by school affiliation.

"Social networks do offer one of the best-described systems that you can monitor in the most precise way," says Albert-László Barabási, director of the Center for Complex Network Research at Northeastern University. "We are using them to find fundamental organizing principles that can be tested in other systems as well." In 1999, Barabási used Web-crawling data to show that many complex networks were scale-free—a few nodes are highly connected hubs. Models that involve universality laws for complex networks are being applied to studies of how viruses spread on the internet and in human and biological populations, among other things, says physicist Mark Newman of the University of Michigan Center for the Study of Complex Systems. Online advertisers and developers can also take advantage of such network models to tailor their services for users based on interaction patterns or even devise incentives and mechanisms to influence people's behavior, says CSCS physicist Lada Adamic, who with Huberman in 1999 also showed that Web growth is scale-free.

Spin-glass payoff

Some condensed-matter physicists are drawn to social network modeling because it is similar to a many-body problem, says Huberman. Like spin-glass materials that have disordered and unpaired magnetic spins, individuals have conflicting interactions with their neighbors, and their uniqueness leads to disorder, says Université de Paris-Sud physicist Marc Mézard. It's a patent from Mézard's spin-glass theory work that is now paying off for Microsoft: He, Chayes, and collaborators are using that patent to solve optimization problems such as sending messages from one node to others, bypassing intermediates.

The researchers interviewed for this story say precautions are taken to protect the privacy of the personal information they use. "There's a very sticky privacy issue here," says Yahoo Research head Prabhakar Raghavan. "Data that we get from [our academic collaborators] goes through all manner of scrubbing and approval procedures within the company from the legal department. The principle we follow is, we use the data as we need it, then it gets destroyed."

Complex network models do not capture the nuances of human behavior, says Huberman. "People, unlike atoms and spins, are intentional beings, which limits the validity of many-body physics approaches." Sometimes individuals do alter their behavior, adds Barabási, "but at the end of the day, collective behavior doesn't change."

Jermey N. A. Matthews

Budding engineers compete to build more efficient, greener cars

University teams take varied technological approaches in vying for the Challenge X prize.

The 17 Chevrolet Equinox sport utility vehicles that pulled up to the US Department of Energy headquarters on 21 May were identically equipped when they came off the assembly line in 2005. Four years later all resemblance ended at the exterior. In the intervening time, teams of students from 17 universities had torn the guts out of their donated crossover SUVs—those built on a car frame—and installed radically new drive systems of their own design. The goal of the makeover contest, sponsored by DOE, General Motors Corp, and others, was to improve the fuel economy and reduce the tailpipe emissions of the SUVs without sacrificing vehicle safety or performance.

For GM and other US automakers, the Challenge X: Crossover to Sustainable Mobility competition got a new generation of engineers and scientists to work on "sustainable and innovative solutions" to reducing the country's dependence on oil, GM vice president for environment and energy Beth Lowery told the crowd at the ceremonial finish line. GM is beginning to move to electric-powered vehicles, she said, adding, "There has never been a more exciting time to be involved in the auto industry."

The winning team, from Mississippi State University, achieved a 38% gain in mileage over the stock vehicle with a "through-the-road parallel" hybrid system powered by a turbo-diesel engine running on 20% biodiesel fuel. Through-the-road parallel hybrids, the architecture selected by 13 teams, feature one set of wheels powered by the engine and the other set driven by electric motors. Ryan Williams, an MSU mechanical engineering undergraduate, said his team used computer-aided design software to help marry the drive train to the vehicle. Team members fabricated the one-of-a-kind brackets and other necessary structural components using computer numerical control tools available in the university's machine shop. Like many other participants in the Challenge X, Williams said he hopes to go on to a career in the automotive industry.

Bells and whistles

The University of Wisconsin–Madison team won second place with a virtually identical drive architecture, adding a few bells and whistles that included an expensive stereo and an infrared camera that can spot a deer on the road ahead. Ben Fjellanger, a UW mechanical engineering student, said that several 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 acceptability 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

MARK FINKENSTAEDT/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.

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, 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."

FERMILAB

Oddone

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. NO*v*A, 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 significant 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-

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.

ment that is important for physics and fusion energy," says Prager. Its termination "is a scientific loss, but given the cost situation, DOE made a justified decision." **Toni Feder**

Report: Young scientists need more support

A blue-ribbon committee of scientists and science policy experts has urged federal agencies, universities, and industry to step up their support for the research projects of early-career scientists and engineers and for high-risk, "potentially transformative" research. The panel also broke new ground in calling for research universities to pay a greater portion of their faculties' salaries.

The committee of the American Academy of Arts and Sciences says that early-career scientists are being squeezed out by their senior colleagues in the competition for limited federal research funding. Sponsoring agencies should establish new targeted programs and grant mechanisms or adapt existing grant programs to foster potentially transformative research, which could produce breakthroughs but also carry a high likelihood of failure. Proposals for such research are typically rejected by the traditional peer-review process in favor of less risky applications.

Other reports in recent years have made similar recommendations, and NSF and the National Institutes of Health have instituted new grant mechanisms that begin to address the issues. But the "boldest and most controversial" of the committee's recommendations, said committee chair Thomas Cech, is its call for universities to pay a greater portion of their faculties' salaries. Currently, up to 100% of a faculty member's salary can be charged to a research grant, depending on the field and how much time that individual spends on the research. And universities typically require faculty members to obtain grants that cover at least their summer salaries. Salary support for established researchers reduces the number of new projects federal agencies can fund.

"A number of university leaders have called this naive, impractical, or were shaking their heads when we proposed this," admitted Cech, a Nobel laureate and president of the Howard Hughes Medical Institute. "It came out of the realization that many of the problems encountered by the early-career investigators and the lack of support for potentially transformative research were directly tied to the fact that salaries had to be obtained, 100% in many cases, from federal research grants."

A related problem has been the tendency for universities to build new research facilities without consideration for the operating costs. Institutions are allowed to recover their construction costs through the indirect costs they tack onto the direct costs of individual research grants. But much of the construction in recent years was based on unrealistic expectations about a continued expansion of the federal research enterprise, particularly at NIH.

The committee urged NSF, NIH, the Department of Energy, and other federal granting agencies to adopt career-stage-appropriate expectations when conducting merit reviews of their grantees. Universities should strengthen or develop mentoring programs to encourage early-career faculty, reconsider promotion and tenure policies for young investigators, and address the needs of scientists who are primary caregivers.

New investigators face increasingly stiff competition, especially at NIH, where the average age of a first-grant recipient climbed from 39 in 1998 to 42.4 in 2006. At NSF, success rates for first-time grant applicants plummeted from 22% in 2000 to 15% in 2006, and the average time from receiving a degree to a first NSF award has risen from 8.5 years in 1990 to 9.3 years in 2006.

Transformative research, the sort that the committee said led to the invention of the transistor and the discovery of angiogenesis, has been stifled by an increasingly conservative peer-review system, by the need for investigators to demonstrate publishable progress in order to keep new awards coming, and by other factors.

Panel member and former NSF director Neal Lane said the agency's program officers need to "get out in the community"—attend scientific gatherings and make site visits as they once did regularly. "The decisions these program officers are making are critical to the future of science, engineering, and medicine in this country," he said, and jobs need to be attractive to the best people. Lane, who also was science adviser to President Bill Clinton, said agencies need to collect more data about their funding activities so that comparisons can be made among programs. "At NSF half the people who get a new grant don't show up again. So what happens to them? Perhaps they're getting funding from other agencies. We know anecdotally that many of them do," Lane said. "But if we believe that the future of the science and engineering enterprise depends on the career development of these young people, we need to know who they are, how they're doing, and how the system that's supporting them is doing." The report is available at http://www.amacad.org/ARISE. **David Kramer**

Industrial physics practices highlighted

Physicists in industry are abandoning the use of laboratory notebooks and R&D managers are wary of relationships with academia, according to a forthcoming American Institute of Physics report.

From 2002 to 2007, Joe Anderson and his associates at AIP's Center for History of Physics interviewed more than 120 R&D managers, senior bench physicists, and records managers at 15 US-based companies from among the 27 that employ about half of all physicists in the corporate sector. Findings from the History of Physicists in Industry (HOPI) project report, which will be available in September, showed that more than half of the physicists who graduated with PhDs from US universities in the late 1990s chose in-

AIP

The IBM Thomas J. Watson Research Center was the first site visited for the History of Physicists in Industry project. From left to right are first project historian Tom Lassman, project director Joe Anderson, and IBM physicist Jim Wynne.

dustry over academic appointments (see PHYSICS TODAY, April 2007, page 28). The study also tracked record-keeping practices and communication patterns of industrial physicists as well as business restructuring patterns of research labs (see http://www.aip.org/history/HOPI.htm for more information).

Use of hard-copy notebooks is on the decline, the study finds. Computers have sped up experiments so that scientists no longer have time to fill in lab notebooks, says a Ford Motor Co interviewee in the report. The widespread adoption of electronic records has also proved challenging for R&D managers and company archivists who face the problem of preserving digital records and making them easily accessible. The study found that increased government regulations are putting more pressure on companies to preserve business records, while rules that govern intellectual capital such as R&D records are left to each company's discretion. Knowledge management is "a big huge mess . . . and no one wants to fund it," says long-time Raytheon Co librarian Mark Baldwin in the report.

The HOPI study found that company funds have periodically shifted between research and development since World War II. There has also been a recent trend in industrial research toward knowledge assessment and acquisition at the expense of knowledge creation. Companies are acquiring startup businesses and outsourcing research to industry consortia and universities, but many R&D managers favor limiting relationships with academia to projects that are least focused on product development. Jeffrey Newmeyer, a manager at defense contractor Lockheed Martin Corp, suggests in the study that companies should keep industry–university collaborations at the "precompetitive, preweaponizable level." He adds, "It also frankly doesn't help the situation that universities have become very business and intellectual-property-ownership oriented over the past 5 or 10 years."

Jermey N. A. Matthews

news notes

AIP energy journal. The American Institute of Physics's new *Journal of Renewable and Sustainable Energy* will cover everything from biofuels to wind and waves to fission and fusion. "From examination of the periodical literature, there is no single journal dedicated to addressing all of the technical research and applications in the areas covered by the new journal," says Aravind Akella, AIP's manager of journal development. "The published literature spans more than 20 different journals."

A peer-reviewed, Web-based publication, *JRSE* opens for submissions on 1 August, and the first articles will be published this fall. It is AIP's second online-only publication; the first, *Biomicrofluidics*, debuted last year. For more information, visit http://jrse.aip.org. **TF** ■

web watch

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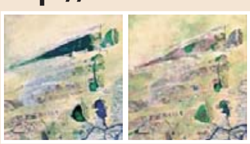
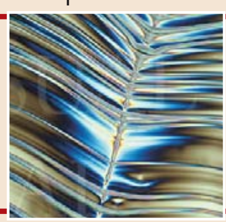
http://www.na.unep.net/atlas/AfricaAtlas



The United Nations Environment Programme has just published ***Africa: Atlas of Our Changing Environment***. Based on recent and archival satellite images, the atlas documents natural and manmade changes to Africa's forests, plains, lakes, and other features. A hard copy of the atlas costs $150, but you can download PDFs of all the chapters for free.

http://www.internano.org



InterNano is a new, open-source clearinghouse for researchers engaged in nanomanufacturing. The site offers tools, news, calendars, and other resources. But even if nanomanufacturing is not your field, the gallery of images is worth a visit.

http://www.perimeterinstitute.ca/Outreach/Public_Lectures/View_Past_Public_Lectures

Canada's Perimeter Institute for Theoretical Physics invites its distinguished vistors to give **public lectures**. Gerard 't Hooft's "Science Fiction and Reality" is among the lectures that you can watch, read, or hear on the institute's website.