tokamak, some 200 meters away. Synchronized to the master arms are the slave arms, which do the actual work from the end of a several-meter-long boom. "We have feedback on the system," says Hermon. "You can feel weight, or rubbing. We don't use robots as manipulators. There is always a man in the loop. We have submillimeter tolerance. You need a human."

As part of their interviews for the robotic handling team, operators had to use robotic arms to stack toy building blocks. "You have to be dexterous," says Hermon. "A good operator can build a tower. He can go in and feel if a block is moving." The JET work can be delicate, he adds, "almost like threading a needle. And plug-in sockets, for example, are easily damaged because they have ceramic insulation. We are not allowed to damage the surface at all." The individual beryllium tiles weigh up to about 12 kg and cost tens of thousands of dollars, he adds.

"There is an enormous amount of work, and so many strands that have to come together," says Hermon. "Some components are still being manufactured, and there is the occasional last-minute design change. The major challenge is sheer time."

EFDA-JET

The thousands of carbon tiles lining the plasma-facing wall inside the vacuum vessel of the Joint European Torus are being replaced using a remote-controlled slave arm.

Scaling up to ITER

JET "will be a completely new machine when it comes back," says Cowley. Although tungsten and beryllium have each been tested alone, says Romanelli, "the combination has never been tested. Our plan is to demonstrate that we can run up to the highest performance reliably with the combination." Experiments exploring how the new wall behaves and any required modifications will take about three years, he says. Then, for the first time since 1997, JET will embark on a tritium campaign in late 2013.

ITER will be about twice JET's size, its pulses will be about 20 times as long (400 seconds compared with about 20 seconds at JET), and it is intended to produce around 30 times the power (500 MW compared with 16 MW). Still, says Mario Merola, who oversees planning for ITER's plasma-facing components, "we need the information coming from [JET] for finalizing the scenarios for the ITER machine, which will have exactly the same situation as far as the plasma-facing wall.

"JET will address major scientific topics," Merola says. "For example, how the melted layer of beryllium—which results from large, fast energy deposition in off-normal plasma events, like vertical displacement or plasma disruptions—behaves under electromagnetic loads, and how eroded beryllium penetrates into the gaps between tungsten tiles. We will also get information on the behavior of tungsten under high and cyclic thermal loads and on how the plasma behaves with a tungsten diverter." Cooling the much larger number of tiles in ITER using pressurized water will be a technological challenge, he adds. JET is also key for training physicists and engineers in remote handling, beryllium and tritium handling, and burning plasmas, among other things.

Merola says he doesn't expect the JET results to lead to changes in the ITER design, "but they will provide us with information on the lifetime of components, and from a physics standpoint, how the plasma behaves with a combination of beryllium and tungsten. We are very keen on getting these results." **Toni Feder**

Augustine panel urges more autonomy for NASA

Congressionally imposed restrictions limit NASA managers' capacity to streamline operations.

On 29 October, one week after a blue-ribbon advisory committee declared that NASA's timetable for returning astronauts to the Moon is unrealistic, a prototype of the Ares-1 rocket that will lift humans into space launched successfully from Kennedy Space Center. Several options for a future US human space exploration were presented to President Obama by a committee led by retired Lockheed Martin chairman Norman Augustine. In the coming weeks, the president will choose from among those options.

In addition to its recommendation that NASA's exploration budget be boosted by $3 billion, the panel's report urges that NASA administrators be given greater latitude to manage the agency, realign its bloated 1960s-era infrastructure, and adjust the workforce.

"You [can] either spend your money on fixed costs and overhead, or you can spend it doing exciting exploration," Augustine said at the press conference marking the release of the committee's final report. "I think NASA is going to have to face that question, but if they are not given any latitude by the Congress, basically, or the White House—I should say both—they won't be able to do that."

Although the committee was asked only to chart a course for future manned space missions, the report argues that the agency's severely constrained resources make it vital that the administrator be allowed to move resources around. "Good management is especially difficult when funds cannot be moved from one human spaceflight budget line to another, and where new funds can ordinarily be obtained only after a two-year budgetary delay (if at all)," the report says.

The comments are clearly meant for Congress, which has frequently meddled with NASA, mostly to protect the workforces at the agency's 10 centers. NASA's current authorizing legislation, enacted last year, prohibits the layoff of any of NASA's 18 000 employees through the end of the 2010 calendar year. According to the report, though, only a small fraction of NASA workers can be considered to possess critical skills that the space program must retain. But since the agency must keep its existing workforce and facilities configuration, at least for now, it is forced to produce in-house items that could be purchased commercially for less.

In an interview with PHYSICS TODAY, former NASA administrator Michael Griffin said he "couldn't agree more" with the report's admonitions about management, but he noted that a significant restructuring would require "finding a congressman to raise his hand and say it's okay to close the center in his district." Although "you could run NASA effectively with fewer centers," Griffin said, he would leave the federal workforce untouched. The agency operates the same number of facilities today, he said, as it did in the peak years of the Apollo program in the 1960s, when it had twice the workforce it has now and, in inflation-adjusted terms, twice the budget.

Griffin suggested that any downsizing of NASA will require a process analogous to the Defense Base Closure and Realignment Commission (BRAC), which took decisions on post–cold war closings of military bases out of the hands of lawmakers. Other civilian research facilities, including the Department of Energy's national laboratories, should be included in the exercise, he added.

NASA

A prototype of the Ares-1 rocket, which will carry astronauts into space in the coming decade, blasts off from NASA's Kennedy Space Center on 29 October. An advisory committee has recommended changes to NASA's human space exploration program.

John Logsdon, emeritus director of the Space Policy Institute at the George Washington University, agrees that congressional interference has been "a significant obstacle" to streamlining NASA. Some procedure outside the political arena will be needed to make the workforce and facilities adjustments, he says, but with only 10 NASA centers, a BRAC approach isn't likely to work. Given that downsizing has been needed for decades, Logsdon says he's not optimistic it will happen soon.

Other restrictions and practices impair NASA's ability to make effective use of US industry, the report says. Examples include the inability to use loan guarantees and mechanisms that other agencies, such as the Department of Defense, have used to create a market and attract private investment from commercial suppliers. The committee also was critical of the "spiral development" model that NASA has used for the procurement of some items. The report notes that the model, in which the requirements for an engineering project aren't known at the outset and are determined as the item is being built, "inevitably leads to a very expensive result."

David Kramer

DOE names winners of long-shot energy research grants

Billions of dollars will flow into 'smart grid' projects.

A broad portfolio of 37 risky concepts for the production of clean energy were selected on 26 October for funding by the Department of Energy's new Advanced Research Projects Agency (ARPA–E). The following day, President Obama announced that DOE will hand out a total of $3.4 billion to 100 utilities and other energy companies to spur modernization of the US electricity grid.

In a speech at Google Inc's headquarters in Mountain View, California, Secretary of Energy Steven Chu said the $151 million in ARPA–E awards comprises "a portfolio of bold new research projects, any one of which could do for energy what Google did for the internet." ARPA–E was authorized in 2007 legislation but was not funded until this year. Its role is to support long-shot carbon-free energy concepts that could produce breakthrough technologies if successful. All the awards went to projects headed by academic researchers or companies both large and small; national laboratories were relegated to partnering with several of the awardees. The selected projects span renewable energy, energy storage, industrial and building efficiency, petroleum-free vehicles, and carbon capture. A number of awards will support work on advanced battery concepts, such as a $6.9 million effort by MIT researchers to make a low-cost, all-liquid, metal cell with the potential to store enough electricity to smooth out the inherent peaks and valleys in wind and solar energy generation.

Several ARPA–E grants will fund novel approaches to capturing carbon dioxide emissions from fossil power generation. One of those is a $2.2 million project at United Technologies Inc to mimic an enzymatic process by which the body captures CO_2 from cells, transports it through the bloodstream,