Sandia Bets on Mega-Microsystems Facility, Holds Off on Pulsed Power

Sandia National Laboratories will back microsystems R&D, and at least for now won't build a new pulsed power machine. This past summer the Department of Energy (DOE) gave its nod to the Albuquerque, New Mexico, lab's proposed Microsystems and Engineering Science Applications facility. To get started on the $300 million project, Sandia still needs Congress to appropriate $20 million this month for fiscal 2000. If funding for MESA comes through, construction would begin in 2001, and the facility would be slated to open in 2004.

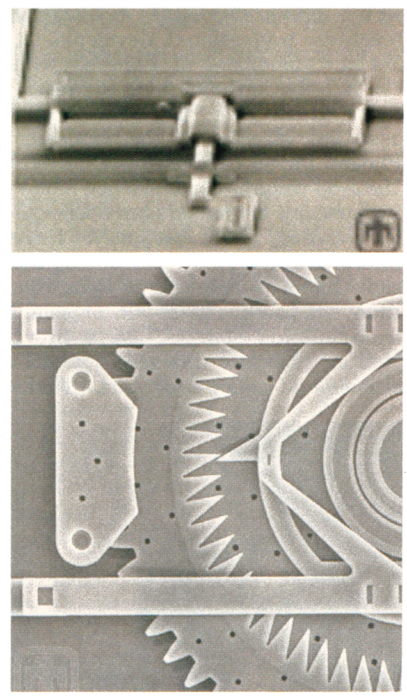
The lab knew that DOE couldn't pay for both MESA and a bigger pulsed power facility, says Tom Hunter, who heads Sandia's nuclear weapons programs. "It was a matter of deciding which one best fit the total spectrum of activities at Sandia, and which one had the best opportunity within the national labs' weapons program." ZX, as the proposed successor to Z, the lab's current pulsed power facility, is known, is very important, continues Hunter, "but it doesn't have as broad an implication as MESA."

Think small

In going with MESA, Sandia is sticking with its historic role of overseeing the development of electronic switches and other nonnuclear parts of nuclear weapons—DOE's labs in Livermore, California, and Los Alamos, New Mexico, are responsible for the nuclear parts. With the full-scale testing of nuclear explosions no longer legal, DOE's approach to its task of ensuring the reliability of the nation's nuclear weapons—the controversial $4.5 billion-a-year science-based stockpile stewardship program—is to use laboratory experiments and simulations to study how bomb components age under various chemical and physical conditions, and to check and replace them. Says Gil Weigand, DOE's deputy assistant secretary for research, development, and simulation, "For us to be a world power in terms of nuclear deterrence, we have to be at the forefront in small-scale devices. That's where you have to go."

The microsystems field includes micromechanics, microelectronics, microoptics, and microsensors. "We incorporate new structures on chips, enabling new functionality," says Paul McWhorter, who oversees microsystems R&D at Sandia. "So we make chips that can not only think, but can sense, act, and communicate. We have devices that have optical signals as inputs or outputs, and we can put micromachined accelerometers and gyros on a chip to detect motion. Once you start putting more than just transistors on a chip, the possibilities are endless."

Virtual reality and micromachines would be wed at MESA, with the aim of making both weapons and commercial products.



MICROMACHINES ARE MADE by etching layered polysilicon; aluminum materials can be used to enhance micromachined mirrors. The piston on the world's smallest steam engine (top) is about 4 μm across, and the indexing motor (bottom) has teeth 10 μm wide (tip to tip) to finely control other micromachine components. (Courtesy of Sandia National Laboratories.)

Sandia is strong in microsystems research already, McWhorter adds. "But it's basically making do with retooled microelectronics facilities." The plan is for MESA to gather under one roof the lab's microsystems research and production activities, and couple computer simulations to the design process. Says McWhorter, "You create a virtual world for your design, crawl around it, and see how [the design] behaves in normal and hostile environments. This will allow you to more effectively see how they work, and get all the bugs out." There are lots of ideas for micromachines, adds McWhorter, but very few products to date. That will soon change, he predicts: "The impact of micromachines is not their size, it's their cost—you can build complex electromechanical functions for a dollar that with traditional methods may cost $5000. MESA will really be an enabler to seeing microsystems reach their potential."

MESA's main mission would be to design new components for old weapons. For example, Sandia's vice president for science and technology, Al Romig, envisions chemical sensors that would detect precursors to corrosion in a weapon. So, when Sandia was weighing ZX against MESA, says Don Cook, who this past spring moved from heading Z to the top MESA job, one factor that tilted the decision in MESA's favor was the upcoming refurbishment of the W80 and W76 nuclear warheads, scheduled to begin in 2006. MESA would also work with industry. For one thing, says McWhorter, if a sensor for deploying airbags, or some other micromachine, "is in 20 million cars, it helps give you confidence that you understand the technology—and are ready to put it into a weapon." Sandia also wants to get out the word on its exciting science, adds Cook, to attract bright scientists to be the next stewards of the nation's stockpile.

The real bugaboo

With ZX on hold, what's the outlook for pulsed power? Last year, after a streak of energy and power fusion records with Z, Sandia was abuzz with hopes of building a high-yield successor, which it called X-1 (see

PHYSICS TODAY, June 1998, page 56). But, says Z director Jeff Quintenz, "when the cost came in at over $1 billion, with DOE's other mortgages, it was clear X-1 was a nonstarter." So Sandia settled instead on ZX, which was designed to produce about one-third the power, at about one-fourth the cost, of X-1. The price would have been lower largely because ZX would have produced less radioactive waste than X-1, so, Quintenz says, waste handling would be minimal, and ZX could be built at Sandia using existing infrastructure, whereas the plan was to build X-1 on a green field site, probably in Nevada. ZX would have combined efficient production of hard x rays from pulsed power with fusion implosion, he continues, "and would be a reasonable step if it answered some of the physics questions. That's how we scoped ZX."

Sandia plans to keep using Z, however, both to push pulsed power further, and to test the effects of radiation on weapons parts—including those MESA makes. The lab recently inherited the Beamlet laser—a prototype for Lawrence Livermore National Laboratory's National Ignition Facility. Says Quintenz, "We now have the third or fourth most energetic x-ray source as a diagnostic for the world's most powerful and energetic one. We can take a picture in x rays during a z-pinch."

In the national inertial confinement fusion program, pulsed power has always been a bit of an underdog, continues Quintenz. Not getting to go ahead now with ZX "is just another hurdle. The goal is high-yield fusion. That's what's required by the weapons program. We've got to get there somehow." Cook too believes that a successor to Z will be built someday: "The technological development of pulsed power is so impressive—it's not incredible, because it's been achieved—I know it's only a matter a time. The real bugaboo is where the money will come from."

TONI FEDER

Scientists' Counsel Counts in Congress

"People outside of physics always ask how my work is going to benefit society," says particle physicist Greg Jaczko, the American Institute of Physics' 1999–2000 congressional science fellow. As one of 26 scientists and engineers in the Congressional Science and Engineering Fellowship program run by the American Association for the Advancement of Science, Jaczko will spend the next year analyzing and crafting science and technology policy as a congressional staffer. "One of the things I really like about the fellowship is having the opportunity to make some direct impact in the short term," he says. AIP, the American Physical Society (APS), the American Geophysical Union (AGU), and the Optical Society of America (OSA) are among the 21 professional societies that sponsor congressional science fellows each year.

Among the legislation before Congress that AIP member societies were following with interest at press time were bills that would slash the budgets of NASA's Earth and space science programs; establish a biomedical imaging institute at the National Institutes of Health; revive an office of noise control within the Environmental Protection Agency; and allow local education agencies to waive federal guidelines for science teachers' professional development. Yet few members of Congress can claim a background like Representative Rush Holt (D–N. J.), former assistant director of the Princeton Plasma Physics Laboratory and APS 1982–83 congressional science fellow. Because few lawmakers have scientific training, "it's better to have informed input . . . by persons at the right hand of members of Congress, than not to have it at all, or solely from outside sources," says Steve Nelson, associate director of AAAS's science and policy programs. "That's one of the main functions of the fellowships." In recent years, however, many societies have seen the number of applicants drop; APS didn't even award a fellowship this year.

Key decisions

The hope is that by placing scientists in staff positions, the fellowships will lead to more informed debate on technical matters and "raise the sophistication level in Congress on these issues," says Peter Rooney, who as APS's 1997–98 fellow worked for Senator Joseph Lieberman (D–Conn.). Staff "make lots of key decisions, and wield a lot of influence behind the scenes," he adds. For Rooney, the fellowship served as a professional stepping stone: With the support of several prominent senators, he founded the Washington, DC–based Forum on Technology and Innovation, which conducts nonpartisan briefings for lawmakers and their staffs on technology-related issues. The fellowship

MALCOLM TARLTON/AIP

MILDRED PORTER

RECENT CONGRESSIONAL SCIENCE FELLOWS Lowell Ungar (left) and Peter Rooney, who is now director of the Forum on Technology and Innovation. Rooney is shown briefing (from left) Richard Perle of the American Enterprise Institute, and Senators Bill Frist (R–Tenn.) and John D. "Jay" Rockefeller (D–W. Va.) on computer export controls.