OTA Report Brief

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Contributions of DOE Weapons Labs and NIST to Semiconductor Technology

The national laboratories of the United States possess resources and facilities that could, if properly managed, contribute significantly to national security in an expanded sense, says the OTA report, *Contributions of DOE Weapons Labs and NIST to Semiconductor Technology*. Until the fall of the Berlin Wall and the collapse of the Soviet Union, national security meant military security to most people. Now that the most serious challenges to the nation's well-being are not military but economic, there is an opportunity to rechannel the government's laboratories to support technology development and industrial competitiveness for civilian purposes. Many such opportunities have been identified in the semiconductor industry.

The Department of Energy's nuclear weapons laboratories (Lawrence Livermore, Los Alamos, and Sandia National Laboratories) and the National Institute of Standards and Technology (NIST) of the Department of Commerce are among the federal labs best equipped to advance semiconductor technology. All four have contributed in the past: NIST by providing reference materials and metrologies for commercial semiconductor manufacture, and the weapons labs as a consequence of their efforts to develop technologies for defense systems. All four labs are currently participating in R&D partnerships with the semiconductor industry. For example, Sandia recently signed a 5-year, $100-million cooperative research and development agreement (CRADA) with SEMATECH, the semiconductor manufacturing technology consortium, to support multiple projects in areas such as contamination-free manufacturing and equipment design. Lawrence Livermore and Los Alamos are working with individual companies, other labs, and the Semiconductor Research Corporation (an SIA-sponsored research consortium) to develop advanced lithography technologies, advanced tool and factory simulators, and computer automated design technologies. The technology roadmaps recently developed by the Semiconductor Industry Association (SIA) recommend that NIST take the lead in developing metrology to support technological advances in the semiconductor industry. Together, the labs are spending well over $100 million a year on shared research and development with the semiconductor industry, focusing on civilian or dual-use technologies.

According to the SIA, more effort will be needed to advance microelectronics technologies as rapidly as in the past. The series of technology roadmaps put together by scores of industry, lab, and academic experts under the auspices of the SIA in 1992 call for a program of strategic research, development, and deployment aimed at introducing a new generation of semiconductor technology every three years for the next 15 years. Short-term technology development and diffusion is best handled by industry; long-term technology development (e.g., technologies ready for insertion ten years or more from the present) are being pursued by universities, often through the SRC. But there is insufficient investment in technologies that could be deployed in three to ten years. It is this type of technology development that SIA hopes the labs can help develop.

OTA concludes that there is room for all four labs to expand industry partnerships without treading on the toes of other laboratories, private or public. However, there are several issues that must be resolved if those contributions are to be made in effective, efficient, and synergistic ways. Though many useful technologies have been and will continue to be developed in one-on-one lab/company partnerships, the best contributions are unlikely to happen automatically. Given the fiscal pressure on all federal programs and the fact that working with the DOE weapons labs is a relatively new exercise for most companies, some overarching management structure is needed to oversee and coordinate the labs' efforts in civilian microelectronics technologies. An interagency, public/private managerial body could be an effective means of preventing needless redundancies in the work of the various labs and channeling limited funds to the projects of greatest strategic importance to the institutions with the best competencies. Regardless of the mechanism used to manage the labs new tasks, the labs must continue to discharge their other public missions effectively.

Performance standards will also need to be developed for the labs, particularly if Congress decides to

authorize a coordinated, public/private program of microelectronics research and development with its own management structure. Such standards would establish criteria for project selection and performance, for the proportion of the work that is publicly funded. These criteria are necessary to assure that the labs' efforts are concentrated in the areas of their greatest competence and industry's greatest priority. Criteria could also help to assure that industry has a strong voice in initiating or augmenting the most promising projects, and curtailing projects for which the need has diminished, or in which performance has been disappointing.

Finally, some consideration should be given to ensuring that there are viable private companies to accept the handoff of publicly developed technologies and bring them to commercial markets. Although U.S. semiconductor manufacturers and equipment suppliers have gained strength in the past few years, there are still many areas of weakness in the U.S. semiconductor industry in which U.S. companies are precariously situated compared with larger, more powerful foreign competitors. In lithography equipment, for example, many experts doubt whether any American company will survive long enough to take the handoff of work that the labs are already beginning in advanced lithography technologies.

Microelectronics is a key industry in the United States. Advances in semiconductor technology not only support sizable semiconductor manufacturing and equipment industries, but help to improve products and productivity in a host of downstream industries, from computers and telecommunications systems to automobiles. Semiconductor manufacturing is also a difficult business. Generational changes in technology are swift, averaging three years over the past decade. R&D and plant and equipment investment costs are rising much more rapidly than inflation and sales revenues, and American producers are up against competitors that often are not only large, integrated companies but have more support from their governments than the U.S. government has provided in the past (with the exception of military microelectronics). There are still many in the United States who doubt that government can effectively support civilian technology development and diffusion, much less improved industrial competitiveness; and while there are several examples in which public investment has laid the foundation for strong industries, there are also reasons for caution. If Congress does wish to augment public support, through the DOE and NIST labs, for civilian semiconductor technology development, up-front attention to management, project priorities, performance criteria, and strategic focus could help to minimize the risks inherent in the venture.

Copies of the report for Congressional use are available by calling 4-9241.

Copies of the report for non-Congressional use can be ordered from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954. The GPO stock number for the OTA report, "Contributions of DOE Weapons Labs and NIST to Semiconductor Technology," is 052-003-01349-5. The price is $5.50.