Annual Report
on
Technology Transfer and Related Technology Partnering Activities
at the
National Laboratories and Other Facilities

Fiscal Year 2003

Prepared by:

Office of Policy and International Affairs
U.S. Department of Energy

In Coordination With:

National Laboratory Technology Partnerships Working Group
Department of Energy Technology Transfer Working Group

U.S. Department of Energy

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FOREWORD

On behalf of the U.S. Department of Energy (DOE), I am pleased to present this *Annual Report on Technology Transfer and Related Technology Partnering Activities at the National Laboratories and Other Facilities* for Fiscal Year (FY) 2003. It is submitted in fulfillment of the requirements of the Technology Transfer and Commercialization Act of 2000 [15USC 3710(f)1].

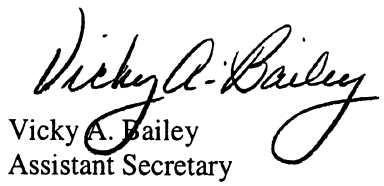
DOE's technology transfer and partnering activities are robust and expanding. In FY 2003, there were an unprecedented 11,633 technology transfer-related transactions negotiated and executed by DOE and its laboratories and facilities, including 5,333 user facility agreements; 1,952 work-for-others projects involving non-Federal entities; 3,687 licenses of intellectual property; and 661 new or active cooperative research and development agreements. In addition, DOE disclosed 1,469 inventions; filed 866 patent applications; and was issued 627 patents. As part of these activities, DOE reported $25.8 million in licensing income, and $6.6 million in earned royalties.

In this year's *Report*, there is a special focus on efforts by DOE laboratories and facilities to facilitate economic development at the community, state and regional levels. Highlighted activities include: science and technology parks; technical assistance programs; venture capital and investor networks; entrepreneurial leave programs; incubators for start-up companies; and participation in economic development organizations. These activities are important to DOE in that they help develop competencies accessible by DOE's sites and facilitate commercialization and deployment of technologies necessary for effecting DOE's mission accomplishment.

Appendix B of the *Report* highlights 36 examples in FY 2003 of successful technology transfer outcomes. These outcomes span a broad range research areas and DOE missions, ranging from a new technology for cancer treatment (nuclear medicine), to an innovative means for fabricating thin-film materials for semiconductor devices (solar power), to a handheld analyzer capable of detecting both bacterial and viral pathogens (national and homeland security).

DOE's partners in this area find working with DOE laboratories and facilities useful, perhaps best evidenced by their continued and enthusiastic participation. DOE, in turn, is assured that important discoveries and technology developments arising from its research will reach, through its partners' participation, the widest possible audience with the broadest possible potential for advancing the national security, energy and environmental goals of the Nation.

It is our intent that this *Report* inform the public of DOE's activities in this area, facilitate feedback and discussion on opportunities for improvement, and encourage practitioners throughout DOE's laboratories and facilities to expand and strengthen their technology partnering activities.



Vicky A. Bailey
Assistant Secretary
Office of Policy and International Affairs

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OVERVIEW AND HIGHLIGHTS

The transfer of Federally-developed technologies and capabilities to non-Federal technology partners, including private firms, has been an aim of Government policy since the passage of Bayh-Dole (P.L. 96-517, as amended by P.L. 98-620) and Stevenson-Wydler (P.L. 96-480) technology transfer legislation in the early 1980s. In 1989, the National Competitiveness Technology Transfer Act (P.L. 99-502) strengthened this aim by establishing technology transfer as a mission of Federal R&D agencies, including the Department of Energy (DOE). DOE has since encouraged its laboratories and production facilities to enter into technology partnering activities with non-Federal entities, as appropriate, using a variety of mechanisms, including cooperative research and development agreements (CRADAs), and to patent and license intellectual property (IP) that may arise from DOE research and development (R&D).

Today, technology partnering is an active and significant component of DOE's overall mission, particularly in areas associated with its scientific, engineering and related technical activities. As authorized by DOE through provisions in its management and operating (M&O) contracts, technology transfer is now carried out at all 11 of DOE's national laboratories and at 13 other DOE research and production facilities.

Technology partnering, broadly defined, has since emerged as a significant mechanism for the DOE laboratories and facilities to engage non-Federal entities in partnering arrangements in order to advance the process of technology development and commercialization. Motivated by mutual self-interest, and notably without transfer of Federal funds to the non-Federal partner, these arrangements provide means for collaboration and cooperation between DOE and the private sector, leverage resources and serve as useful alternatives to traditional contracting.

For DOE, technology partnering is important to the vibrancy of DOE's technical competencies at its research laboratories and facilities. DOE cannot afford to home-grow or replicate all the required skills in isolation inside its own fences. In order to accomplish its mission, DOE must have access to the rapidly evolving technical expertise and commercial technology of selected non-Federal entities, in effect "reverse technology transfer", that is transferring know-how and technology from the private sector to the Federal sector. Also, DOE laboratories and facilities create and own intellectual property, which can only be diffused into society for public benefit if developed further and commercialized. Non-Federal entities often have more experience in getting this goal accomplished successfully. DOE needs ways to partner with these firms.

At the same time, private firms and other non-Federal entities have found that DOE's research laboratories and facilities can provide, to the benefit of their own objectives, valuable and often unique problem solving capabilities. They are also interested in building long-term relationships that pay dividends over time. Technology partnering can enable and facilitate the productive leveraging of different but aligned motivations, benefiting both DOE and its partners, in addition to furthering Federal missions and national priorities.

Technology Partnering Goals

In 2003, DOE reissued its Order 482.1, which governs technology partnering at its laboratories and facilities. In concert with the relevant statutes in this area, DOE Order 482.1 establishes technology transfer as a mission of DOE and its facilities and sets the policy context in which partnering is to take place, requiring of its practitioners, for example, a public purpose (e.g., a DOE mission) and procedures to ensure fairness of opportunity and protect against potential excesses. The DOE Order assigns roles and responsibilities to various DOE organizational elements for the oversight, management and administration of DOE facility technology partnering activities. To the extent that they are consistent with the terms of the facility contract, and its delegation of authority for technology transfer and partnering, the DOE Order also sets forth a series of broad purposes for such activities:

- Facilitate the efficient and expeditious development, transfer, and exploitation of Federally owned or originated technology to non-DOE entities for public benefit and to enhance the accomplishment of DOE missions;

- Leverage DOE resources, through its programs and facilities, through partnering; and

- Ensure fairness of opportunity, protect the national security, promote the economic interests of the United States, prevent inappropriate competition with the private sector, and provide a variety of means to respond to private-sector concerns and interests about facility technology partnering activities.

Technology Partnering Activities

Activities covered by DOE Order 482.1 and authorized to be performed by DOE facility operators and contractors include:

- *Intellectual Property*. Identifying and protecting intellectual property made, created, or acquired at or by a DOE facility. This includes new invention disclosures; creation and filings of patent applications; patent issues, and associated monitoring and reporting. In FY 2003, there were 1,469 invention disclosures, 866 patent applications filed, and 627 patents issued.

- *Cooperative Research and Development Agreements*. Negotiating all aspects of and entering into Cooperative Research and Development Agreements (CRADAs), performed under the National Competitiveness Technology Transfer Act of 1989. Such agreements focus on mutually beneficial collaborative research. They may involve resource commitments by each partner for its own use, or resource commitments from the non-Federal partner to the Federal partner, but no resource commitments from the Federal partner to non-Federal partner. In FY 2003, there were 661 active CRADAs.

- *Licensing*. Negotiating and entering into license agreements and bailments that provide rights in intellectual property made, created, or acquired at or by a DOE facility, which is controlled or owned by the contractor for that facility. A license transfers *less* than ownership rights to intellectual property, such as a patent or software copyright, to permit its use by the licensee. Licenses may be exclusive, or limited to a specific field of use, or limited to a specific geographical area. A potential licensee must present plans for

commercialization. Royalties and income may be associated with the licensing. In FY 2003, there were 3,687 active licenses.

- *Work-for-Others*. Performing work for non-Federal sponsors under DOE Order 481.1. WFO agreements permit reimbursable work, mostly research and development, to be carried out at DOE laboratories or facilities. This work is usually categorized into that for Federal agencies and non-Federal entities (NFE). It is the NFE work that is of interest to technology partnering in this report. For proprietary R&D conducted for NFEs, the Federal laboratory or facility is reimbursed for the full cost of the activity. If the work will be published, cost may be adjusted. Intellectual property rights generally belong to the NFE, but may be negotiated. In FY 2003, there were 1,948 Work-for-Others agreements with non-Federal organizations.

- *User Facilities*. Making available laboratory or weapon production user facilities. User facility agreements permit non-Federal entities to conduct research and development at a laboratory or use a particular scientific facility or instrument. For proprietary R&D, the laboratory is reimbursed for the full cost of the activity. If the work will be published, cost may be adjusted. Intellectual property rights generally belong to the investigator. In FY 2003, there were 5,333 projects performed at user facilities.

- *Technical Consulting*. Technical consulting usually takes the form of technical assistance to small businesses, undertaken in response to an inquiry or request for such assistance from an individual or organization seeking knowledge, understanding or solutions to a problem, or means to improve a process or product. The extent of such consulting is often limited to a relatively low level of overall effort.

- *Personnel Exchanges*. These arrangements allow facility staff to work in a partner's technical facilities, or the partner's staff to work in the government laboratory, in order to enhance technical capabilities and/or support research in certain areas. Costs are typically borne by the sponsoring organization. IP arrangements may be negotiated as part of these exchanges.

Laboratories and Facilities Engaged in Technology Partnering

DOE authorizes 24 laboratories and facilities to conduct such technology partnering activities. Most of these laboratories and facilities have established formal technology transfer programs. Many also have staff dedicated to the facilitation of the administrative and negotiating processes involved in entering into agreements with non-Federal partners. This Report presents trends and analyses of the technology transfer activities at the aggregate level for DOE. It does not show individual facility data.[1]

[1] Considerable differences exist among the DOE laboratories and facilities. These differences consist of two main determinants: amount of R&D funding and type of R&D. Laboratories and facilities receive R&D funding from six Cognizant Secretarial Offices (CSO), including Defense Programs, Office of Science, Energy Efficiency and Renewable Energy, Fossil Energy, Nuclear Energy, and Environmental Management. Each CSO exercises primary oversight, management, and administrative responsibility for technology partnering activities at the laboratories and facilities under their respective cognizance. Some of these differences are brought out in the Report.

The laboratories and facilities authorized by DOE to carry out technology transfer activities are listed below. These 24 entities constitute the scope of data included in this Report.

- Albany Research Center
- Ames Laboratory
- Argonne National Laboratory
- Bettis Atomic Power Laboratory
- Brookhaven National Laboratory
- Fermi National Accelerator Laboratory
- Idaho National Engineering & Environmental Laboratory
- Kansas City Plant
- Knolls Atomic Power Laboratory
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Energy Technology Laboratory
- National Renewable Energy Laboratory
- Nevada Test Site
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Pantex Plant
- Princeton Plasma Physics Laboratory
- Sandia National Laboratory
- Savannah River Site
- Stanford Linear Accelerator Center
- Thomas Jefferson National Accelerator Facility
- Y-12 National Security Complex

Summary of Transactions

In FY 2003, there were an unprecedented 11,633 technology transfer-related transactions negotiated and executed by DOE and its laboratories and facilities. These include 5,333 user facility agreements; 1,952 work-for-others projects involving non-Federal entities; 3,687 licenses of intellectual property; and 661 new or active cooperative research and development agreements (CRADAs). In addition, DOE disclosed 1,469 inventions; filed 866 patent applications; and was issued 627 patents.

As part of these activities, DOE reported $25.8 million in licensing income and $6.6 million in earned royalties. A summary of FY 2003 technology partnering activities for the DOE's laboratories and facilities is presented in Table 1. Additional data are provided in Appendix A.

Successful Outcomes

Successful outcomes from these activities are too numerous to list. A representative selection of outcomes (36) from FY 2003, spanning a range research areas and DOE missions, is presented in Appendix B.

Table 1: Summary of FY 2003 Technology Partnering Activities at DOE National Laboratories and Facilities

Technology Transfer Data Element	FY 2003
Transactions and Activities	
CRADAs, total active in the FY	661
New inventions disclosed	1,469
Patents applications filed	866
Patents issued	627
Total Licenses; Active in the FY	3,687
• Invention Licenses	1,223
• Other IP (copyright, material transfer, other) Licenses	2,464
Licenses that are income-bearing	2,523
Work-for-Others Agreements, Non-Federal Entities	1,952
User Facility Projects and Associated Agreements	5,333
Reported Income (Thousands of Dollars)	
Total Licensing Income Received	$ 25,805
• Invention (Patent) Licenses	$ 23,620
• Other Licenses	$ 2,136
Total Royalty Income Earned	$ 6,612

Organization, Management and Oversight

DOE exercises oversight, management and administration of its technology partnering activities at its national laboratories and facilities in two ways. First, DOE's secretarial officers and heads of associated field organizations, guided by the applicable statutes and DOE Orders, set policy, establish procedure and provide oversight and accountability for all technology partnering activities at the laboratories and facilities under their cognizance. Second, DOE's "matrixed" organizations, known as working groups, assist in this effort by meeting regularly to coordinate, communicate and integrate these policies and practices into daily activity across the all of the DOE sites. These working groups also provide support to, and enable consistency across, all of the DOE mission areas and program offices. These working groups also take note of and address, as appropriate, issues or concerns as they arise and do so in a timely manner.

There are two DOE working groups. For DOE Headquarters and its Field Offices, there is the Technology Transfer Working Group (TTWG), composed of Federal employees appointed to represent their organizations. For the DOE laboratories and facilities, there is the Technology Partnerships Working Group (TPWG), composed jointly of employees from DOE Field Offices and from the DOE laboratories and facilities.

DOE Technology Transfer Working Group

At DOE Headquarters, the Technology Transfer Working Group (TTWG) is comprised of about 35 Federal employees engaged in the oversight of technology partnering or transfer activities across the R&D program elements of DOE Headquarters, and the administrative elements at the DOE Field Offices. The TTWG provides a Departmental forum for exchange of information on current activities and a focal point, when needed, for the review, development, and integration of technology transfer policies. The TTWG serves to inform DOE headquarters and its program offices about ongoing activities and emerging issues.

The TTWG meets monthly via a teleconference. Its agenda and meeting exhibits are prepared in advance and transmitted to all TTWG members. The Director of the Office of Science and Technology Policy, in DOE's Office of Policy and International Affairs, chairs the TTWG. The TTWG is co-chaired by the Assistant General Counsel for Technology Transfer and Intellectual Property, in DOE's Office of General Counsel. In addition to the 35 Federal members of the TTWG, a number of leading technology transfer managers and practitioners of the DOE laboratories and facilities, including those elected to the TPWG executive committee, are regularly invited to participate. Through these means, the TTWG builds, maintains and regularly exercises a network of communications among professionals in the Headquarters and the field.

DOE Technology Partneships Working Group

The field-led DOE Technology Partnerships Working Group (TPWG) is comprised of members from the DOE laboratories and facilities, representing more 200 DOE-complex technology partnering practitioners. An executive committee, comprised of six annually elected members, three from DOE Field Offices, and three from DOE laboratories or facilities, leads the TPWG. All members of the executive committee participate in the TTWG monthly teleconferences.

The TPWG serves to address common needs of technology partnering offices and professionals across the DOE complex and facilitates the sharing of best practices. It also provides services to the TTWG. It identifies field personnel who can contribute to ad hoc groups addressing current issues or planning activities, and ensures completion. The TPWG organizes periodic training and information exchange sessions on technology partnering. It serves as the coordinating body for gathering and compiling data to meet the needs of the DOE Annual Report. The TPWG holds three or four video-teleconferences per year. With guidance from the TTWG, the TPWG helps organize the agenda and acquires speakers for the DOE Annual Meeting on Technology Partnering. In FY 2003, the Annual Meeting was held in June in the San Francisco area (Burlingame, CA). About 150 DOE technology transfer professionals participated.

Federal Multi-Agency Coordination and Liaison Activities

In addition, DOE was active in a number of interagency and liaison activities. The Director of DOE's Office of Science and Technology Policy, and chair of DOE's TTWG, is designated as the DOE representative to the Federal Interagency Working Group on Technology Transfer, led by the Technology Administration, U.S. Department of Commerce. The IWG meets monthly and is attended by agency representatives and patent counsels from about 17 Federal agencies. The IWG serves as an interagency forum for the exchange of information, and means to raise, address, and coordinated on issues and concerns across the Federal agencies. In FY 2003, DOE

representatives provided presentations on DOE technology transfer, exchanged information with other agencies on licensing of copyrighted software, and provided leadership of an multi-agency initiative to assist the Federal Laboratory Consortium in developing improved relations with its sponsoring agencies and the formulation of certain amendments to the FLC Bylaws.

Federal Laboratory Consortium on Technology Transfer

The Federal Laboratory Consortium for Technology Transfer (FLC) is formally chartered by U.S. Congress to facilitate technology transfer in the United States. Its membership draws from more than 225 Federal laboratories, including DOE 24 technology transferring laboratories and facilities. In DOE, the Director of DOE's Office of Science and Technology Policy, and chair of DOE's TTWG, was the designated "agency representative" to the (FLC). As required by statute, DOE contributed funds (about $400,000), along with funds from other research and development agencies (totaling about $2.3 million), to the operations and management of the FLC. The FLC is supported by a contract, recently competed, between the National Institute of Standards and Technology, U.S. Department of Commerce, and the Universal Technical Resource Services, Inc., of Cherry Hill, New Jersey.

The DOE-designated agency representative, and the designated alternate, both of the Office of Policy and International Affairs, participated in several FLC Board Meetings and the FLC annual meeting in Tucson, Arizona, in May 2003. The representatives also coordinated the update and certification of voting membership lists from DOE laboratories, and contributed to a 16-agency proposal to amend the FLC Bylaws, to which there were no objections.

DOE Technology Transfer Website

In late FY 2003, DOE began development of a technology transfer website, as part of the Secretary of Energy's e-government initiative. When completed, the website will provide the public with information on DOE's technology transfer policies, procedures, and activities. It will enable public access to information regarding technologies available for licensing from the DOE Laboratories and Facilities. It will serve as a comprehensive reference for technology transfer activities. In the future, it is envisioned that "search-engine" capabilities will enable visitors to the website to search for technologies available for licensing, so that the website will provide a single point of access to DOE-funded technology available to the public for licensing.

External Review of DOE's Policies

The Secretary of Energy requested the Secretary of Energy Advisory Board (SEAB), an external body organized under the auspices of the Federal Advisory Committee Act, to undertake an external review of DOE's policies and practices regarding industry partnering and technology transfer. The SEAB, in turn, requested that its subordinate body, the Laboratory Operations Board (LOB), organize a panel or working group to: (1) identify barriers to industry partnering, as well as strategies for attracting and working with industry; (2) make recommendations to facilitate participation by small businesses; and (3) address management and oversight requirements to facilitate industry partnering.

In December 2003, the LOB Working Group developed a set of recommendations that addressed the key barriers to industry partnering and technology transfer.[2] The recommendations stated that:

- The Department should state, in an unequivocal fashion, its support for industry partnering and technology transfer across the departmental complex.
- A senior-level staff person, with a small, permanent staff, reporting directly to the Deputy Secretary should be given the portfolio as advocate and champion for industry partnering and technology transfer within the Department of Energy and its associated national laboratories.
- Program Secretarial Officers must demonstrate a clear commitment to an enhanced integrated industry partnering and technology transfer program consistent with Departmental and Program Office Missions. Program Secretarial Officers, beginning with the Department's Corporate Review Budget, will be held accountable by the Deputy Secretary for identifying and funding an industry partnering and technology transfer portfolio related to mission objectives.

In a June 2003 letter to the Chair of the SEAB, DOE's Deputy Secretary supported the LOB's recommendations and requested that plans be developed on how to best implement these recommendations. This process is continuing.

Alternative Dispute Resolution

DOE's Office of Dispute Resolution, in DOE's Office of General Counsel, provides assistance to DOE national laboratories and facilities regarding the use of alternative dispute resolution as an alternative to formal disputes requiring investigations or litigation. The Office assists by providing measures that range from techniques, such as partnering, processes for acknowledging and addressing differing professional opinions, and ombuds, to mediation of complaints involving intellectual property, contract, environment, grants, or whistleblower issues. Because non-Federal partners are often not familiar with Federal statutes and rules governing technology partnering, there is always opportunity for confusion and misplaced expectations. It is important for DOE to communicate clearly and to be sensitive to potential complaints and disputes.

In FY 2003, ombuds at DOE's national laboratories and facilities were involved in 26 potential disputes involving CRADAs, patents, licenses, WFO or other issues. Eighteen of these issues were resolved, two were withdrawn and three are still pending. Three of disputes were not resolved using this process and are being addressed by way or other avenues.[3]

The overall rate of incidence of disputes is considered low, in light of the total number of partnering arrangements of one kind or another initiated or continued each year between a DOE laboratory or facility and a non-Federal partner. Every such arrangement may be seen as an active engagement with a partner, and an opportunity for a dispute if not handled properly. In FY 2003, there were 11,633 such active arrangements, either new or continuing.

[2] Laboratory Operations Board (2003). *Recommendations Regarding Industry Partnering/Technology Transfer Within the Department of Energy -- Draft Report*, Laboratory Operations Board, U.S. Department of Energy.

[3] Data provided by DOE's General Counsel on Technology Transfer, Dec. 17, 2003.

Multi-Year Trends in Key Indicators

In order to understand better the dynamics of technology transfer and technology partnering activities across the DOE complex, it is useful to examine a number of multi-year trends, as represented by a few key indicators. The data sources vary, and span various periods, reflecting availability. Indicators selected for presentation are: (a) CRADAs; (b) invention disclosures, patent applications, and patents issued; (c) active licenses; (d) income from licenses; (e) work-for-others, involving only non-Federal entities (WFO from other Federal agencies are excluded); and (f) user facilities project agreements.

Cooperative Research and Development Agreements

Cooperative Research and Development Agreements (CRADAs) are used by DOE authorized laboratories and facilities to partner with industry and other non-Federal entities. Congress authorized the CRADA mechanism in 1986 to encourage the Federal laboratories to participate in R&D.

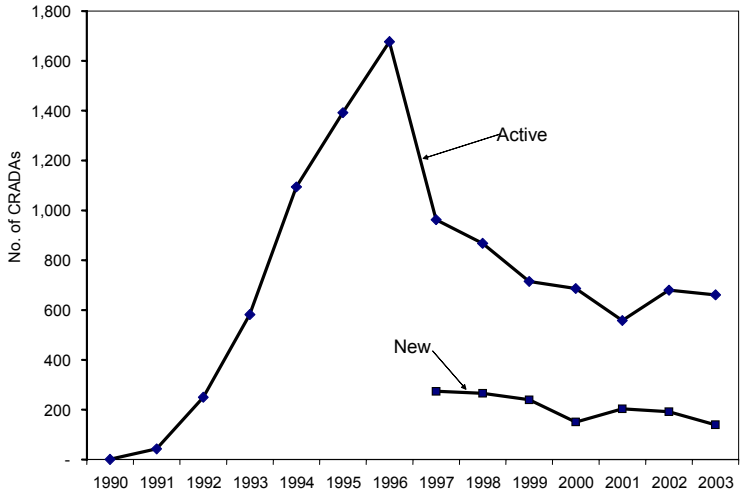

Figure 1: Cooperative Research and Development Agreements (CRADAs)

Figure 1 indicates that the number of active CRADAs peaked to just over 1,600 in FY 1996. After FY 1996, the number of CRADAs decreased by nearly 60 percent, to 687 in FY 2000. In FY 2003, the number of active CRADAs was 661. The number of new CRADAs executed by laboratories and facilities in FY 2003 was 140, which continues a trend in the gradual slowing in the use of these instruments over the last eight years.

The initial growth and subsequent decline in the use of CRADAs over the entire period, from 1990 to 2003, reflects the availability of resources provided by DOE to support activities on the DOE-side of such partnerships. Congress, through the Technology Partnership Program (TPP) and the Laboratory Technology Research (LTR) Program, provided dedicated funding for CRADAs, which peaked at $261 million in FY 1995, and then declined to $3 million in FY2002. Reflecting a prevailing view within DOE that dedicated funding for these activities competed with other and more important priorities for direct mission support, the TPP Program ended in FY 2000, and the LTR program will be terminated in FY 2004. The issue of resource support for CRADAs remains an issue of concern and was addressed by DOE's Laboratory Operations Board of the Secretary of Energy Advisory Board.

Figure 2 shows invention disclosures, patent applications, and patents issued. While invention disclosures have varied in recent years, between 1,300 and 1,500 per year, the numbers of patent applications and patents issued has increased over time, with both hitting new highs in FY 2003, at 866 and 627, respectively.

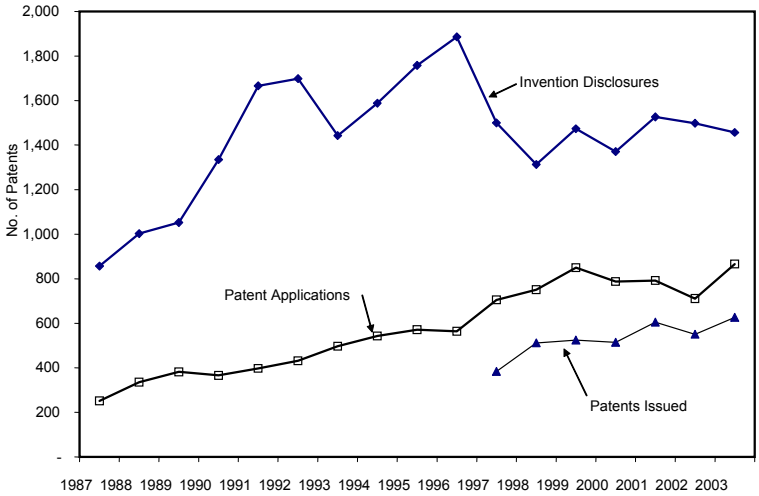

Figure 2: Invention Disclosure and Patenting

Intellectual Property Management

In FY 2003, there were 3,686 active licenses for inventions and other intellectual property from all the Department's laboratories and facilities.

Figure 3 present data from 1999 to 2003 for the total number of active licenses, and the division of these into two classes, patent (invention) licenses and other licenses. Other licenses are attributed to licensing of copyrighted software, biological materials and other inventions, not patented. This latter category is now the largest category of licenses, with 2,464 in FY 2003. It has also shown marked growth over the last 3 years, signaling new and growing areas for future licensing activity across the DOE complex. The number of patent (invention) licenses, by contrast, has remained fairly steady over these years. In FY 2003, there were 1,223 active licenses of patented inventions.

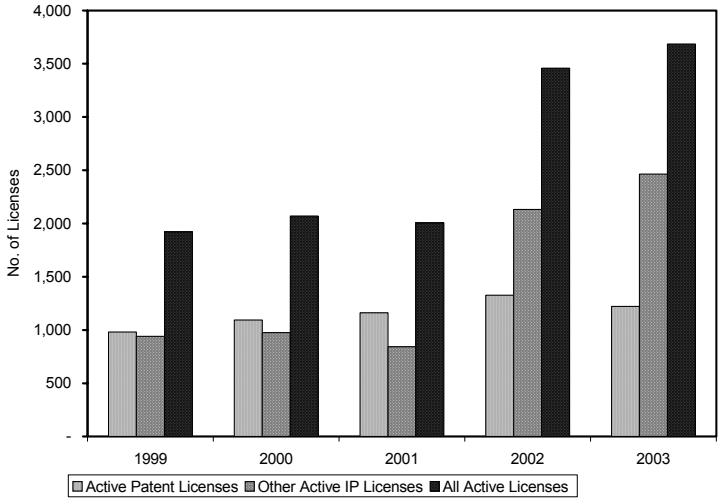

Figure 3: Active Licenses

Figure 4 shows the upward trend in income from licensing of inventions, which topped $25 million in FY 2003. The average rate of growth since 1996 was 17 percent. DOE policies guide, and the negotiated M&O contracts specify, the uses to which this income may be applied. In general the income is shared between the inventor and the M&O contractor. The contractor may use the funs for scientific research and development, technology transfer, and education, consistent with the research and development missions of the laboratory or facility.

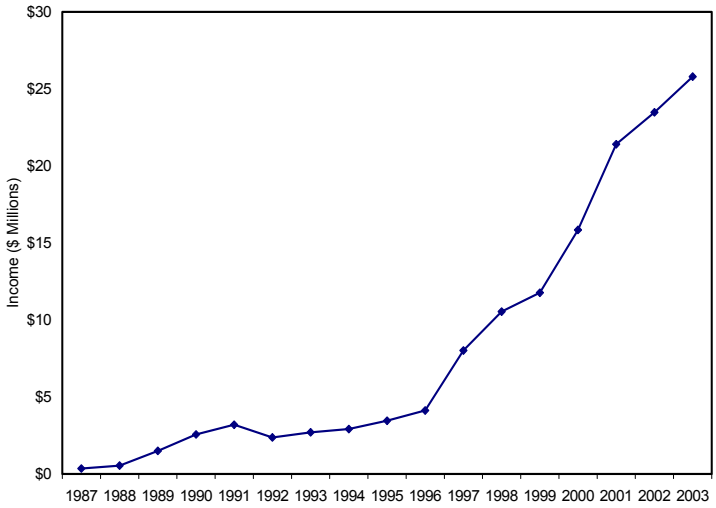

Figure 4: Income from Invention (Patent) Licensing

Other Technology Partnering Agreements

Figure 5 displays trends in Work-for-Others (WFO) agreements with non-Federal entities (NFEs). While historical data are not available for all DOE laboratories and facilities, data are available for 12 laboratories from a recent GAO report.[4] As Figure 5 shows, technology partnering at these 12 laboratories and facilities grew rapidly, with an accompanying influx of funds from businesses and other non-Federal entities for this purpose. Work-for-Others agreements with NFEs grew four-fold over 10 years, from 1992 to 2001. For the larger set of 24 DOE laboratories and facilities covered in this year's *Report*, including the 12 studied by GAO, the total number of WFO-NFE agreements was 1,952 in FY 2003.

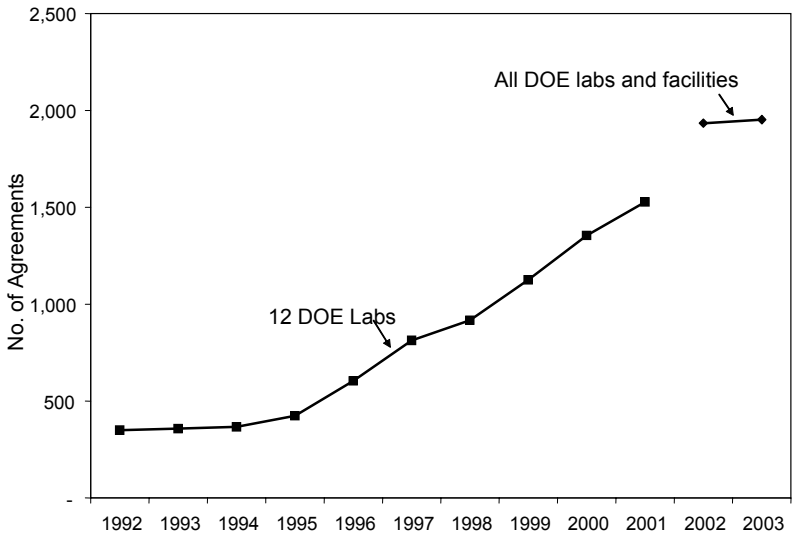

Figure 5: Work-for-Others Agreements, NFE

[4] U.S. General Accounting Office (2002), *Technology Transfer – Several Factors Have Led to a Decline In Partnerships at DOE's Laboratories,* GAO-02-465.

Figure 6 shows data on the number of partnering or project agreements negotiated at DOE scientific user facilities. These agreements provide access to unique DOE research equipment and facilities. They are regarded as another measure of technology partnering activity. In FY 2003, the first year of collecting data across the entire DOE complex, there were 3,688 active agreements for user facility projects. Earlier, as shown for the purposes of comparison, the GAO reported such data on 12 DOE laboratories. According to the GAO report, the number of DOE user facility agreements grew eightfold, from 252 in FY 1992, to more than 2,000 in FY 2001.

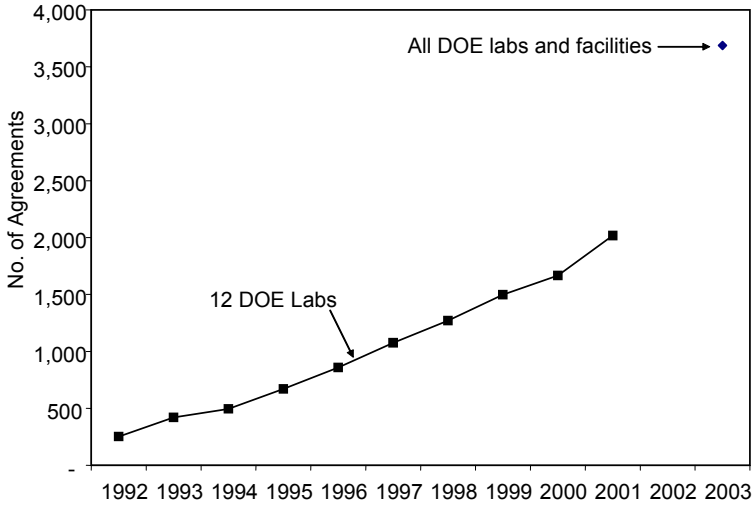

Figure 6: User Facility Agreements

CHAPTER 2

ACTIVITIES AND PROGRAMS AT THE NATIONAL LABORATORIES AND FACILITIES THAT PROMOTE ECONOMIC DEVELOPMENT

DOE laboratories and facilities are pursuing a variety of activities that contribute to DOE missions and also facilitate economic development in the communities and states where they are located. A recent published report by the Department of Commerce, *Partners on a Mission: Federal Laboratory Practices Contributing to Economic Development,*[5] documents some exemplary practices by Federal laboratories and DOE laboratories in support of local economic development. The report covered a wide range of activities initiated by Federal laboratories and intermediary organizations working directly with the Federal laboratories.

Three DOE laboratories were interviewed for the Commerce report; Los Alamos National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. In addition to these interviews, DOE staff conducted seven additional interviews with Argonne National Laboratory, Brookhaven National Laboratory, Idaho National Engineering and Environmental Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, National Renewable Energy Laboratory, and the Oak Ridge National Laboratory. The findings of the combined interviews (Commerce Report and additional DOE interviews) show that DOE laboratories and facilities are pursuing a variety of activities that benefit the DOE laboratories' missions as well as the communities where the laboratories and facilities are located.

The economic development activities carried about by the laboratories and facilities are summarized in the sections below, and include: (1) entrepreneurial leave programs, (2) technical and business assistance, (3) incubators and research parks, (4) networks, (5) seed and venture capital linkages, and (6) activities with local and state economic development groups.

Entrepreneurial Leave Programs

Many laboratories have started entrepreneurial leave programs, whereby laboratory personnel are given the opportunity to take unpaid leave to participate in the formation and management of technology firms. Many DOE laboratories have cited successful business startups as an outcome of this program. A few examples are provided below that illustrate the success of these programs.

- At Los Alamos National Laboratory (LANL), almost 40 of the 70 start-up technology firms formed since 1997 in the Los Alamos area have involved LANL employees on entrepreneurial leave or those who have voluntarily terminated employment.
- At Pacific Northwest National Laboratory, 40 employees have started 27 businesses under a similar program, of which two-thirds of the businesses have successful operations.

[5] U.S. Department of Commerce (2003). *Partners On a Mission: Federal Laboratory Practices Contributing to Economic Development*. Washington, D.C., Department of Commerce.

- The Idaho National Engineering and Environmental Laboratory (INEEL) has had about six dozen employees participate in the program.
- Oak Ridge National Laboratory's (ORNL) leave program involved two researchers who successfully launched ImTek, a licensee of its MicroCat technology.

Business Assistance Programs

Many DOE laboratories have recognized that business assistance programs can provide additional support to their technology transfer efforts. Assistance comes in many forms, but some of the most common include intellectual property management, ISO-9000 (International Standards Organization's quality management standards) training, business management training, and e-business.

Several laboratories use MBA students to assist small businesses. At several of the DOE laboratories and facilities, MBA interns from leading business schools assist the laboratories' technical staff and regional entrepreneurs in identifying commercially viable technologies, perform market assessments and create business strategies and plans. LANL, for instance, has sponsored 47 MBA interns from 18 leading business schools over the past 5 years. Of these students, 10 have relocated to New Mexico as full-time employees of LANL or other regional businesses, thus serving to attract talented entrepreneurs to the region.

Sandia National Laboratories' (SNL) small business assistance/advocacy programs illustrate another approach to business assistance. SNL helps New Mexico firms by providing up to $10,000 of assistance/firm and at no cost. Since July 2000, SNL has conducted over 650 projects in support of small businesses. Other activities within SNL's small business programs include support for Hispanic businesses become e-commerce competent and competitive in e-business. In addition, some 150 businesses are provided assistance each year through referrals to appropriate SNL staff. The most common request from the small businesses is help in conducting business at SNL.

Incubators and Research Parks

Incubators and research parks have been created at many DOE national laboratories that aid in connecting industry partners with the laboratories. The Sandia Science and Technology Park, for example, was opened and, by late 2002, had attracted 13 companies to the park. In order to reside in the park, a company is required to have a relationship with SNL, or relationship with another firm in the park that has an existing link to SNL.

In another example is the Tri-Cities Enterprise Center located near Pacific Northwest National Laboratory (PNNL). The City of Richland contributed the land for the Center, and the U.S. Economic Development Administration provided a $1.4 million grant for construction of the building. Small businesses are offered business assistance and technical support to help them commercialize technologies originating out to the lab. Currently there are 12 resident companies at the park that are spin-offs from PNNL. To date, some 135 firms have graduated, with at least one-fifth of those affiliated with PNNL.

The Oak Ridge National Laboratory (ORNL) also established an incubator, the Center for Entrepreneurial Growth (CEG). CEG works toward improved dissemination of ORNL technology through the creation and support of early-stage companies focused on growth and

long-term sustainability. CEG provides business counseling, planning and financial services support, contract reviews, and assists in pursuit of debt or equity financing, and other support services. Since 2000, 39 successful companies have been established through support of the CEG.

Some DOE laboratories provide space at their facilities for startup companies. Lawrence Livermore National Laboratory (LLNL), for example, established the Tri-Valley Technology Enterprise Center that provides space for startups that are licensing technologies from LLNL. At Argonne National Laboratory (ANL), the Illinois Technology Enterprise Center, co-sponsored by ANL and the State of Illinois, assists early stage startup companies in technology assistance and user facility access, as well as identification of technologies that offer potential for startup candidates.

Networking Activities

Networking activities sponsored by many DOE national laboratories and facilities are important sources to foster economic growth. Most of the laboratories provide networking activities. The National Renewable Energy Laboratory's (NREL) Growth Link and Clean Energy Investor Directory, for example, provides business networking services to better foster connections between investors and start-up energy technology companies.[6] In another instance, ANL staff participates in multiple local business and professional organizations such as the Technology Managers Association, Licensing Executives Society, East-West Corridor Association, and the Commercial Development Association.

Seed and Venture Capital Activities

Laboratory sponsorship of, and participation in, seed and venture capital activities are a useful means of attracting potential investors in start-up companies. One illustration of laboratory sponsorship is NREL's Industry Growth Forums. The Industry Growth Forums are the largest national venture event focused exclusively on companies developing clean energy products to serve the energy market. The 2003 Forum had its largest attendance to date with 350 attendees including 100 investors, 34 presenting companies, and a variety of clean energy executives, entrepreneurs, state, and local officials. The Forum allows entrepreneurs to present and receive critical feedback on summary business plans before a panel of investors and other business executives. This feedback helps the entrepreneurs strengthen their business case, and also helps them make connections with potential investors.

There are many other examples of where the laboratories help startup companies get access to seed and venture capital. At Los Alamos National Laboratory (LANL), seed capital is provided through its Technology Maturation Fund, which began in 2002. The Fund provides up to $50,000 for maturing LANL technologies with high commercial potential. The total amount of the Fund is about $450,000 per year. Oak Ridge National Laboratory funds start up technology companies through Battelle's Venture fund. The Battelle Venture Fund provides funding for very early stage companies that have as their foundation technologies from DOE laboratories managed by Battelle and its subsidiary companies. Finally, Lawrence Livermore National

[6] National Renewable Energy Laboratory's Clean Energy Investor Directory contains information on about 100 investors who are interested in clean energy technologies. The Growth Link is a web-based directory of clean energy businesses who are seeking financing, partnering, or growth opportunities.

Laboratory and Lawrence Berkeley National Laboratory work with Diablo Ventures Alliance, a group of local venture capitalists that meets monthly to listen to presentations from start up companies.

Activities with Local and State Economic Development Groups

Many DOE laboratories are actively involved in state, and local business development to help improve and expand opportunities in their regions. One example is a program between SNL and the State of New Mexico. Through a special legislated return of gross tax receipts from SNL, the Lab is able to continue its technical assistance to small and minority-owned businesses. In another example, the senior managers from Idaho National Engineering and Environmental Laboratory (INEEL) serve on several boards of economic development organizations as well as provide corporate capital to support statewide economic development meetings, including the 2003 Governor's Business Opportunity Conference and in developing the state's Science and Technology Strategic Plan and marketing plan for Idaho.

Another example illustrates how a number of DOE laboratories and facilities take on local, state, and regional economic development initiatives. At a local level, ORNL provides funds for the Jobs Now Initiative, a multi-organizational program designed to bring 35,000 new jobs to the East Tennessee area over the next 5 years. Statewide, ORNL supports the FedEx Technology Institute and the Tennessee Biotechnology Association. At the regional level, ORNL supported the establishment and growth of the Tennessee Valley Technology Corridor.

Lawrence Berkeley National Laboratory assists in regional economic development through the Bay Area Science Innovation Consortium. The Consortium is a collaboration of the region's major research universities, national laboratories, research institutions, and technology businesses. The focus recently has been on homeland security and nanotechnology R&D.

Conclusion

DOE laboratories and facilities are pursuing a number of innovative approaches that support economic development within their local communities, as well as at the state and regional level. The laboratories and facilities stimulate economic growth through support for entrepreneurial development as well as by providing incentives for new start-up companies. In addition, the DOE laboratories and facilities support economic development by sponsoring technical and business assistance programs, seed and venture capital funds, networking opportunities, and training that, in turn, promotes the growth of start up enterprises.

These activities, while geared towards local and regional economic development, realize important benefits for DOE's missions, by facilitating the movement of mission-related technology into the marketplace, and by strengthening the competencies and capabilities of DOE's laboratories and facilities. By nurturing the scientific, engineering and technical expertise of local and regional firms, DOE gains access to rapidly evolving, cutting-edge technical expertise and new commercial technology, in effect cultivating a means for "reverse technology transfer" with relatively minor up-front costs. These firms, in turn, seek business with DOE and provide unique skills and know-how to the Federal laboratories and facilities.

As documented in the Commerce Report, *Partners on a Mission,* [7] Federal laboratories can realize other ancillary, but important benefits, namely:

- Laboratories are able to attract more qualified employees when the geographical area is more economically developed, when the spouses of laboratory employees can find employment, and when the school systems are attractive.
- Laboratories benefit from helping their suppliers improve the quality of their products, so that can better meet the laboratories' standards for quality.
- Finally, the laboratories benefit from those technologies originating from the laboratories become commercial products and processes that are returned back to the laboratories for its use.

In sum, DOE and its laboratories and facilities benefit from such activity, as do local, state and regional economies and communities and, ultimately, as does the Nation.

[7] U.S. Department of Commerce (2003). *Partners On a Mission: Federal Laboratory Practices Contributing to Economic Development*. Washington, D.C., Department of Commerce.

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APPENDIX A

TECHNOLOGY TRANSFER INDICATORS FOR FISCAL YEARS 1999-2003

The Technology Transfer Commercialization Act of 2000 requires each Federal agency that operates or directs Federal laboratories (or engages in patenting or licensing of Federally owned inventions) to provide the Office of Management and Budget with an annual report on its technology transfer plans and recent achievements. A copy is also provided to the Technology Administration Office of the Department of Commerce. The Secretary of Commerce then prepares an overall Federal assessment for the President and Congress based on the program information in these agency reports. Specific data requirements to be reported each year are established by the Department of Commerce.

In accordance with the Department of Commerce's reporting guidelines, DOE's technology transfer data for fiscal years 1999-2003 is shown in Table 2.

Table 2: Department of Energy's Technology Transfer Activities, Fiscal Years 1999-2003

	Fiscal Year				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**
Collaborative Relationships for Research & Development					
• **CRADAs**, total active in the FY[8]	715	687	558	680	661
▪ New, executed in the FY	240	151	204	192	140
• Traditional[9] CRADAs, total active in the FY	--	--	--	--	nr
▪ New, executed in the FY	--	--	--	--	nr
• Non-traditional CRADAs, total active in FY	--	--	--	--	nr
▪ New, executed in the FY	--	--	--	--	nr
• **Invention Disclosure and Patenting**					
• **New Inventions** disclosed in the FY	1,474	1,371	1,527	1,498	1,469
• **Patent Applications** filed in the FY	850	788	792	711	866
• **Patents issued** in the FY	525	515	605	551	627
Licensing					
Profile of Active Licenses					

[8] "Active" refers to those agreements in force anytime during the fiscal year. "Total active" is comprehensive of all agreements executed under CRADA authority (15 USC 3710a)

[9] CRADAs involving collaborative research and development by a Federal laboratory and non-Federal partners.

	Fiscal Year				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**
• **All Licenses**, number total active in the FY	1,922	2,070	1,162	3,459	3,687
▪ New, executed in the FY	202	169	226	694	711
▪ Invention licenses, total active in the FY	981	1,094	1,162	1,327	1,223
- New, executed in the FY	202	169	226	206	172
▪ Patent licenses, total active in FY(see note)	981	1,094	1,162	1,327	1,222
- New, executed in the FY	202	169	226	206	171
▪ Material transfer, total active in FY	--	--	0	0	0
- New, executed in the FY	--	--	0	0	0
▪ Other invention licenses, total active in FY	--	--	--	--	--
- New, executed in the FY	--	--	--	--	--
▪ Other IP licenses, total active in the FY	941	976	843	2,132	2,464
- New, executed in the FY	--	--	--	488	539
- Copyright licenses (fee bearing)	--	--	--	1,525	1,823
New, executed in the FY	--	--	--	332	348
- Material transfer (non-inv.), total active in FY	--	--	--	581	604
New, executed in the FY	--	--	--	153	180
- Other (bailment agreements, trademarks, etc.)				26	37
New, executed in the FY				3	11
All Income Bearing Licenses [10]	--	--	1,012	2,523	2,523
▪ Exclusive	--	--	174	301	246
▪ Partially exclusive	--	--	112	136	235
▪ Non-exclusive	--	--	726	2,086	2,042
• **Invention Licenses**, income bearing [11]	--	--	--	1,123	1,056
▪ Exclusive	--	--	--	263	215
▪ Partially exclusive	--	--	--	123	196
▪ Non-exclusive	--	--	--	737	645
• **Patent Licenses**, income bearing	--	--	--	1,123	1,056
▪ Exclusive	--	--	--	263	215
▪ Partially exclusive	--	--	--	123	196
▪ Non-exclusive	--	--	--	737	645

[10] "All income bearing licenses" are equal to the sum of "invention licenses" and "other IP licenses."
[11] For purposes of DOE reporting, "invention licenses" are the same as "patent licenses."

	Fiscal Year				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**
• **Other IP Licenses**, income bearing	--	--	--	1,400	1,467
▪ Exclusive	--	--	--	38	31
▪ Partially exclusive	--	--	--	13	39
▪ Non-exclusive	--	--	--	1,349	1,397
▪ Copyright licenses	--	--	--	1,173	1,352
- Exclusive	--	--	--	29	25
- Partially exclusive	--	--	--	7	35
- Non-exclusive	--	--	--	1,137	1,292
All Royalty Bearing Licenses[12]	193	220	1,012	2,523	2,523
• **Invention Licenses**, royalty bearing	--	--	--	1,123	1,056
• **Other IP Licenses**, royalty bearing	--	--	--	1,400	1,467
- Copyright licenses				1,173	1,352
Licensing Management					
• **Elapsed Execution Time**, licenses granted in FY					
▪ Invention licenses					
- average (or median)	--	--	--	127	133
- minimum	--	--	--	8	8
- maximum	--	--	--	471	745
▪ Patent licenses (see note)					
- average (or median)	--	--	--	127	133
- minimum	--	--	--	8	8
- maximum	--	--	--	471	745
• **Number of Licenses Terminated** for cause in FY					
▪ Invention licenses					
- Patent licenses	--	--	60	77	35
License Income					
• **Total Income**, all licenses active in FY (thousands)	$11,764	$15,840	$21,403	$23,477	$25,805
▪ Invention licenses	$10,199	$12,710	$18,922	$21,253	$23,670
- Patent licenses	--	--	--	$21,253	$23,670
▪ Other IP licenses, total active in the FY	$1,545	$2,836	$1,870	$2,223	$2,136

[12] For this report, "all royalty bearing licenses" are the same as "all income bearing licenses."

	Fiscal Year				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**
- Copyright licenses	--	--	--	$1,870	$2,101
• **Total Earned Royalty Income** (ERI)	$1,975	$2,228	$7,832	$5,609	$6,612
▪ Median ERI	--	--	--	$4	$3
▪ Minimum ERI	--	--	$0.002	$0.023	$0.003
▪ Maximum ERI	--	--	$1,585	$794	$913
▪ ERI from top 1% of licenses	--	--	$2,699	$1550	$1,478
▪ ERI from top 5% of licenses	--	--	$5,272	$3,696	$3,789
▪ ERI from top 20% of licenses	--	--	$7,163	$4,571	$5,962
• **Invention Licenses**					
▪ Median ERI	--	--	--	$6	$5
▪ Minimum ERI	--	--	--	$0.025	$0.003
▪ Maximum ERI	--	--	--	$794	913
▪ ERI from top 1% of licenses	--	--	--	$794	1,478
▪ ERI from top 5% of licenses	--	--	--	$3,419	$3,197
▪ ERI from top 20% of licenses	--	--	--	$5,068	$5,363
• **Patent Licenses**					
▪ Median ERI	--	--	--	$6	$5
▪ Minimum ERI	--	--	--	$0.025	$0.003
▪ Maximum ERI	--	--	--	$794	$913
▪ ERI from top 1% of licenses	--	--	--	$794	$1,478
▪ ERI from top 5% of licenses	--	--	--	$3,419	$3,197
▪ ERI from top 20% of licenses	--	--	--	$5,068	$5,363
• **Other IP Licenses**					
▪ Median ERI	--	--	--	$1	$1
▪ Minimum ERI	--	--	--	$0.023	$0.010
▪ Maximum ERI	--	--	--	$69	$168
▪ ERI from top 1% of licenses	--	--	--	$69	$168
▪ ERI from top 5% of licenses	--	--	--	$115	$316
▪ ERI from top 20% of licenses	--	--	--	$197	$480
▪ Copyright licenses					
- Median ERI	--	--	--	$2	$1
- Minimum ERI	--	--	--	$0.023	$0.010
- Maximum ERI	--	--	--	$69	$168

	Fiscal Year				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**
- ERI from top 1% of licenses	--	--	--	$69	$168
- ERI from top 5% of licenses	--	--	--	$100	$272
- ERI from top 20% of licenses	--	--	--	$187	$480
Disposition of License Income					
• **Income Distributed** (thousands)					
▪ Invention licenses, total distributed	--	--	$16,356	$16,423	$19,540
- To inventors	--	--	$5,942	$6,386	$5,624
- To other	--	--	$10,414	$10,036	$13,916
▪ Patent licenses, total distributed (see note)	--	--	$16,356	$16,423	$19,540
- To inventors	--	--	$5,942	$6,386	$5,624
- To other	--	--	$10,414	$10,036	$13,916
Other Technology Partnering Measures					
Work-for-Others Agreements, active in the FY[13]					
New, executed in the FY				1,934	1,952
User Facility, active in the FY[14]					
• Agreements					3,688
• Projects					5,333

Notes:
-- = Data was not requested in previous years' reports.
nr = Data is not report by DOE

[13] Data not required by OMB but provided as an additional measure of technology partnering activities.
[14] Data not required by OMB but provided as an additional measure of technology partnering activities.

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APPENDIX B

SELECTED OUTCOMES

There are many examples of technology transfer and industry partnering activities that reflect successful programs at DOE national laboratories and facilities. Thirty-six representative examples of successes are presented below to illustrate the range and nature of technology transfer activities across the DOE complex. The success stories that follow include:

- ADVISOR™ Improves Automotive Design Productivity
- Alpha Particle Immunotherapy for Treating Leukemia and Solid Tumor Metastases
- Battery chemistry is the Key to Tiny Rechargeble Battery for Microstimulator
- Cancer Treatment Using Brachytherapy
- Cold Ion Deposition Technology
- Decontamination Solution for Chemical and Biological Warfare Agents
- Efficient Photovoltaic Solar Cells Becoming Widely Deployed
- Electrodynamic Ion Funnel
- Field-ready DNA Testing Systems
- Globus Alliance Leaders Win FLC Award
- GREET Model Now Includes Additional Hydrogen Fuel Pathways and Fuel Cell Vehicle Opt.
- Grid Technology Is Successfully Integrated with inSORS Software
- Guestroom Occupancy Sensor/LED Nightlight – Wattstopper CRADA
- Handheld Advanced Nucleic Acid Analyzer (HANAA)
- Implantable Drug Delivery Devices
- Inductively Coupled Plasma/Mass Spectrometry Collision Cell Technology
- Inductrack Technology
- Magnetic-microsphere-based Technology for Molecular Separation and Detection
- Micro-High G Acceleration Devices in Collaborative Development
- Millimeter-Wave Holographic Screening Device
- Miniature Integrated Nuclear Detection System with Improved Detection Capability
- Monitor for Air Particulates
- Novel Chemical Sensing Technologies for Safety
- Opening New Markets for Agricultural Byproducts
- ORNL wins four R&D 100 awards
- Processing Technology for Cleaning, Decontaminating, and Etching Surfaces
- PVScan and Reflectometer
- RadScout Radiation Detector and Analyzer
- R&D Awards for Sandia National Laboratories' Technologies
- RAM/VAM Technology Aids in Assessing Vulnerabilities to the Nation's Infrastructure
- Safer Stun Grenades Protect Hostages, Can be Reused for Training
- Simulation of Comet Impact
- Solar Water Heating Technology Transferred
- Tank Retrieval Process
- U.S. Military Using Gun-shot Residue Kit in Iraq
- VISTA, Intuitive Web-based Software for Visualizing Genome Comparisons

ADVISOR ™Improves Automotive Design Productivity

ADVISOR™ (ADvanced Vehicle SimulatOR) software provides a specialized tool for the automotive engineering community to quickly simulate the performance of a large number of vehicle design options, therefore reducing the time and expense involved in building and testing prototypes. ADVISOR™ software can simulate and analyze light and heavy vehicles—including hybrid electric and fuel cell vehicles. It tests the effect of changes in vehicle components (such as motors, batteries, catalytic converters, climate control systems, and alternative fuels) and other modifications that might affect fuel economy, performance, or emissions. Using ADVISOR™ software, companies can: (1) reduce testing time to evaluate various vehicle powertrain alternatives, (2) assist in developing fuel-efficient vehicles and components, and (3) provide a shared simulation tool for government, universities, and industry.

The Vehicle Systems Analysis Team at the National Renewable Energy Laboratory (NREL) developed the first version of ADVISOR™ in 1994 with the help of industry partners to simulate and analyze various performance aspects of conventional and advanced vehicles. ADVISOR 2003™ was also licensed to AVL Powertrain Engineering Inc. (AVL). The license agreement for the ADVISOR software and a related CRADA facilitates the transfer of the ADVISOR software from NREL to AVL and ultimately to wide application in the transportation sector. AVL will in turn provide a highly visible commercial outlet for NREL's advanced vehicle simulator research, leading to more significant uses of the ADVISOR™ software by automakers and ultimately the development of more efficient advanced vehicles worldwide. The associated three-year CRADA will also enhance the transfer of the ADVISOR™ software to market and will help position AVL to provide comprehensive services and solutions to its clients. By facilitating the design of more efficient vehicles, ADVISOR™ will directly contribute to the reduction of petroleum use and oil imports in the U.S. economy.

Alpha Particle Immunotherapy for Treating Leukemia and Solid Tumor Metastases

One promising new cancer treatment is alpha particle immunotherapy (APIT), a technology that makes it possible to treat patients with malignancies of the hematopoietic system, such as leukemia, as well as metastasis from many solid tumors effectively and with fewer side effects than other treatments. This technology combines the power of alpha particle-emitting radioactive isotopes (actinium-225 or bismuth-213) with monoclonal antibodies that bind to and destroy specific cancer cells, but not the nearby healthy tissue. Early trials at major research centers yielded encouraging results.

The primary supplier of APIT is MedActinium, a small radiopharmaceutical firm in Oak Ridge, TN. MedActinium turned to researchers at Pacific Northwest National Laboratory (PNNL) to help solve two obstacles to commercial use of APIT: purifying the isotope and binding it to the antibody to create a stable product. This resulted in new separations chemistry for generating bismuth-213 and a key enabling technology for putting actinium-225 on monoclonal antibodies. The result is that these powerful new radioisotopes are now available to treat patients with leukemia or fast-spreading solid-tumor cancers.

This technology partnership involved collaborative efforts among private industry, academic research institutions, and U.S. government agencies. PNNL built on relationships with the pharmaceutical industry dating from 1986. PNNL research in APIT-enabling technologies was

part of a larger effort to develop beneficial uses for radioactive materials remaining from weapons production during the Cold War. The technology partnering arrangements were fast-tracked during the planning for initial clinical trials. The effort included exclusive license agreements for five immunology patents, negotiation and conclusion of a separate Technology Management Agreement with an earlier research partner, and establishment of a Cooperative Research and Development Agreement for further research. The transfer was completed in January 2003.

The transfer of technologies from PNNL to MedActinium is a contributing factor in the ability of the Memorial Sloan-Kettering Cancer Center and other research medical centers to continue the quest for effective cancer treatments. A second round of clinical trials is scheduled to begin the fall of 2004 at Sloan-Kettering.

Battery Chemistry is the Key to Tiny Rechargeable Battery for Microstimulator

Battery chemistry developed by Argonne National Laboratory (ANL) and its research partners enabled the development of a microbattery to power an implantable bion® microstimulator that could help restore nerve and muscle function in patients suffering from a variety of medical conditions, including stroke, Parkinson's disease, and urinary urge incontinence. In feasibility trials, a prototype bion was implanted in patients to treat urinary urge incontinence, with promising results. The battery chemistry will provide calendar life significantly greater than that of commercially available lithium-ion batteries.

The bion® currently in feasibility trials comprises three integrated parts: the battery, which operates at normal body temperature, developed by Quallion LLC and ANL; an advanced microstimulator, developed by Advanced Bionics Corporation; and a control system, developed by Advanced Bionics Corp., to manage remote reprogramming and battery recharging.

ANL is working with the University of Wisconsin and Quallion, LLC, to develop a next-generation cell chemistry that could give even longer life. Development of the bion microstimulator was funded by a grant to Quallion under the National Institute of Standards and Technology's Advanced Technology Program. The foundation for ANL's research was provided by battery development for hybrid electric vehicles, funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, FreedomCAR and Vehicle Technologies program.

Cancer Treatment Using Brachytherapy

Oak Ridge National Laboratory (ORNL) and an industry partner, Isotron, are collaborating through a CRADA to boost the treatment possibilities for brain tumors and other types of cancer resistant to conventional techniques with X-rays or gamma radiation. The objective is to miniaturize the radioactive sources and enhance a cancer treatment known as neutron brachytherapy. The treatment could enable physicians to deliver a powerful dose of cell-killing neutrons directly to a tumor, using a catheter to funnel the radioactive wire to the site. These research scientists have reduced the diameter of the californium source by more than half, and the neutron emitter can now be applied to organs previously inaccessible. By concentrating the radioactivity, the treatment time can also be shortened – thus limiting the exposure to medical

staff. ORNL produces californium 252 in its High Flux Isotope Reactor; nuclear researchers fabricate the wire-like sources in shielded "hot cells" near the reactor.

Cold Ion Deposition Technology

Researchers at the Princeton Plasma Physics Laboratory (PPPL) have developed a unique and proprietary method of rapidly killing bacterial spores. The technology uses the positive ions from a light atom and accelerates them through a high energy potential. The ions are driven toward a surface on which the bacterial spores are located with energy sufficient to damage the spores and render them no longer viable.

The commercial application of this technology is the cleaning and sanitizing of plastics used in food and beverage packaging and has been called the cold ion deposition technology (CID) by the company seeking to commercialize the process. Rather than using heat, water, or chemicals to kill germs, the system uses non-thermal plasma. CID technology uses the ions generated from the plasma to destroy any microbial spores on the inner surface of the container. This is a safe, efficient, inexpensive mechanism for cleaning and sanitizing plastics, and will not alter the taste of the beverage. PlaZtec, LLC was formed to commercialize technologies that are beneficial to the environment and global societies as a whole. Cold ion deposition (CID) is the first technology that PlaZtec is focusing on, with an initial application being in the non-alcoholic beverage bottling industry.

Decontamination Solution for Chemical and Biological Warfare Agents

A decontamination formulation originally developed at Sandia National Laboratories (SNL) that renders harmless chemical and biological warfare agents has been selected for use by the U.S. Central Command (CENTCOM). CENTCOM placed an order with EnviroFoam™ Technologies for several thousand gallons of the company's EasyDECON™ solution. EnviroFoam licensed the formulation for EasyDECON from Sandia in August 2000. The formulation neutralizes both chemical and biological agents and is nontoxic, noncorrosive, and environmentally acceptable. The formulation can be deployed as a foam, mist, fog, spray, or liquid. The Sandia formulation, on which EasyDECON is based, has proven effective against both biological and chemical agents, can be applied with current military hardware, has shown no collateral damage, and creates an effluent capable of being washed down the drain. EnviroFoam was one of two U.S. companies granted nonexclusive licenses to the decontamination formulation, which has been under development at Sandia since 1997.

Efficient Photovoltaic Solar Cells Becoming Widely Deployed

CIGS ($Cu(In,Ga)Se_2$) is a recrystallization method for fabricating thin-films on a substrate for semiconductor device applications, particularly solar cells. GSE's thin-film technology involves sequentially depositing thin layers of CIGS materials onto stainless steel substrates. The resulting product is lightweight, flexible and free of the fragility of crystalline silicon PV technologies. CIGS cells have reached efficiencies of more than 19%, higher than other thin-film PV cells, such as amorphous silicon.

The National Renewable Energy Laboratory (NREL) has entered into a licensing agreement with Global Solar Energy. The CIGS technology will provide Global Solar Energy a highly effective way to manufacture and sell thin-film PV solar cells, introducing "the world's lightest, most

flexible solar panel." The solar cells come in 5, 10 or 20-watt sizes and can be used as a battery charger as well as direct power source for portable electronics such as GPS, cell phones and laptop computers. These applications have a wide range of civilian and military uses for field applications such as heaters for personal warmth and survival, as well as powering equipment. The technology may ultimately find uses in micro-grid and village power stations, telecommunications, and stand-alone and remote power systems.

Upon securing the CIGS patent license, Global Solar Energy signed an exclusive agreement with CIP Global Technologies of Montreal, the world's largest manufacturer of consumer solar products, to commercialize the CIGS thin film products. It is anticipated that the thin film products will be sold at stores like Radio Shack, Wal-Mart and Costco. Global Solar Energy also signed an agreement with SunWize, a photovoltaics company in New York, who will be sole distributor of the CIGS thin film products to a worldwide client base.

Electrodynamic Ion Funnel

Mass spectrometry is a widely used tool in environmental, biotechnology, clinical, and drug testing applications, as well as in medical, biological, and other broad areas of scientific research. The use of mass spectrometry is strongly affected by the sensitivity of the measurement that can be made. Pacific Northwest National Laboratory's (PNNL) Electrodynamic Ion Funnel can be used to increase sensitivity for many forms of mass spectrometry.

The Electrodynamic Ion Funnel is a revolutionary development that focuses ions in gases, greatly improving the sensitivity of analytical devices such as mass spectrometers that depend on ion formation and transfer in the presence of gases. An additional benefit of the ion funnel can be a significant reduction in the cost of mass spectrometers as a result of its use.

Through a non-exclusive licensing mechanism, PNNL successfully transferred the ion funnel technology to three leading manufacturers of mass spectrometers: Micromass in 2001, Biospect, Inc. in 2002, and Bruker Daltonics, Inc. in 2003, all major manufacturers of mass spectrometers. Micromass' applications focus on the biotechnology, pharmaceutical, clinical, analytical, environmental and geologic sciences. Bruker Daltonics, Inc. is a leading manufacturer of mass spectrometry instruments and accessories for pharmaceutical, biochemical and chemical research. Biospect, Inc., wants to use mass spectrometry to analyze human bodily fluids as a way to predict for diseases. The ability to define and monitor biological states through analysis of bodily fluids could lead to a revolution in medicine and biomedical research. Through their connections, these two companies will enable broader use of mass spectrometers using the ion funnel.

Field-ready DNA Testing Systems

Cepheid – A California start-up company that executed its license with Lawrence Livermore National Laboratory (LLNL) in 1996. The company has recently received much attention for its field-ready DNA testing systems for rapid detection of deadly bio-threat agents such as anthrax. Cepheid is developing fully integrated portable instruments and laboratory systems that can be used for rapid detection of infectious disease agents, human genes, and industrial and environmental contaminants quickly and accurately. These products will enhance U.S. biodectector capabilities, which limit current ability to protect against biological terrorism,

thereby supporting DOE's mission in responding to weapons of mass destruction and to counter terrorism. The adaptation of LLNL technology, which is the basis of the Smart Cycler®, a portable unit that allows customers to obtain bio-analytical results when and where they are needed.

In May 2003, Cepheid announced that the United States Postal Service (USPS) awarded Northrop Grumman Corporation's Security Systems LLC unit a contract to manufacture and integrate Biohazard Detection Systems (BDS) nationwide. Northrop Grumman is the prime contractor and systems integrator of the BDS, which uses polymerase chain reaction (PCR) technology, developed by Cepheid, to rapidly analyze air samples taken from the mail sorting systems and detect trace levels of DNA from anthrax spores and other biological agents as it moves through the mail processing equipment. The BDS incorporates Cepheid's GeneXpert® modules as its detection and identification system. Cepheid's GeneXpert® fully automated gene analysis system also won an R&D 100 Award in 2002. Technology licensed from LLNL is at the heart of this instrument as well. In a September 2003 Global Security Newswire article, a USPS representative indicated that a 15-city test of the BDS was completed last month, and a USPS spokesman was quoted as describing the test as a "resounding success".

Globus Alliance Leaders Win FLC Award

The Federal Laboratory Consortium (FLC) gave a 2003 Award for Excellence in Technology Transfer to Argonne National Laboratory's scientists in recognition of their leadership in Grid computing on behalf of the Globus Alliance. The FLC awards annually recognize Federal laboratory employees who have taken technology from the laboratory and applying it in the outside world.

Since 1996, the Globus Alliance has developed open-source Globus Toolkit software that is central to virtually every major deployment of the Grid, a interconnected computing environment that is transforming the nature of science and engineering research. The technology lets users share computing power, databases, and other tools securely online across corporate, institutional, and geographic boundaries without sacrificing local autonomy. In addition to its broad adoption for research, the Globus Toolkit is a de facto standard adopted by major Information Technology companies.

First funded by the Department of Energy as fundamental research and development, the Globus Alliance has been embraced by companies like IBM, Oracle, Platform, Entropia, Compaq, Cray, SGI, Sun, Veridian, Fujitsu, Hitachi, and NEC, each of which uses the Globus Toolkit as the basis for significant commercial products and services. The project's Federally sponsored mission continues while scientists are working with public- and private-sector partners to define new standards called the Open Grid Services Architecture, which promises a increases in the availability of Grid applications.

GREET Model Now Includes Additional Hydrogen Fuel Pathways and Fuel Cell Vehicle Options

When advanced vehicle technologies and new transportation fuels are being introduced, they first must be examined on a full fuel-cycle basis, including energy feedstock production, fuel production, and vehicle operations. To assist in this evaluation, Argonne National Laboratory (ANL) scientists developed a model called GREET (Greenhouse-gases, Regulated Emissions,

and Energy use in Transportation) to conduct full fuel-cycle analyses. The computer tool evaluates more than 35 fuel production pathways and more than 50 vehicle technologies/fuel systems on a consistent, systematic basis. Since the first version was released in 1996, the model has been updated in response to changing users' needs and industry trends. There are now 1,100 registered GREET users in both the public and private sectors throughout North America, Europe, and Asia. The model provides information for a variety of industry, government, and academic organizations and institutions.

In one instance, GREET was used to analyze advanced vehicles and new fuels in a major well-to-wheels study conducted for General Motors Corp (GM). GM, ANL scientists, British Petroleum, ExxonMobil, and Shell participated in the study. When Phase 1 of the study was completed, GM noted, "The results of the work will continue to influence the automotive and energy industries and government policymakers as we progress toward the introduction of advanced fuels and powertrains." Phase 2 of the study, with a focus on criteria pollutant emissions, will be completed by GM, ChevronTexaco, and Shell.

GREET was also used for a milestone government study on ethanol. GREET's analysis of ethanol's greenhouse gas emissions (GHG) emissions may have influenced the public debate on ethanol's energy and GHG emission benefits. In a cover letter for the study, Jim Edgar, then Governor of the State of Illinois, said, "Illinois is very pleased to have sponsored and published the results of this research study. The results clearly identify that ethanol outperformed conventional and reformulated gasoline with respect to energy use and reducing greenhouse gas emissions. The institution responsible for this study, Argonne National Laboratory, is the recognized leader in modeling fuel cycle fossil energy use and greenhouse gas emissions related to the transportation sector. . . .What this means for the agriculture community, ethanol producers, environmentalists, and policy makers is that ethanol fuel deserves a major role in any global climate change strategy to reduce greenhouse gas emissions in the transportation sector."

Grid Technology Is Successfully Integrated with inSORS Software

The Access Grid Toolkit 2.0 and the inSORS software IG2.0 are now interoperable, thanks to collaboration between Argonne National Laboratory (ANL) and inSORS Integrated Communications, Inc. This technical milestone is critical in meeting the increasing demand for group-to-group collaboration across the computing environment, using multimedia large-format displays for distributed workshops, lectures, and training. The integration of the two technologies combines the benefits of the ANL-developed Access Grid, including open source software, with the specialized applications features provided by the inSORS software, such as record and playback capabilities and remote control for cameras.

Guestroom Occupancy Sensor/LED Nightlight – Wattstopper CRADA

As part of a small CRADA partnership with The Wattstopper, Inc. and in collaboration with the Sacramento Municipal Utility District (SMUD), Lawrence Berkeley National Laboratory (LBNL) developed an integrated occupancy sensor/nighlight providing significant energy and cost savings. LBNL research showed that hotel bathroom lights are repeatedly left on when rooms are vacated or used as nightlights during slumber. According to the research, bathroom lights remained on anywhere from four to eight hours. To address the problem, LBNL and Wattstopper developed an occupancy sensor with a built-in nightlight. When the main bathroom

lights are shut off (also timer controlled), a pair of super bright LED's built into the switch turn on automatically – providing an effective very low energy nightlight.

In cooperation with the partnership, the Double Tree Hotel in Sacramento recently installed the combination occupancy sensor/LED nightlights in 400 guestrooms. The new integrated occupancy sensor/nightlights resulted in a 50% reduction in guestroom light usage with cost savings exceeding $8,000 per year. Guests of one hotel commented on improved comfort and safety, because the LED lights provide enough light to safely navigate a room without the blinding glare from turning on the lights in a dark room. While occupancy sensors and nightlights have been around for years, this partnership-developed occupancy sensor is the first to have a built-in high-efficiency nightlight.

Steps are under way to implement the energy saving device in Hawaii where there are many hotels and electricity costs are among the highest in the nation. The program is targeted at 50,000 units with a projected energy savings of $8,000,000 over ten years. In addition to hotels, the device is suitable for residential construction, military housing, senior housing and convalescent homes. Implementing the technology is simple and inexpensive; without risk, it improves safety and results in a significant energy savings.

Handheld Advanced Nucleic Acid Analyzer (HANAA)

In January 2003, Lawrence Livermore National Laboratory (LLNL) signed a non-exclusive license for the Handheld Advanced Nucleic Acid Analyzer (HANAA) technology, expected to be useful for chemical and biological detection, with Smiths Detection – Edgewood, Inc. (formerly Environmental Technologies Group, Inc. (ETG) and now a subsidiary of Smiths Aerospace). The HANAA technology is at the heart of Smiths Detection Bio-SeeqTM product, currently being marketed as the first portable, hand-held thermocycler capable of detecting both bacterial and viral pathogens. Smiths Detection's objective is to provide the Department of Defense and the intelligence agencies with highly portable, advanced, bio-detection instruments and to further the DOE objective of putting advanced instrumentation for the detection of biological terrorist agents into the hands of first responders. The HANAA analyzes biological samples for the presence of specific DNA sequences that serve as the fingerprints of specific pathogens. It can simultaneously test four samples, and each sample for two different DNA sequences and have the results in about 20 minutes. The HANAA provides the first truly man-portable, handheld, field-worthy, real-time PCR bio-detection instrument. It is ideally suited for emergency response where biological pathogens are suspected, and for field monitoring where portability and fast answers are critical (e.g., monitoring water or food supplies for biological contamination in real time). It can also be used in intelligence, combat or reconnaissance missions.

Implantable Drug Delivery Devices

Advanced Neuromodulation Systems, Inc. (ANS) and Sandia National Laboratories (SNL) recently executed a Work-for-Others agreement and related intellectual property agreements to explore the possibility of using a microelectromechanical system based microvalve in implantable drug delivery devices. ANS designs, develops, manufactures, and markets advanced implantable neuromodulation devices that deliver electrical current or drugs directly to targeted areas of the body to manage chronic pain. Commercialization of the microvalve technology in a

medical application could lead to other applications that directly support SNL's national security mission.

Inductively Coupled Plasma/Mass Spectrometry Collision Cell Technology

The Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) Collision/Reaction Cell (CRC) Technology developed at Pacific Northwest National Laboratory (PNNL) has advanced the analysis capabilities of mass spectrometer instruments worldwide. ICP/MS can now detect and measure many important elements that are not detectable with conventional mass spectrometry. This technology has had a significant and widespread impact in the analytical chemistry world because of its broad applications in environmental monitoring and testing, biotechnology, semiconductor manufacturing, and homeland security. Battelle, operating contractor for PNNL, successfully licensed this technology to manufacturers in several countries. Currently, more than 60% of the mass spectrometers sold worldwide incorporate the CRC technology developed at PNNL.

Inductrack Technology

In July 2003, General Atomics signed license with Lawrence Livermore National Laboratory (LLNL) for the Inductrack technology, a magnetic levitation system using new configurations of high-field permanent magnets to create its own levitating fields for urban and high-speed maglev train systems. The features of this unique technology include passive levitation leading to fail-safe behavior upon power loss, lower cost and maintenance requirements compared to those of existing maglev systems, tight turn radius, steep hill-climbing capability, low noise, and low environmental impact. General Atomics is the prime contractor for the General Atomics Low Speed Maglev Technology Development Project, one of the projects funded by the Federal Transit Administration (FTA) as part of their Urban Maglev Program. The overall objective of this FTA program is to develop magnetic levitation technology as a cost effective, reliable, and environmentally sound transit option for urban mass transportation in the United States. The Inductrack system represents an enabling technology for urban maglev transportation that General Atomics hopes to apply to cities throughout the nation.

Magnetic-microsphere-based Technology for Molecular Separation and Detection

Biophoretix, an Albuquerque-based biotechnology startup company, entered into a exclusive license agreement with Los Alamos National Laboratory (LANL) to commercialize a magnetic-microsphere-based technology for molecular separation and detection. The technology has the potential of ensuring the safety of the world's food, water, and air supplies to monitoring the efficacy of medical treatments. Biophoretix develops, manufactures, and markets diagnostic and discovery systems based on its multiplexed separation technology, which integrates easily with existing bioassay and detection systems. The Biophoretix platform can make current tests more sensitive, cheaper, and faster, while enabling many tests that are currently not possible.

Initial applications of the technology include accurate CD4/CD8 lymphocyte counts, necessary for monitoring drug therapies for AIDS, at a cost and speed that make access to monitoring attainable in the developing world. Monitoring in the U.S. and other developed nations is slow, expensive, and reliant on central clinical laboratories. This technology offers promise of closing that gap with its rugged, inexpensive, and portable platform. Other applications include a

hepatitis panel, complete blood counts, and any testing that requires the sorting of cells or other biological material. Target markets for separating biological materials include: clinical diagnostics, drug discovery, environmental monitoring, and for use in bioterrorism detection.

Micro-High G Acceleration Devices in Collaborative Development

Recently, Sandia National Laboratories (SNL) and ENDEVCO Corporation, a leading supplier of dynamic instrumentation for vibration, shock, inertial motion, and dynamic pressure measurements, signed a CRADA to develop a high-g robust (60,000 g's) low-volume, low-power, accelerometer and acceleration recording device. The CRADA will help SNL design and develop smaller, lower power, acceleration recording devices in support of its Defense Program and Emerging Threats missions. ENDEVCO will be better able to meet its needs as a supplier to both the defense industry and DOE/DP by increasing capabilities for future weapon systems.

Millimeter-Wave Holographic Screening Device

During research originally intended for the Federal Aviation Administration to augment current airport security systems, a breakthrough technology was developed. This technology, with applications spanning entertainment, health, apparel and security arenas, has significant benefits to each industry and their consumers. The millimeter-wave holographic screening device, developed by researchers at the Pacific Northwest National Laboratory (PNNL) will be used by two different companies in two very different industries — security and apparel.

The screening device uses non-harmful, ultrahigh-frequency radio waves to penetrate clothing, enabling security personnel to detect both metallic and nonmetallic concealed objects. This technology can also be used to obtain accurate volumetric body measurements for improved apparel fitting. The high-speed, full-body measurements capability offers significant advantages over systems currently in the marketplace.

This innovative technology uses radar cylindrical holographic techniques invented at PNNL and a new combined imaging algorithm to obtain complete body measurements while the individual remains fully clothed in normal attire. The system rapidly scans objects and sends reflected signals into a high-speed image processing computer and then produces a high-resolution 3-D image from the data.

PNNL has successfully licensed this technology to a company formed to offer it to the security market and is under option to a second company whose vision is to transform the way clothing is marketed and produced.

Miniature Integrated Nuclear Detection System With Improved Detection Capability

The Miniature Integrated Nuclear Detection System (MINDS) is a type of radiation detector. The MINDS system acts as a warning system to detect radiation from gamma and/or neutron emitters, contained in objects, containers, or vehicles, or carried by a pedestrian, and differentiate between sources of radiation from threatening radio nuclides. If the source of radiation is from a threatening radionuclide, the MINDS activates an alarm when the signal from the detection system exceeds a threshold. The system is very small and can be manufactured for a very modest cost. A field prototype has been developed. The combination of low cost, modest size and ease of manufacturability makes the MINDS a potential system that can be deployed fairly

soon and perhaps provide the detection and monitoring capability needed to prevent another terrorist attack.

The development of the MINDS technology is a joint effort between the U.S. Department of Energy's Princeton Plasma Physics Laboratory, and the Rutgers University Center for Advanced Information Processing (CAIP). The effort was also supported by funding from the U. S. Army at Picatinny Arsenal. The Princeton University Office of Research and Project Administration is in discussions with potential licensees for the technology.

Monitor for Air Particulates

Los Alamos National Laboratory (LANL) has licensed an environmental monitoring tool to Advanced Realtime Technologies (ART), LLC, to develop a commercial version of a cost-effective, real-time, continuous, field-portable, air-particulate monitor. The core technology for ART was developed at LANL to compliment the Department of Energy's Chronic Beryllium Disease Prevention Program. The Laboratory's Industrial Business Development (IBD) Division is assisting Advanced Realtime Technologies with business development. The technology will have broad applications in environmental monitoring, occupational safety inspection, mining processes, and the aerospace, semiconductor, and petrochemical industries.

The instrument will combine the advantages of a highly sensitive laboratory technique with the portability and ease-of-use of an in-the-field instrument. It can be used for onsite environmental pollution monitoring, real-time occupational safety inspection, and industrial process control. Through real-time, highly sensitive detection in the field, the instrument can provide instant feedback to site-workers, allowing them to take prompt action to avoid overexposure to harmful chemicals or environmental hazards.

Novel Chemical Sensing Technologies for Safety

Development of chemical sensing technologies, and especially sorbents for surface acoustic array (SAW) sensors, is a long standing aim of researchers at Pacific Northwest National Laboratory (PNNL). Arising out of this work is a patented hydrogen bonding polymer sorbent directed towards the detection of nerve agents, which was recently licensed by Battelle, operator of PNNL, to BAE Systems Integrated Defense Solutions. This hydrogen bonding hybrid organic/inorganic polymer was designed to be selective for nerve agents, and displays four times greater sensitivity to nerve agents than any other known polymer used in SAW devices. BAE Systems uses this polymer in the "JCAD *Chem Sentry*™" (Joint Chemical Agent Detector) currently being delivered to the armed services. This is a small, hand-held device that offers state-of-the-art chemical warfare detection capabilities. BAE's system using PNNL developed technology will soon to be available in a version for sale to civilian markets.

Opening New Markets for Agricultural Byproducts

Each year the U.S. corn milling industry generates almost 14 billion pounds of fiber as hulls during the processing of corn kernels to obtain starch, protein and vegetable oils. Cattle feed is the primary use for this fiber byproduct and is typically the lowest value product of corn milling. But processes developed through a Cooperative Research and Development Agreement (CRADA) between Pacific Northwest National Laboratory (PNNL) and the National Corn Growers Association (NCGA) show promise for chaning the way corn kernels are processed.

Researchers at PNNL have developed processes that will reclaim greater value from this resource by separating the corn fiber into its basic components—lipids, carbohydrates, proteins. These products will then be used to produce fuel ethanol and the building blocks for industrial chemicals, as well as higher value food, feed and consumer products. The group is taking a low-market value byproduct and opening up new markets, while also creating new supplies for existing, higher-margin markets.

Initiated in 2001, the CRADA extends previous work which resulted in technology for converting of five-carbon and six-carbon sugars derived from corn fiber to ethylene glycol or propylene glycol. In order to commercialize the technology, Battelle and NCGA have entered into license and income sharing agreements. Battelle, as operator of PNNL, serves as the commercialization agent for Laboratory derived technologies.

Depending upon how the conversion process is conducted, one may obtain either mixed or pure streams of the glycol products. The mixed products production process was licensed to NCGA for use as coalescing solvents, paraffin substitutes, and industrial emulsifiers; with Battelle retaining responsibility for licensing the pure products production process, and then sharing that licensing income with NCGA. Researchers from Michigan State University also contributed to the work developing the six-carbon conversion process, and the license and income sharing agreements between Battelle and NCGA were specifically crafted to reflect their contribution and to return licensing income to Michigan State.

ORNL Wins Four R&D 100 awards

In FY 2003, researchers at the Department of Energy's Oak Ridge National Laboratory won four R&D awards from R&D Magazine, which since 1963 has given the awards for the 100 most significant innovations of the year. ORNL's total of 116 awards is second only to General Electric. The following inventions received honors:

RAMiTS, Raman Integrated Tunable Sensor, is a compact, "point-and-shoot," fully integrated, battery-operated Raman monitor and is based on solid-state acoustooptic tunable filter technology. Outside the laboratory, this device can perform qualitative analysis of chemical and biological samples in seconds. RAMiTS can identify hundreds of substances, including toxic chemicals, by-products from explosives, biomedical markers, pharmaceuticals and illicit drugs. RAMiTS also could help revolutionize sensing applications such as environmental monitoring, medical diagnostics and homeland security, researchers said.

MicroTrapMS is a highly miniaturized ion trap mass spectrometer that is based on ORNL patented technology. The product can be used for applications from on-line screening for toxins in municipal watersheds to detecting hazardous substances at airport checkpoints. MicroTrapMS will enhance real-time capabilities of field engineers to sweep many local areas for pesticides, drugs, explosives and more. MicroTrapMS has the power of a conventional mass spectrometer at a lower cost.

CF8C-Plus is designed to drastically improve high-temperature durability, performance and reliability based on ORNL's unique engineered microstructure alloy development methodology. The engineered microstructure method dramatically changes CF8C-Plus from steel that cannot be used above 600-650 degrees Celsius to steel that can be used up to 850 degrees Celsius and

resists failure during creep, mechanical fatigue and thermal fatigue. Developers said that end users like Caterpillar or commercial foundries like MetalTek will benefit from CF8C-Plus because it is a cost-effective product with higher performance and immense reliability.

Uncooled Micromechanical Infrared Camera (UMIR-Cam) is a sensitive, miniature imaging and infrared photo-detection device. It runs at room temperature and can be used in a number of endeavors, including night vision, industrial process monitoring and medical imaging. It also can help firefighters see through smoke and has particularly important uses in the commercial and military sectors, because infrared radiation is the second-most intense source of radiation in our environment.

Processing Technology for Cleaning, Decontaminating, and Etching Surfaces

APJeT, a startup company, holds an exclusive license for materials processing technology developed at Los Alamos National Laboratory (LANL), recently announced $3 million in funding by two strategic investors. APJeT's technology was invented at Los Alamos National Laboratory by, a LANL physicist who is now APJeT's president and CEO. The technology produces a gas stream of reactive chemicals that can clean, decontaminate, etch or coat surfaces at atmospheric pressure and low temperatures. Heretofore, such plasma treatments could take place only in a vacuum, a process that is considerably slower and more costly than the APJeT solution.

The new technology aids in treating synthetic fibers to make them absorb or repel water, removing photo-sensitive material from silicon wafers, depositing thin films, and decontaminating surfaces exposed to chemical and biological warfare agents, such as anthrax spores. It could also be used in sterilizing medical products for the health care industry. Other investors in the company include Air Products & Chemicals of Allentown PA, a market leader in industrial gas and chemical processing, and Advanced Energy Industries of Fort Collins CO, a global leader in plasma source and power supply systems used in the manufacture of semiconductors, data storage products and flat panel displays.

PVScan and Reflectometer

PVScan is a high-speed optical scanner designed for characterizing photovoltaic (PV) materials and devices. It is used to analyze defects in semiconductor material and identify problems in the fabrication of electro-optical devices such as PV cells. The system is capable of measuring defect densities, grain-boundary distributions, reflectance, and light-beam-induced current (LBIC) on devices up to 20 cm x 20 cm and at rates up to 10 cm per second. The system, recognized by an R&D100 award as one of the best technologies of the year in 1993, provides valuable information for both crystal growers and process engineers, who require quick feedback on process changes. It has worldwide economic development applications for the semiconductor and PV markets by being able to quickly test for and identify defects in the wafers so that the manufacturing processes may be changed and quality may be improved, thus improving the efficiency and cost-effectiveness of the product.

Reflectometer is a patented optical system for determining physical characteristics of a solar cell. It is used to help PV manufacturers and R&D laboratories produce high yields of high-quality cells to make high-quality PV modules. Using reflectance spectroscopy, the Reflectometer can

measure physical parameters of wafers, wafer surfaces, and other materials deposited during solar cell fabrication. The market strength for the Reflectometer is through its unique design approach to production monitoring systems that is capable of very high throughput with accuracy and sensitivity.

The National Renewable Energy Laboratory (NREL) entered into licensing agreements with GTi Equipment Technologies, Inc. (GTi) to further develop and commercialize the PVScan and Reflectometer technologies. GTi is a small but profitable business specializing in the design and production of semi-custom and specialty equipment for materials processing industries, serving niche markets for semiconductor and photovoltaic applications. GTi's solar division provides equipment, support, and training for turnkey solar panel manufacturing projects worldwide. GTi has already begun selling new products that integrate these technologies.

RadScout Radiation Detector and Analyzer

The ORTEC Products business unit of AMETEK signed a non-exclusive license agreement with Lawrence Livermore National Laboratory (LLNL) in April 2003 to commercialize the Lab's RadScout radiation detector and analyzer. The technology is a premier example of Homeland Security applications moving to the market place. ORTEC, based in Oak Ridge, Tennessee, will incorporate the RadScout technology into its next generation of advanced portable nuclear detection systems. The detector features a miniaturized refrigeration system that eliminates the need to carry liquid nitrogen to cool the device's high-purity germanium crystals. Those crystals are used to detect minute amounts of neutrons and gamma rays emitted by radioactive materials. First responders can use these high-performance, high-resolution portable systems at border crossings, cargo ship docks, transportation terminals, post offices, etc. to quickly differentiate between potentially dangerous radioactive materials and harmless radiation sources, and to determine whether or not they pose a threat. ORTEC plans to market the detector within a year as the Detective and Detective-EX. The detectors are part of a suite of technologies either offered or under development by ORTEC for Homeland Security.

R&D Awards for Sandia National Laboratories' Technologies

Developed under a Shared Vision program, the SnifferStar™ mounts on a drone aircraft for remote surveillance of battlefield situations where suspect plumes or clouds are present. The detector's primary purpose is to save lives by warning soldiers that chemical weapons are present on a battlefield. The entire module weighs less than a golf ball, operates on 0.5 watts, and uses the wind generated by the motion of the craft to collect samples for analysis. SnifferStar technology isolates compounds of concern from common interferents and is capable of analyzing chemical blister and nerve agents in 20 seconds. The device also has potential for use in public buildings and military bases.

Acoustic telemetry technology, developed at SNL in cooperation with Extreme Engineering Ltd. of Calgary, Alberta, and with support from DOE, represents the fulfillment of an oil-industry quest that goes back to the 1940s. As more accessible reserves have been depleted, deeper and more complex extraction techniques have become necessary, making better communication between the driller and the drill bit more critical. Existing communication methods, based on mud-pulse techniques, were revolutionary when introduced in the early 1980s. But mud-pulse is slow—much, much slower than even first-generation telephone modems. Acoustic telemetry

technology uses the well-drilling tubing as the data transmission medium and sound waves as the data carrier, creating a 10-fold improvement in data rates and thereby improving drilling control and accuracy.

A large group of collaborators from SNL, Lawrence Livermore National Laboratory, and Lawrence Berkeley National Laboratory were honored for developing the Extreme Ultraviolet Lithography (EUVL) Full-Field Step-Scan System, a technological advance that will lead to dramatic improvements in the speed and memory of computer systems. (See also previous section). Researchers created the only system that can pattern full chip-size areas on silicon wafers with features as small as 50 nanometers. It is the embodiment of a set of groundbreaking technologies that were considered by many to be impossible as recently as a few years ago. In addition to the national laboratory team, the award is being given jointly to Northrop Grumman Space Technology/Cutting Edge Optronics. The work was done in partnership with an industrial consortium comprising Intel, Motorola, AMD, Infineon, IBM, and Micron. Intel ordered the first production-level instrument based on this technology last year.

The Low Emissions Atmospheric Metering Separator (LEAMS) is a family of atmospheric geothermal separators used in developing geothermal power. LEAMS safely contains and cleans the steam vented into the atmosphere of polluting solids, liquids, and noxious gasses. LEAMS can be used in drilling, well testing, and geothermal power plant start-up. In partnership with Sandia, LEAMS technology was developed by Two-Phase Engineering and Research, Inc., Santa Rosa, Calif., and fabricated by Drill Cool Systems, Inc., Bakersfield, Calif.

The Adaptive Optics Phoropter system uses microelectromechanical (MEMS) based deformable mirror technology in a compact, transportable system that expands upon traditional devices used for optometry. In addition to determining corrections needed for near-sightedness, far-sightedness and astigmatism, it also determines correction needed for high-order aberrations that can interfere with night vision and can provide a preview of correction to a patient. Technologies from astronomy and micromachining are combined to advance the study and treatment of retinal diseases. Applications for the tool include generation of improved prescriptions for custom contact lenses or laser eye surgery, as well as high-resolution retinal imaging. The partnership, led by Lawrence Livermore National Laboratory, includes Sandia, the University of Rochester, Wavefront Sciences, Boston Micromachines Corp., and Bausch & Lomb.

Lightning strikes, equipment failures, or other anomalies in electric powered transmission systems can cause brown-outs or even network failures. But a fast-response semiconductor device developed under Sandia's direction allows a utility to rapidly convert energy stored in a DC device into AC power and minimize the effects of interruptions on electrical devices. Under the auspices of the DOE Energy Storage Systems Program, Sandia led researchers at Virginia Tech in developing the advanced semiconductor unit, called an ETO (emitter turn-off thyristor). The ETO is rated at 4000A and 4500V and can switch power at 1-3 kHz—far exceeding other devices. The component could become a critical part of inverters, motor controllers, and many other power electronics systems that require medium voltage and high-current switches. In addition to inventors at Virginia Tech, the ETO was developed with Solitronics (a Blacksburg small business marketing the ETO) and the American Competitiveness Institute in Philadelphia.

RAM^{SM}/VAM^{SM} Technology Aids in Assessing Vulnerabilities to the Nation's Infrastructure and Facilities

In response to an increased need for assessing the vulnerabilities of dams, transmission lines, water utilities, communities, and chemical facilities, Sandia National Laboratories (SNL) has developed a variety of risk assessment methodologies (RAMs^{SM}) and vulnerability assessment methodologies (VAMs^{SM}) and licensed these technologies to the private and public sector. These commercial licenses are offered with very reasonable financial terms in an effort to encourage the participation of many small business entities. The licenses allow non-SNL personnel to train third parties in the use of some of the methodologies (i.e. RAM-W^{SM} and CVAM^{SM}) and standard licenses that allow access some of the methodologies quickly (i.e. RAM-D^{SM} and RAM-T^{SM}). Beyond simply developing the licensing mechanisms, techniques have been developed to ensure that export control requirements are met while still providing exceptional turn-around when licensing requests are made, with licenses being placed within 24 hours of the initial contact in time-critical situations. In all, more than 200 licenses have been put in place for the various RAMs^{SM} and VAMs^{SM} technologies.

Safer Stun Grenades Protect Hostages, Can be Reused for Training

Diversionary devices – also called stun grenades or flash-bangs – are used when law enforcers need to temporarily disable the occupants of a room, for example, in hostage situations. To use a stun grenade, the officers break down a door or smash a window of the room containing the hostages and captors, then lob in the explosive device. The nonlethal device – about the size of a soda can – creates a blinding, deafening, but not deadly explosion. Most devices currently in use contain a metal powder that violently combines with an oxidizer. When this mixture is ignited by a grenade-style fuse, an explosion takes place within the body of the device, creating a zone of extreme pressure that may be dangerous if the device lands too near a person. The explosion also destroys the shell of the device, making the current flash-bangs expensive to use as training tools.

Prison officials require a grenade that, if remaining whole after use, is too soft and flexible to be used as a weapon by rioting convicts. Soldiers need a lightweight canister that can be carried over long distances. Police do not want the canister to contain any explosive material that could be turned into a bomb.

SNL's new configuration satisfies a variety of law enforcement needs. The explosive source in Sandia National Laboratories' (SNL) stun grenade fans out as an airborne powder before it ignites, making it less dangerous. This new device is made of plastic and contains metal powder but no oxidizer. Instead of ignition within the device, the particles are forced out like a burst of talcum powder through holes in the bottom of the canister. The particles form a sheet of metal dust about five feet in diameter before igniting by combining with oxygen present in the atmosphere. The distributed powder lowers the pressure in the immediate vicinity of the exploded device to a safer level. This design leaves the canister undamaged, making it more economical to use as a training device.

Simulation of Comet Impact

Sandia National Laboratories (SNL) has been asked by the Denver Museum of Nature and Science to develop a realistic computational simulation of a comet impact on the Jovian Moon Europa. This work builds on SNL's past analysis of the Shoemaker-Levy (SL9) impact on Jupiter itself. The SL9 work won several international awards and was generally regarded as the most predictive of analyses completed before the impact. SNL will use the shock physics code CTH to model the first few minutes of the hypothetical impact event. SNL is the developer of the CTH code, which is widely used in the DOE and DoD weapons laboratories. CTH was developed with DOE funds for Defense Program needs and is currently receiving support and development funds from the DoD/DOE Memorandum of Understanding for conventional munitions.

Solar Water Heating Technology Transferred

Salt River Project (SRP) Agricultural Improvement and Power District (Arizona) has signed both a CRADA and "Work for Others" agreements with Sandia National Laboratories (SNL) and a manufacturing license agreement with Energy Laboratories, Inc., to develop an innovative all-stainless-steel solar domestic water heater. SNL developed and patented a laser welding process used in assembling the solar array. The laser welder and associated equipment will be loaned to SRP for the duration of the agreements and used at the Energy Labs' manufacturing facility in Jacksonville, Fla. to prove this technique in a manufacturing environment. SNL also has the expertise and data on stainless steel to achieve certification from the Solar Rating and Certification Corporation. Two other SNL patents (pending) are used for the solar selective black coating that is applied to the copper fins used in the solar panels.

Tank Retrieval Processes

Sandia National Laboratories (SNL) has recently completed a USIC/IPP-funded CRADA with Mississippi State University's Diagnosis and Instrumentation Analysis Laboratory (MSU/DIAL) for developing technologies to retrieve liquid and solid radioactive wastes from tanks used during cold-war weapons production. The partners, including participants from the Newly Independent States of the Former Soviet Union, successfully demonstrated three technologies: chemical softening of hard sludges, bulk retrieval of liquid and solid sludges, and separation of radioactive components in aqueous solutions. One emerging technology, the pulsating mixing pump, has been demonstrated to Hanford and Savannah River Site personnel. The pump has no replaceable parts inside the tank, is easily mounted on the tank top, and recirculates the water or other liquid being used to mobilize the tank wastes. The Russian-developed pulsating mixing pump offers a cost-effective and operationally efficient way to support DOE's commitment to resolve tank waste problems at contaminated sites. The technology is now being commercialized through the creation of a company (employing the Russian personnel and management) that will offer tank retrieval and decontamination services worldwide. This second-phase activity is conducted under the Nuclear Cities Initiative Program of DOE-NNSA Russian Transitions Initiative Office.

U.S. Military Using Gun-shot Residue Kit in Iraq

MSNBC News reported on August 5, 2003 that U.S. military forces in Iraq are using a Sandia National Laboratories' developed gun powder residue kit to identify whether a suspected shooter has fired a weapon in the previous 24-48 hours. The field test kits, known to the military as RIFFs, are produced by Law Enforcement Technologies, Inc. of Colorado Springs, CO. MSNBC quotes retired Army special operations forces leader Col. Andy Gembara, now a board member of Law Enforcement Technologies, "The Army wanted something small. It is meant to be provided to patrols and to MPs (military police) so they can help sort out the good guys from the bad guys." Gembara says the Army and Marine Corps have purchased thousands of cases of the kits in the past few months.

VISTA, Intuitive Web-based Software for Visualizing Genome Comparisons.

Now that the Human Genome Project is nearly complete, one of the most promising paths to gaining useful knowledge from the human DNA sequence is the growing field of comparative genomics. By comparing the human genome with the genomes of various other organisms, scientists can identify common regions of DNA, gain insights into how genes are switched on and off, and further their understanding of the human genome's evolution, structure and function.

Lawrence Berkeley National Laboratory (LBNL) has developed a user-friendly computer program, VISTA, which enables researchers to quickly compare the genomes of various organisms. VISTA (Visualization Tool for Alignments) software depicts long sequence alignments of DNA from two or more species in an easy-to-read graphical format that clearly illustrates the extent to which the sequences are similar or different. VISTA also functions to match common regions of DNA from two different organisms, at lengths of DNA ranging from less than a single gene to whole genomes.

LBNL has also implemented a multi-pronged approach to ensure the software's broad dissemination. The lab developed a web site and web interface so that the programs could be used over the Web or downloaded to the user's computer. VISTA has become one of the most popular and widely praised comparative genomics tools available to biologists, geneticists, and biomedical researchers. In fiscal year 2003, researchers from 41 countries used the system, submitting nearly 22,000 DNA sequences to the VISTA website for analysis. LBNL also granted close to 1000 academic research licenses in FY 2003 and sold its eighth commercial license. LBNL continues to make the program available over the Web free of charge.