Annual Report
on
Technology Transfer and Related Technology Partnering Activities
at the
National Laboratories and Other Facilities
Fiscal Year 2002

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

July 2003

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Department of Energy
Washington, DC 20585
July 22, 2003

Mr. Richard Mertens
Chief
Energy Branch
Office of Management and Budget
725 17th Street, N.W.
Washington, D.C. 20503

Dear Mr. Mertens:

In accordance with the requirements of the Technology Transfer Commercialization Act of 2000, 15USC 3710(f), I am forwarding the Department of Energy's (DOE) *Annual Report on Technology Transfer and Related Technology Partnering Activities at the National Laboratories and Other Facilities Fiscal Year 2002.* The *Report* describes the Department's technology partnering programs and plans, submits required data covering FY 2002 activities, and presents required information on outcomes in the form of selected cases of successful technology transfer and partnering arrangements.

The Department finds technology partnering in addition to traditional authorities for contracting and awarding financial assistance is an increasingly cost effective means in which DOE accomplishes R&D and its missions. Similarly for our partners, technology partnering is becoming an increasingly attractive means for non-Federal entities to access unique technical expertise of the Department's National Laboratories and Facilities. These complementary motivations have resulted in an expansion of technology partnering activities, as described in the *Report*, along with increased benefits to DOE, its partners and the public. In FY 2002, the *Report* notes there were 10,500 such transactions executed by DOE and its Laboratories and Facilities. In addition, there were about 2,800 invention disclosures, patent applications, and issued patents in FY 2002.

If you have any questions concerning this *Report*, please contact Dr. Robert C. Marlay, Office of Policy and International Affairs. Dr. Marlay leads the virtual organization known as the Technology Transfer Working Group, which assisted in organizing the systematic collection of agency-wide data and preparing the *Report*. Dr. Marlay can be reached at 202-586-3900.

Regards,

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

Cc: Bruce P. Mehlman
Assistant Secretary of Commerce for
Technology Policy

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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 and Stevenson-Wydler technology transfer legislation in 1980. In 1989, the National Competitiveness Technology Transfer Act 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 accomplishment, particularly in areas associated with scientific, engineering and related technical activities. It is carried out at all 11 national laboratories and 13 other research and production facilities, where DOE has authorized such activities.

This Report presents data on DOE's technology partnering activities for one-year period ending on September 30, 2002, that is, Fiscal Year 2002. It is the second such annual report submitted in fulfillment of the requirements of the Technology Transfer Commercialization Act of 2000 [15USC 3710(f)1]. In addition to providing required data on technology partnering activities, the Report provides analysis of recent trends in technology partnering and illuminates a number of dynamics and changes taking place within the management of technology partnering at the DOE laboratories and facilities. The Report also highlights a number of recent contributions to mission and other public benefits that have resulted from facility technology partnering activities with non-Federal entities.

Summary of FY 2002 Activities

A summary of FY 2002 technology partnering activities for the DOE's laboratories and facilities is presented in Table ES-1. In addition to the technology partnering activities summarized in Table ES-1, there were also a number of related and crosscutting activities involving DOE Headquarters and Field Offices, including policy and management developments as well as at the national laboratories and facilities.

Organization, Management and Oversight
DOE continued to refine and enhance a number of organizational approaches towards the management and oversight of technology partnering activities across the DOE Complex. It reestablished and strengthened the use of virtual or "matrixed" organizations that serve to coordinate, communicate, and integrate the policies and practices of technology partnering across DOE, and to raise and address emerging issues of interest or concern.

Reporting and Appraisal Guide
Under the auspices of the TTWG and TPWG, DOE published the *Reporting and Appraisal Guide for Technology Partnering Programs* in June 2002. This *Guide* serves as an aid to systematic organization and reporting of technology partnership data, suggests objectives and

measures for comprehensive and consistent evaluations of laboratory and facility performance in the technology partnering, provides standard definitions, and improves the administrative efficiency and lessen burdens of reporting to higher authorities.

Policy Review
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 Laboratory Operations Board (LOB), a standing subcommittee of the SEAB, developed a set of recommendations that addressed the key barriers to industry partnering and technology transfer. 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.
- 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.

Alternative Dispute Resolution
DOE's Office of Dispute Resolution oversees the mediation of complaints involving intellectual property, contract, environment, grants, or whistleblower issues. In FY 2002, ombuds at DOE's national laboratories and facilities were involved in dozens of potential issues or complaints, touching on CRADAs, patents, licenses, WFO and other areas. The majority (83 percent) of these were either satisfactorily resolved or withdrawn at the lowest organizational level. All but a few now require no further pursuit.

Ongoing Dynamics at DOE Laboratories and Facilities
As the strongly funded periods for CRADAs of the 1990s waned, with little or no line-item funding for CRADAs in the current year budget requests, technology transfer offices at many of the national laboratories began to rethink their facility technology partnering strategies. In FY 2002, many offices found themselves evolving into a different, more self-sufficient, business-oriented operating context, supported by an entrepreneurial climate for technology transfer activities. Top-level laboratory managers placed more emphasis on strategic planning, attracting long-term strategic partners, and establishing metrics that focus on technology transfer results. Managers increasingly applied business approaches to the management of intellectual property management and technology transfer, instituting processes that evaluate and track intellectual property for commercial application. Marketing plans and portfolio management processes became the norm. Technology assessments and market analyses were increasingly used to identify licensing opportunities early and build marketing strategies for the technologies. With limited resources, technology transfer managers were forced to be more selective in partnering

decisions, regarding both the technology and the non-Federal partner, and weighed carefully decisions to supplement technology development funding with contractor-funded technology transfer, venture capitalists, and/or state and local investment incentive programs.

With limited resources for matching funds, the use of CRADAs declined. CRADAs dropped in FY 2002 to 687, down from a peak in FY 1996 of over 1,600. The decline in CRADAs over this period mirrors the change in the Department's dedicated funding for technology partnering activities.

As the number of CRADAs declined, other technology partnership agreements increased. Work-for-Others and User Facility Agreements increased in FY 2002. The number of new inventions, patents, and licensing activity also increased in FY 2002. Since FY 1997, the number of invention disclosures has remained about steady, in the range of 1,300 to 1,500 per year.

The number of licenses continued to increase. In FY 2002, there were 3,459 active licenses for inventions and other intellectual property from all the Department's laboratories and facilities, an increase of more than 70 percent from the previous year.

"Funds-In" Increase

Over the last decade, as more and more industry partners and other non-Federal entities have come to know and value the special competencies of DOE laboratories and facilities, external funding of the technology partnering activities has increased. From FY 1992 to FY 2001, funds in from non-Federal entities increased from $46 million to over $246 million.

Table ES-1: Summary of FY 2002 Technology Partnering Activities at DOE national laboratories and facilities

Technology Transfer Data Element	FY 2002
CRADAs, total active in the FY	680
New inventions disclosed	1,498
Patents applications filed	711
Patents issued	551
Total Licenses; Active in the FY	3,459
• Invention Licenses	1,327
• Other IP (copyright, material transfer, other) Licenses	2,132
Licenses that are income-bearing	2,523
Licenses Terminated for Cause	77
Total Income Received	$23,476,716
• Invention Licenses	$21,253,279
• Other Licenses	$2,223,437
Total Earned Royalty Income (ERI)	$5,608,744

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CHAPTER 1

OVERVIEW AND SUMMARY OF MAJOR FINDINGS

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 and Stevenson-Wydler technology transfer legislation in 1980. In 1989, the National Competitiveness Technology Transfer Act 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 accomplishment, particularly in areas associated with scientific, engineering and related technical activities. It is carried out at all 11 national laboratories and 13 other research and production facilities, where DOE has authorized such activities.

Beyond the more common modes of interaction with non-Federal partners, namely contracting and financial assistance, technology partnering, broadly defined, has emerged as a significant alternative for pursuing such interactions. Motivated by mutual benefit, notably without transfer of Federal funds or resources to the non-Federal partner, technology partnering provides an array of mechanisms engaging potential non-Federal partners. There were 10,500 transactions of one form or another took place at DOE laboratories and facilities in FY 2002. In addition, there were about 2,800 invention disclosures, patent applications, and issued patents in FY 2002.

For DOE, technology partnering is seen as important to the renewal and strengthening of DOE's scientific and technical competencies at its research laboratories and facilities. DOE simply cannot afford to replicate all the required skills inside its own fences. In order to accomplish its mission, DOE must depend, in part, on non-Federal partners to gain access to evolving technical expertise and certain commercial sector technology, in effect transferring know-how and technology to the Federal sector. On the other hand, 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 are best at understanding how to do this.

At the same time, private firms and other non-Federal entities have discovered that DOE's research laboratories and facilities can provide valuable and often unique problem solving capabilities, to the benefit of their own objectives. They are increasingly interested in long-term relationships that can 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.

This Report presents data on DOE's technology partnering activities for one-year period ending on September 30, 2002, that is, Fiscal Year 2002. It is the second such annual report submitted in fulfillment of the requirements of the Technology Transfer Commercialization Act of 2000 [15USC 3710(f)1]. In addition to providing required data on technology partnering activities, the Report provides analysis of recent trends in technology partnering and illuminates a number of dynamics and changes taking place within the management of technology partnering at the DOE laboratories and facilities. Finally, the Report highlights a number of recent contributions to mission and other public benefits that have resulted from facility technology partnering activities with non-Federal entities. The recent contributions were identified from interviews with selected laboratories that had the largest number of technology partnering activities during the fiscal year.

Technology Partnering Policy Context

To provide policy context for the Report, it is noted that DOE issued Order 482.1 in 2001. This DOE Order, along with a set of related and accompanying DOE Directives, governs technology partnering at its laboratories and facilities. The Order, reissued in 2003, formally recognizes that technology transfer, through partnering in all its varied forms, is a mission of DOE and its facilities. The Order is consistent with similar provisions found in the National Competitiveness Technology Transfer Act; the Stevenson-Wydler Technology Innovation Act (Public Law 96-480), as amended by the Federal Technology Transfer Act (Public Law 99-502); and other legislation.

In addition to setting the policy context for technology partnering, the DOE Order assigns roles and responsibilities to various DOE organizational elements for the oversight, management, and administration of DOE facility technology partnering activities. In keeping with these roles and responsibilities, the DOE Order sets a series of expectations for facilities' technology partnering activities, to the extent they are consistent with the terms of the facility contractor delegation of authority, including the following:

- 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

Under DOE Order 482.1, activities covered by the Order and performed by DOE facility operators and contractors include the following broad classes of technology partnering:

- *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.

- *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.

- *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.

- *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.

- *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.

- *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

DOE Laboratories and Facilities

DOE authorizes 24 laboratories and facilities to conduct one or more of the above technology partnering activities. The laboratories and facilities that constitute the scope of data included in this Report, include:

- 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

Most of these laboratories and facilities have established formal technology transfer programs and have dedicated staff to facilitate 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 only at the aggregate level, and does not show individual facility data.[1]

Summary of Transactions

A summary of FY 2002 technology partnering activities for the DOE's laboratories and facilities is presented in Table 1. Additional detailed data is provided in Chapter 2.

[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.

Table 1: Summary of FY 2002 Technology Partnering Activities at DOE national laboratories and facilities

Technology Transfer Data Element	FY 2002
CRADAs, total active in the FY	680
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Total Earned Royalty Income (ERI)	$5,608,744

Summary of FY 2002 Activities

In addition to the technology partnering activities summarized in Table 1, there were also a number of related and cross-cutting activities involving DOE Headquarters and Field Offices, including policy and management developments as well as at the national laboratories and facilities. These activities are described below.

Organization, Management and Oversight

DOE continued to refine and enhance a number of organizational approaches towards the management and oversight of technology partnering activities across the DOE Complex. It reestablished and strengthened the use of virtual or "matrixed" organizations, known within DOE as working groups, that serve to coordinate, communicate, and integrate the policies and practices of technology partnering across DOE, and to raise and address emerging issues of interest or concern.

At DOE Headquarters, the Technology Transfer Working Group (TTWG) is comprised of about 35 key 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. It provides a Departmental focal point for review, development, and integration of technology transfer policies. The TTWG meets monthly, for about two hours 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. It is co-chaired by the Assistant General Counsel for Technology Transfer and Intellectual Property, in DOE's Office of General Counsel. Apart from the Federal members of the TTWG, a number of key members of DOE laboratories and facilities are invited to participate, as may be appropriate to the agenda.

Through these means, the TTWG also serves to reinforce and exercise a network of professionals in the field.

Across the DOE Complex, the Technology Partnership Working Group (TPWG) is comprised of a larger body of members from the DOE laboratories and facilities, amounting to more 200 technology partnering practitioners. The TPWG serves to address common needs of technology partnering offices and professionals across the DOE complex. It provides services to the TTWG, by identifying personnel who can contribute to current issues or activities and carrying them to completion. The TPWG organizes the DOE annual meeting on technology partnering and serves as the coordinating body for gathering and compiling data to meet the needs of the DOE Annual Report. An executive committee of six annually elected members, three from DOE Field Offices, and three from DOE laboratories or facilities runs the TPWG. The executive committee also participates in the TTWG monthly teleconferences. The TPWG holds about three video-teleconferencing meetings a year.

Reporting and Appraisal Guide

Under the auspices of the TTWG and TPWG, DOE published the *Reporting and Appraisal Guide for Technology Partnering Programs* in June 2002. This *Guide* serves as an aid to systematic organization and reporting of technology partnership data. It suggests objectives and measures for comprehensive and consistent evaluations of laboratory and facility performance in the technology partnering area. The *Guide* provides standard definitions for nearly a hundred terms in the field. The *Guide* improve administrative efficiency and lessen burdens of reporting to higher authorities by lending coherence in advance to record-keeping and standardized or automated reporting formats.

Policy Review

The Secretary of Energy requested the Secretary of Energy Advisory Board, 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.

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

- The Department should state, in an unequivocal fashion, its support for industry partnering and technology transfer across the departmental complex.

[2] Laboratory Operations Board (2003). *Recommendations Regarding Industry Partnering/Technology Transfer Within the Department of Energy*, Laboratory Operations Board, U.S. Department of Energy, December 31, 2002.

- 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.

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. This 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.

In FY 2002, ombuds at DOE's national laboratories and facilities were involved in dozens of potential issues or complaints, touching on CRADAs, patents, licenses, WFO and other areas. The majority (83 percent) of these were either satisfactorily resolved or withdrawn at the lowest organizational level.[3] In some instances, additional consultations or inquiries were required. All but a few now require no further pursuit. 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. This success rate of alternative dispute resolution in these settings is high, especially in view of the large body of annual partnering interactions (13,000 per year) with non-Federal partners.

Ongoing Dynamics at DOE Laboratories and Facilities

As the strongly funded periods for CRADAs of the 1990s waned, with little or no line-item funding for CRADAs in the current year budget requests, technology transfer offices at many of the national laboratories began to rethink their facility technology partnering strategies. In FY 2002, many offices found themselves evolving into a different, more self-sufficient, business-oriented operating context, supported by an entrepreneurial climate for technology transfer activities. Top-level laboratory managers placed more emphasis on strategic planning, attracting long-term strategic partners, and establishing metrics that focus on technology transfer results. Managers increasingly applied business approaches to the management of intellectual property management and technology transfer, instituting processes that evaluate and track intellectual property for commercial application. Marketing plans and portfolio management processes became the norm. Technology assessments and market analyses were increasingly used to

[3] Data on alternative dispute resolution provided by DOE's General Counsel's Office on Technology Transfer, March 3, 2003.

identify licensing opportunities early and build marketing strategies for the technologies. With limited resources, technology transfer managers were forced to be more selective in partnering decisions, regarding both the technology and the non-Federal partner, and weighed carefully decisions to supplement technology development funding with contractor-funded technology transfer, venture capitalists, and/or state and local investment incentive programs.

With limited resources for matching funds, the use of CRADAs declined. CRADAs dropped in FY 2002 to 687, down from a peak in FY 1996 of over 1,600. The decline in CRADAs over this period mirrors the change in the Department's dedicated funding for technology partnering activities. 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 declined to $ 3 million in FY2002.[4] The TPP Program ended in FY 2000 and the LTR program will be terminated in FY 2004.

As the number of CRADAs declined, other technology partnership agreements increased. Work-for-Others and User Facility Agreements increased in FY 2002. The number of new inventions, patents, and licensing activity also increased in FY 2002. Since FY 1997, the number of invention disclosures has remained about steady, in the range of 1,300 to 1,500 per year.

The number of licenses continued to increase. In FY 2002, there were 3,459 active licenses for inventions and other intellectual property from all the Department's laboratories and facilities, an increase of more than 70 percent from the previous year. Other forms of intellectual property, including copyrights of software, biological materials and other protected data, accounted for most of the increase.

"Funds-In" Increase

Over the last decade, as more and more industry partners and other non-Federal entities have come to know and value the special competencies of DOE laboratories and facilities, external funding of the technology partnering activities has increased. From FY 1992 to FY 2001, funds in from non-Federal entities increased from $46 million to over $246 million. With the current downturn in the economy, some reversal of this trend appeared recently. It is not clear whether this change in funds-in activities is short-lived or whether it is indicative of longer-term trends.

[4] General Accounting Office (2002). *Technology Transfer -- Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*. Washington DC, United States General Accounting Office.

CHAPTER 2

TECHNOLOGY TRANSFER DATA FOR FY 2002

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.[5] 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 FY 2002 is shown in Table 2.

Table 2: FY 2002 Technology Partnering Activities at DOE national laboratories and facilities

Technology Transfer Data Element	FY 2001	FY 2002
I. Collaborative Relationships for R&D (Note 1)		
▪ CRADAs, total active in the FY	558	680
- New, executed in the FY	204	192
II. Intellectual Property Management		
New inventions disclosed	1527	1498
▪ Patents applications filed	792	711
▪ Patents issued	605	551
III. Profile of Active Licenses (Note 2)		
All Licenses active in the FY	-	3459
- New, executed in the FY	-	694
Invention Licenses, active in the FY	1162	1327

[5] The statutory annual agency report (termed and "agency report on utilization") is described by 15 U.S.C. 3710 (f). The Secretary of Commerce's report (termed an annual "Summary Report") is described by 15 U.S.C. Sec. 3710 (g)(2).

Technology Transfer Data Element	FY 2001	FY 2002
- New, executed in the FY	226	206
Patent Licenses, active in the FY	1162	1327
-New, executed in the FY	226	206
Other IP Licenses, active in the FY	843	2132
-New, executed in the FY	-	488
Copyright Licenses	-	1525
-New, executed in the FY	-	332
Material Transfer Licenses	-	581
-New, executed in the FY	-	153
Other Licenses	-	26
-New, executed in the FY	-	3
▪ Total Royalty-Bearing Active Licenses	1012	2523
Exclusive	174	301
Partially Exclusive	112	136
Non-exclusive	726	2086
▪ Licenses that are income-bearing, total	-	2523
Number Excl/Part-Excl/Non-Excl	-	301/136/2086
Invention Licenses	-	1123
- Number Excl/Part-Excl/Non-Excl	-	263/123/737
Patent Licenses	-	1123
- Number Excl/Part-Excl/Non-Excl.	-	263/123/737
Other IP Licenses	-	1400
- Number Excl/Part-Excl/Non-Excl	-	38/13/1349
IV. Licensing Management		
▪ Elapsed Execution Time (average calendar days)		
Invention Licenses (average/min/max)	Note 3	127/8/471
▪ Licenses Terminated for Cause		

Technology Transfer Data Element	FY 2001	FY 2002
Patent Licenses	60	77
V. License Income		
▪ Total Income Received	$21,403,362	$23,476,716
Invention Licenses	$18,921,843	$21,253,279
Patent Licenses	-	$21,253,279
Other Licenses	$1,870,071	$2,223,437
Copyright Licenses		$1,869,644
▪ Total Earned Royalty Income (ERI)	$7,832,481	$5,608,744
Average ERI	-	$31,383
Min-Max ERI	$2 - $1,584,922	$23 - $793,802
ERI from top 1%	$2,699,134	$100,052
ERI from top 5%	$5,271,631	$196,945
ERI from top 20%	$7,162,951	$238,565
Invention Licenses		
Average ERI	-	$40,632
Min-Max ERI	-	$25 - $793,802
ERI from top 1%	-	$793,802
ERI from top 5%	-	$3,418,529
Other IP Licenses		
Average ERI	-	$5,087
ERI from top 20%	-	$5,067,977
Min-Max ERI	-	$23 - $68,802
ERI from top 1%	-	468,802
ERI from top 5%	-	$114,591
ERI from top 20%	-	$196,945
Copyright Licenses		
Average ERI	-	$5,609
Min-Max ERI	-	$23 - $68,802

Technology Transfer Data Element	FY 2001	FY 2002
ERI from top 1%	-	$68,802
ERI from top 5%	-	$100,052
ERI from top 20%	-	$187,169
VI. Disposition of License Income		
▪ Patent Licenses, total distributed	$16,356,052	$16,422,696
To Inventors	$5,942,497	$6,386,213
To Other Purposes	$10,413,555	$10,036,483

Notes

1. In FY 2002 the definition of Active CRADAs changed from "Active at the end of the FY" to "Active during the FY."
2. Data reported for FY 2001 included "Royalty Bearing Active Licenses." For FY 2002 data this was changed to "Income Bearing Licenses."
3. This data was not reported for FY 2001

CHAPTER 3

TRENDS IN TECHNOLOGY PARTNERING DATA

This section examines trends in selected areas of technology partnering. There are two data sources: (1) *Technology Transfer – Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*, General Accounting Office, GAO-02-465, April 2002, spanning the time period of 1992 through 2001, and (2) primary data reported from the DOE national laboratories and facilities, spanning the time period 1987 through 2002. Due to limitations of available data, this section focuses both on technology partnering at 12 of the larger DOE laboratories, and in data reported from all 24 DOE laboratories and facilities authorized to conduct partnering activities.

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 1980 to encourage the Federal laboratories to participate in R&D partnerships for the purpose of advancing the innovation of technologies.

Figure 1 indicates that the number of new CRADAs peaked in the mid-1990s, to just over 1,600 in FY 1996. Since that time, the number of active CRADAs had dropped by nearly 60 percent, to 687 in FY 2002. In FY 2002, the number of both new and active CRADAs increased for the first time. Laboratories and facilities have executed roughly around 200 new CRADAs annually.

The initial growth and subsequent decline in CRADAs over this period mirrors the change in the Department's dedicated funding for technology partnering activities. 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 declined to $ 3 million in FY2002.[6] The TPP Program ended in FY 2000 and the LTR program will be terminated in FY 2004.

Intellectual Property Management

The number of new inventions, patents, and licenses are often used as indicators of management of intellectual property assets. Figure 2 shows that the overall level of invention disclosure steadily increased throughout the 1990s, followed by a slight decline since FY 1999. Since FY 1997, the number of invention disclosures has remained in the range of 1,300 to 1,500 per year.

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[6] General Accounting Office (2002). *Technology Transfer -- Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*. Washington DC, United States General Accounting Office.

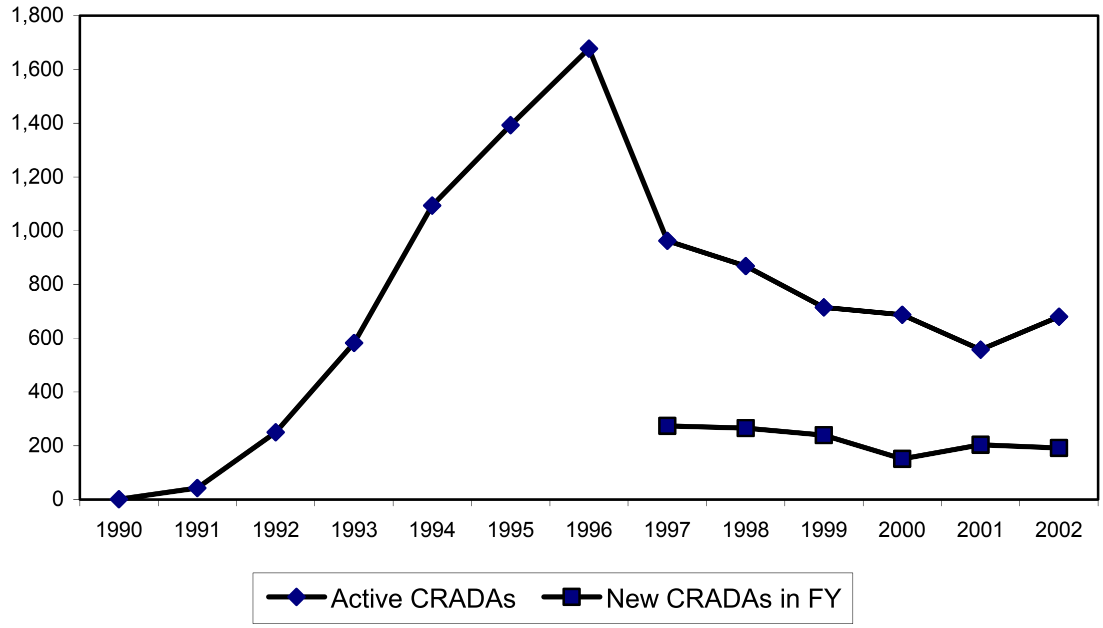

Figure 1: Cooperative Research and Development Agreements (CRADAs)
Source: Data reported from 24 DOE laboratories and facilities.

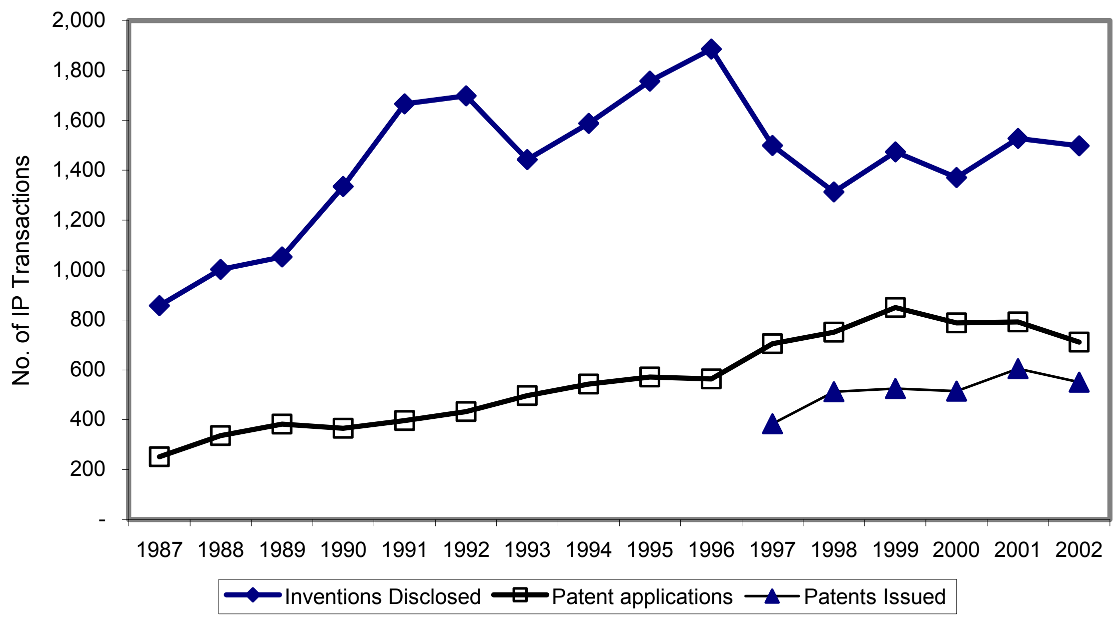

Figure 2: Invention Disclosure and Patenting
Source: Data reported from 24 DOE laboratories and facilities.

The total number of active licenses continues to grow, as is seen from Figure 3. In FY 2002, there were 3,459 active licenses for inventions and other intellectual property from all the Department's laboratories and facilities, up over 70 percent from the previous year. Other intellectual property, such as software copyright, biological materials, and other protected data account for most of this increase over the past years.

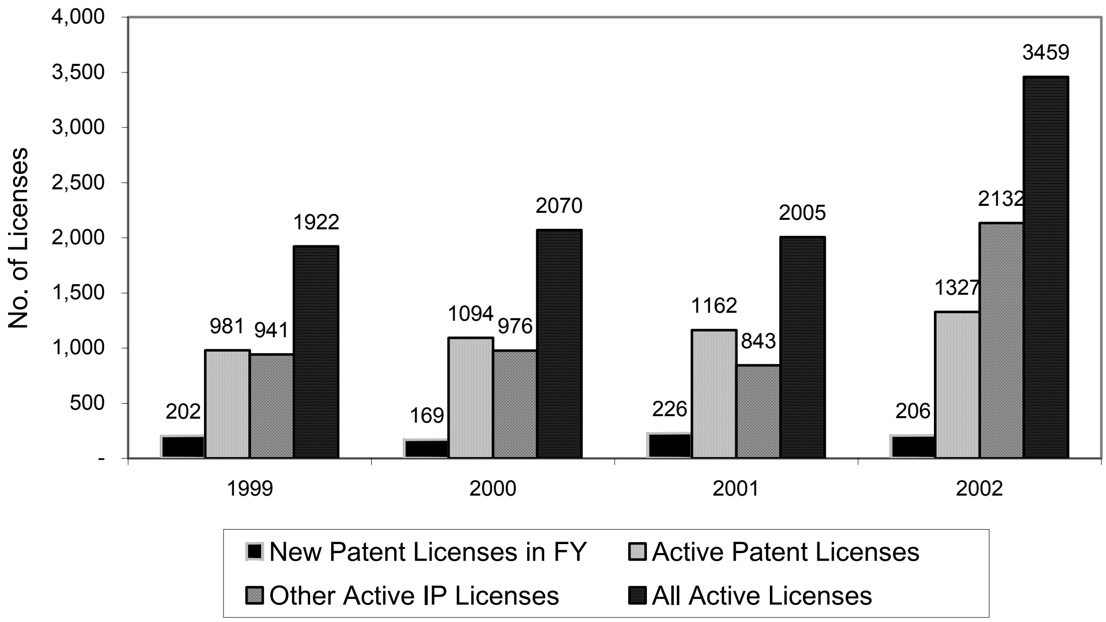

Figure 3: Licensing of Inventions and Other Intellectual Property [a]

[a] Other intellectual property is defined to include: computer software, tangible research products (such as biological materials), and protected data.
Source: Data reported from 24 DOE laboratories and facilities.

In FY 2002, licensing income (Figure 4) grew to $23 million, continuing a long upward trend. Since 1996, there has been a sharp increase in the amount of licensing income, growing at an annual rate of approximately 17 percent per year.

In a separate report prepared by the General Accounting Office, 12 DOE Laboratories were surveyed that have accounted for most of the technology transfer activities and funding.[7] Figure 5 shows the trends in technology transfer activities from those 12 DOE National Laboratories. The technology transfer activities shown here include CRADAs, Technology Assistance to Small Businesses, Licenses, Work-for-Others Agreements, and User Facility Agreements.

Several trends are observed in Figure 5. First, the rate of change in the number activities was greater in the early 1990s, indicating a greater number of technology transfer activities during these years. Second, since the mid-1990s, the number of activities has been increasing at a more or less steady rate.

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[7]Ibid.
Laboratories included: Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratory, Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, National Renewable Energy Laboratory, Idaho National Engineering and Environmental Laboratory, and the National Energy Technology Laboratory.

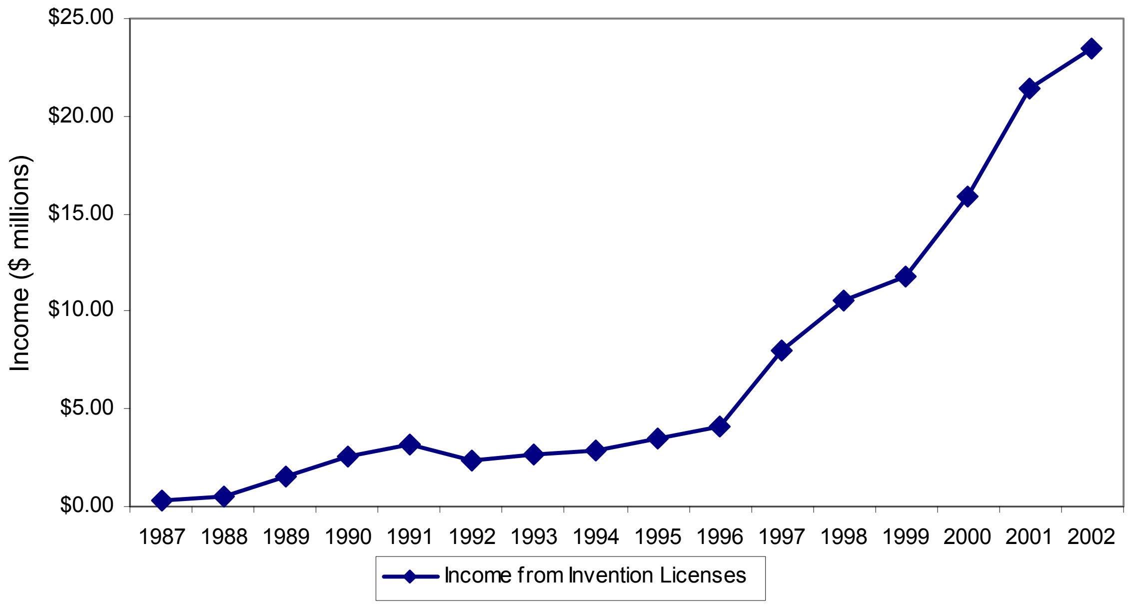

Figure 4: Income from Invention Licenses
Source: Data reported from 24 DOE laboratories and facilities.

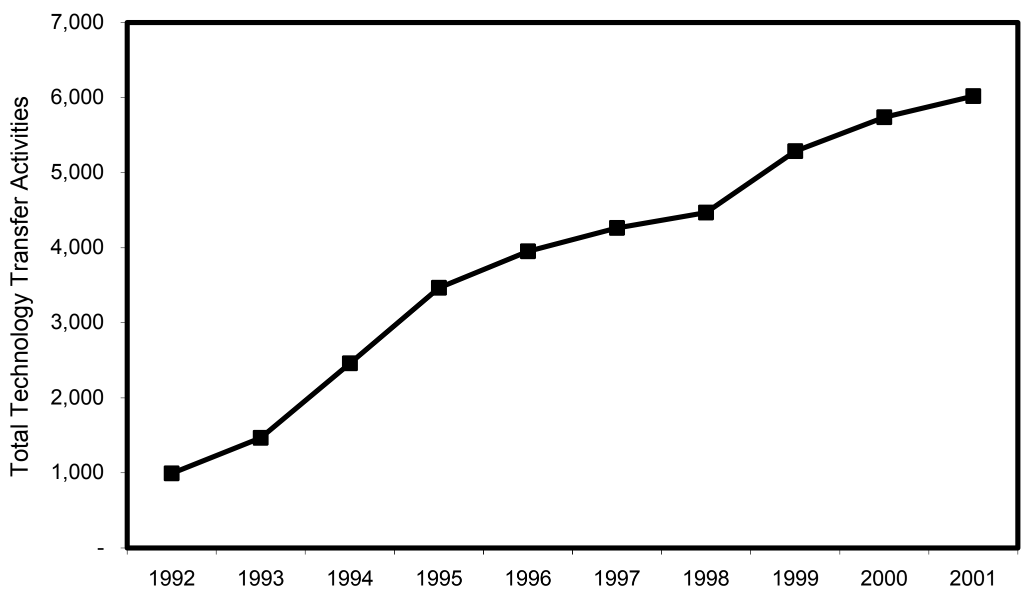

Figure 5: Technology Transfer Activities at 12 DOE Laboratories [a]

[a] Technology transfer activities include CRADAs, Technology Assistance to Small Businesses, Licenses, Work-for-Others Agreements, and User Facility Agreements.
Source: General Accounting Office (2002). *Technology Transfer -- Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*. Washington DC, United States General Accounting Office.

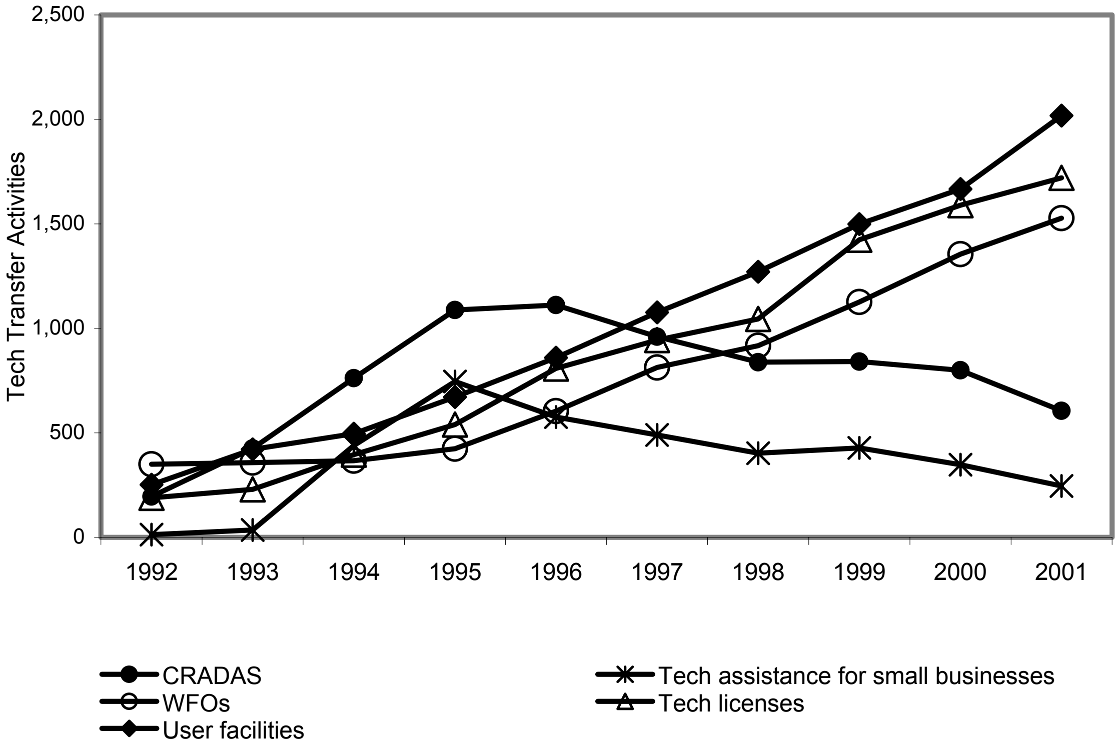

Figure 6: Agreement Types and Technology Transfer Activities for 12 DOE Laboratories
Source: General Accounting Office (2002). *Technology Transfer -- Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*. Washington DC, United States General Accounting Office.

Figure 6 disaggregates the GAO data by type of agreement, i.e., CRADAs, Technology Assistance for Small Business, Work-for-Others Agreements, Licenses, and User Facility Agreements. The number of CRADAs peaked in the mid-1990s and began to decline thereafter. Similarly, the number of Technical Assistance For Small Businesses agreements also declined. Conversely, the number of Work-for-Others and User Facility Agreements, and technology licenses have steadily increased since the early 1990s.

Work-for-Others activity, which is essentially reimbursable work, has some benefits for a laboratory. Scientific and technical capabilities are maintained, resources flow into the laboratory where otherwise excess capacity may have required contraction or layoffs, and research frontiers are advanced. On the other hand, Work-for-Others activity may not be as beneficial to the laboratory as CRADAs or other direct Federal funding.

Regarding the increase in Work-for-Others activity, the GAO stated that,

> "[R]esearch under work-for-others agreement typically is less beneficial for the DOE laboratory than research under a CRADA because (1) it is not required to provide direct benefit to program missions, although it must be consistent with them; (2) the

laboratory's scientists typically do not collaborate on research with the nonfederal entity's scientists; and (3) the laboratory does not normally have right to any resulting intellectual property."[8]

Funding for technology transfer activities by non-federal entities is shown in Figure 7. Funding from nonfederal entities increased more than fivefold, from about $46 million in FY 1992 to over $265 million in FY 2001, which represents over 3 percent of the total DOE R&D budget during the same period. Nonfederal funded activities have continued to increase up until 1999 and declined thereafter. It is unclear whether this change in funds-in activities is short-lived or whether it is indicative of longer-term trends.

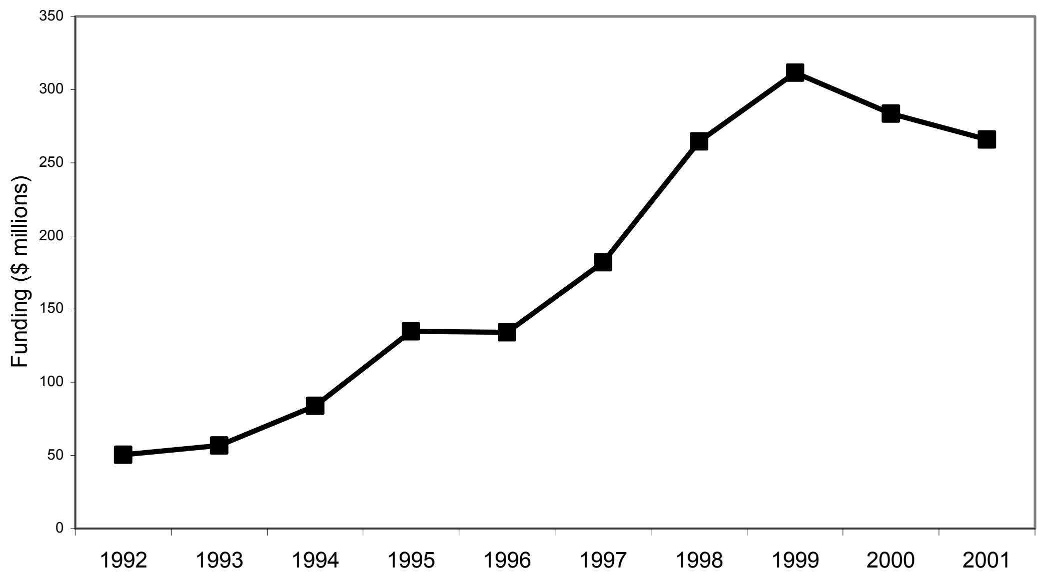

Figure 7: Funding and In-Kind Support by Nonfederal Entities for Technology Transfer Activities [a]

[a] Includes CRADAs, Licenses, Work-For-Others Agreements, and User Facility Agreements.
Source: General Accounting Office (2002). *Technology Transfer -- Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*. Washington DC, United States General Accounting Office.

[8] Ibid., p.9

CHAPTER 4

KEY ACCOMPLISHMENTS AT DOE NATIONAL LABORATORIES AND FACILITIES

In response to the changing circumstances noted in the previous section, particularly with regard to reduced funding of CRADAs and other types of technology partnering agreements, the management of technology transfer at many of the DOE national laboratories and facilities has evolved toward a greater entrepreneurial climate. The laboratory managers are now placing greater emphasis on strategic planning, attracting strategic partners, and revising metrics to measure success in technology transfer. These and other trends were illuminated in a series of interviews conducted by the DOE Office of Policy and International Affairs. Interviews were conducted with senior managers of the technology transfer offices at selected DOE national laboratories and facilities. Selections were based on the most technology transfer activities during the fiscal year. A summary of the key findings is presented below.

Strategic Planning and Marketing

In many of the laboratories and facilities, greater emphasis is being placed on strategic planning and business management approaches to intellectual property management and technology transfer. Marketing plans and portfolio management processes are now the norm, with technology assessments and market analyses used to identify opportunities early. Marketing strategies are built around technology portfolios with the emphasis to enhance the market opportunities of the technologies available for licensing. Some managers have reorganized their offices such that marketing teams bear responsibility for the entire technology commercialization process, i.e., technology assessment or evaluation, identification of potential industry partners, technology development, market intelligence, and technology licensing agreements.

Not only has strategic planning and marketing led to improved intellectual property management and technology transfer results, industry partners increasingly find DOE laboratory and facility staff have a greater understanding of business and market needs along with the ability to speak the same language.

Strategic Partnerships

In parallel with strategic planning and marketing approaches, many laboratories and facilities have worked to identify companies whose research interests are closely aligned with the laboratories' research fields. Since the laboratories possess unique facilities, industry finds them attractive in carrying out joint research. In other cases, laboratories look to strategic partnerships as a means for mass production of needed technologies to support the laboratory in fulfilling its mission. For example, weapons technology may be invented and developed to early stages of completion, but requires companies with resources to produce the technologies. The laboratories will support this type of technology partnership because the industry partner becomes a supplier of technologies used in further development of the defense weapons.

Some DOE laboratories also use their laboratory "user facilities" as a means of attracting funded research, both from industry partners as well as other federal agencies. Some of the laboratory facilities are designated as user facilities, which are accessible by industry partners. The User Facility agreements provide access to the unique, mostly large facilities operated by the laboratories. For proprietary R&D, the laboratory is paid for the full cost of the activity.

Laboratory technology transfer managers recognize that the user facilities offer unique resources for industry and have targeted outreach activities to specific industry partners, such as pharmaceutical companies. Pharmaceutical companies find the user facilities to be especially attractive in developing new drugs. Similarly the emerging field of nanoscience and nanotechnology are attracting many different types of industry partners, primarily because of the broad applications across many fields, such as plastics, biotechnology, and nanoscale manufacturing. Companies view the laboratories as an important resource of knowledge and capabilities and enjoy having access to the scientists.

New Metrics for Success

Most technology transfer managers recognize that numbers of CRADAs, patents, licenses, spin-off companies, etc. do not fully represent the value of technology transfer. In order to more accurately measure success, several laboratories are developing new metrics to more accurately capture the effects of technology transfer activities. More useful indicators are linked to the functions of technology transfer, including licensing revenue, time to license and time to patent application (IP management), product development investments and return on investment, and other indicators. In other instances, metrics are being designed that parallel the steps of the technology commercialization process, i.e., intellectual property protection, technology development, marketing, licensing and commercialization.

Alternative Funding Mechanisms for Technology Development

Laboratories are using other approaches to supplement funding for technology partnering. Some laboratory M&O contractors are investing their own funds (from corporate headquarters or from their own fee) to further develop and commercialize attractive technologies. In other cases, laboratories establish relationships with venture capitalists that, in turn, work with startup companies that seek to develop and commercialize technologies. However, attracting venture capital has had limited success, due largely to the nature of traditional venture capitalists, which is to focus on mature technologies and strong business cases. Many of the laboratories' technologies are in very early-stages of development and require further work to get them to the stage where venture capitalists can see more attractive business opportunities.

Laboratories are also working with state and local governments to support technology development and regional development programs. These programs take various forms, such as early-stage seed funding, incubators for startups, and science and technology parks. Such programs are intended to satisfy the needs of the Laboratory, that is, to further develop and license the technology, and the needs of the state and local governments by stimulating local economic growth and the creation of new jobs.

Shifting Technology Interests

Some of the Laboratories are seeing a shift in the kinds of technologies that are garnering interest from industry. Technology fields, such as nanoscale science and technology, and defense technologies are emerging as long-term opportunity areas. Collaboration between industry and those laboratories with strong capabilities in these areas is increasing, both in terms on increased licensing and in technical consultations.

Technologies related to weapons and homeland security also are gaining greater interest. There is an increase in the amount of R&D funding for weapon technologies, which has led to an increase in the number of technology partnerships between some of the national laboratories and the large defense contractors. In homeland defense, there is great interest in the capabilities in technologies for detecting chemical and biological attacks, integrated sensors, video, and other technologies.

Energy-related technologies continue to attract interest from industry partners. There has been resurgence in the number of funded CRADAs in energy efficiency, renewable energy, and fossil energy.

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CHAPTER 5

RESULTS OF TECHNOLOGY TRANSFER ACTIVITIES

There are numerous examples of successful technology transfer and partnering relationships. Twenty such examples are summarized below to illustrate the range and nature of technology transfer activities across the DOE complex.

- "Near-Frictionless Carbon" Coating Moves Toward Commercialization
- Computer Modeling and Simulation that Benefits Industry and National Nuclear Security Administration
- Combinatorial Techniques Used in Discovering New Drugs
- EnergyPlus Will Save Tax Payers $9 Million on Federal Building Energy Costs
- Commercial EUV Lithography Tool Ensures More Efficient Microchips Over the Next Decade
- Laser Peening Process Widely Used in Metal Improvement Process
- Compact Vacuum Insulation Reduces Cold-Start Emissions in Automobiles
- Joining/Brazing and Resin Curing Technologies Lead to Efficiency Gains
- Nickel Aluminide Fixtures Lead to Reductions in Energy Use
- Technology to Aid Emergency Management
- Software Supports Advanced Building Systems
- Non-Thermal Plasma-Assisted Catalysis Leads to Cleaner Emissions
- Non-invasive Inspection Technology Used in Detecting Illegal Weapons
- Assessing the Vulnerability of the Nation's Infrastructure Facilities
- Shared Vision Program Challenges Defense and Security Threats
- Instant Shooter ID Kit brings Forensics Lab to Crime Scene
- Decontamination Formulation Widely Distributed – Effective Against Nerve Gas, Mustard Gas, and Anthrax
- Parallel Computing for Weather Forecasting
- Radioactive "Seeds" to Treat Prostate Cancer
- Initiatives for Proliferation Prevention Program with Kirkham Motorsports

"Near-Frictionless Carbon" Coating Moves Toward Commercialization

Near-Frictionless Carbon" coating, developed in 1997 at DOE's Argonne National Laboratory (ANL), stands on the brink of commercialization. After its disclosure, 3,000 engineers expressed interest in the new coating, which has the lowest coefficient of friction ever measured. Not only is the material slick, it is extremely hard and wear-resistant. A sample of the coating survived 17.5 million passes of a steel ball pressed against its surface—the testing machine failed, but the coating didn't. ANL scientists then turned their efforts to converting the laboratory curiosity into something industry could use. Collaborative research with CemeCon USA adapted a coating technique, allowing hundreds of small parts to be carbon-coated.

Computer Modeling and Simulation that Benefits Industry and National Nuclear Security Administration

When Sandia National Laboratory (SNL) and the Goodyear Tire & Rubber Co. teamed up in 1993, Goodyear was hoping that SNL could apply its computer modeling and simulation capability to help the company design and manufacture better tires. SNL technologists believed the work would allow them to test their computer tools and to sharpen their skills in materials development and analysis. They became even more interested as they realized that simulating the performance of laminated tire structures consisting of fabric, steel, and various rubber compounds was a particularly difficult challenge, and that this capability would ultimately be useful in their own programs. SNL brought to the partnership its substantial computer power and insight while Goodyear contributed its expertise and experience in polymer science.

Ultimately, the combination of capabilities produced breakthroughs that not only provided insight into tire design, but also were applicable for weapons design and manufacturing. As Goodyear applied SNL's computer code innovations to better optimize tire performance for new car platforms, SNL was able to improve its neutron generator manufacturing and to develop more accurate computer models of polymer stresses, deformations, and aging effects, which in turn helped to improve the fidelity of its weapon-system models.

Over time, the partners pursued other common interests in areas as diverse as manufacturing, fluid dynamics, vibration, acoustics, materials, and chemical-separations technologies. SNL is drawing technological innovations from industry and both partners learned an important lesson: Partnerships based on mutual benefit are the most enduring. Recently, SNL and Goodyear bolstered their already strong collaborative relationship by signing an umbrella cooperative research agreement, the eighth CRADA executed over the past nine years. The new CRADA will facilitate changes and additions to work in progress and enable Goodyear and SNL to easily establish new projects.

Combinatorial Techniques Used in Discovering New Drugs

In the early 1990s Lawrence Berkeley National Laboratory (LBNL) scientists invented a materials research process that combined miniaturizing with parallel processing. In 1994 the start-up company Symyx Technologies, Inc., licensed the invention and began developing research tools that eventually were able to create and screen new materials with respect to their client properties and characteristics, and do so at hundreds to thousands of times faster than traditional methods, and at a fraction of the cost.

Earlier, combinatorial techniques had been successfully applied in the pharmaceutical industry to discover new drugs. The Molecular Design Institute of LBNL proposed that the same approach could be extended to materials science. The term "combinatorial" refers to a large-scale trial and error technique. When searching for a new material, scientists define its desired properties then decide which combinations of elements are most likely to yield those properties. Using automated devices to maximize speed, and drawing from a library (physical inventory), as many as 10,000 distinct materials can be placed onto a one square inch surface area. This library is subjected to varying environmental conditions and tests are employed to screen for specific chemical and physical properties. The LBNL concept is a radical improvement on traditional materials development where compounds are created one at a time and painstakingly tested to search for desired qualities. Chemical catalysts, genomic probes, fuel cell components, and battery electrodes are just some of the materials that can be developed with this methodology.

Since 1994 when Symyx licensed the LBNL technology, the now profitable company has commercialized a polymer used for coating proteomics arrays and has identified twelve new materials that are in development. In a collaborative effort with Dow Chemical, Symyx has identified several new classes of catalysts to enable the production of novel high value plastics and reduce the cost of polymer manufacturing. Symyx has also entered into collaborative agreements with Merck &Co., Eli Lilly and Company, Exxonmobil Chemical Company, Rhodia S.A, Celanese, ICI, Unilever and others.

EnergyPlus Will Save Tax Payers $9 Million on Federal Building Energy Costs

EnergyPlus software, an energy simulation program for buildings distributed by Lawrence Berkeley National Laboratory (LBNL), allows architects to calculate the impacts of different heating, cooling, and ventilating systems, as well as the effects of various types of lighting systems and windows. Since Berkeley Lab first released the software in April 2001, it has licensed to over 10,000 end users, 55 collaborative developers, and seven commercial distributors. The program has already been used to generate energy savings estimates on buildings around the world.

The simulation software has been integral to the design of a new federal office building, which had a July 2002 groundbreaking in San Francisco. On this one application, it is calculated that EnergyPlus saved nearly $9 million in energy costs projected over 20 years. The modeling tool was also used to simplify the building's facade, saving taxpayers an additional $1.5 million in construction costs.

The new San Francisco building will use natural ventilation to provide cooling without the use of fans or refrigeration. Most of the year the building will be cooled by natural airflow through the windows. In hot weather, interior heat is absorbed during the day by exposed heavy weight ceiling slabs; the stored heat then dissipates at night when the air is cooler. Orienting the building and its windows to take advantage of sun angles and prevailing wind patterns maximized cooling and ventilation.

Commercial EUV Lithography Tool Ensures More Efficient Microchips Over the Next Decade

In 1997, a pall was cast over the semiconductor industry by the prediction that the traditional method of printing circuits onto microchips would be reaching insurmountable physical limits around 2005. Thereafter the chip-making industry would be prevented from increasing functionality by doubling the number of transistors that can be packed into a chip every 18 months or so—a pace that has propelled the industry for the last 30 years.

To address this concern, an unprecedented $250 million Cooperative Research and Development Agreement (CRADA) was initiated in 1997 between an Intel-led consortium and the Virtual

National Lab—Sandia, Lawrence Livermore, and Lawrence Berkeley National Laboratories. The goal of the CRADA was to strengthen the capability of the labs in using EUV light, via application, while also developing a new Extreme Ultraviolet (EUV) lithography system that would extend the current pace of semiconductor innovation at least through the end of this decade. Last year, the CRADA team developed and integrated the first full-field EUV lithography chip-patterning tool, known as the Engineering Test Stand, at Sandia National Laboratory.

This year, the EUV lithography chip-patterning tool became a reality with the first commercial order from the world's largest exposure tool manufacturer, ASML. The beta tool is expected to be delivered in 2005, and the first commercial chip production with EUVL should take place in 2006-2007.

Laser Peening Process Widely Used in Metal Improvement Process

Discovered in the early 1970s, laser peening remained a laboratory technical curiosity until GE used it to solve a critical problem on the B1 bomber turbine engine. However, the slow laser-firing rate hampered development of significant commercial applications. In 1997 Metal Improvement Company (MIC), an established provider of conventional shot peening services to industry, entered into a CRADA with the Lawrence Livermore National Laboratory (LLNL) to develop a commercially viable laser peening process based on a high-energy and high-pulse rate LLNL laser. The collaboration was successful, and now metals can be laser peened effectively and economically, resulting in stronger metals. This process is expected to extend the service lifetime of some metal parts like aircraft engine fan blades by a factor of 3 to 5. Pushing their collaboration a giant step further, LLNL and MIC researchers developed the Lasershot Marking System to imprint permanent, high-resolution identification marks on safety-critical parts and Laser Peen Forming, which can open a new frontier in net shape manufacturing.

These remarkable achievements have been recognized by receiving coveted R&D 100 Awards for two of the LLNL/MIC discoveries. In 2001, MIC finalized a contract with a major aerospace company for laser peening and broke ground for a new facility in Livermore. In 2002, the construction was completed and the Livermore facility is in the process of doubling its size. Laser peening and laser marking applications are being explored for aviation parts, medical devices (such as hip and knee implants), and automotive components. Interestingly, several "spinback" applications for laser peening have surfaced related to DOE's programs for stockpile stewardship, fuel-efficient vehicles, and long-term nuclear storage. This technology has been used on NASA's space shuttle since 2001. MIC estimates that laser peening automobile frames could potentially save the U.S. 285 million liters of gas annually.

Compact Vacuum Insulation Reduces Cold-Start Emissions in Automobiles

Compact vacuum insulation (CVI) is a technology being incorporated into the automobile catalytic converter. CVI, a National Renewable Energy Laboratory (NREL) innovation that won an R&D 100 Award in 1991, provides benefits for the catalytic converter to minimize cold-start emissions. By maintaining its operating temperature 24 hours or longer, CVI can greatly reducing "cold start" pollution. NREL collaborations with Benteler Industries, which has licensed the catalytic-converter technology, have resulted in a production-ready version in FY2002. Compared to other concepts on the market, the new converter is cheaper, more versatile, lighter, and longer lasting. It is the only one that deals with cold-start emissions. After sitting cold for 24 hours, a Taurus with the NREL/Benteler catalytic converter showed hydrocarbon emissions were 84% less and carbon monoxide emissions were 91% less than with the car's conventional catalytic converter.

Joining/Brazing and Resin Curing Technologies Lead to Efficiency Gains

Researchers at Oak Ridge National Laboratory (ORNL) and Ford Motor Company worked cooperatively to develop improved joining/brazing and resin curing technologies. Current manufacturing processes of Ford's Lincoln LS vehicle are operator dependent and susceptible to quality concerns and throughput issues. A focused tungsten halogen lamp based technology line heater in ORNL's Infrared (IR) Processing Center showed promise for curing after multiple heating methodologies were investigated. The infrared line heater can be operated from cold to full power in less than one second, converts electrical power into radiant power at 90% efficiency, and targets energy to only the area on the part that needs curing. Upon completion of the work at ORNL, Ford Motor Company adopted the IR lamp technology as used at ORNL, in one of its plants.

The benefits of using the epoxy filler with the IR curing include a cost saving of $28 per vehicle, with other benefits that include less porosity in the coating and a full 2-minute reduction in cycle time. The elimination of the metallic alloy thermal spray resulted in reduced energy consumption through elimination of energy intensive powder production process, plasma generation during the coating process, and the elimination of five subsequent grinding steps.

Nickel Aluminide Fixtures Lead to Reductions in Energy Use

Delphi Automotive Systems successfully implemented nickel aluminide heat-treated fixtures developed jointly under a CRADA with the Oak Ridge National Laboratory (ORNL). The use of the fixtures, instead of traditional steel fixtures, in the company's manufacturing process extended the fixture life by more than two times. Researchers at ORNL invented the nickel aluminide alloy as fixture life as a heat-resistant material that would lead to more energy-efficient processes. Engineers at the company worked with ORNL to apply the material in Delphi's heat-treat facilities to replace steel rack assemblies used to hold automotive parts. The implementation of nickel aluminide for this use also has the potential to save energy through enhanced component life. Delphi has now made the decision to make nickel aluminide fixtures standard in its facilities worldwide and is in the process of casting and installing hundreds of nickel aluminide assemblies to replace other fixtures in its carburizing furnaces.

Technology to Aid Emergency Management

Pacific Northwest National Laboratory (PNNL) developed an emergency management software system, EMADVANTAGE that simultaneously supports planning, daily operations, incident identification, emergency declaration, and emergency response activities for multiple users within an emergency operations center (EOC). This system enables decision makers within the

EOC to make informed decisions and share information in real time with the larger emergency management community, including incident command centers, shelters, schools, hospitals, joint information centers, and others involved in emergency planning and response activities. EMADVANTAGE combines modeling, visualization, and communications capabilities that enable emergency managers to identify hazards, perform threat and risk analysis, declare emergencies, execute and track responses, register and reunify evacuees, and make and implement informed protective action decisions.

Recent extensions of EMADVANTAGE are the web-based operational status board (Web-OSB) and the wireless PDA-OSB. Web-OSB enables access to the information at an EOC from any PC with Internet access and a secure ID. This makes it possible for remote areas with small populations and small budgets to access the features of EMADVANTAGE. PDA-OSB allows users to submit information and update the EOC with current conditions from the field using a PDA. The ability of EMADVANTAGE to handle highly dynamic information, display it on a map, and integrate it into its hazard analysis and consequence assessment makes hand-held wireless devices more capable in emergency management situations.

The system is based on components of the Federal Emergency Management Information System (FEMIS), another breakthrough technology PNNL developed to safeguard communities near the nation's chemical weapons depots. Recognizing the need for a general operations and emergency management system for natural disasters and human-caused hazards, PNNL researchers enhanced the program into a broadly applicable suite of capabilities and transferred this technology to a refinery in Mexico, a small business in Maryland, the National Aeronautics and Space Administration (NASA), and the U.S. Army.

Software Supports Advanced Building Systems

Researchers at PNNL developed an expert operations and maintenance system called Decision Support for Operations and Maintenance (DSOM®). This diagnostic software/hardware system monitors, diagnoses, and documents plant performance; provides guidance that enables plant operators to optimize efficiency; and issues maintenance directives. The system is based on the concept of condition-based management, focusing on finding the balance between high-production rates, machine stress, and failure.

The DSOM® software operates on a Microsoft Windows NT 4.0 system in a networked environment, with a central server database providing coordination and management of information flow and storage. A network of sensors, usually an extension of existing monitoring capabilities, constantly feeds information about facility component performance into a computer. The software integrates the sensor data, continuously evaluates instrument performance, and compares the data to information in the database. DSOM® lets the operators know in real-time, and with an intuitive and user-friendly point-and-click interface, how the system is performing and what and when maintenance steps can be taken to optimize efficiency and ultimately minimize costs.

As a Department of Housing and Urban Development (HUD) funded organization, the New York City Housing Authority (NYCHA) faces federal mandates to reduce energy costs and reduce harmful emissions while increasing reliability and overall system life so as not to create additional costs. DSOM® provides a comprehensive system that goes a long way toward meeting NYCHA's service and efficiency goals through a low-risk installation leading to a permanent and reliable solution that could also be applied to additional NYCHA systems.

Non-Thermal Plasma-Assisted Catalysis Leads to Cleaner Emissions

Working with industry partners, Pacific Northwest National Laboratory (PNNL) developed an exhaust after-treatment system for lean-burn diesel and gasoline engines based on non-thermal plasma- (NTP) assisted catalysis. This system converts harmful oxides of nitrogen (NO_x) and particulate matter (PM) emitted from vehicle engines into clean air components. In lab tests with a simulated gas mixture, this technology reduced NO_x by nearly 100%. Tests with actual diesel engines have achieved >75% NO_x reduction over a range of operating conditions and up to 50% PM reduction. By adding an optional particulate filter, this system can reduce PM emissions by up to 90%. This exhaust after-treatment system performs well in the lean-burn conditions of energy-efficient diesel engines, where conventional 3-way catalytic converters are inadequate. It also can be easily incorporated into existing tailpipe designs with little modification as a retrofit option for older vehicles.

The system combines an electrically energized gas, or plasma, with specialized catalyst materials that selectively bring about chemical reactions to reduce NO_x. In the plasma step, vehicle exhaust loaded with NO_x flows into an NTP reactor, where nitric oxide (NO) is converted to nitrogen dioxide (NO_2). The plasma step also activates the hydrocarbons that are the reductant in the second step, where a chemical reaction occurs on the surfaces of the catalyst materials. The specialized catalysts reduce NO2 to harmless nitrogen. In addition to the NTP reactor and the catalyst unit with its specially formulated ceramic materials, the system contains a high-voltage electrical power supply, a control system for the NTP reactor, and an optional particulate filter.

Non-invasive Inspection Technology Used in Detecting Illegal Weapons

Helping to combat terrorism, DOE's Pacific Northwest National Laboratory developed the Acoustic Inspection Device (AID), which is now manufactured and marketed by Mehl, Griffin & Bartek Ltd. (MGB). AID provides a means for non invasive examination of contents in sealed container and can help screen bulk solids. This technology aids in the detection of hidden contraband and weapons and prevents such items from entering the country illegally. It can also help deter smuggling, and aids in the verification of treaty compliance.

The AID, a hand-held device, consists of on-board, real-time data acquisition, and signal conditioning electronics; operations software and interactive database; and the front-end, ultrasonic detection/measurement system. It rapidly discriminates and identifies liquid contents in sealed containers, determines if there are concealed compartments within sealed containers of liquid, and detects hidden compartments in solid forms such as metal ingots and tar kegs that may contain contraband or weapons of mass destruction. The device allows these determinations to be made without opening the container, reducing health and safety risks associated with intrusive inspections. Additionally, the AID saves the end-user time and money by providing a safe, rapid method for examining shipments without having to use time-consuming and costly invasive methods (i.e., sampling and laboratory analysis methods).

The AID's ability to identify contents in sealed containers is particularly useful. Normally, it takes 20 minutes to sample one 55-gallon drum on a truck that potentially carries many drums. Using AID, that time is reduced to just a few seconds per drum. With more than 70,000 long-haul trucks on the road every day, the improvement in inspection time reduces the potentially disruptive and costly effects of such inspection on commerce.

MGB is currently customizing AID for the US Customs Service, anticipated to be a prime user of the technology along with new and emerging customers and applications as a result of the on-going marketing efforts by MGB. Other potential end-users include the Air Force, hazardous material personnel, and the power, pipeline and pharmaceutical industries.

Assessing the Vulnerability of the Nation's Infrastructure Facilities

In May 1998, concerns over possible terrorist attacks on critical physical infrastructure assets, such as dams, buildings, power plants, and electrical systems led to the issuance of two Presidential Decision Directives that encouraged Federal agencies to find new ways to deter and prevent terrorist attacks on U.S. infrastructure. In response to these directives, Sandia National Laboratory (SNL) developed a series of Risk Assessment Methodologies (RAM), which are based on the formal risk-assessment tools and techniques developed for DOE by Sandia to protect U.S. nuclear weapons facilities.

Currently, there are four RAM products: RAMPARTTM (Risk Assessment Method — Property Analysis and Ranking Tool), which performs multidimensional risk analyses on buildings; RAM-DSM, for risk analyses of dams; RAM-TSM for transmission systems; and RAM-WSM for water utilities. In FY02, SNL issued more than 70 licenses (all no-fee) for RAM products to utility and government organizations across the United States. The owners of buildings, dams, hydroelectric facilities, and power transmission systems can now use the step-by-step security risk assessment processes to assess and mitigate the vulnerability of their sites to terrorist attacks.

Each RAM product allows the owners, operators, and security managers of buildings, dams, transmission systems, or water utilities to critically examine the facility's unique situation (for example, its potential adversaries and their motives and resources, facility vulnerabilities, consequences if the facility is attacked, and existing security measures) and perform cost-benefit analyses of possible security upgrades. For instance, a hydroelectric dam operator might use RAM-D to determine where to place sensors, cameras, or lights, or whether to invest in walls, barriers, higher fences, better doors, extra training, or improved policies.

Shared Vision Program Challenges Defense and Security Threats

The Shared Vision Program, formed through an umbrella CRADA between Sandia National Laboratory and Lockheed Martin Corporation in 1999, has continued to grow, recently doubling in size. This highly successful collaboration is applying technologies and systems developed by both organizations to the challenging defense and security threats of our changing world.

Projects with applications for both government and industry have included microelectronics and photonics, sensors, robotics, situation and decision support modeling, cognition, and logistics.

An interesting example of a recently completed project is "Automatic Assembly / Disassembly with Human Motion Planning." The project developed a constraint-based motion planning software tool comprising motion-planning algorithms for human motions required in maintenance and manufacturing assembly and disassembly operations of aircraft components. The system generates assembly sequences and associated human motions, evaluates them, and identifies problematic component designs and human factors causing the inefficiencies.

Early indications are that this tool will prove highly valuable, with potential savings to the Joint Strike Fighter and other aircraft programs in the millions of dollars. In one instance, the F-16 fighter program successfully applied the new motion planner to solve a difficult part removal problem and a solution was found in twelve minutes. Prior to this, the engineer had been trying to manually generate a path for the removal process for four days with no success.

Instant Shooter ID Kit brings Forensics Lab to Crime Scene

Law enforcement investigations need a tool that quickly, accurately, and inexpensively identifies whether a person recently fired a gun. A new Sandia National Laboratory-developed gunpowder residue detection technology can do that even if the shooter attempts to wash off the traces of gunpowder. This technology could also assist airport security personnel or others who need to determine if an individual has recently been in contact with gunpowder-based explosives. Law enforcement officials can use the technology at a crime scene to save crucial investigative time. In the past, the apprehension of a shooting suspect sometimes required results from a remote forensics laboratory, thereby hampering the ability to quickly solve the crime.

Sandia National Laboratory (SNL) developed the field-portable detection technique to provide police with immediate confirmation of recent gun use. "Statistics show that the first 72 hours are crucial for investigation of a crime scene," said Pam Walker, a project manager in SNL's Explosive Components Facility. "When called to the scene of a shooting, officers need to rapidly isolate suspects from witnesses."

The technology was licensed to and is being distributed by Law Enforcement Technologies, Inc. (Colorado Springs, CO) as the Instant Shooter ID Kit (ISid-1®). Law Enforcement Technologies, Inc. is a privately held company specializing in technologies for law enforcement, corrections, private security, and military markets. In the first three months of distribution, the kit was directly responsible for identifying the perpetrators of at least seven homicides and was instrumental in determining that four suspicious deaths were actually suicides. Numerous kits were also distributed to law enforcement in Maryland and Virginia during the recent sniper attacks.

Decontamination Formulation Widely Distributed – Effective Against Nerve Gas, Mustard Gas, and Anthrax

MODEC, Inc. and EnviroFoam Technologies, Inc. (EFT) are two Sandia National Laboratory (SNL) partners that hold nonexclusive rights to commercialize SNL's decontamination formulation technology. This decontamination technology neutralizes chemical and biological agents and can begin decontaminating a site even before a specific contaminant is identified. The formula is nontoxic, noncorrosive, and environmentally benign, yet highly effective when used as a first response against chemical-biological agents such as VX, mustard, soman, and anthrax. The decontamination formulation can be deployed as a foam, mist, fog, spray, or liquid. The Department of Energy's Chemical and Biological National Security program funded the development of the decontamination formulation.

In FY02, MODEC and EnviroFoam supplied decontamination solutions to help remediate the anthrax contaminations in Washington, D.C. (EnviroFoam) and New York City (MODEC). Federal authorities used the decontamination formulation to remediate the mailrooms and freight elevators in the Hart Senate Office Complex as well as in the Dirkson and Ford Congressional Offices in Washington, D.C. The formulation, dispersed as a fog, was used to decontaminate portions of the ABC and New York Post offices in New York City. More recently, EnviroFoam Technologies received an order from the U.S. Army Central Command (CENTCOM) for several thousand gallons of its EasyDECON™ solution.

Parallel Computing for Weather Forecasting

Capitalizing on their expertise in parallel computing, Argonne National Laboratory (ANL) computer scientists have played a key role in the development of atmospheric models that provide faster, more accurate weather forecasts in critical areas of the national interest including civilian and military operational weather forecasting and research applications. ANL developed the parallel version of MM5, a community weather model that is currently used by more than 500 researchers worldwide. Tools and techniques developed at Argonne allowed parallelization of the original source code model, providing portable performance on a wide array of different parallel computing systems. This "same-source" implementation has obvious benefits for software maintainability, preserving the many person-years invested in the original non-parallel software while avoiding the additional effort to maintain multiple, specific versions. The approach employs an application-specific parallel library and a compile-time source translator that automates and hides the special mechanisms for achieving parallelism in the code.

The parallel code provides the real-time operational forecasts at the U.S. Air Force Weather Agency, Offutt Air Force Base. The U.S. Environmental Protection Agency, the California Air Resources Board, and a number of other research, university, and government institutions in the United States, Europe, and Asia also use the code.

Radioactive "Seeds" to Treat Prostate Cancer

SourceTech Medical (STM, Carol Stream, Ill.), a start-up company established in April 1998, approached Argonne National Laboratory (ANL) for help in developing a new method of producing radioactive medical "seeds" for use as permanent implants in treating early-stage prostate cancer. When faced with the technical challenges of working with radioactive materials, one of STM's first tasks was to identify a laboratory that could help. The company worked with ANL under a Work for Others (WFO) agreement, completed in July 1999. STM has finished construction on a new facility in Carol Stream and is currently manufacturing and distributing I-125 seeds in the United States.

Initiatives for Proliferation Prevention Program with Kirkham Motorsports

Two brothers are finding that former Eastern bloc countries can be rich resources for their family-based car-making business. A factory in Poland that once produced MiG fighter jets for the communist north during the Korean War is now turning out aluminum car bodies for David and Thomas Kirkham of Kirkham Motorsports in Provo, Utah.

The unlikely conversion of the Warsaw plant started with the Kirkhams' dream to replicate the unique, ultra-fast and pricey Shelby Cobra sports car. In Poland, the brothers found the facility, equipment and skilled craftsmen needed to produce the car bodies to exacting aircraft specifications and with precision accuracy.

Now, through the Initiatives for Proliferation Prevention program and the NNSA's Kansas City Plant, the Kirkhams are building on their success in Poland and taking another giant step for their business. In late 2001, Kirkham Motorsports entered an IPP partnership for the design and manufacture of parts and components to go inside the Cobra-replica bodies. Doing the design and production work will be former nuclear weapons workers at the Spektr Conversion facility, located about 2,000 miles east of Moscow in the Ural Mountains.

The Kansas City Plant's Logistics Projects contacted the Kirkhams about the IPP program and a possible partnership. The Spektr facility, which during the Cold War had been used for nuclear weapon design work and the storage of highly enriched uranium, was found to be a suitable location for the project. Once the agreements were signed, the program funded six-month residencies for two Russian design engineers at the Kirkham Motorsports facility in Provo. There the Russian engineers worked on converting existing parts and component designs from U.S. to Russian manufacturing standards. They also trained on computerized numerical control equipment and computer-design software.

Since returning to Russia, the design engineers are teaching what they learned in Provo to other engineers at the Spektr Conversion facility. Part of the project's total funding of $1.47 million is going toward the purchase of computerized numerical control equipment that Spektr Conversion ill use to manufacture mufflers, tailpipes, connecting rods, and other high-end components for the aftermarket automotive industry.