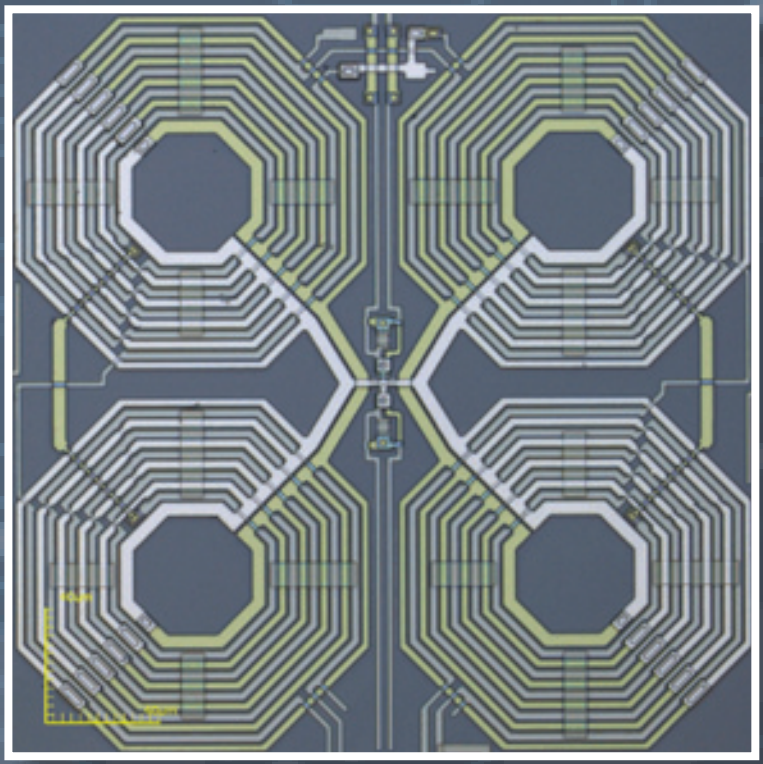
Federal Laboratory Technology Transfer

Fiscal Year 2013

Summary Report to the President and the Congress



Prepared by:

National Institute of Standards and Technology

U.S. Department of Commerce

October 2015

FOREWORD

The Department of Commerce is pleased to submit this Fiscal Year 2013 Technology Transfer Summary Report to the President and the Congress. This report illustrates the continuing efforts of Federal laboratories to ensure that the Nation's investment in innovative research is transferred from our laboratories to the American people.

Federal laboratories, through their basic and mission-oriented research and development investments, have historically been at the forefront of scientific discovery, invention, and technological innovation. Technology transfer facilitates the practical application of Federal research directly through the transfer of laboratory results and by providing non-federal entities opportunities to partner with Federal laboratories on innovative research of mutual interest. Over the years, new products, services, and the formation of new companies have occurred through technology transfer initiatives.

The Administration recognizes the importance of invention and technological innovation as drivers of economic growth and has challenged Federal laboratories to accelerate their technology transfer operations. The President issued this challenge formally on October 28, 2011, in the Memorandum for the Heads of Executive Departments and Agencies, entitled *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses*. This Presidential Memorandum reiterated the important role of innovation in accelerating the development of new industries, products, and services that lead to economic growth and job creation. In addition to directing agencies to accelerate technology transfer activities, it directed the Secretary of Commerce to improve and expand, where appropriate, the collection of metrics regarding the effectiveness of Federal technology transfer activities.

In response to these directives, agencies have established performance goals, metrics, and evaluation methods to enhance the efficiency and impact of their technology transfer activities. These tasks are now being implemented and procedures have been developed to track their progress. The present report will help serve as a baseline to measure progress toward achieving this ambitious challenge, while maintaining excellence in performing mission-focused research. In addition to reporting traditional metrics, this report includes the following additional metrics:

- the number of science and engineering articles by agency and technology;
- the number of citations within U.S. patents by agency and technology;
- the number of small businesses involved in CRADAs;
- the number of licenses granted to small businesses; and
- the number of startup companies supported by tech transfer activities.

Agencies also engage in efforts to measure the economic impact of their tech transfer activities. This involves the assessment of data gathered outside of the government to determine the economic impact of federally developed technologies that have been transferred to the private sector. Beginning with this report, a summary of impacts, as demonstrated by published papers, reports, and studies, is presented. Summaries for DOC, DoD, and NASA are included in this edition; the remaining agencies will be covered in subsequent editions.

This report fulfills the requirement of Title 15 of the United States Code, Section 3710(g) (2), for an annual report summarizing the use of technology transfer authorities by Federal agencies. It highlights the achievements of Federal technology transfer and includes data on the use of specific transfer authorities. We will use future editions of this report to continue to keep the President and the Congress informed of the on-going efforts of Federal laboratories to expand our technology transfer efforts in partnership with U.S. industry, academic institutions, non-profit foundations, and state, local and tribal governments. These efforts will continue to play a vital role in building the Nation's economic strength.

Willie E. May
Under Secretary of Commerce for Standards and Technology

Table of Contents

Chapter 1 Overview of Federal Technology Transfer 1
Federal Technology Transfer Summary 4
Chapter 2 Agency Performance in FY 2013 30
Department of Agriculture (USDA) 31
Department of Commerce (DOC) 42
Department of Defense (DoD) 55
Department of Energy (DOE) 65
Department of Health and Human Services (HHS) 74
Department of Homeland Security (DHS) 83
Department of the Interior (DOI) 90
Department of Transportation (DOT) 101
Department of Veteran Affairs (VA) 113
Environmental Protection Agency (EPA) 123
National Aeronautics and Space Administration (NASA) 131
Chapter 3 Conclusion 140
Appendix A 142
Appendix B 150
Appendix C 152

This page intentionally left blank

Chapter 1 Overview of Federal Technology Transfer

Many Federal agencies conduct research and development activities as part of their mission that often result in the creation of new information, innovations, and technologies. To make effective use of their resources, Federal agencies leverage their research activities by collaborating with other Federal agencies as well as many non-federal organizations in industry, academia, the non-profit sector, and state, local, and tribal governments. Through these partnerships, Federal agencies are better able to effectively develop and transform the results of their research from the bench scale in a laboratory to new products and services available in the marketplace. The transfer of federally developed information and technology to industry promotes economic growth and benefits society.

Federal agencies use a variety of legal authorities to evaluate, protect, license, transfer, and monitor the utilization and commercialization of technologies. By making these technologies available to private, academic, and other government entities, Federal research and development (R&D) activities provide the United States a competitive edge in today's global market and improve the quality of life for all Americans.

This annual report summarizes the technology transfer and R&D activities of each of the 11 Federal agencies that have significant Federal laboratory operations:

- Department of Agriculture (USDA)
- Department of Commerce (DOC)
- Department of Defense (DoD)
- Department of Energy (DOE)
- Department of Health and Human Services (HHS)
- Department of Homeland Security (DHS)
- Department of the Interior (DOI)
- Department of Transportation (DOT)
- Department of Veterans Affairs (VA)
- Environmental Protection Agency (EPA)
- National Aeronautics and Space Administration (NASA)

Each of these agencies has established programs for promoting the transfer and commercialization of intellectual property developed in its R&D laboratories and has provided the data contained in this report. The Department of Commerce's National Institute of Standards and Technology (NIST) prepared and organized this report. An electronic version of this report is available at http://nist.gov/tpo/publications/federal-laboratory-techtransfer-reports.cfm.

Federal R&D Spending

Research spending by the Federal government supports a wide variety of agency-specific missions, e.g., military objectives, health and human services issues, energy development, space exploration, etc. In FY 2013, the U.S. Federal research budget was $132,436 million.[1] Of this amount, $90,146 million (68%) was used to support research and development activities that occurred outside of the Federal government's laboratories. This includes funding for grants, cooperative agreements, awards, etc. Only 32% of the total research budget was used to support research and development activities within the Federal government. This includes two specific

[1] National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, preliminary results for FYs 2012–14, Table 9. http://www.nsf.gov/statistics/nsf14316/content.cfm?pub_id=4418&id=2

categories, intramural activities totaling $32,678 million (25%) and FFRDCs (federally funded research and development centers) totaling $9,612 million (7%).

Federal Obligations for Research and Development
By Agency FY 2013 ($ million)

	Total R&D	Intramural[a]	FFRDCs[b]	Intramural and FFRDCs
All agencies	$132,436	$32,678	$9,612	$42,290
DoD	$68,084	$18,520	$1,548	$20,068
DOE	$9,496	$1,099	$5,999	$7,098
HHS	$31,292	$6,513	$378	$6,891
NASA	$10,354	$1,638	$1,238	$2,876
USDA	$2,387	$1,492	$7	$1,499
DOC	$1,127	$886	$1	$887
DOI	$748	$648	$10	$658
VA	$593	$593	$0	$593
DHS	$633	$274	$121	$395
DOT	$984	$275	$85	$360
EPA	$525	$240	$0	$240
Other agencies	$6,214	$501	$226	$727

(a) Intramural activities cover costs associated with the administration of intramural and extramural programs by Federal personnel as well as actual intramural performance.
(b) FFRDC = federally funded research and development center.

Of the agencies covered in this report, DoD spent the greatest amount on intramural activities and FFRDCs, $20,068 million (42%), followed by DOE, $7,098 million (17%) and HHS, $6,891 million (16%).

Technology Transfer Principles and Approach

In many cases, technology developed meets specific agency needs as well as the needs of commercial partners to produce goods or services. In other cases, since agency-specific missions drive Federal research activities, technologies developed for a particular agency's use might otherwise be overlooked or go unused outside the agency without the dedicated efforts of Federal technology transfer offices that promote the dissemination and utilization of these technologies.

Promoting U.S. economic growth and creating jobs through the transfer and commercialization of federally developed technologies is a high priority for Federal laboratories. Collaborations between Federal agencies and non-federal organizations provide leverage that promotes more efficient and timely development of new technologies and facilitates the creation of new information and knowledge. These collaborations create better access to the results of Federal agency research and play an important role in the efficient and timely development of innovative technologies and new products.

Effective technology transfer promotes real economic growth through the development of new products, processes, medical treatments, services, and other benefits that serve a market need. The economic growth spurred by the transfer of Federal R&D results to industry creates a stronger job market, resulting from the manufacture and marketing of new products and services. In addition to strengthening domestic and regional economies, successful partnerships with non-Federal entities provide other benefits, including:

- Stimulating the flow of ideas between the government and other research sectors;
- Creating new businesses, especially small businesses;
- Attracting and retaining talented scientific personnel within the Federal laboratories;
- Providing support to the mission of each agency;
- Accelerating the development and reducing the costs of products and services to reach the marketplace;
- Supporting further research by generating licensing revenue;
- Rewarding innovative accomplishments of Federal employee inventors through royalty sharing; and
- Developing a wide variety of new and efficient products in health care, defense, domestic security, and many other sectors of the economy.

The Presidential Memorandum, *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses,* (PM) specifically addresses the need to streamline technology transfer operations in order to address the needs of businesses and, in particular, of small businesses that are especially vulnerable to a slow-moving bureaucratic system.[2] Although there have been many improvements over the years, the PM and the more recent Lab2Market initiative, have led agencies to review their operations and propose new ways to improve overall customer experience. Some of these changes are internal to the agencies, by which agencies seek to improve understanding and capabilities throughout their research and development programs to open doors to more efficient technology transfer. Other improvements target the way customers interact with the federal system.

[2] See https://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commerciali

Federal Technology Transfer Summary

Technology transfer involves the transition of research from the laboratory into products and services in the economy. Federal legislation[3] provides a variety of vehicles through which technology developed with U.S. government funds can be transferred to non-government entities in ways that benefit the Nation. These vehicles facilitate the potential commercialization of inventions produced from Federal funds, enable the use of Federal laboratory facilities by non-Federal entities, and allow for the establishment of research partnerships between Federal government laboratories and other entities. Federal legislation provides Federal agencies with the authorization to apply for patents or other forms of protection on inventions in which the Federal government owns a right, title, or interest. Federal agencies are also authorized to grant nonexclusive, exclusive, or partially exclusive licenses to patented, federally owned inventions.

Agencies make the decisions to exercise these authorities within the context of their missions. Every Federal agency that operates or directs one or more Federal laboratories or that conducts research and development is required to prepare and submit an annual report of its technology transfer activities as described in 15 U.S.C. § 3710(f). These reports contain details on each agency's technology transfer program and include agency plans to use technology transfer to advance the agency's mission and to promote U.S. competitiveness. The following tables summarize Federal technology transfer activities for the five-year period from FY 2009 through FY 2013.[4] In addition to data provided by agencies, this report uses selected information derived from data provided by the National Science Foundation to provide additional details about the nature of work conducted.

Invention Disclosures and Patenting

The protection of intellectual property can be vital to attracting the additional investment and product development resources necessary for early stage research products to be brought to their full commercial potential. Federal laboratory achievements in the areas of invention disclosures[5] and patents obtained are often cited as metrics of the active management of intellectual assets and technical know-how by Federal agencies.

---

[3] The primary legislation addressing Federal technology transfer includes the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480), Patent and Trademark Act Amendments of 1980 (P.L. 96-517) (Bayh-Dole Act), Small Business Innovation Development Act of 1982 (P.L. 97-219), Federal Technology Transfer Act of 1986 (P.L. 99-502), Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418), National Competitiveness Technology Transfer Act of 1989 (P.L. 101-189), American Technology Preeminence Act of 1991 (P.L. 102-245), Small Business Research and Development Enhancement Act of 1992 (P.L. 102-564), National Department of Defense Authorization Act for 1994 (P.L. 103-160), National Technology Transfer and Advancement Act of 1995 (P.L. 104-113), Technology Transfer Commercialization Act of 2000 (P.L. 106-404), Energy Policy Act of 2005 (P.L. 109-58), and the America COMPETES Act of 2007 (P.L. 110-69). Numerous other acts indirectly affect federal technology transfer activities.

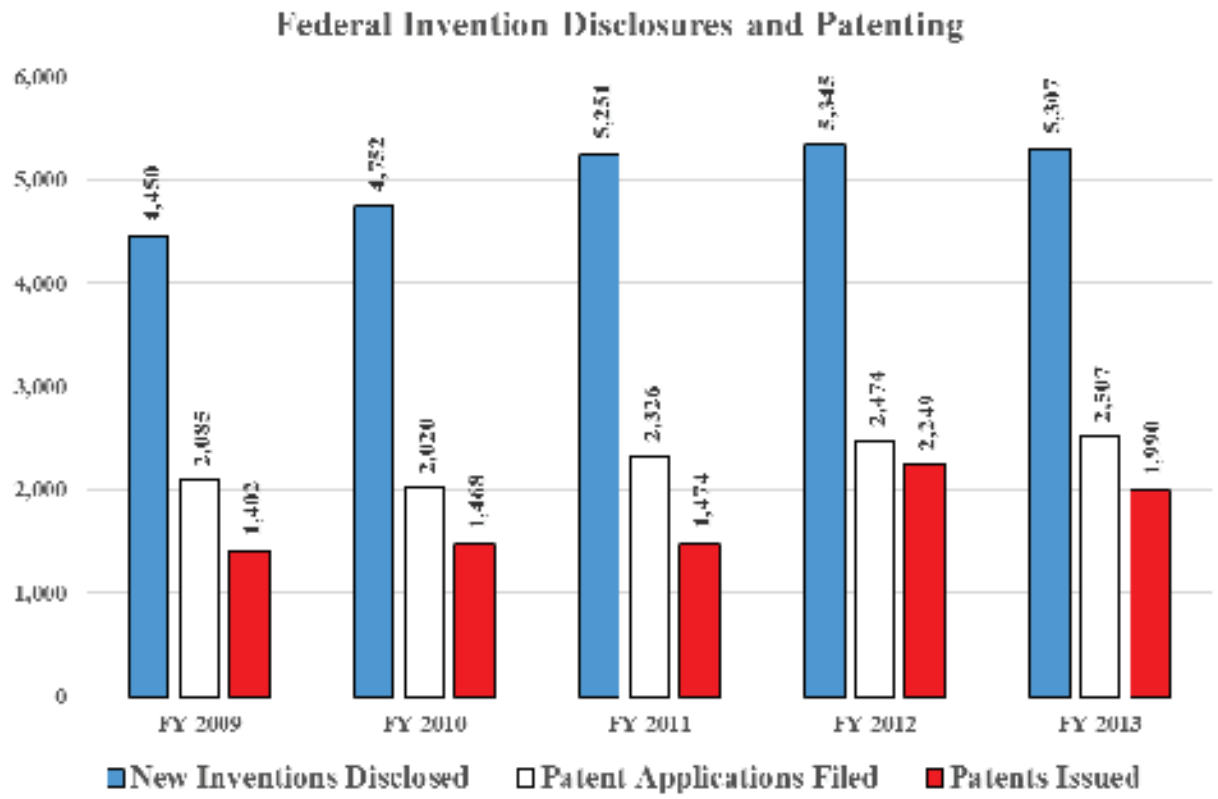
[4] Technology transfer data are typically adjusted over time to account for new information resulting from changes in reporting procedures, patent decisions, programmatic changes, etc. Throughout this report, data prior to FY 2013 have been adjusted where necessary, to reflect the most accurate estimates for each year reported.

[5] An "invention disclosure" is the report of a potential invention by an employee for determination of rights as described in 37 CFR 501.

Between FY 2009 and FY 2013, the number of invention disclosures reported by Federal agencies increased by 19% to 5,307. The number of patent applications filed increased by 20% to 2,507, and the number of patents issued increased by 42% to 1,990.

DOE has reported the largest number of invention disclosures (1,796) for FY 2013, followed by NASA (1,615) and DoD (1,032). These three agencies accounted for 84% of all invention disclosures reported in this year.

DOE has reported the largest number of patent applications (944) and patents issued (713). DoD was second in both categories (942 and 648) and HHS was third (230 and 428). In FY 2013, these three agencies accounted for 84% of patent applications and 90% of patents issued.

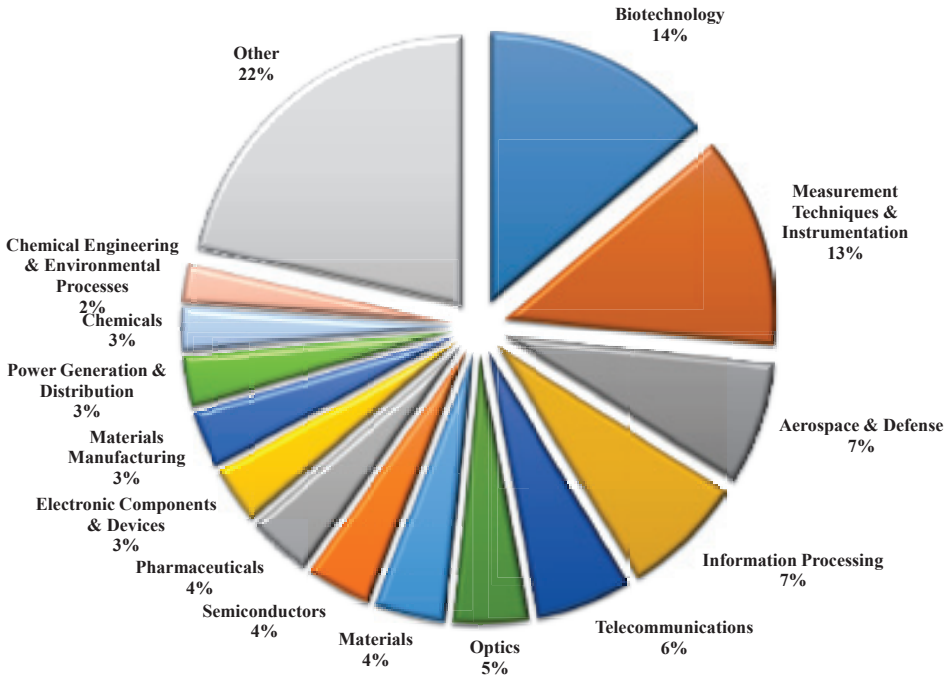


	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	4,450	4,752	5,251	5,345	5,307
Patent Applications Filed	2,085	2,020	2,326	2,474	2,507
Patents Issued	1,402	1,468	1,474	2,249	1,990

Technical Area Summary of U.S. Federal Agency Patents

The chart below uses data from the U.S. Patent Office (USPTO), to illustrate the technical areas covered by patents issued to Federal agencies in FY 2013. The chart shows the percentage of patents issued to Federal agencies by technology area based on a fractional count of patents.[6] In FY 2013, the largest number of patents assigned involved biotechnology developments.[7]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2013



Licensing

Licensing of federally developed technologies is one of the primary mechanisms used to create incentives for industry to invest the resources necessary to develop and commercialize nascent leading-edge technologies. Successful development and commercialization creates benefits to the economy and contributes to competitiveness and domestic economic growth. The ability to grant licenses to the non-federal sector to develop and commercialize government-owned technologies helps protect federally developed innovations, which would otherwise not be further developed into commercial products or services. The terms and conditions under which Federal intellectual property is licensed vary based upon many factors, including the extent of development of the technology, the financial resources needed to further develop the technology for consumer use, fields of use, projected market impact, and other factors.

---

[6] For this study, patents are credited on a fractional-count basis (i.e., for patents with assignees from multiple Federal agencies, other U.S. institutions, or foreign institutions, each Federal agency receives fractional credit on the basis of the proportion of its participating institution(s)). Patents assigned by The Patent Board's technology area classification. Sources: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2013). Copyright 2013 © The Patent Board, used with permission.

[7] Definitions of all technology areas addressed are included in Appendix 1.

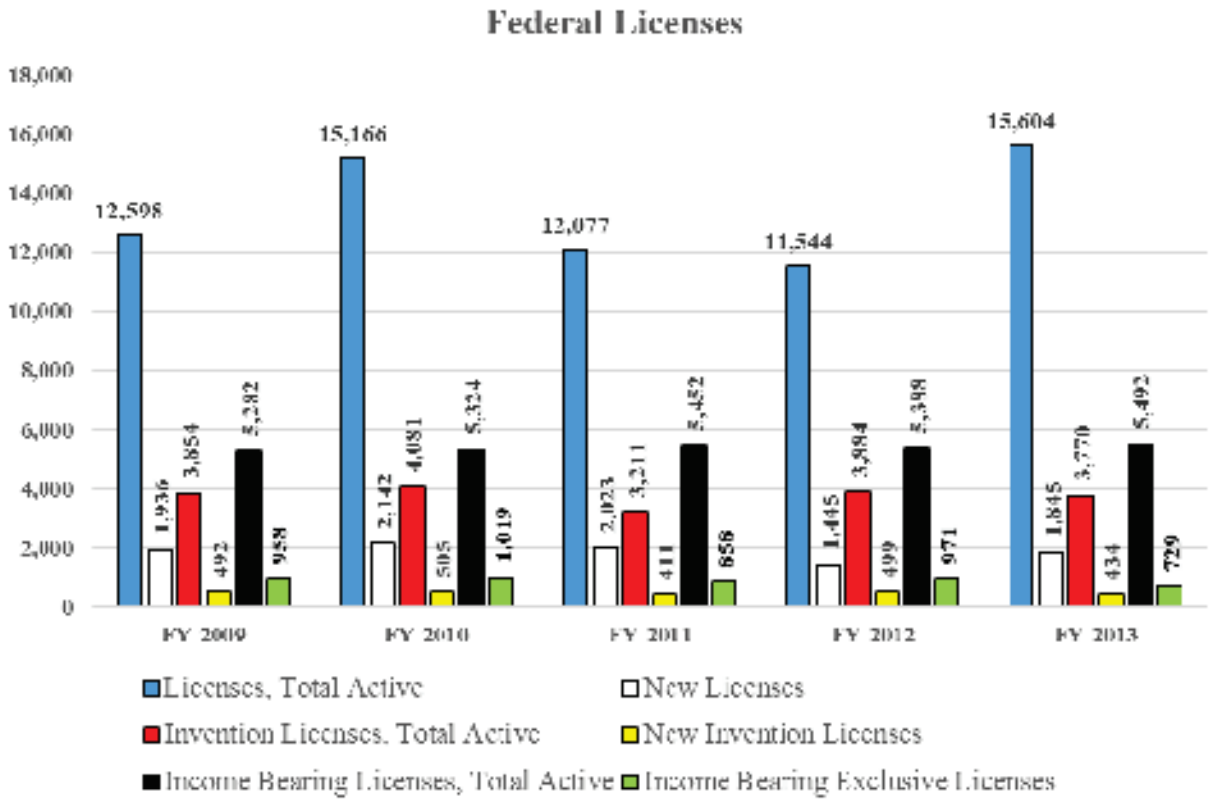
Between FY 2009 and FY 2013, the number of total active licenses reported by Federal laboratories increased by 24% to 15,604. The number of new licenses decreased by 5% to 1,845. The number invention licenses decreased by 2% to 3,770. The number of new invention licenses decreased by 4% to 434. The number of income-bearing licenses increased by 4% to 5,492, and the number of exclusive licenses decreased by 24% to 729.

DOE reported the largest number of licenses (9,148), followed by NASA (2,540) and HHS (1,426). These three agencies accounted for 84% of all licenses reported in FY 2013. DOE reported the largest number of invention licenses (1,353), followed by HHS (1,069) and DoD (425). Together these three agencies accounted for 75% of invention licenses.

DOE reported the largest number of income-bearing licenses (3,709), which was significantly higher than all other agencies combined. This number includes software licenses under copyright. While software is increasingly a key element of Federal laboratory R&D outputs, most other Federal agencies cannot copyright software developed by their employees.[8] HHS was second (809) followed by USDA (397). Together these three agencies accounted for 89% of income-bearing licenses.

USDA reported the largest number of income-bearing exclusive licenses (291), followed by DOE (199) and NASA (76). Together these three agencies accounted for 90% of income-bearing exclusive licenses.

[8] Under 17 U.S.C. § 105, copyright protection in the United States is not available for any work of the United States Government.

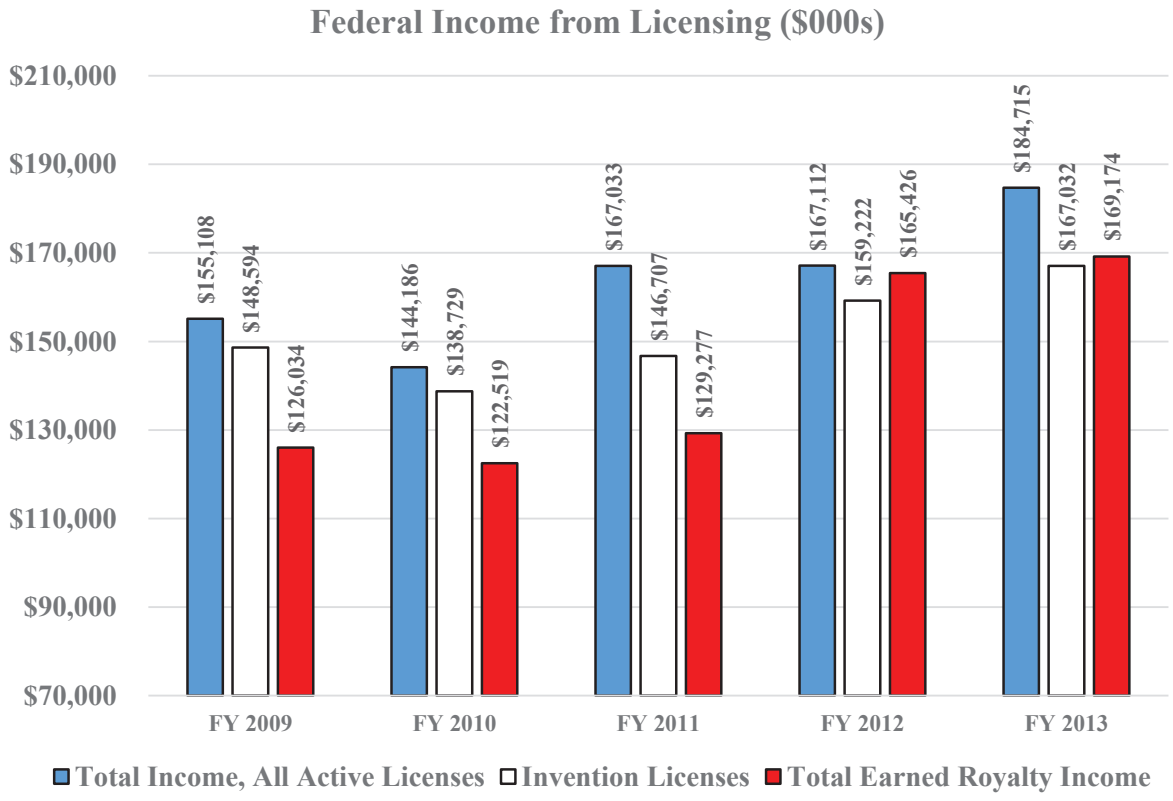


	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	12,598	15,166	12,077	11,544	15,604
New Licenses	1,936	2,142	2,023	1,445	1,845
Invention Licenses, Total Active	3,854	4,081	3,211	3,884	3,770
New Invention Licenses	492	505	411	499	434
Income Bearing Licenses, Total Active	5,282	5,324	5,452	5,388	5,492
Income Bearing Exclusive Licenses	958	1,019	858	971	729

Licensing Income

Licensing income includes income received for earned royalties from partners, license issue fees, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee, including patent costs. Between FY 2009 and FY 2013, income from all licensing increased by 16% to $184.7 million. Income from invention licenses increased by 11% to $167 million and total earned royalty income increased by 34% to 169,174.

HHS accounted for the most licensing income in FY 2013 ($116.4 million) and the most invention licensing income ($103.7 million) followed by DOE ($39.6 million / $36.1 million), and DoD ($21.6 million / $20.9 million). Together these three agencies accounted for 96% of reported licensing income and 96% of reported income from invention licenses.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active Licenses	$155,108	$144,186	$167,033	$167,112	$184,715
Invention Licenses	$148,594	$138,729	$146,707	$159,222	$167,032
Total Earned Royalty Income	$126,034	$122,519	$129,277	$165,426	$169,174

Collaborative Research and Development Relationships

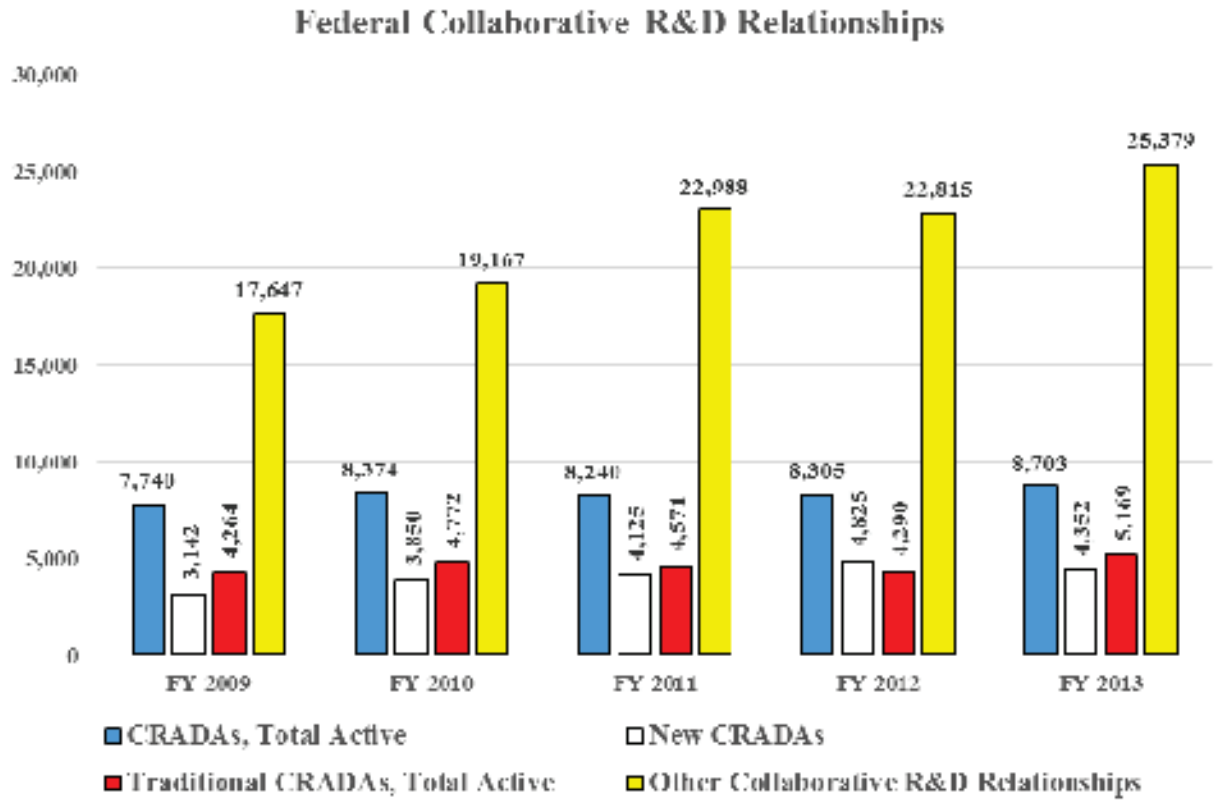
Collaborative research and development relationships between Federal laboratories and non-Federal collaborators are widely viewed as an effective and economical means of transferring technology through joint research. These relationships create a mutually advantageous leveraging of Federal agency and collaborator resources and technical capabilities, as well as provide avenues for both the collaborator and the Federal laboratory to gain new competencies and develop new skills.

One frequently used mechanism for establishing joint research relationships is the Cooperative Research and Development Agreement (CRADA). The CRADA is a multifaceted mechanism that can be used to address several kinds of partnership needs. A “traditional CRADA” refers to formal collaborative research and development agreements between a Federal laboratory and non-federal partners. Other special CRADA arrangements are used by Federal agencies to address special purpose applications such as material transfer agreements or agreements that facilitate technical assistance activities.

In addition to CRADAs, agencies have other specific authorities that also facilitate cooperative R&D relationships, such as Space Act Agreements (NASA) or Other Transaction Authorities.

Between FY 2009 and FY 2013, the number of active CRADAs increased by 12% to 8,703. The number of new CRADA agreements increased by 39% to 4,352. The number of traditional CRADAs increased by 21% to 5,169 while other collaborative R&D relationships increased by 44% to 25,379.

In FY 2013, DoD reported the largest number of CRADAs (2,682), followed by DOC (2,428) and VA (1,422). DoD reported the largest number of traditional CRADAs (2,076), followed by DOE (742) and VA (1,422). USDA reported the largest number of other collaborative R&D relationships (16,102), NASA was second (5,226 Space Act Agreements), and DOC was third (2,977).



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	7,740	8,374	8,240	8,305	8,703
New CRADAs	3,142	3,850	4,125	4,825	4,352
Traditional CRADAs, Total Active	4,264	4,772	4,571	4,290	5,169
Other Collaborative R&D Relationships	17,647	19,167	22,988	22,815	25,379

New Technology Transfer Metrics

There has long been a desire to expand the types of metrics gathered for this report in order to improve both quantitative and qualitative measures of technology transfer activities and other efforts used to disseminate federally developed technologies. The PM explicitly directs agencies to improve the monitoring of technology transfer operations and in response, agencies have expanded their annual agency tech transfer report to include a more comprehensive set of activity

metrics.[9] In addition, the Federal Interagency Working Group on Technology Transfer (IAWGTT) routinely reviews new and better means to improve both quantitative and qualitative measurements of technology transfer activities and other means to improve the dissemination of federally developed technologies.[10] As a result of these efforts, the following metrics have been added to the standard set of technology transfer metrics provided in past annual versions of this report.

Science and Engineering (S&E) Articles

Although intellectual property has traditionally been tracked in terms of the number of patents, licenses, and collaborative efforts, most Federal research results are transferred through publication of S&E articles. Unfortunately, a uniform tracking system for S&E articles across all Federal agencies does not exist; however, data from Thomson Reuters' Science Citation Information (SCI) and Social Sciences Citation Index (SSCI) databases can provide insight into the nature of S&E articles published by technology area even though not all articles published by Federal agencies are included in the publications covered by these databases. For example, in FY 2013, Thomson Reuters reports that Federal researchers authored or coauthored 39,147 articles using a whole-count basis (where each agency gets full credit for each article even if the article has co-authors from different agencies). Using additional data provided by agencies in their annual reports on technology transfer activities that takes into account publications not included in the Thomson Reuters' database, the number of publications increases to 44,802.

The Thomson Reuters' databases provide the additional benefit of identifying publications by their science and engineering categories. Using a fractional-count basis, the number of publications reported by Thomson Reuters was 17,534 articles. Of this, the greatest number of articles address research in biological sciences (22%), medical sciences (19%), physics (15%), geosciences (12%), chemistry (11%), and engineering (10%).[11]

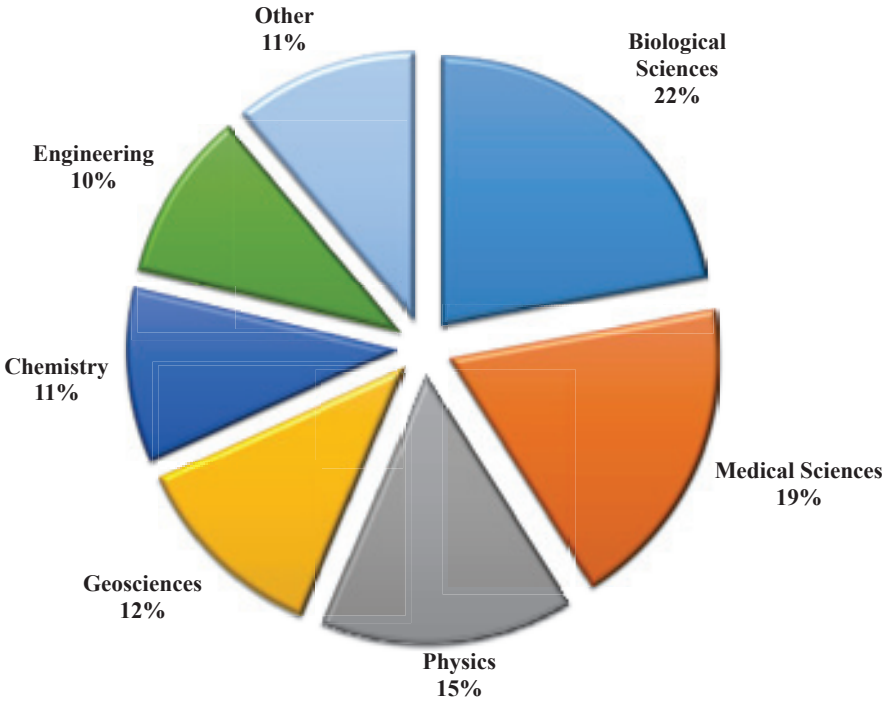
---

[9] For a list of agency technology transfer reports see http://nist.gov/tpo/publications/agency-technology-transfer-reports.cfm

[10] This group, which is comprised of agency leaders from across the Federal government, serves as a broad forum to identify and discuss best practices, better metrics, emerging concerns, and trends through dialogue, interagency comparisons, and experience-sharing. Agencies participating in the IAWGTT, established pursuant to Executive Order 12591 of April 10, 1987, include USDA, DOC, DoD, DOE, HHS, DHS, DOI, DOT, VA, EPA, and NASA.

[11] Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple Federal agencies, other U.S. institutions, or foreign institutions, each Federal agency receives fractional credit on the basis of the proportion of its participating institution(s)) and are classified by the year they entered the database, rather than the year of publication, and are assigned to a Federal agency on the basis of the institutional address(es) listed in the article. Sources: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board ™ special tabulations (2014) from Thomson Reuters. Certain data included herein are derived from the Science Citation Index and Social Sciences Citation Index ® prepared by THOMSON REUTERS ®, Inc. (Thomson®), Philadelphia, Pennsylvania, USA: © Copyright THOMSON REUTERS ® 2014. All rights reserved. Used with permission.

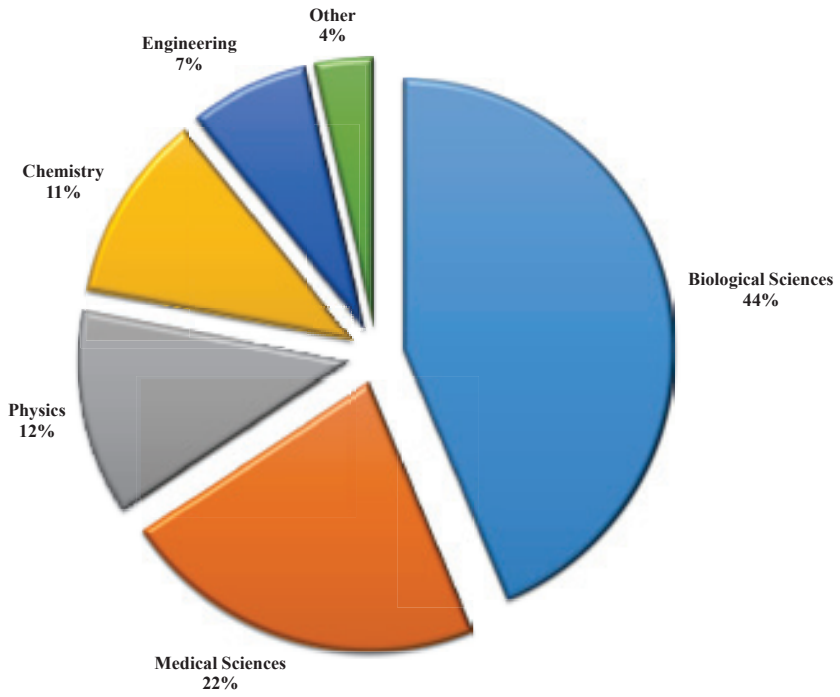
S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: FY 2013



Citations within U.S. Patents

Thomson Reuters' data also provides insight into the commercial relevance of S&E articles authored by Federal researchers through the number of articles cited in U.S. patents. In 2013, more than 13,026 articles authored or coauthored by Federal researchers were cited in U.S. patents.[12] Of these, the greatest number of articles addressed research in the biological sciences (44%), medical sciences (22%), physics (12%), chemistry (11%), and engineering (7%).

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2013



[12] Citations are classified on a fractional-count basis (i.e., for cited articles with collaborating institutions from federal agencies, other U.S. institutions, or foreign institutions, each Federal agency receives fractional credit on the basis of the proportion of its participating institution(s)) and are classified by the year of publication, Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2013 are references in USPTO patents issued in FY 2013 to articles published in 1998–2008). Sources: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2014) from Thomson Reuters. Certain data included herein are derived from the Science Citation Index and Social Sciences Citation Index ® prepared by THOMSON REUTERS ®, Inc. (Thomson®), Philadelphia, Pennsylvania, USA: © Copyright THOMSON REUTERS ® 2014. All rights reserved. Used with permission.

Small Businesses Involved in Active Traditional CRADAs

Under 15 USC 3710a(c)(4)(A), Federal agencies are required to give special consideration to small business firms and consortia involving small business firms when establishing CRADAs. The definition as to what qualifies as a small business is given by the Small Business Administration and varies by industrial sector. For research and development, a business with fewer than 500 employees is considered a small business.[13] For the purpose of this study, we use the measure of 500 employees or fewer to classify a company as a small business. Unfortunately, owing to various administrative issues, not all agencies are able to report small business data at the time of the preparation of this report. A partial set of data is available for seven agencies. This data reveals that out of 3,095 traditional CRADA agreements with these agencies, 554 (18%) involve small businesses as participants.

	Number of Active Traditional CRADAs involving Small Businesses	Total Number of Active Traditional CRADAs	% Small Business
DOC	37	197	19%
DOE	54	742	7%
DOT	7	41	17%
EPA	24	55	44%
HHS[(a)]	165	427	39%
USDA	117	211	55%
VA	150	1,422	11%
Total	554	3,095	18%

(a) NIH only

[13] See https://www.sba.gov/content/summary-size-standards-industry-sector

Licenses Granted to Small Businesses

In addition to CRADAs, agencies support small businesses through the licensing of technologies. Again, owing to various administrative issues, data from only six agencies is available at the time of this report. This data reveals that out of 10,336 active licenses granted by these agencies, 744 (7%) were issued to small businesses.

	Number of Active Licenses Granted to Small Businesses	Total Number of Active Licenses	% Small Business
DOC	7	39	18%
DoD	65	527	12%
DOE	467	9,148	5%
EPA	18	42	43%
HHS[(a)]	48	180	27%
USDA	139	400	35%
Total	744	10,336	7%

(a) NIH and FDA

Startup Companies Supported

Many federally developed technologies are transferred through the actions of startup companies. Companies that have been in existence for five years or less and have spun off federally developed technologies or have received critical technical support of their core development areas from Federal laboratories provide an effective means of transferring technologies. Unfortunately, while most agencies have a long history of working with startup companies, few have established systematic methods to identify and track the startup companies they nurture. At present, preliminary data from three agencies identifies 78 companies that started between the years of 2008 and 2013, and have received critical technical support from Federal laboratories. Additional information on the economic impact of technology transfer through startups is reported in the next section based on the results of economic impact studies.

	Number of Startups Supported
DOC	25
DOE	40
USDA	13
Total	78

Economic Impact Measures

The PM calls on Federal agencies to establish performance goals, metrics, evaluation methods, and implementation plans to improve the efficacy of Federal technology transfer activities. In response, Federal agencies have developed and are currently implementing plans to improve the monitoring and assessment of the impact of their technology transfer operations.

The task of identifying and measuring economic impact is complex and time-consuming. Ideally, once a technology has been developed and transferred from a Federal laboratory it will be utilized directly by end users or it will be incorporated within other developmental processes. Technologies that are utilized directly will likely create economic impacts that are readily apparent and relatively easy to measure. Technologies that are incorporated within other developmental processes create impacts that are far more difficult to identify and measure. Because many projects at Federal laboratories are focused on basic science research and early stage developments, many of the technologies transferred from these laboratories will go through multiple stages of development and will generate multiple intermediary impacts that are dispersed over an extended period.

In order to get a more comprehensive understanding of what research has actually been done in this area, NIST commissioned a review of contemporary literature dealing with efforts to assess Federal technology transfer activities. This study, *The evolving state-of-the-art in technology transfer research: Revisiting the contingent effectiveness model*, focuses on peer-reviewed studies published between 2000 and 2012 that assess the impact of technologies developed in and transferred from Federal laboratories.[14] Of more than 200 technology transfer studies reviewed, only a third quantitatively assessed impact, but they provide a wealth of knowledge about the theory and practice of measuring Federal economic impact.

Additionally, for more than two decades, many Federal agencies have prepared impact studies to assist with the internal evaluation of programs or in response to statutory requirements such as those included in the Government Performance and Results Act of 1993 (GPRA) (P.L. 103-62).[15] These studies are the best sources of currently available impact metrics because they are typically prepared by independent contractors who have access to detained cost and benefit data. Such agency studies will provide the foundation for future studies called for by the PM.[16]

Beginning with reports from the DOC, DoD, and NASA, summaries of agency impact studies will be presented in this report. Summaries from other agencies, as well as updates to the agency information presented here, will be provided in future versions of this report.

From a review of these studies, it becomes clear that different analytical approaches are used to assess economic impact. The approach used often depends on the nature and magnitude of the expected impact(s), the quantity and quality of available data, and the resources that are available

---

[14] Dr. Barry Bozeman, Heather Rimes, and Jan Youtie, "The evolving state-of-the-art in technology transfer research: Revisiting the contingent effectiveness model," Research Policy, Volume 44, Issue 1, February 2015, Pages 34-49.

[15] See https://www.whitehouse.gov/omb/mgmt-gpra/index-gpra

[16] For a list of agency studies that assess the economic impact of Federal technology transfer activities see http://nist.gov/tpo/publications/other-agency-economic-impact-studies.cfm.

to perform the study. One approach is to prepare a case study of a specific transfer event. Activities that follow from this transfer event are tracked and analyzed. Those who directly acquired and utilized the technology then report the impact metrics. This approach is typically used for technologies that are directly utilized by end users and have targeted, short-term impacts. Alternative approaches involve detailed statistical studies that estimate impacts over time and over a broad range of an economy. These approaches incorporate either a targeted, microeconomic approach, or a broad macroeconomic approach. Under the microeconomic approach, an analysis is made of how end-users have benefited from a specific technology or group of technologies. Economic impact is then estimated in terms of the net benefits derived from the technologies transferred. This approach is typically used to assess specific technologies or technologies that affect discrete groups of end-users or consumers.

Under the macroeconomic approach, a computer program is used to simulate the equilibrium state of a regional or national economy. Changes are then made to the program to simulate changes in specific technology transfer activities (e.g. licenses, CRADAs, etc.). The computer program then simulates estimates of economic impact as it makes adjustments to re-compute the equilibrium state. Measures of impact are then derived from direct effects (e.g. changes in sales), indirect effects (e.g. changes in inter-industry purchases), and induced effects (e.g. changes in household expenditures). Under this approach, impact metrics typically include changes in regional or national output, employment, value added, labor income, and tax revenues. To be effective, this approach requires the expected impact of the transfer activities to be large enough to influence a broad section of an economy over a given period. This approach is used to assess a large number of technology transfer activities (e.g. licenses) that are similar in nature and can be aggregated to reveal an impact on a regional, national, or global economy.

DOC Economic Impact Studies

Within the DOC, NIST has had a long history of assessing the economic impact of standards and related technologies transferred from its research and standards programs.[17] These studies have focused on assessing the economic impacts of test methods, calibration services, reference materials, and other services developed by NIST.

Between 2000 and 2011, sixteen microeconomic studies were performed that assessed technologies transferred to nine different industries. Each of these studies measured economic impact in terms of the net benefits society experienced as a result of NIST's technology transfer activities. Measures of net benefits include net present value (NPV), social rate of return (SRR), and benefits to cost ratio (BCR). NPV is the inflation adjusted value of net benefits (benefits-costs) discounted over the course of the study period. A positive NPV indicates that the mechanism being assessed yields greater benefits than the cost to provide it. SRR is the interest rate that reduces the NPV to zero. The SRR is similar to the internal rate of return metric commonly used to judge the worthiness of investment projects. The modifier "social" indicates that the value of this performance metric accounts for the benefits and costs that accrue to all beneficiaries, not just the project investors. The BCR is the ratio of the net present value of benefits to the net present value of costs. A positive BCR value indicates the number of dollars in benefits that have resulted from the technology transfer activity for each of the dollars invested, adjusted for inflation.

[17] See http://nist.gov/tpo/economic-impact-studies.cfm

For example, as shown in the table below, in 2000 a study was made to assess the economic impact of NIST's standard reference materials (SRMs) used in the production of fossil fuels (*Economic Impact of Standard Reference Materials for Sulfur in Fossil Fuels*[18]). SRMs are quality assurance materials that are used, among other things, to evaluate measurement accuracy and to provide compatibility of measurement data. They play a key role in manufacturing by helping users verify the accuracy of measurement methods and calibrate measurement systems. In this example, SRMs are used to provide more accurate sulfur content information for fossil fuels manufactures. Improving the accuracy of content information reduces the likelihood of disputes between sellers and purchasers of fossil fuels, such as coal companies and electric utilities. It also enhances production efficiency for the petroleum industry, resulting in reduced sulfur emissions into the environment. This study quantified a portion of the economic benefits associated with sulfur SRMs. Included in the measures of economic benefits were improvements in product quality, production efficiency, and reductions in transaction costs and sulfur dioxide emissions to the environment. In addition, the study identified and qualitatively described the impact of NIST SRMs on other less tangible areas, such as research and development programs.

This study estimated that industry significantly benefited from the development and transfer of NIST's sulfur SRMs. According to the measures of benefits and costs analyzed, NIST's sulfur SRMs yielded a NPV of $409 million in 1998 dollars, which equates to a SRR of 1056%. The BCR of 113 indicates that for each dollar NIST spent on developing sulfur SRMs, $113 in net benefits accrued to those who used the SRMs in the manufacturing of fossil fuels.[19]

[18] See http://nist.gov/director/planning/upload/report00-1.pdf

[19] The study provides other measures that can be used to describe the same net benefits. For a discussion of alternative measures of economic impacts please see *Methods for Assessing the Economic Impacts of Government R&D, NIST Planning Report #03-1,* http://nist.gov/director/planning/upload/report03-1.pdf

NIST Economic Impact Studies 2000-2011

Impact Study/ Transfer Mechanism	Outcomes	NPV(Year)[a]	SRR[b]	BCR[c]
Building Technology				
"Benefits and Costs of Research: A Case Study of Construction Systems Integration and Automation Technologies in Commercial Facilities" (2001)	Increase productivity, reduced costs	$140M (1997)	n.c.	4
•Construction System Integration and Automation Technologies				
"Benefits and Costs Of Research: A Case Study of Fire Dynamics Simulation" (2003)	Improved efficiencies reduced R&D costs	$282M (2000)	27%	73
•Fire Dynamics Simulator				
Chemicals				
"Economic Impact of Standard Reference Materials for Sulfur in Fossil Fuels" (2000)	Increased product quality & production efficiency, reduced transaction costs & pollution	$109M (1998)	105.6%	113
•Sulfur in Fossil Fuels/SRM				
"The Economic Impact of the Gas Mixture NIST Traceable Reference Materials Program" (2003)	Increase productivity, reduced costs	$16M (2001)	225%	24
•National Traceable Reference Materials, SRD; Calibration Services				
Electronics				
"Economic Impact Assessment of the NIST's Josephson Volt Standard Program" (2001)	Increased product quality & production efficiency, reduced development costs	$45M (2000)	87.7%	5
•Josephson Voltage Standard/SRM				
Information Technology				
"The Economic Impacts of NIST's Data Encryption Standard (DES) Program" (2001)	Increase productivity, reduced technical risks	$768M (2000)	270%	102
•Data Encryption Standards/Standard Conformance Test Methods				
"Economic Analysis of Role-Based Access Control" (2010)	Improved system efficiencies & reduced downtime	$835M (2000)	n.c.	249
•Computer Security (RBAC)				
"The Economic Impact of Role-Based Access Control" (2001)	Increase productivity, reduced R&D costs	$292M (2000)	62%	109
•Role Based Access Control/Reference Models (RBAC)				
"Economic Impact Assessment of NIST's Text Retrieval Conference (TREC) Program" (2010)	Increase productivity, reduced R&D costs	$51M (2009)	189%	4
•Search Engines (TREC)				
Manufacturing				
"Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries" (2002)	Improved system efficiencies & reduced costs	$180M (2001)	32%	8
•STEP/STDS; Conformance Test Methods and Services				
"The Economic Impacts of Documentary Standards: A Case Study of the Flat Panel Display Measurement Standard(FPDM)" (2011)	Improved system efficiencies, reduced costs	$56M(2010)	48%	4
•Documentary Standards				
Materials				
"Retrospective Economic Impact Assessment of the NIST Combinatorial Methods Center" (2009)	Increased R&D, production & technology adoption efficiency	$118M (1998)	161%	9
•Consortium Based Combinatorial Methods Development and Transfer				
Pharmaceuticals				
"The Economic Impacts of NIST's Cholesterol Standards Program" (2000)	Reduced production costs, improved quality & accuracy	$4M (1999)	15.7%	5
•Cholesterol Measurement/SRM				
Photonics				
"Economic Impact Assessment: NIST (NIST) Laser and Fiberoptic Power and Energy Calibration Services" (2000)	Increase productivity, reduced costs	$30M (1999)	13.6%	9
•Laser and Fiber Optic Power and Energy Calibration/Calibrations				
Semiconductors				
"Economic Analysis of NIST's Investments in Super Filling Research" (2008)	Reduced R&D costs	$8M (2008)	71%	5
•Superfilling Research Techniques				
"Economic Analysis of NIST's Low-K Materials Characterization Research" (2008)	Reduced R&D, adoption, & production costs	$17M (2008)	n.c.	8
•Low K Materials Characterization				

n.c. = not calculated
(a) NPV(Year) = Net Present Value and base year for dollars
(b) SRR = Social Rate of Return
(c) BCR = Benefit to Costs Ratio

Thirteen of the studies presented in the table estimated SRR. The SRR values for these studies ranged from a low of 27% to a high of 1056%. The mean value is 254%, but given the standard deviation for this sample (327%), the median value of 154% is more representative of the typical study. Sixteen studies calculated BCR. The BCR values ranged from a low of 4 to a high of 249. The mean value is 46 but again, given the standard deviation for the sample (69) the median value of 9 is more representative of the typical study. The median value of 9 indicates that for a typical study on this list each dollar NIST spent, $9 in benefits were created. Note that given the data presented here, the NPV measures from different studies cannot be aggregated into one value because different base years are used to calculate benefits and costs.

Summary of NIST's Economic Impact Studies (2000 – 2011)[20]

	SRR	BCR
Number of Studies Reporting	13	16
Min	27%	4
Max	1056%	249
Mean	254%	46
Std Dev	327%	69
Median	154%	9

DoD Impact Studies

DoD has produced several macroeconomic studies that assess how its technology transfer efforts contribute to new economic activity and job creation in the United States.

In one recent study,[21] researchers estimated the economic contribution to the U.S. economy of DoD license agreements that were in effect during the 2000-2011 period. The purpose of this study was to determine the extent to which these license agreements (1) contributed to new economic activity and job creation in the United States, and (2) resulted in the transition of new technology to U.S. military use. An economic-impact assessment software program called IMPLAN[22] was used to estimate the economic impacts related to sales generated by the licenses. Total economy-wide sales, as measured by output, were estimated at $36.3 billion. Value added was estimated at $17.4 billion, representing new wealth creation in the economy. Employment

[20] When multiple estimates were generated in a particular study, for example to reflect best and worst case scenarios, the average is reported.

[21] National Economic Impacts from DoD License Agreements with U.S. Industry: 2000-2011 (See: http://nist.gov/tpo/publications/upload/National-Economic-Impacts-from-DOD-License-Agreements-2013.pdf) This and other economic-impact studies were conducted for DoD by TechLink, a federally funded technology transfer center at Montana State University, Bozeman, Montana, in collaboration with the Bureau of Business and Economic Research (BBER) at the University of Montana, Missoula, Montana. Since 1999, TechLink has served as DoD's principal national "partnership intermediary," helping to develop technology transfer partnerships between DoD's laboratories and U.S. industry nationwide. TechLink' s primary focus is helping DoD labs to transfer their inventions to U.S. companies through license agreements. TechLink currently brokers or facilitates approximately 60 percent of all DoD license agreements with industry. See: http://techlinkcenter.org/economic-impacts.

[22] See: https://implan.com/index.php?option=com_djtabs&view=tabs&Itemid=435

impacts included 163,067 jobs with an average wage of $65,000. The change in labor income was estimated to be $10.6 billion. The $13.4 billion in sales and its economy-wide effects generated approximately $2.3 billion in Federal tax revenues and over $1.3 billion in state and local tax revenues.

Nationwide Economic Impacts from DoD License Agreements, 2000-2011

	Output (Billions)	Employment (Jobs created or retained)	Value Added (Billions)	Labor Income (Billions)	Tax Revenue (Billions)
Direct Impact	$13.4	27,128	$4.5	$2.7	
Indirect Impact	$11.6	56,728	$6.4	$4.2	
Induced Impact	$11.3	79,210	$6.5	$3.7	
Federal Tax Revenues					$2.3
State and Local Tax Revenues					$1.3
Total Economy-Wide Impact	$36.3	163,067	$17.4	$10.6	$3.7

Source: BBER, University of Montana; IMPLAN

Another DoD study estimated the economic contribution of technology transfer agreements (both CRADAs and licenses) brokered or facilitated by TechLink between 2000 and 2011.[23] Of the 361 companies contacted for this study, 178 (49 percent) reported that they had sales of products or services related to the technology transfer agreements with DoD that TechLink had facilitated. The total cumulative sales reported by these 178 companies amounted to slightly over $1 billion ($1,032,669,174). Of the remaining companies, 65 (18 percent) were still developing or commercializing the technology that had been licensed from DoD, co-developed with this agency, or funded by DoD. In short, two-thirds of the companies were either already selling the DoD-related technologies or were continuing to pursue this objective. Approximately a third of the companies, 116 (32 percent), had not achieved any sales and had abandoned efforts to commercialize the subject technology.

The total economy-wide contribution combines the direct, indirect, and induced impacts. Total economy-wide sales, as measured by output, were estimated to be $2.9 billion. Value added was estimated at $1.6 billion, representing new wealth creation in the economy. Employment impacts include 17,818 jobs with an average wage of $59,000. The resulting change in labor income was estimated at $1.0 billion. The $1.0 billion in sales and its economy-wide effects generated (in 2011) approximately $217 million in Federal tax revenues and over $114 million in state and local tax revenues.

[23] TechLink was established as a federally funded technology transfer center at Montana State University in 1996. Since 1999, it has served as DoD's primary national "partnership intermediary," helping to broker productive partnerships between DoD labs and U.S. industry nationwide. TechLink specializes in helping DoD labs to out-license their inventions to industry, mainly to small or mid-sized companies that are not traditional defense contractors. To date, it has helped to establish approximately 425 license agreements, resulting in the transfer of approximately 1,050 DoD invention to industry for conversion into new commercial and military products. Since 2005, TechLink has brokered or facilitated over half of all DoD license agreements. See http://techlinkcenter.org/

National Economic Impacts from DoD TechLink-Brokered Partnerships, 2000 to 2011

	Output (Billions)	Employment (Jobs created or retained)	Value Added (Billions)	Labor Income (Billions)	Tax Revenue (Billions)
Direct Impact	$1,033	5,766	$510	$439	
Indirect Impact	$792	4,211	$398	$248	
Induced Impact	$1,114	7,839	$646	$361	
Federal Tax Revenues					$217
State and Local Tax Revenues					$114
Total Economy-Wide Impact	$2,935	17,818	$1,553	$1,049	$331

Source: BBER, University of Montana; IMPLAN

The Navy commissioned a similar macroeconomic study in 2009. This study examined 101 organizations that were involved in technology transfer agreements (both CRADAs and licensing agreements) for technologies developed by the Navy.[24] In order to estimate the economic ripple effects of this program, the IMPLAN program was used to conduct a standard input-output analysis of the private sector revenues generated by technology transfer agreements in 2009.

The study found that the agreements generated a total annual economic output of $545 million with more than $200 million of this total associated with the direct sales of technology transfer partners. Through purchases of production inputs and household spending of employees, this direct output generated another $345 million annually in economic ripple effects throughout the nation. The level of direct output created an estimated 670 jobs for these 101 companies with technology transfer agreements. The ripple effects caused by purchases and household spending supported another 1,960 jobs. The study estimated that the combined impact from these technology transfer mechanisms generated an additional $60 million in Federal, state, and local taxes.

Estimated Impacts of Technology Transfer Agreements (U.S. Navy)

	2009
Direct Economic Effect	$200 million
Indirect and Induced Economic Effects	$345 million
Total Economic Impact	$545 million
Jobs Created	2,630
Estimated Federal, State and Local Taxes Generated	$62 million

NASA Tech Transfer Impacts

Over the past several decades, there have been many efforts to quantify the benefits of NASA's technology transfer efforts. The table below indicate some of the early studies that have used different economic approaches and have produced a wide range of impact metrics.

[24] See: http://www.ibrc.indiana.edu/studies/t2.pdf

NASA Technology Transfer Studies

Study	Methodology	Quantitative Findings
Economic Impact of Stimulated Technological Activity," *Final Report, Midwest Research Institute (1971)*	Macroeconomic Projections	Average 7:1 rate of economic return on each dollar invested in NASA / Discounted rate of return on NASA investments of approximately 33%.
"Quantifying the Benefits of the National Economy from Secondary Applications of NASA Technology," *Mathematica (1976)*	Case studies of four major NASA technology categories	$1B estimated benefit of NASA contribution to cryogenics / $5B estimated benefit of NASA contribution to integrated circuits / $111M estimated benefits of NASA contribution to gas turbines / $701M estimated benefit of NASTRAN (NASA's structured analysis software program).
Michael K. Evans, "The Economic Impact of NASA R&D Spending," *Chase Econometric Associates, Inc., Bala Cynwyd (1976)*	Simulations and Modeling	Average 7:1 rate of economic return on each dollar invested in NASA / Historical rate of return from NASA R&D spending of 43%.
"Economic Impact and Technological Progress of NASA Research and Development Expenditures," *Midwest Research Institute, Kansas City, Missouri, for the National Academy of Public Administration (1988)*	Macroeconomic Projections	Average 9:1 rate of economic return on each dollar invested in NASA / Discounted rate of return on NASA investments ranging between 19 and 35%.
"An Exploration of Benefits from NASA 'Spinoff'," Richard L. Chapman, Loretta C. Lohman, and Marilyn J. Chapman (1989)	Examination of 259 published *Spinoff* stories, Telephone interviews and Inquiries	$21.3B NASA contributions to sales / $315.7M NASA contributions to cost savings / 325,000 jobs created or saved / $365M in tax receipts.
"The Nature and Extent of Benefits Reported in NASA 'Spinoff'," Richard L. Chapman, Marilyn J. Chapman, Mary F. Chapman, and Jody Briles (1993)	Examination of 353 published *Spinoff* stories, Telephone interviews and inquiries (Continuation of 1989 Chapman Report)	$32B NASA contribution to sales / $1B NASA contributions to cost savings.
"The Economic Impact of the Space Program: A Macro and Industrial Perspective," prepared for Rockwell International by *The WEFA Group (1994)*	Economic Modeling	Estimated 380,000 NASA-generated jobs by 1997 / $153.5B in GDP generated by NASA-related activity by 2000.
"Space as an Investment in Economic Growth," Henry R. Herzfeld (1997)	Surveys, Telephone interviews and inquiries, Literature review, and Case studies	Over $1.5B in value added to 15 NASA life sciences partner firms.

While somewhat dated, these studies illustrate particular aspects of the economic benefits of space research and technology development, as well as the different approaches that can be used to measure economic impact.

More recently, NASA has developed a more systematic approach to the assessment of quantitative benefits using anecdotal evidence of benefits featured in its annual Spinoff publication.[25] This approach identifies a small number of quantitative measures that capture predominant categories of benefits. In some cases, the benefits can be fully attributed to the original NASA technology, although in most cases the application of NASA technology is a contributing factor in the innovation that has ultimately generated the benefits.

In one recent study, 187 technologies featured in *Spinoff* magazine from 2007-2010 were examined in detail to extract quantifiable measures of benefit and/or success, due in part or in full, to NASA's influence on the subject company's product or service.[26] Examination of a critical mass of these benefits revealed emerging patterns, and thus common areas of quantification became readily apparent. This analysis allowed NASA to identify a subset of quantitative measures that capture the predominant categories of benefits. In some cases, the benefits can be fully attributed to the original NASA technology, although in most cases the application of NASA technology is a contributing factor to the innovation that ultimately generates the benefits. The five standard categories of quantifiable benefits and units of measure identified by this study were jobs created, revenue generated, productivity and efficiency improvements, lives saved, and lives improved.

Summary of Quantifiable Benefits Featured in *Spinoff* (2007-2010)

	Estimated Impact	Companies Reporting
Jobs Created	9,200	75
Revenue Generated	$1.2 billion	83
Productivity and Efficiency Improvements	$6.2 billion	46
Lives Saved	12,000	20
Lives Improved	86 million	18

Efforts to Enhance Technology Transfer Outcomes and Entrepreneurship

In addition to individual agency streamlining activities and developing new metrics to quantify technology transfer impact, Federal agencies have also been involved in activities that have been designed to promote awareness and enhance the effectiveness of technology transfer activities.

[25] See http://spinoff.nasa.gov/
[26] See http://spinoff.nasa.gov/pdf/IAC%202011%20Quantifying%20Spinoff%20Benefits.pdf

The Innovation Corps Program
In 2011, the National Science Foundation (NSF) established the Innovation Corps (I-Corps™)[27] program to help scientists and engineers focus their attention upon critical business-related issues that are fundamental to the commercialization of new and emerging technologies. Originally designed to broaden the impact of NSF-funded basic research projects, pilots of this successful program have recently been initiated to help other Federal agencies enhance the economic impact of their own technology transfer efforts.

Recently, NIH collaborated with NSF to establish a pilot of the I-Corps™ program. This new program was designed to accelerate the development and commercialization of new products and services arising from projects supported by currently funded NIH Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards. The program set up a nine-week boot camp in which experienced, business-savvy instructors worked closely with teams of researchers to help them explore potential markets for their federally funded innovations. Researchers learned how to build scalable business models around new technologies, protect intellectual property, and develop regulatory and reimbursement strategies. Four NIH institutes participated in the pilot program: the National Cancer Institute; the National Heart, Lung and Blood Institute; the National Institute of Neurological Disorders and Stroke; and the National Center for Advancing Translational Sciences.

DOE has launched a similar pilot program to accelerate the transfer of innovative clean energy technologies from the DOE's National Laboratories into the commercial marketplace. This program, known as Lab-Corps,[28] aims to better train and empower DOE national lab researchers to transition their discoveries into high-impact, real world technologies in the private sector. Lab-Corps, which builds on the I-Corps™ model, is designed to provide a specialized technology accelerator and training curriculum for the national laboratories that enables lab-based teams to gain direct market feedback on their technologies and pursue the development of startup companies, industry partnerships, licensing agreements, and other business opportunities. Six DOE national laboratories have been selected to participate in the Lab-Corps pilot program. Over the next year, these labs will assemble, train, and support entrepreneurial teams to identify private sector opportunities for commercializing promising sustainable transportation, renewable power, and energy efficiency lab technologies.

Entrepreneur in Residence Programs
Several agencies have established Entrepreneur in Residence (EIR) programs that mentor technical researchers on the fundamentals of commercializing new technologies. While these programs vary across agencies, the common goal is to provide sound entrepreneurial advice from experienced business experts to accelerate technology transfer. Topics that are common to these programs include methods of establishing market values, managing intellectual property rights, performing due diligence, fund raising, and requirements for starting a new business.

DOE's EIR initiative was started in 2007 by the Office of Energy Efficiency & Renewable Energy to address long-standing concerns that national laboratory inventions were not being

[27] See http://sbir.cancer.gov/resource/icorps/
[28] See http://energy.gov/articles/energy-department-announces-new-lab-program-accelerate-commercialization-clean-energy

sufficiently transferred into the marketplace. By placing venture capital-sponsored entrepreneurs at key national laboratories, the goal of the program is to accelerate laboratory technology transfer by enabling start-up entrepreneurs to work directly with the laboratories and bridge the gap between leading scientific and business talent – conducting technology assessments and proposing business structures to commercialize promising technologies. Entrepreneurs are permitted to work directly with laboratory staff for a hands-on look at various inventions and potentially viable technologies.

The NIH Office of Technology began its first EIR program in 2012. BioHealth Innovation, Inc., a non-profit, private-public partnership, manages the EIRs under a Partnership Intermediary Agreement with NIH. BioHealth pays for the salaries of the two EIRs. The EIRs are charged with three key activities: 1) review NIH technologies to assess commercial relevance; 2) work with the private sector to facilitate commercialization of the NIH technologies into marketable products; and 3) educate scientists on life science product development and commercialization.

USDA's Agricultural Research Service has seven Technology Transfer Coordinators (TTCs) stationed in different geographical areas around the country. Each TTC acts as a type of EIR. The TTCs are engaged in numerous activities including planning, administrating, coordinating, and evaluating technology transfer activities of their assigned geographic region's research programs in order to effect the optimum transfer of research for development and commercialization. They work closely with ARS researchers to select the most beneficial and expeditious mechanism(s) for technology transfer on a case-by-case basis. They participate in the planning of research programs and preparing material that illustrates ARS research results and accomplishments.

NIST has also initiated an EIR program in cooperation with the Maryland Technology Development Corporation. This initiative brings individuals with demonstrated experience in developing, operating, and existing start-up technology businesses to work with NIST researchers and the NIST Technology Partnerships Office to identify opportunities for licensing and commercialization of innovative technology emerging from NIST mission-oriented research. NIST EIRs are not full-time paid positions; rather, they are guest researchers who undertake a variety of tasks to identify the commercial value of NIST technologies and mentor and educate NIST researchers on career opportunities in technological entrepreneurship.

Lab-to-Market Initiative

Building on the Administration's Startup America initiative to promote high-growth entrepreneurship, as well as the ongoing implementation of the PM, the Lab-to-Market initiative has proposed a number of actions to accelerate and improve the transfer of new technologies from the laboratory to the commercial marketplace. Implementation, including the preparation of government-wide plans, is being coordinated as a cross agency priority goal under the GPRA Modernization Act (P.L. #111-352).

Developing Human Capital
Research agencies will finalize a government-wide plan to develop the Nation's human capital assets for promoting technology transfer, including:

1. Significantly expanding the number of individuals with private-sector experience in technology transfer who serve within the research agencies for limited-term fellowships and "Entrepreneur in Residence" engagements;
2. Establishing clear ethical and policy guidelines that enable and encourage Federal researchers to work outside government for limited periods on industrial/entrepreneurial detail, as appropriate; and
3. Providing widespread opportunities for experiential entrepreneurship education among both students and investigators who work on federally funded R&D projects, including by expanding eligibility for competitive programs such as the NSF Innovation Corps across research agencies.

Empowering Effective Collaborations
Research agencies will finalize a government-wide plan to implement new policies that further streamline and promote technology transfer collaborations, including:

1. Increasing the priority level of R&D commercialization activities and outcomes at Federal laboratories, consistent with agency mission and commercialization strategy, including:
    a. institutionally through Management and Operating contracts with government-owned contractor-operated labs; and
    b. individually through the annual performance plans of relevant Federal employees, including Senior Executive Service personnel with R&D responsibilities, where appropriate;
2. Optimizing technology transfer authorities and best practices across Federal laboratories in order to remove barriers to collaboration with external entities, as appropriate, including efficient CRADA authorities, updated intellectual property policies, effective Laboratory-Directed Research and Development programs, and relatively low patent fees for small businesses and universities; and
3. Increasing the impact of technology transfer activities by fully utilizing existing authority for all research agencies to (a) co-fund joint projects between agencies, and (b) leverage charitable gifts to advance R&D commercialization.

Opening R&D Assets
Research agencies will work with the Federal Laboratory Consortium, the National Technical Information Service, and the Presidential Innovation Fellows program to implement a national framework for (a) all intellectual property developed by Federal laboratories to be easily discovered, reasonably understood, and rapidly licensed by U.S. entrepreneurs and innovators, wherever appropriate; and (b) all research agencies to maximize their ability to provide U.S. entrepreneurs and innovators with access to federally funded research facilities and equipment, where appropriate and consistent with agency mission, including by:

1. Fully including relevant data about both (a) Federal laboratory IP and (b) R&D facilities, equipment, use policies, and agency contact information in the

implementation of the Open Data Executive Order (EO 13642) and Open Data Policy (OMB Memorandum M-13-13), such that this data is open and machine-readable, available to third parties through application programming interfaces, and tagged with concise summaries and other relevant metadata;

2. Dramatically reducing the time, cost, and complexity of executing IP licenses, by adopting the most innovative and effective approaches from industry, universities, and Federal agencies;
3. Improving agencies' abilities to (a) transfer excess/surplus property to innovators and entrepreneurs, through a combination of effective platforms, policies, and outreach; (b) facilitate the use of core facilities, including clarifying policies for partnership agreements to access underutilized facilities and use of third-party platforms to streamline access; and (c) facilitate direct use of equipment and facilities that are not part of core facilities, including authority to provide temporary access on a cost recovery basis; and
4. Working with university stakeholders to achieve these outcomes to the maximum extent possible for university inventions and facilities as well as Federal laboratory inventions and facilities, with an emphasis on the broad-based economic and social impact of federally funded R&D.

Fueling Small Business Innovation

Research agencies with Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs will work with the Small Business Administration (SBA to finalize a government-wide plan to maximize the economic impact of these programs, consistent with the SBIR/STTR Reauthorization Act of 2011 and subsequent SBA policy memoranda, including by:

1. Ensuring that all SBIR/STTR solicitations are open and machine-readable, available to third parties in real time through application programming interfaces, and discoverable through at least one unified and comprehensive Federal government search tool;
2. Streamlining the SBIR/STTR application process for small businesses by allowing submissions to multiple agencies based on a common small business profile, reducing the time from application to award to below the current cross-agency median, allowing small businesses to predictably track the progress of their applications, and reducing or eliminating lag time between successful Phase I completion and Phase II awards for meritorious applicants, wherever possible;
3. Reducing undue burdens on small businesses during the award performance period, wherever appropriate, including by streamlining accounting and reporting requirements and allowing flexibility for small businesses to adapt their performance benchmarks based on new commercialization pathways discovered during the performance period;
4. Publishing and sharing best practices for Phase III commercialization from all agencies on a regular basis, based on relevant commercialization data, and encouraging small business awardees to commercialize federally funded R&D; and

5. Encouraging alignment of SBIR/STTR solicitation topics with the annual memorandum from the Director of OMB and the Director of OSTP describing multi-agency science and technology priorities.

Evaluating Impact

The Interagency Workgroup on Technology Transfer will finalize a plan to develop and report the following R&D commercialization metrics:

1. Building on the implementation of the 2011 Presidential Memorandum, which includes new metrics tracking commercialization outputs (e.g., number of IP licenses, number of CRADAs, number of new startups created), developing additional metrics that track the goals set forth in this executive actions' plan, such as reducing the processing time required to complete IP licensing agreements, increasing the number of federally-funded researchers who receive experiential entrepreneurship education, and increasing the percentage of federally funded IP and facilities that can be discovered through open and machine-readable data; and
2. Working with the research community to develop outcome metrics that capture longer-term economic impact (e.g., dollars of follow-on capital attracted, revenue generated, jobs created, and new products developed by companies commercializing federally funded R&D).

Chapter 2 Agency Performance in FY 2013

Each Federal research and development agency prepares and submits an annual report covering data on technology transfer as described in 15 USC 3710(f). These reports include details on each agency's technology transfer program and plans to use technology transfer to advance the agency's mission and promote U.S. competitiveness.[29]

This chapter provides a comparable summary of the content of these 11 Federal agency reports. Three main topic areas are addressed:

- Statistical data on the agency's technology transfer activity levels for a number of measures (e.g., CRADAs, invention disclosure and patenting, and intellectual property licensing) for the most recently closed fiscal year (FY 2013) and several prior years (chiefly, FY 2009-2013);
- Reported examples of successful downstream outcomes arising from the agency's technology transfer activities, such as new products or improved industrial processes available in the marketplace that arise from the transfer and commercialization of Federal lab inventions; and
- Streamlining activities at each agency to lower administrative burden and make technology more accessible.

[29] See http://nist.gov/tpo/publications/agency-technology-transfer-reports.cfm

Department of Agriculture (USDA)

Last year marked the 150th anniversary of the Department of Agriculture. Established on May 15, 1862, President Abraham Lincoln later coined the phrase "the People's Department" in acknowledging the role of the Department in solving problems for the agriculture sector that benefits all people every day. Thus, well before the coining of the modern day phrase of "technology transfer," it was the culture of USDA to deliver these solutions to the people of the United States. Today, USDA broadly defines technology transfer as the adoption of research outcomes (i.e., solutions) for public benefit. Seemingly, a simple statement, that process of adoption is complicated, requiring integration of many assets from disparate sources in the successful delivery of solutions. "Public benefit" is achieved through many mechanisms including public release of information, tools, and solutions (e.g., germplasm, plants and other materials), adoption by partners through collaborative research, formal CRADAs authorized by the Federal Technology Transfer Act (1986), direct Federal, state, or local technical assistance, or through licensing of biological materials or protected intellectual property directly to not-for-profit entities and for- profit private sector firms. Additionally, successful adoption of USDA knowledge and research outcomes typically requires complementary assets and services provided by multiple agencies in USDA, including agencies that are not primarily engaged in direct research in the physical and life science arenas.

Science-based innovations from USDA intramural research, often developed through public/private partnerships, create new or improved technologies, processes, products and services that benefit the nation by increasing productivity, increasing efficiency (keeping costs low) and enhancing global competitiveness for the U.S. agriculture sector. Thus, technology transfer functions are critical to accelerating utility of public R & D investments, creating economic activity, and in creating jobs and sustainable economic development.

The Agricultural Research Service (ARS) has been delegated authority by the Secretary of Agriculture to administer the patent program for ARS, and the review of CRADAs and the technology licensing program for all intramural research conducted by USDA. These activities are housed in the Office of Technology Transfer.

On October 28, 2011, following a series of reports identifying the status of technology transfer from Federal funds and Federal laboratories, the White House issued the Presidential Memorandum – *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses.* Issuance of this Memorandum provided an unprecedented opportunity for unifying technology transfer across USDA S&T agencies as the mechanism to deliver these outcomes for public good. In the USDA's response to the Presidential Memorandum (http://www.nist.gov/tpo/publications/upload/USDA-Tech-Transfer-Plan.pdf), several initiatives were identified to promote technology transfer and commercialization. These initiatives will usher in a new era of unprecedented collaboration among agencies of USDA to enhance services and opportunities to the customers and stakeholders of the Department.

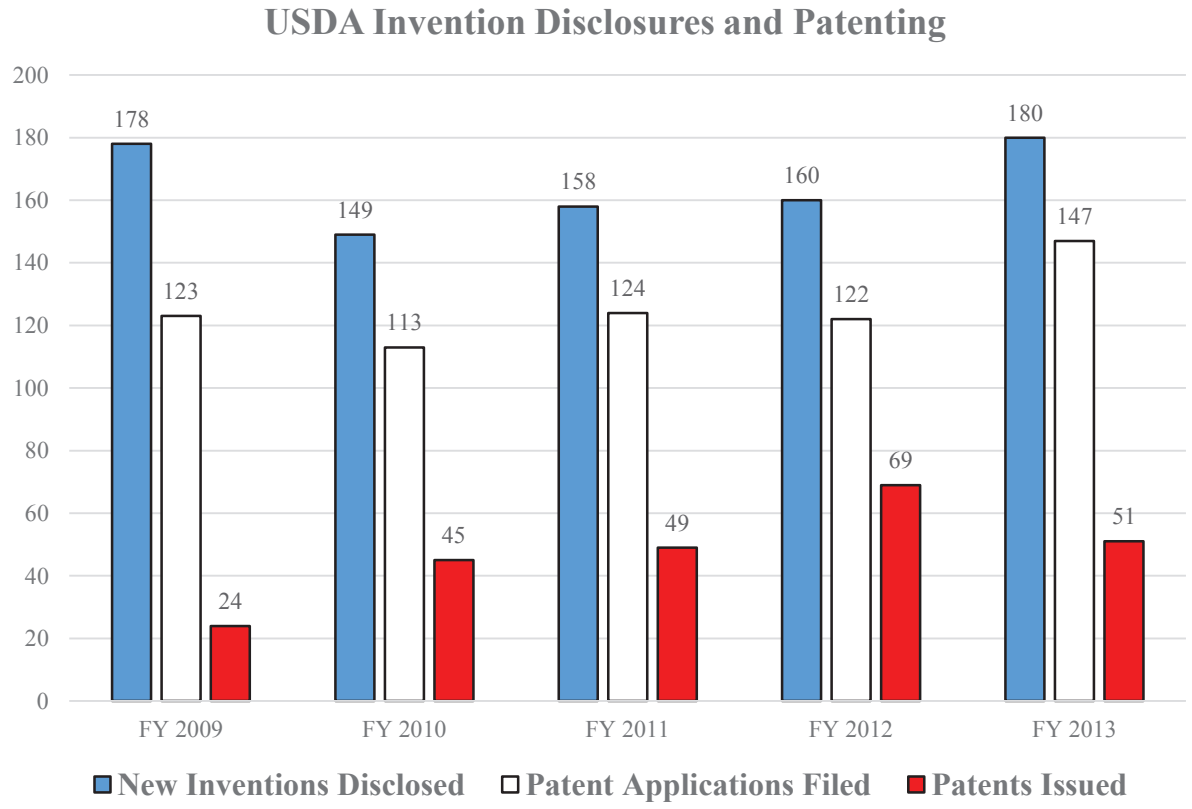
USDA's annual technology transfer report is available online at: https://www.ars.usda.gov/business/Docs.htm?docid=24718.

More information about USDA's technology transfer activities are available on the following websites:

- Agricultural Research Service: http://www.ars.usda.gov/partnering;
- Animal and Plant Health Inspection Service: http://www.aphis.usda.gov/wps/wcm/connect/APHIS_Content_Library/SA_Our_Focus/SA_Wildlife_Damage/SA_Programs/SA_NWRC/SA_Tech_Transfer; and
- Forest Service: http://www.fs.fed.us.

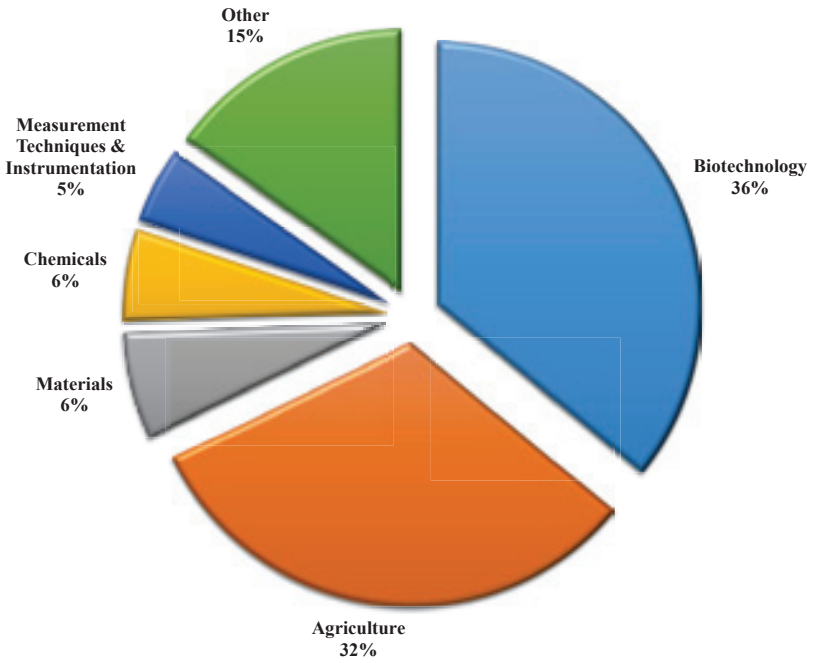
USDA Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of invention disclosures received remained consistent, with an overall 1% increase. The number of patent applications filed increased by 20% to 147. The number of patents issued increased by 113% to 51.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	178	149	158	160	180
Patent Applications Filed	123	113	124	122	147
Patents Issued	24	45	49	69	51

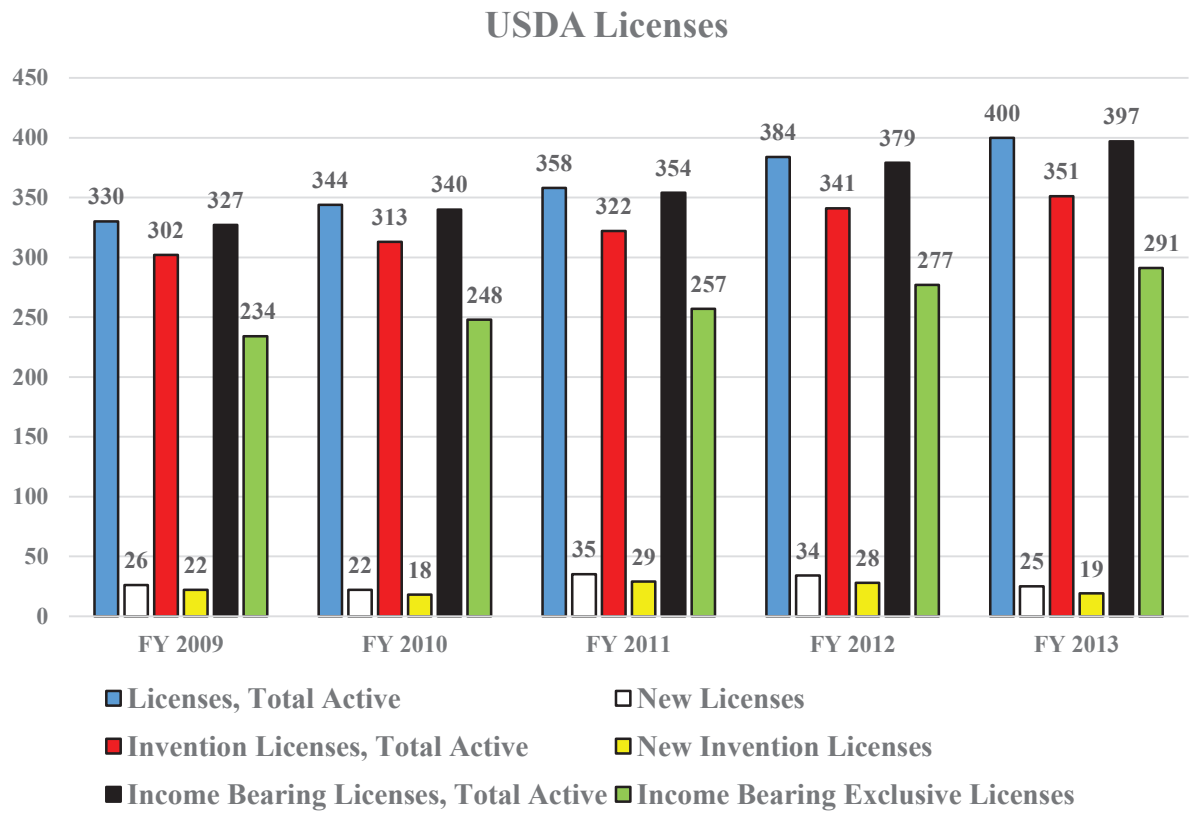
USPTO Patents Assigned to USDA by Technology Area: FY 2013[30]



[30] Source: National Science Foundation and The Patent Board™ (see footnote 5).

USDA Licenses

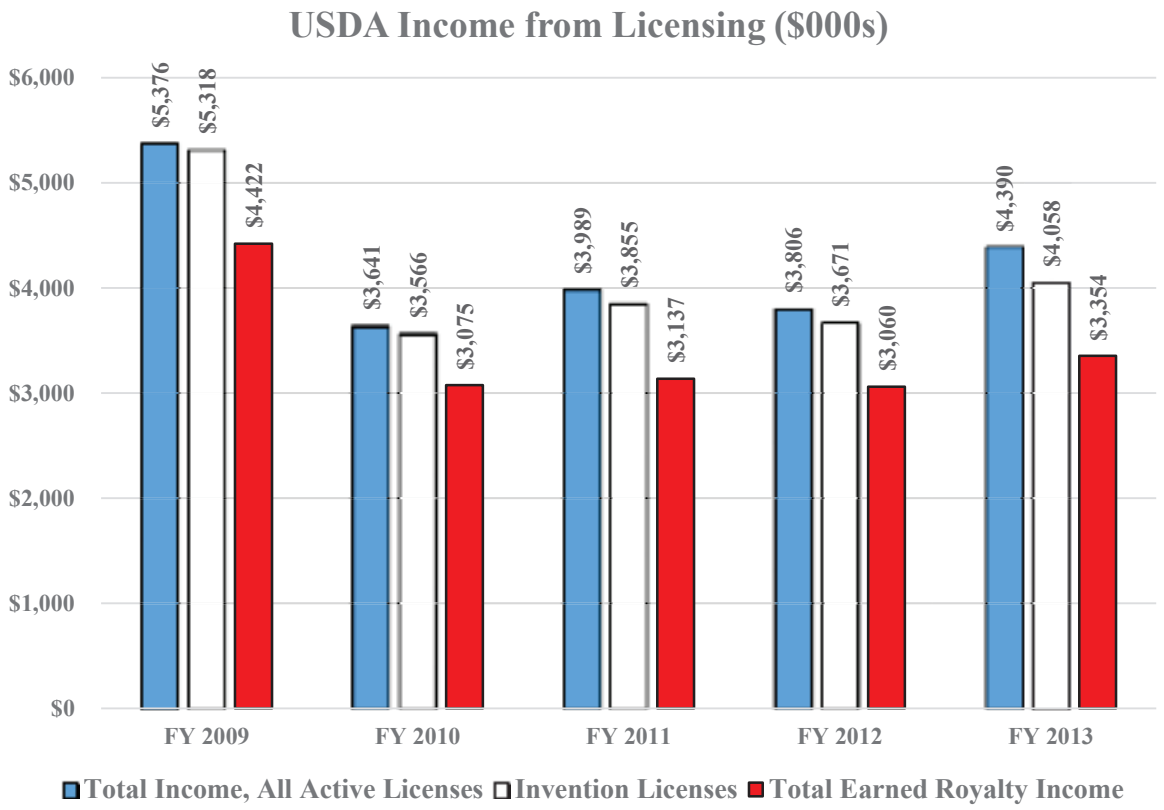
Between FY 2009 and FY 2013, the number of total active licenses increased by 21%, going from 330 licenses in FY 2009 to 400 licenses in FY 2013. Total active invention licenses also increased, reaching 351 licenses in FY 2013; a 16% increase over the five-year period. Total active income bearing licenses increased from 327 licenses in FY 2009 to 397 in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	330	344	358	384	400
New Licenses	26	22	35	34	25
Invention Licenses, Total Active	302	313	322	341	351
New Invention Licenses	22	18	29	28	19
Income Bearing Licenses, Total Active	327	340	354	379	397
Income Bearing Exclusive Licenses	234	248	257	277	291

USDA Income from Licensing

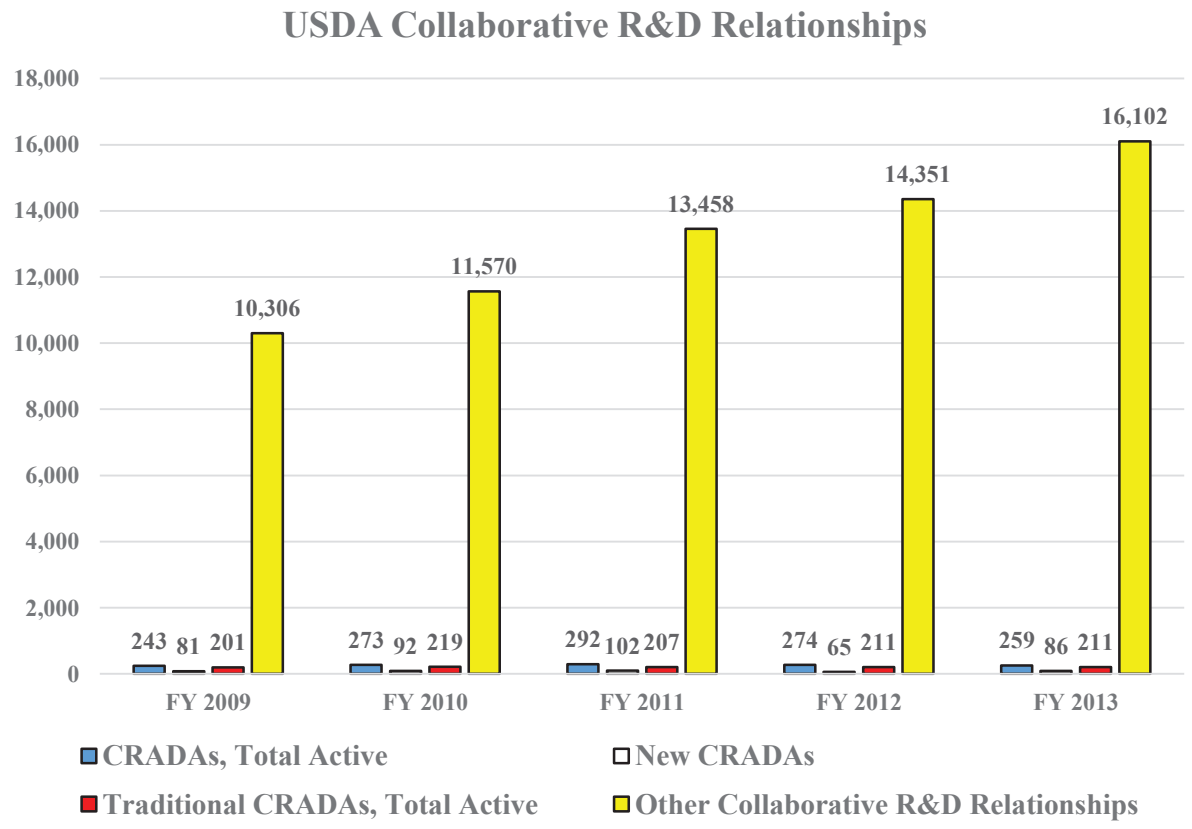
Between FY 2009 and FY 2013, total income decreased by 18.35%, with $4.39 million received in FY 2013. Invention License income, which accounted for 92% of total income, decreased by 23.7% over the five-year period. Total earned royalty income also decreased, with a 24.15% drop, totaling $3.35 million in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$5,376	$3,641	$3,989	$3,806	$4,390
Invention Licenses	$5,318	$3,566	$3,855	$3,671	$4,058
Total Earned Royalty Income	$4,422	$3,075	$3,137	$3,060	$3,354

USDA Collaborative R&D Relationships

During the five-year period, the number of total active CRADAs increased by 6.58%, from 243 CRADAs in FY 2009 to 259 CRADAs in FY 2013. The number of new CRADAs per year increased by 6.17%, reaching 86 new agreements in FY 2013. Other collaborative R&D relationships increased by 56.24% between FY 2009 and FY 2013, reaching 16,102 agreements in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	243	273	292	274	259
New CRADAs	81	92	102	65	86
Traditional CRADAs, Total Active	201	219	207	211	211
Other Collaborative R&D Relationships	10,306	11,570	13,458	14,351	16,102

Efforts to Streamline Technology Transfer Operations

The Office of Technology Transfer (OTT) within the USDA's Agricultural Research Service (ARS) put into place two different interagency funded agreements to provide technology transfer services (policy advice, agreement review, patenting / licensing services, etc.) to the USDA's Animal and Plant Health Inspection Service's (APHIS) and USDA's Forest Service.

Changes were made to ARS's National Patent Committee invention disclosure review process to more effectively and efficiently utilize limited resources. These changes have improved the quality of the committee discussions to determine the most appropriate approach for getting research results adopted. Patent protection is only pursued if a patent-license is required to transfer the research results.

OTT and the USDA's National Institute for Food and Agriculture, who manages the SBIR program for USDA, initiated a collaboration where SBIR applicants that need research expertise are encouraged to contact ARS for help; ARS encourages its CRADA partners to submit SBIR grant proposals.

USDA Downstream Success Stories

Exploiting Avian Vision with Aircraft Lighting to Reduce Bird Strikes

Collisions between wildlife and aircraft result in more than $625 million in losses annually to U.S. civil aviation, more than $1.2 billion annually to civil aviation worldwide, and have been responsible for the loss of more than 200 lives since 1988. Approximately 97.5 percent of these collisions involve birds. Vision is a primary sensory pathway in birds and recent research indicates that aircraft lighting can play a potential role to increase a bird's ability to detect approaching aircraft and, subsequently, reduce bird-aircraft collisions. APHIS-National Wildlife Research Center scientists and several collaborators have successfully transferred technology consisting of new information on the visual and behavioral mechanisms involved in the response of wild birds to approaching objects. By combining information on the visual capabilities of birds with their observed responses to the approach of vehicles under different lighting scenarios, scientists aided the aviation industry in the development of external lighting systems for aircraft that could serve to enhance detection and avoidance by birds.

New Healthy Functional Foods from Oats

Studies revealed that the soft-solid characteristics of various oat carbohydrates (beta-glucan) provided creamier, less runny properties that are valuable for developing new functional foods such as yogurt, instant puddings, custard, batter, smoothies, and ice cream. ARS scientists in Peoria, Illinois, developed the oat concentrates, which appear to have great potential for health-concerned consumers. An industrial partner has licensed this ARS patented digestible, functional food from oats for the production of Calorie-Trim and Nutrim. Z-Trim is licensing this product for expanded markets, including USDA's school lunch program.

Alternatives to Conventional Antimicrobials for Livestock

Finding novel antimicrobials that kill multi-drug resistant pathogens is a worldwide problem for livestock industries and human medicine alike. In collaboration with Spanish scientists, ARS scientists in Beltsville, Maryland, identified a bacterial cell wall degrading protein from a virus of Staphylococcus bacteria that when applied externally, binds and kills Staphylococcus aureus bacteria. The protein was then fused to lysostaphin, another protein that is lethal to S. aureus bacteria, and then to a third bacterial cell wall degrading protein. The combination of these three proteins effectively kills both bovine and human strains of S. aureus, including multi-drug resistant strains. This three-protein fusion strategy, to create cell wall degrading enzymes with multiple simultaneous lethal activities, is potentially applicable to any bacteria with externally exposed cell wall components and should enable production of antimicrobials that are highly refractory to resistance development while not targeting beneficial strains of bacteria. This novel fusion protein has the potential to treat persistent mastitis on dairy farms and multi-drug resistant S. aureus (MRSA) in hospitals and clinics.

Correctly Detecting Salmonella in Foodborne Outbreaks

Salmonella species remain one of the leading pathogens causing outbreaks of illness. Unfortunately, the serotype implicated in actually causing any outbreak (clinical disease) is often difficult to determine since there may be many contaminating strains. During outbreak investigations, it is critical to isolate the relevant strain from food and/or environmental sources. ARS researchers in Albany, California, determined that some Salmonella strains were more likely to be isolated than others. Current selective enrichment media shows a bias for Salmonella enterica strains while strains of serogroup B, which include serovars Typhimurium, Saint-Paul, and Schwarzengrund, were less likely to emerge as dominant strains. This work provides critical information to public health agencies at the Federal and State level, as well as to industry, stressing that during investigations, multiple enrichment protocols should be used to ensure isolation of target strains.

New Modeling Study Suggests Lower Vitamin E Requirement

Ninety-three percent of the American population does not meet the current dietary recommendation for vitamin E. However, there is little if any evidence that deficiency of this vitamin exists in the U.S., suggesting the current requirement may be set too high. An ARS scientist in Beltsville, Maryland, in collaboration with scientists at the University of California, Davis, modeled and quantified the kinetics, bioavailability, and metabolism of alpha tocopherol in healthy adults by measuring tiny doses of the radioactively labeled vitamin excreted in urine or feces over 21 days and amounts in blood over 70 days. The new data suggest the true vitamin E requirement is one third of that set in 2000 by the Institute of Medicine and could form the basis for a revision of that recommendation. Lowering the vitamin E requirement could help the Food and Nutrition Service, which administers the School Lunch Program and is required to provide one third of the Vitamin E daily requirement, address the issue of what is actually needed.

Food for Progress

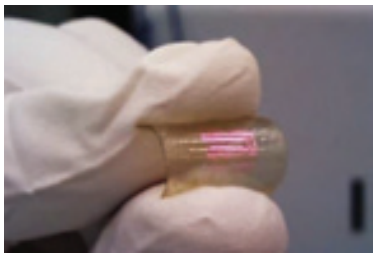
The Food for Progress Program ("FFPr") provides donations of U.S. agricultural commodities to developing countries that are committed to introducing or expanding free enterprise in the agricultural sector. Donated commodities are "monetized" (i.e., sold on the local market) by implementing partners within a participating country and the proceeds are used to support agricultural development activities in that country. In some cases, FFPr activities help accelerate the transfer and commercialization of U.S. technology in partner countries. For example, in FY 2013 Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance (ACDI/VOCA) received a FFPr grant to expand the scope of a 2008 funded Food for Progress project to enhance the development of high-quality manufactured cattle and poultry feeds in five regions of Ethiopia. Specifically ACDI/VOCA will assist cooperatives and unions in three phases of developing feed manufacturing enterprises: establishment, production, and post-production. Within this project, ACDI/VOCA will support the Ethiopian Meat and Dairy Technology Institute in expanding a web-based database of feed ingredients and a parallel market information system for livestock and feed. This initiative will also deliver technical assistance and technology transfer to the Ethiopian Animal Feed Industry Association to enhance feed quality control and regulatory compliance among local feed manufacturers. Overall, training and technology transfers through this initiative will improve Ethiopia's poultry and livestock sectors and further cultivate new market opportunities for U.S. exports of feed ingredients to Ethiopia.

Best Management Practices for Community Wildfire Protection Plans (CWPP)

Community wildfire protection planning has been called one of the most successful tools for addressing wildfire fire management in the wildland-urban interface. Initiating legislation provided little direction for what a CWPP process or product might look like, leaving Wildland-Urban Interface community members and their potential partners with a number of questions about what a CWPP should include and what process should be followed. Case studies

conducted by Forest Service social scientists and their university colleagues in 13 communities nationwide offered some guidance to communities seeking to create or revise a CWPP. The Best Management Practices (BMPs) that emerged from talking to more than 130 people are a collection of lessons that empower communities and their partners to produce a plan that takes into account their social and ecological contexts in addressing local wildland fire issues and concerns. BMPs highlight the importance of drawing on community capacity and necessary networks while creating new capacities for future action. They highlight the linkage between how a community frames the issue of wildland fire management and the scale selected for the CWPP. Finally, the BMPs suggest steps to sustain interest, participation, resources, and support for the CWPP.

Cellulose Nanofiber Composites Can Serve as Substrate for Flexible Electronics



Flexible electronics have many potential applications including malleable displays, solar cells, smart cards, radio frequency tags, medical implants, and wearable computers. Transparent films made from cellulose nanofibers, a renewable nanomaterial, have low thermal expansion and thus the potential to serve as a foundation for flexible electronics. Forest Service researchers recently demonstrated the ability to transfer silicon nanomembranes onto flexible plastic substrates to create working thin-film transistors having a 12-gigahertz maximum oscillation frequency. Current work with high-speed, flexible electronic substrates uses plastics for the flexible substrate. These plastics typically have drawbacks, however, such as high thermal expansion coefficients. Transparent films made from cellulose nanofibers, a renewable material using the smallest workable particles of wood, have low thermal expansion, and thus, the potential to serve as a superior substrate for flexible electronics. Researchers from the Forest Products Laboratory and University of Wisconsin, Madison, have demonstrated the first example of using cellulose nanofiber composite substrates for flexible electronics. Although some challenges remain, the cellulose nanofiber composite showed good chemical and thermal resistance, which is necessary for electronic fabrication, and the use of cellulose nanofibers as a sustainable component for high-speed flexible electronics is extremely promising.

Department of Commerce (DOC)

Technology transfer plays an important role in DOC's mission to promote job creation, economic growth, sustainable development, and improved standards of living for all Americans. DOC works in partnership with businesses, universities, State, tribal and local governments, and communities to promote innovation and improve the Nation's overall competitiveness in the global economy. DOC pursues these objectives through policies and programs directed at strengthening the Nation's economic infrastructure, facilitating the development of cutting-edge science and technology, providing critical scientific information and data, and managing national resources.

DOC conducts R&D in areas of science and technology at the laboratory facilities of NIST, the National Oceanic and Atmospheric Administration (NOAA), and the National Telecommunications and Information Administration's (NTIA) Institute for Telecommunication Sciences (ITS). Technology transfer, which is a key part of the programmatic activities in these laboratories, connects technological advances of DOC's science and engineering programs to the American economy.

In addition to the technology transfer efforts of DOC laboratories, DOC is responsible for coordinating technology transfer activities across Federal agencies. DOC coordinates the Interagency Workgroup for Technology Transfer (IAWGTT) through NIST facilitating interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency technology transfer programs. NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer (FLC), which is a nationwide network of Federal laboratories that provides a forum to develop strategies and opportunities for linking laboratory mission technologies and expertise with the marketplace.[31]

DOC's role in coordinating technology transfer activities across Federal agencies was further expanded by the Presidential Memorandum – *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses* of October 21, 2011.[32] The purpose of this PM is to foster innovation by increasing the rate of technology transfer and the economic and societal impact from Federal R&D investments. The PM directs agencies with Federal laboratories to take actions to establish goals and measure performance, streamline administrative processes, and facilitate local and regional partnerships in order to accelerate technology transfer and support private sector commercialization. The aim is to increase the successful outcomes of agency technology transfer and commercialization activities significantly over the next 5 years, while simultaneously achieving excellence in each agency's research activities.

---

[31] Agencies participating in the IAWGTT, established pursuant to Executive Order 12591 of April 10, 1987, include the Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Health and Human Services, Department of Homeland Security, Department of Interior, Department of Transportation, Department of Veterans Affairs, Environmental Protection Agency, and National Aeronautics and Space Administration.

[32] http://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commerciali

Section 2 of the PM calls for establishing performance goals, metrics, and evaluation methods, as well as implementing and tracking progress relative to those goals. Specifically "[t]he Secretary of Commerce, in consultation with other agencies, including the National Center for Science and Engineering Statistics, shall improve and expand, where appropriate, its collection of metrics in the Department of Commerce's annual technology transfer summary report, submitted pursuant to 15 U.S.C. § 3710(g)(2)."[33]

DOC's annual technology transfer report is available online at:
http://nist.gov/tpo/publications/doc-annual-reports-techtransfer.cfm

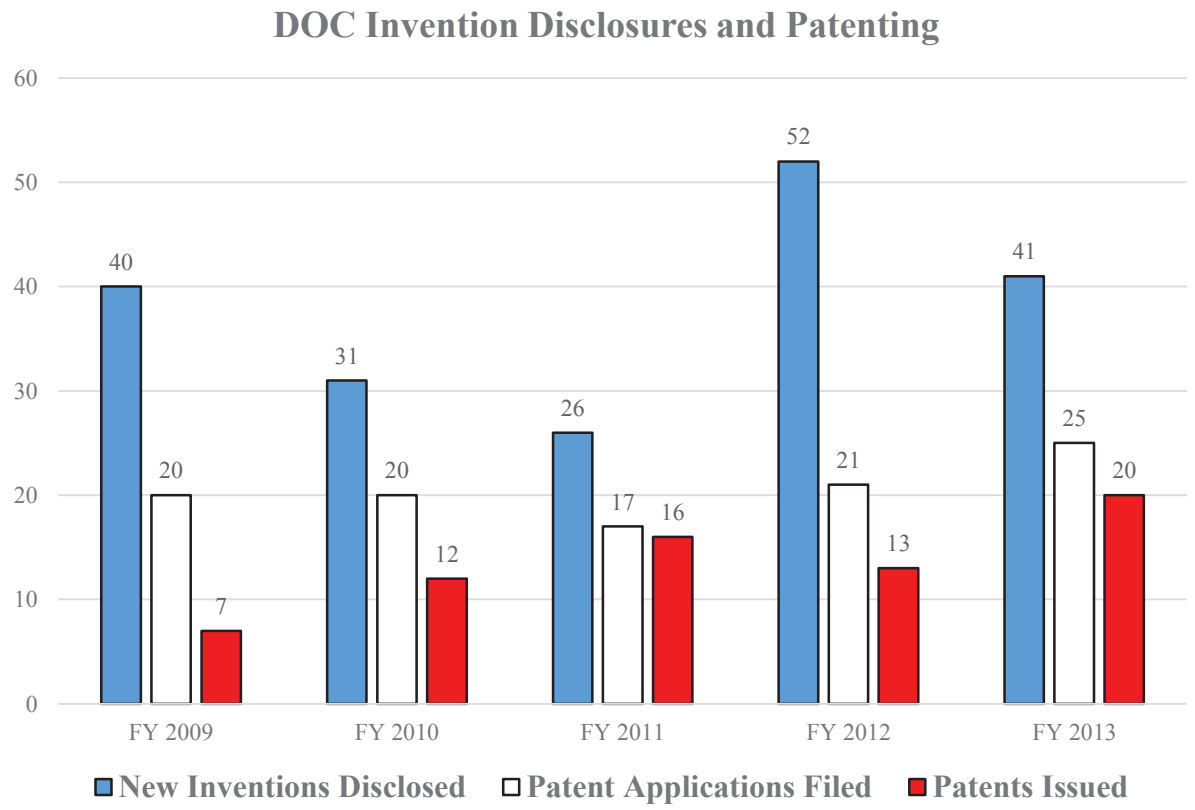
More information about DOC's technology transfer activities is available on the following websites:

- NIST: http://www.nist.gov/tpo/index.cfm;
- NOAA: http://techpartnerships.noaa.gov/; and
- ITS: http://www.its.bldrdoc.gov/.

[33] For a list of available reports see http://www.nist.gov/tpo/publications/doc-annual-reports-techtransfer.cfm

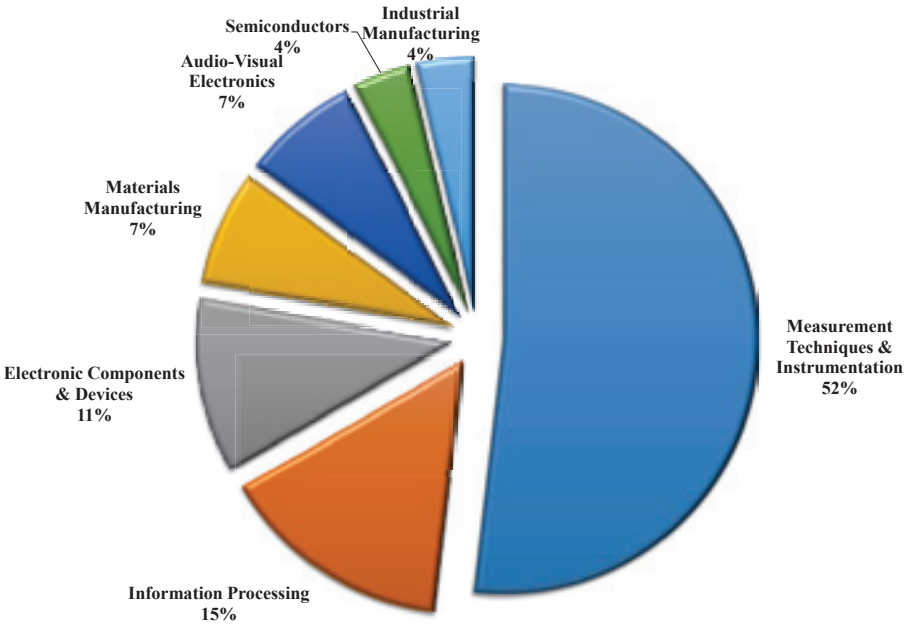
DOC Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased by 3% to 41 inventions. The number of patent applications filed increased by 25% during the five year period to 25 applications in FY 2013. The number of patents issued to the department increased by 186% between FY 2009 and FY 2013 to 20 patents in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	40	31	26	52	41
Patent Applications Filed	20	20	17	21	25
Patents Issued	7	12	16	13	20

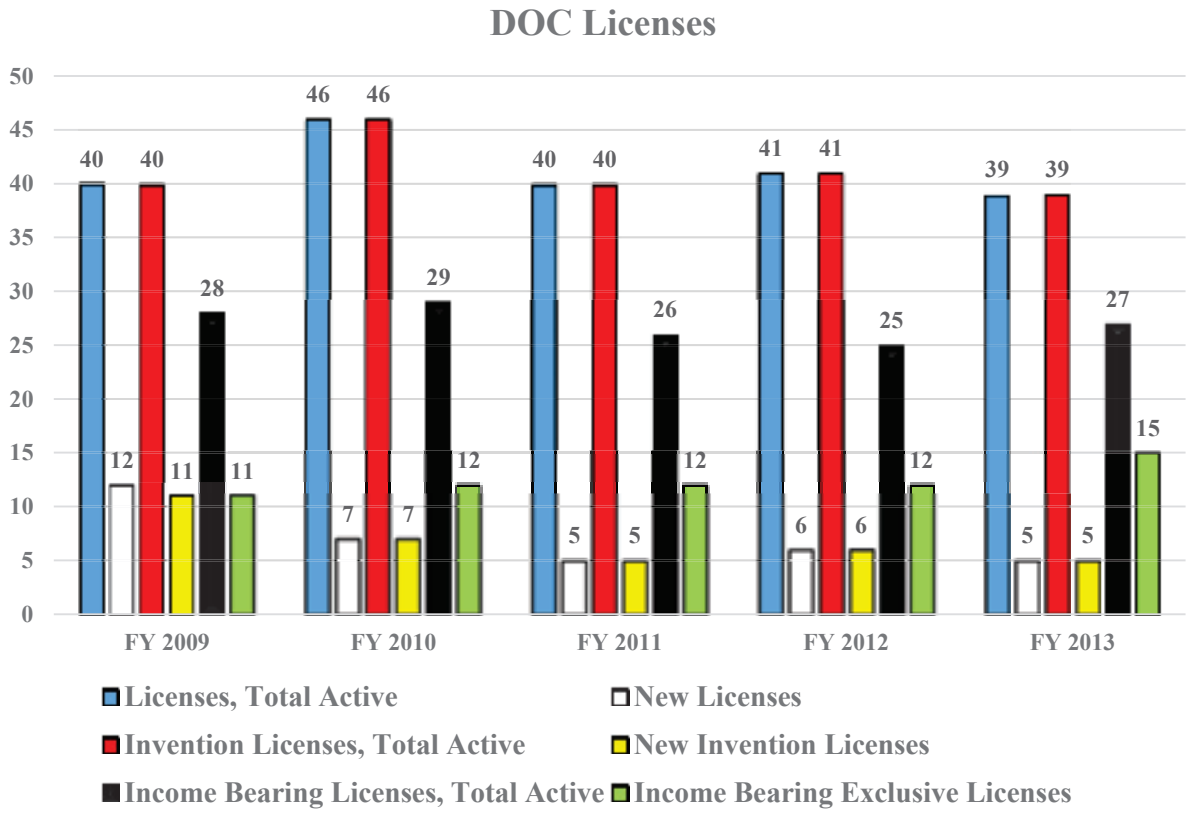
USPTO Patents Assigned to DOC by Technology Area: FY 2013[34]



[34] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DOC Licenses

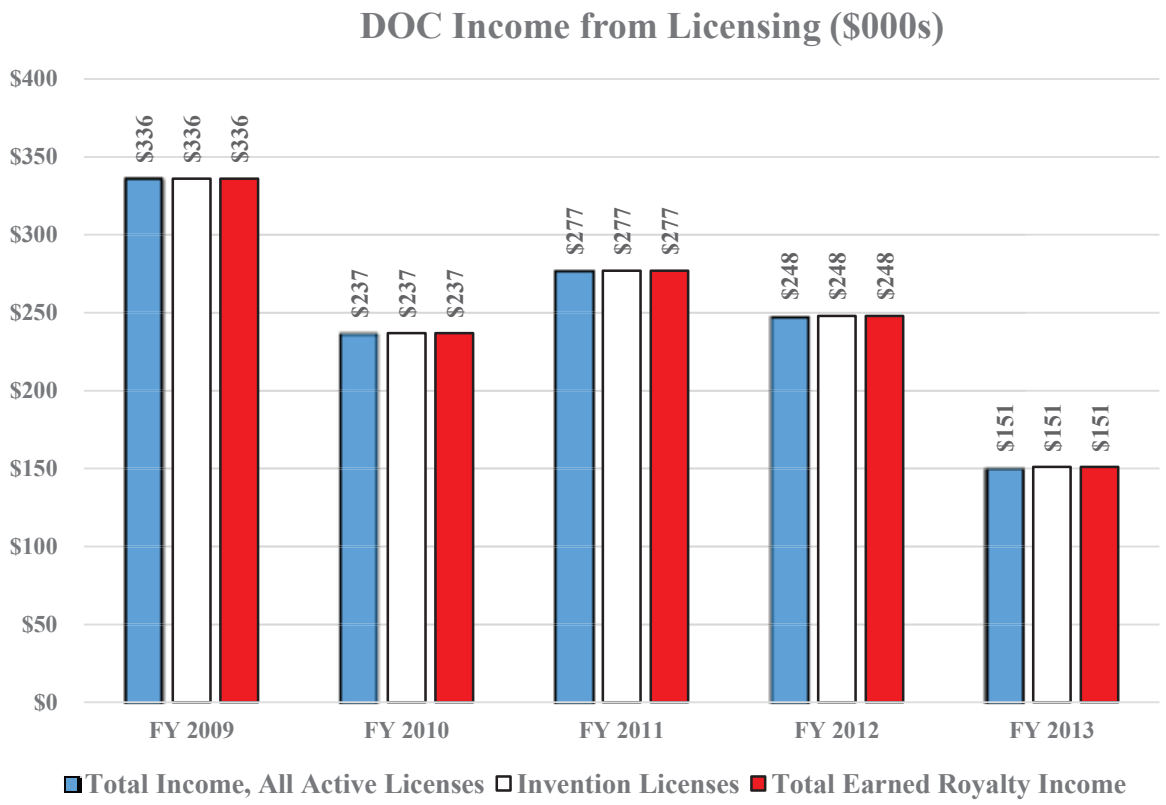
Between FY 2009 and FY 2013, the number of new licenses and new invention licenses decreased by 58% and 55% respectively. The number of licenses in 2009 was somewhat of an anomaly because a large number of no-cost research licenses were granted to small businesses under the Small Business Innovation Research Program. The large number of projects was due to increased funding from the American Recovery and Reinvestment Act of 2009 (P.L. 111-5). Therefore, although there is a decrease in new licenses, there was a 36% increase in the number of income bearing exclusive licenses for the same period.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	40	46	40	41	39
New Licenses	12	7	5	6	5
Invention Licenses, Total Active	40	46	40	41	39
New Invention Licenses	11	7	5	6	5
Income Bearing Licenses, Total Active	28	29	26	25	27
Income Bearing Exclusive Licenses	11	12	12	12	15

DOC Income from Licensing

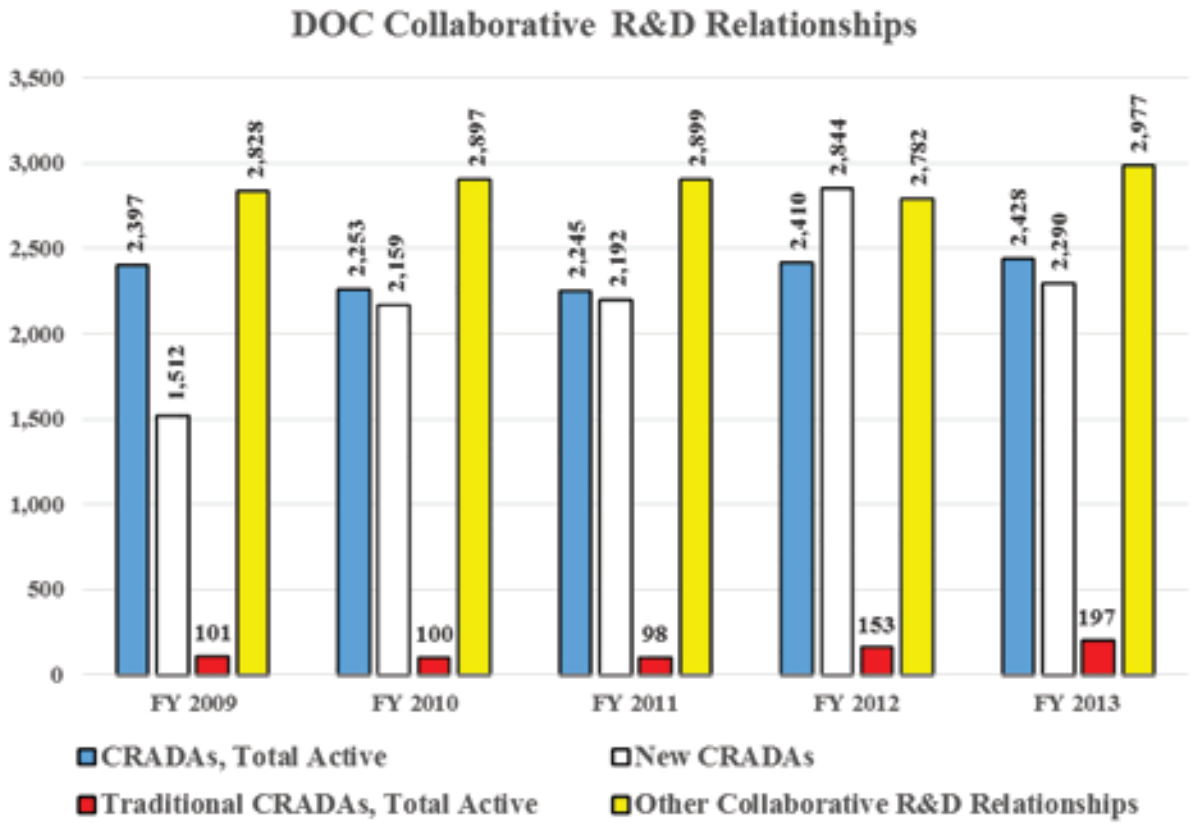
All income from licensing comes from invention licenses. During the five-year period, from FY 2009 to FY 2013, there was a 55% decrease in total income from all active licenses. This is primarily due to the expiration of a single license when the associated patent expired.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$336	$237	$277	$248	$151
Invention Licenses	$336	$237	$277	$248	$151
Total Earned Royalty Income	$336	$237	$277	$248	$151

DOC Collaborative R&D Relationships

The number of total active CRADAs has remained constant between FY 2009 and FY 2013, with an overall 1% increase to 2,428 agreements. The five-year period experienced a 51% growth in the number of new CRADAs and a 95% increase in the number of total active traditional CRADAs. The other collaborative R&D relationships experienced a 5% increase between FY 2009 and FY 2013, reaching 2,977 relationships in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	2,397	2,253	2,245	2,410	2,428
New CRADAs	1,512	2,159	2,192	2,844	2,290
Traditional CRADAs, Total Active	101	100	98	153	197
Other Collaborative R&D Relationships	2,828	2,897	2,899	2,782	2,977

Efforts to Streamline Technology Transfer Operations

NIST has undertaken several efforts to streamline and simplify the technology transfer process. NIST has revised its standard CRADA documents, reducing that document's overall size by approximately one third. This effort has helped to expedite the CRADA negotiation and review process by eliminating provisions not needed for the great majority of NIST collaborations. NIST has also set up a website to enhance communications with outside parties who are interested in developing partnerships with NIST, and implemented several new licensing programs to encourage small businesses to participate. These programs lay out key terms in advance to ease concerns of small businesses about overall licensing costs. NIST is conducting detailed analysis of the flow of documents to understand where significant delays occur within its system. In many cases, these delays are with the partner and NIST does not have direct control. However, through ongoing efforts to identify and understand issues experienced its partners, NIST will continue to identify new ways to simplify and streamline technology transfer practices.

DOC Downstream Success Stories

Public Safety Broadband Demonstration Network

Before Congress passed the First Responder Network Authority (FirstNet) legislation, issues with cross-organization and cross-jurisdiction communications in the land mobile radio environment hindered the effectiveness of public safety communication among first responders. Specifically, the use of proprietary systems and non-contiguous spectrum assignments prevented the standardization of nationwide public safety communications.

To address these issues, NIST's Communications Technology Laboratory and NTIA's ITS have jointly created the Public Safety Communications Research (PSCR) Program. With funding from the Department of Homeland Security, this program has initiated the Public Safety Broad Band (PSBB) Demonstration Network that provides a viable platform by which members of the telecommunications industry can work together to design, develop and implement a variety of public safety 700 MHz broadband technologies for the benefit of emergency service agencies nationwide.

Currently, the PSBB Demonstration Network is set up as a consortium of seventy-nine members (fourteen of which are small businesses), each with its own consortium CRADA with NIST and NTIA that provides access to a wide range of resources including infrastructure, supporting tests, equipment, software and hardware.

The Demonstration Network provides multiple phases of testing and evaluation. The first phase, which has been successfully completed, focused on basic functionality tests to determine if the Long Term Evolution (LTE) equipment provided by user equipment manufacturers has been configured properly to achieve at least a minimal level of functionality. The second phase has also been completed successfully. The goal of this phase was to evaluate the performance of the LTE radio network and evaluate LTE network interoperability between the various CRADA partners and equipment manufactures. The consortium is currently planning the next phase of testing that will include load testing and Quality of Service testing.

Through the creation of a variety of device requirements and minimum operational guidelines, this project provides the means by which manufacturers can enhance the designs of new products that will ultimately enable highly effective and interoperable public safety communications. Furthermore, the activities of the consortium, which has attracted the largest concentration of 700 MHz public safety LTE equipment manufacturers, has promoted PSCR's leadership role in developing solutions for network deployment of LTE broadband. The ongoing work has shown the need to develop standardized implementations of LTE, verify implementations of the LTE standard, and utilize commercial industry products and services to meet public safety requirements.

ERCC Controls for Quality of Gene Expression Measurements

NIST has released a Standard Reference Material designed for use with RNA sequencing (RNA-seq), DNA microarrays, quantitative reverse transcription PCR (qRT-PCR), or any other gene expression measurement technology. This reference material, based on the work of the NIST-hosted External RNA Controls Consortium (ERCC), will pave the path for gene expression studies to enter routine clinical use, enabling doctors to more effectively diagnose patients or design a tailored course of treatment.

The Standard Reference Material (known as NIST SRM 2374, DNA Sequence Library for External RNA Controls) provides a tool that gives users confidence in the technical performance of gene expression measurements. With this foundation, scientists now have an effective and simple way to evaluate the performance of a gene expression test, and the means to collaborate across laboratories.

The reference material consists of a library of 96 DNA templates (for a total of 86,319 bases) used to make RNA controls that allow users to gauge the technical performance of their gene expression tests. The controls can be added, or spiked in, to RNA samples at the start of any gene expression test to improve measurement confidence. These ERCC controls have already been incorporated into products and protocols by all major vendors of gene expression measurement technologies, including Illumina, Agilent, and Nanostring.

SRM 2374 was certified by NIST for DNA sequence. In addition to the primary Standard Reference Material certified and maintained by NIST, mixes of RNA controls created using the SRM DNA templates are also commercially available. Though initially developed for use with gene expression microarrays, these materials have become an indispensable tool for characterizing new and emerging next-generation sequencing instruments and capabilities.

Vitamin D Program

The prevalence of vitamin D deficiency or insufficiency in the general population remains a global concern. Measurements of vitamin D in serum or plasma have been particularly challenging and inconsistent. NIST, in collaboration with the Centers for Disease Control (CDC) and the National Institutes of Health (NIH), has developed and released a vitamin D Standard Reference Material used to qualify Vitamin D measurement systems.

Vitamin D deficiency is associated with rickets in children and osteomalacia (bone softening) in adults. A number of studies have linked vitamin D deficiency or insufficiency with increased

cancer risk, cardiovascular disease, and autoimmune disorders. Accordingly, testing for vitamin D deficiency has increased dramatically over the past decade to hundreds of thousands of clinical tests each year. However, many studies demonstrate multiple inconsistencies in the measurement of vitamin D, between various techniques, across different labs, and even year-to-year, which impede reliable diagnosis of vitamin D deficiency. Further, these discrepancies limit the ability to interpret or compare data from multiple research studies or to assess the nutritional status for diverse populations.

In response to the need for better vitamin D deficiency diagnosis, NIST developed and deployed SRM 972 (Standard Reference Material 972: Vitamin D in Human Serum) to provide a gold standard for qualifying measurements of vitamin D in patients. It was developed in collaboration with the NIH Office of Dietary Supplements and the CDC. The initial reference material was so widely adopted by the clinical testing community that the first batch of 1450 units was exhausted in just two years. A renewal material, SRM 972a (Vitamin D Metabolites in Human Serum), was issued in early 2013 and includes value assignments for several commonly tested metabolites of vitamin D, which will further enhance testing accuracy.

NIST Center for Automotive Lightweighting (NCAL)

The NIST Center for Automotive Lightweighting (NCAL) has been established to develop the measurement methodology, standards, and analysis needed by the U.S. auto industry and base metal suppliers to deploy advanced lightweight materials for auto body components. The lighter vehicles made from these advanced materials will have significantly increased fuel efficiency and reduced emissions. Dramatic weight reductions are often achieved through the incorporation of lightweight aluminum alloys, high-strength steels, and polymer composites. However, the data and material models needed to manufacture components from these new lightweight substitutes are inadequate. Consequently, the U.S. auto industry spends hundreds of millions of dollars every year in lengthy trial-and-error development cycles to design metal-forming dies for specific parts.

NIST has responded by developing new measurement capabilities that allow the direct measurement of the stress-strain response of advanced materials under complex (multi-axial) deformations. These measurements allow direct observations of new lightweight materials under the kinds of stress encountered in high performance applications. Additionally, NIST is working with industrial partners to develop predictive models of the evolving material microstructure during deformation. Current NCAL industry partners include GM, Ford, Chrysler, US Steel, and Alcoa. In addition, the knowledge and data generated by NCAL are used by industry groups such as the Automotive/Steel Partnership, USCAR, and the American Iron and Steel Institute.

NCAL research has produced new measurement capabilities that have been vetted and disseminated via standards organizations (ASTM E-2492, ISO pending) and direct interactions with companies via regular industry workshops hosted at NIST. NIST scientists provide technical expertise for the Auto/Steel Partnership collaboration 061, an industry consortium focused on understanding the behavior of new lightweight materials. Steel manufacturers have already begun to modify material processing based on emerging NIST measurements and modeling so that the materials they produce are more readily deployed in cars. Automotive manufacturing companies have reported that NIST models and data have helped them

significantly reduce die tryout cycles, which will ultimately reduce new model development costs.

Green Button

A new user guide for web developers recently released by NIST will enable electric utilities and vendors to provide customers with tools and applications for convenient access to their energy usage data. These tools and applications were developed as part of the Administration's "Green Button" initiative. Green Button aims to provide electricity and gas consumers with their own energy usage information in an understandable and computer-friendly standardized electronic format via a "Green Button" on a utility's web site. Consumers armed with this information can then use an array of new Web applications to make more informed energy decisions and to verify that their energy-efficiency investments are performing as promised. The User Guide, which is available via the website, provides an overview for those utilities not yet using Green Button, contains information on the composition of Green Button data, how to make Green Button data accessible/comprehensible to users, sample source code showing what data to begin with, as well as examples of finished data sets.

Standard for Automated Guided Vehicles Advances Technology to Improve Safety and Speed

NIST contributions provided the basis for a significant revision of the ANSI/ITSDF1 B56.5-2012 Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles. Revisions to the standard were developed under the direction of the Industrial Truck Standards Development Foundation (ITSDF), and the revisions introduce for the first time the use of non-contact sensing, obstacle detection, and advances in vehicle control. The revised standard overcomes barriers to adopting new technologies that will allow both increased vehicle speeds and reduction of risk of collisions and injury. Specific NIST contributions to this standard over a multi-year period included development and evaluation of new test methods to assess safety performance, development of standard test artifacts, evaluation and demonstration of prototype safety systems, and development of the standards document itself. The safety requirements defined by this revised standard will be incorporated into new automated industrial vehicle product lines sold in the U.S., and manufacturing industry users of these vehicles will benefit from the increased safety and reduced numbers of accidents and injuries, as well as increased efficiency of operations.

New NIST Test for Firefighter Breathing Equipment

As of Sept. 1, 2013, standard firefighter breathing equipment cannot be certified to National Fire Protection Association (NFPA) standards unless the face piece lenses pass a new rigorous test developed by NIST. The new test is designed to reduce the degradation and possible failure of the face piece lens in self-contained breathing apparatus (SCBA) under high-heat firefighting conditions. Under high-heat conditions, SCBA lenses had been found to bubble, deform, and form holes/crazes, exposing a firefighter to toxic gases and resulting in burns to the respiratory tract as well as asphyxiation. The January 2013 version of NFPA's 1981 standard contains a new "Elevated Temperature Heat and Flame Resistance Test" that exposes the SCBA to 500 °F (260 °C) for 5 minutes in an oven, followed by 10 seconds of direct flame contact. In addition, the new version contains a new "Lens Radiant Heat Test" that subjects the SCBA face pieces to a radiant heat flux of 15 kilowatts per square meter (kW/m2) for five minutes. As part of this test,

the face piece is required to maintain an air supply (positive pressure) inside the mask for 24 minutes. The incident radiant heat flux of 15 kW/m2 was determined by NIST researchers in controlled experiments to be representative of the flux experienced by firefighters approaching the onset of "flashover", a state of total surface involvement in a fire of combustible material within an enclosure. The new test and test conditions are important advances in improving the performance of what has been the most vulnerable component of a firefighter's protective gear in high-heat conditions.

National Weather Service Little Rock Provides Geospatial Data for State Operations during Tornados

On April 10, 2013, an EF2 Tornado touched down at Clinton, AR. The track was 17.3miles long and 800 yards wide. That same day, four additional Tornadoes also touched down. Shortly after this event, the National Weather Service provided subjective, storm-centroid tracks to the Arkansas Geographic Information Office, which were then distributed to a number of other state agencies, including the Arkansas governor's office, Arkansas Department of Emergency Management, and local government agencies. These data assisted with the decision support services provided by NOAA's Weather Forecast Office, Little Rock, AR, for "Rescue and Recovery" efforts immediately following the tornado touchdown. The Storm Damage Survey lasted several days, and follow-up information was given each day by NOAA's Warning Coordination Meteorologist to other law enforcement and AR Emergency Management personnel working the detail.

National Weather Service/National Hurricane Center Collaborates with Commercial Venture to Introduce New Communication System for Critical Weather Information

In 2010, NOAA's National Hurricane Center (NHC) entered into a CRADA with America's Emergency Network, Inc. (AEN), whereby regular briefings with NHC specialists during land-falling hurricanes would be broadcast from a fixed, ceiling-mounted camera and linked through an Internet system at NHC via its website to the AEN website, permitting anyone with a personal computer to view the broadcasts.

From 2010 to 2012, the system was used experimentally during four tropical cyclone threats to the U.S. - 2010's Hurricane Earl, 2011's Hurricane Irene and 2012's Hurricane Isaac and Hurricane Sandy. After each event, NHC worked closely with AEN to recommend improvements to the site and process.

In 2012, AEN was sold to Weather Decision Technologies (WDT) and NOAA extended the CRADA until December 2013. NOAA used the technology in 2013 for Tropical Storm Karen, which had prompted a hurricane watch along the Gulf Coast. The NHC would like to implement this technology and is exploring appropriate legal mechanisms to allow delivery of hurricane warning messages to hurricane-threat zones which lack direct communication links with NHC.

Geophysical Fluid Dynamics Laboratory (GFDL) Delivers State-of-the-Science Climate Model Results

The Coupled Model Intercomparison Project is an international effort to improve climate models by comparing multiple model simulations to observations and to each other. These comparisons

can help our understanding of past and future climate changes, and lead to climate model improvements.

Together, these models have produced over 180 terabytes of data that are publically available on GFDL's Data Portal and through the Earth System Grid Federation. To date, over 150 terabytes of data have been downloaded to over 25 institutions in North America, 11 in Europe, nine in Asia, four in Australia, and two in Russia.

Great Lakes Environmental Research Laboratory (GLERL) Transitions Satellite Ice Classification Algorithm for Operational Use

A satellite synthetic aperture radar (SAR) algorithm to classify and map Great Lakes ice types, co-developed by NOAA (GLERL) and NASA Jet Propulsion Laboratory has been transitioned to operational production at NOAA's National Environmental Satellite, Data, and Information Service (NESDIS). The method uses a library that translates digital data from satellite radar instruments such as the Canadian Space Agency's RADARSAT-1/2, the European Space Agency's European Remote Sensing Satellite 2 (ERS-2), and Envisat, to identify and map different types of ice over the Great Lakes. This is done by pairing the satellite SAR-observed ice type to a unique library of radar polarimetric backscatter signatures from ice types measured on the lakes using advanced C-band radar aboard a U.S. Coast Guard icebreaking ship. The method has now been transitioned to NESDIS for routine use in generating ice type maps across the Great Lakes.

These maps will provide important information for environmental management, ice forecasting and modeling, offshore wind farm development, operational ice breaking activities in support of winter navigation, and science research. This work was awarded NOAA's Bronze Medal Award for research and development of an algorithm for automatic lake ice classification utilizing satellite radar data.

Buoy System Power Controller Design Provided to Vendors

The technology to build the System Power Controller (SPC) module designed by scientists at NOAA's Great Lakes lab and used in Realtime Coastal Observation Network (ReCON) buoys and platforms was provided to vendors for the benefit of the public. The SPC module is an essential intelligent device that controls the power of the various components and sensor instrumentation on buoys and other in-situ data collection platforms. Its purpose is to maximize the utility of data collection in platforms that are power-limited because they are operated from solar panels. The electrical design, board layout, software, and quality control testing procedures that were designed by NOAA were made available to any vendor who wanted to manufacture a SPC module. Two companies are currently producing the modules, which are being used by NOAA and are publicly available for the benefit of others.

Department of Defense (DoD)

The purpose of the DoD Office of Technology Transition is to ensure, to the maximum extent practicable, technology developed for national security purposes is integrated into the private sector of the United States in order to enhance national technological and industrial bases as well as reinvestment and conversion activities.

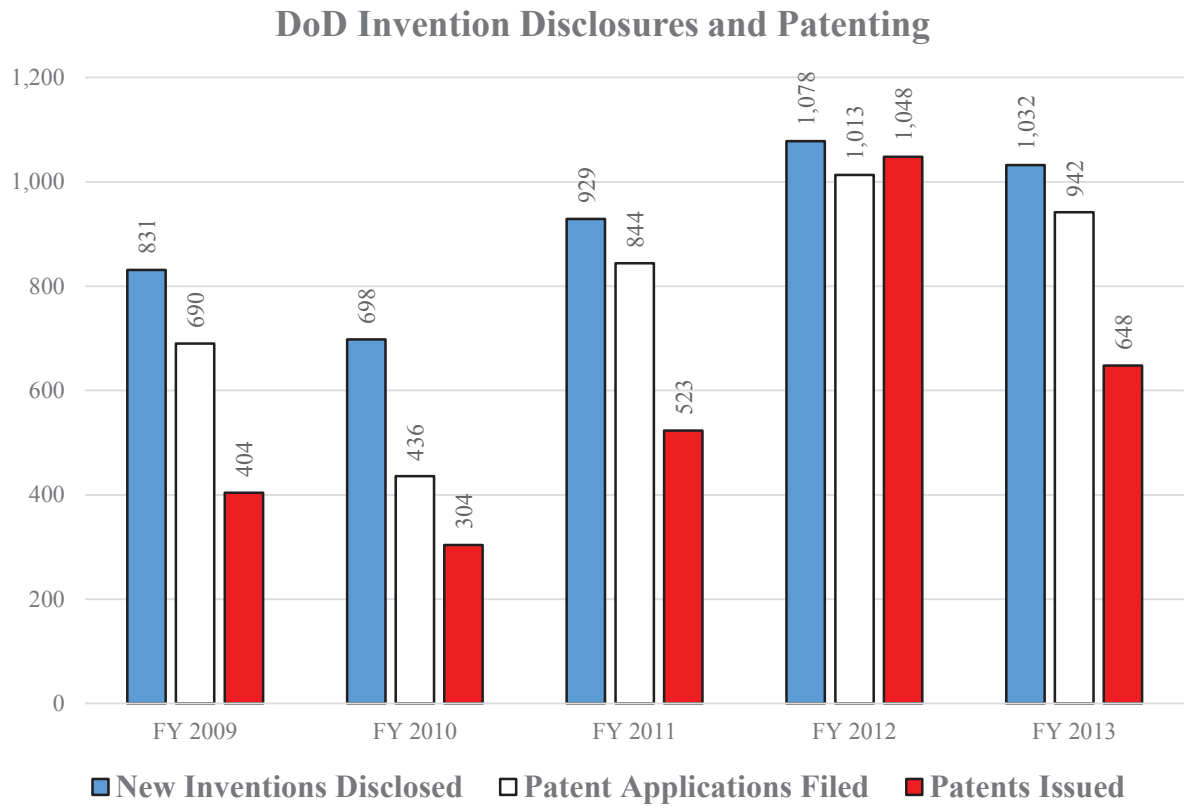
DoD is unique in applying the principles, practices, and tools of technology transfer in the execution of its mission. DoD funds and develops mission-focused technology, and technology transfer statutory authorities enable it to promote and facilitate the commercialization of that technology for both military and civilian purposes. Concurrently, DoD is a technology buyer as it strives to purchase new technology embodied in products and systems to meet the challenges faced by our warfighters. In many instances, technology transfer and technology transition are becoming a seamless path to fielding new technology critical to responding to the new and dynamic threats of asymmetric warfare, the global war on terrorism, and the ever expanding role of civil assistance and disaster recovery worldwide. In the 1980's, when much of the technology transfer legislation was enacted, the Federal government, including DoD, was the principle funding source for R&D. Consequently, technology transfer was viewed as a "spin out" to the marketplace, a stimulus to the domestic economy, and a return on investment for taxpayer funded R&D. Today, the majority of U.S. R&D is industry funded. This shift in funding has led to a greater emphasis on technology transfer as a collaborative effort between DoD labs and their partners in industry, academia, and state and local government.

Each of the Military Services, Defense Agencies, and Office of the Secretary of Defense (OSD) maintain technology transfer websites to inform the public and make available general information. The websites are:

- http://www.acq.osd.mil/chieftechnologist/index.html;
- http://www.arl.army.mil/main/Main/default.cfm?Action=6;
- http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Technology-Transfer-T2.aspx;
- http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=6026; and
- http://www.mda.mil/business/opportunities.html.

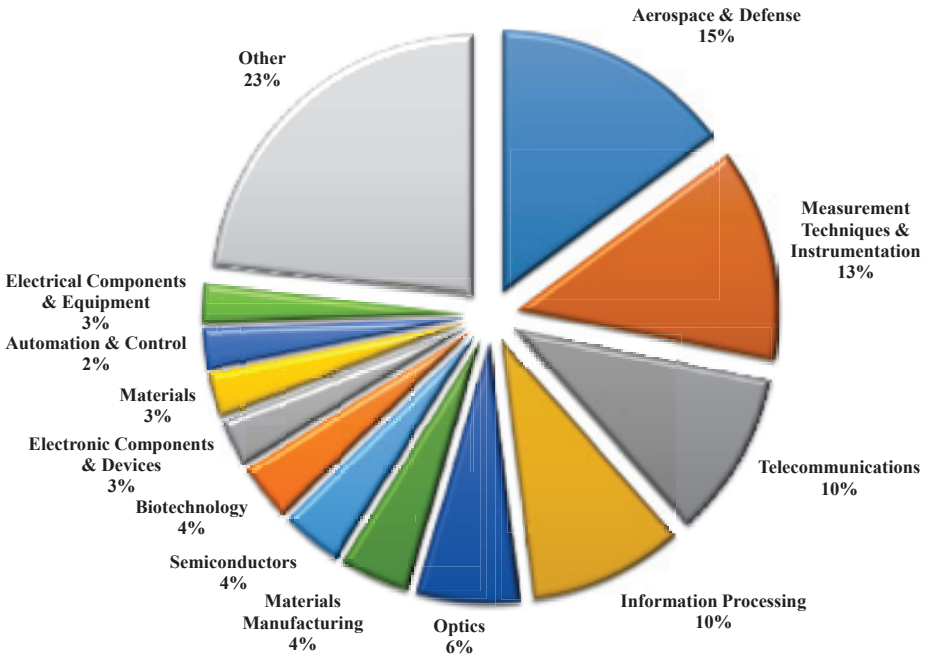
DoD Invention Disclosures and Patenting

Between FY 2009 and FY 2013, there was a 24% increase in the number of new inventions disclosed by the department, reaching 1,032 inventions in FY 2013. The department achieved a 37% increase in the number of patent applications filed during the same period, beginning at 690 applications in FY 2009 to 942 applications in FY 2013. A 60% increase was calculated for the number of patents issued between FY 2009 and FY 2013, reaching 648 issued patents in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	831	698	929	1,078	1,032
Patent Applications Filed	690	436	844	1,013	942
Patents Issued	404	304	523	1,048	648

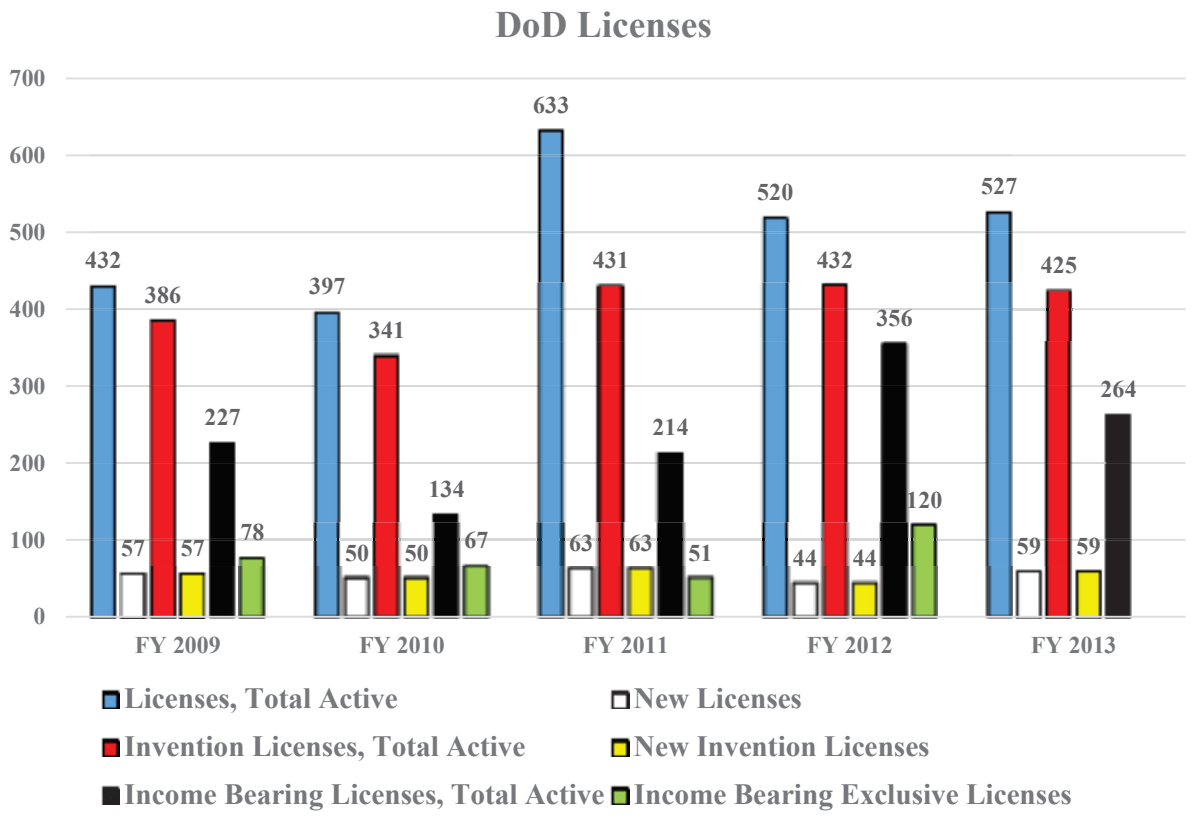
USPTO Patents Assigned to DoD by Technology Area: FY 2013[35]



[35] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DoD Licenses

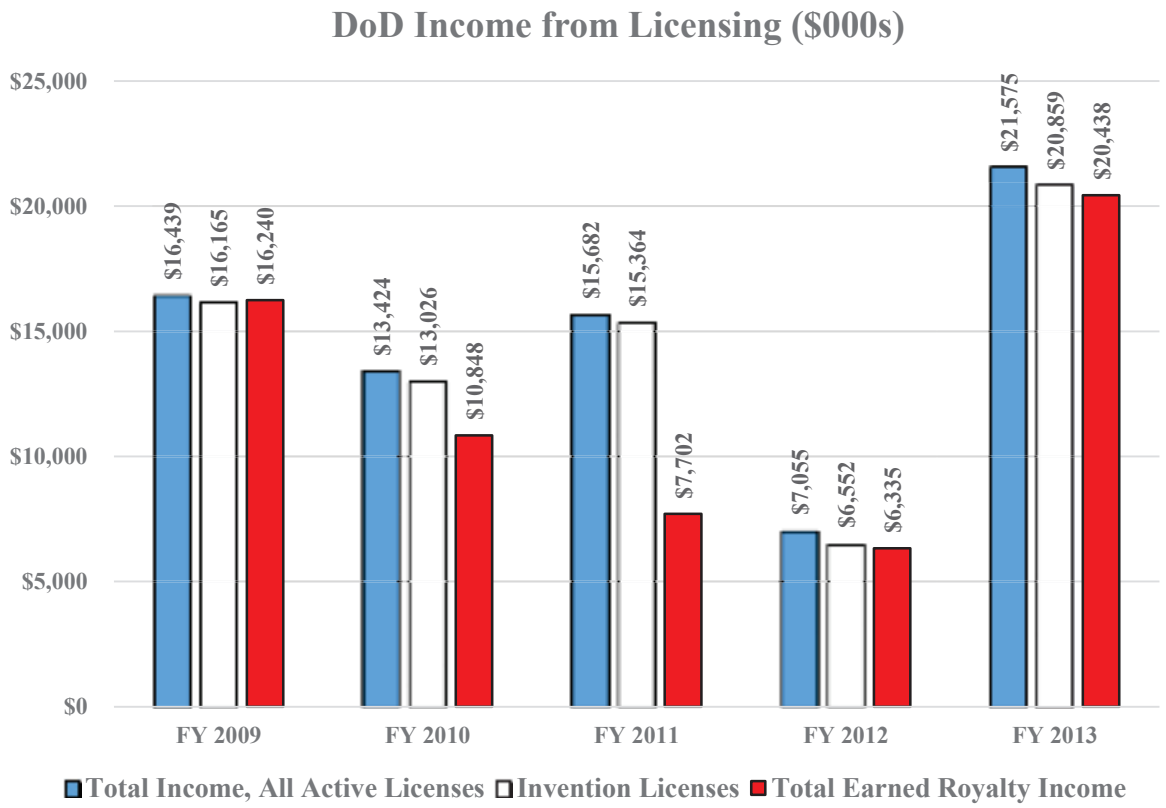
Between FY 2009 and FY 2013, the number of total active licenses increased by 22%, from 432 licenses in FY 2009 to 527 in FY 2013. The number of total new licenses and the number of new invention licenses per year both increased by 4%. Total active invention licenses observed a 10% increase. Total active income bearing licenses increased by 16%, from 227 licenses in FY 2009 to 264 licenses in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	432	397	633	520	527
New Licenses	57	50	63	44	59
Invention Licenses, Total Active	386	341	431	432	425
New Invention Licenses	57	50	63	44	59
Income Bearing Licenses, Total Active	227	134	214	356	264
Income Bearing Exclusive Licenses	78	67	51	120	n/r

DoD Income from Licensing

Between FY 2009 and FY 2013, total income increased by 31%. Invention license income and total earned royalty income also experienced increases, 29% and 26% respectively.[36]

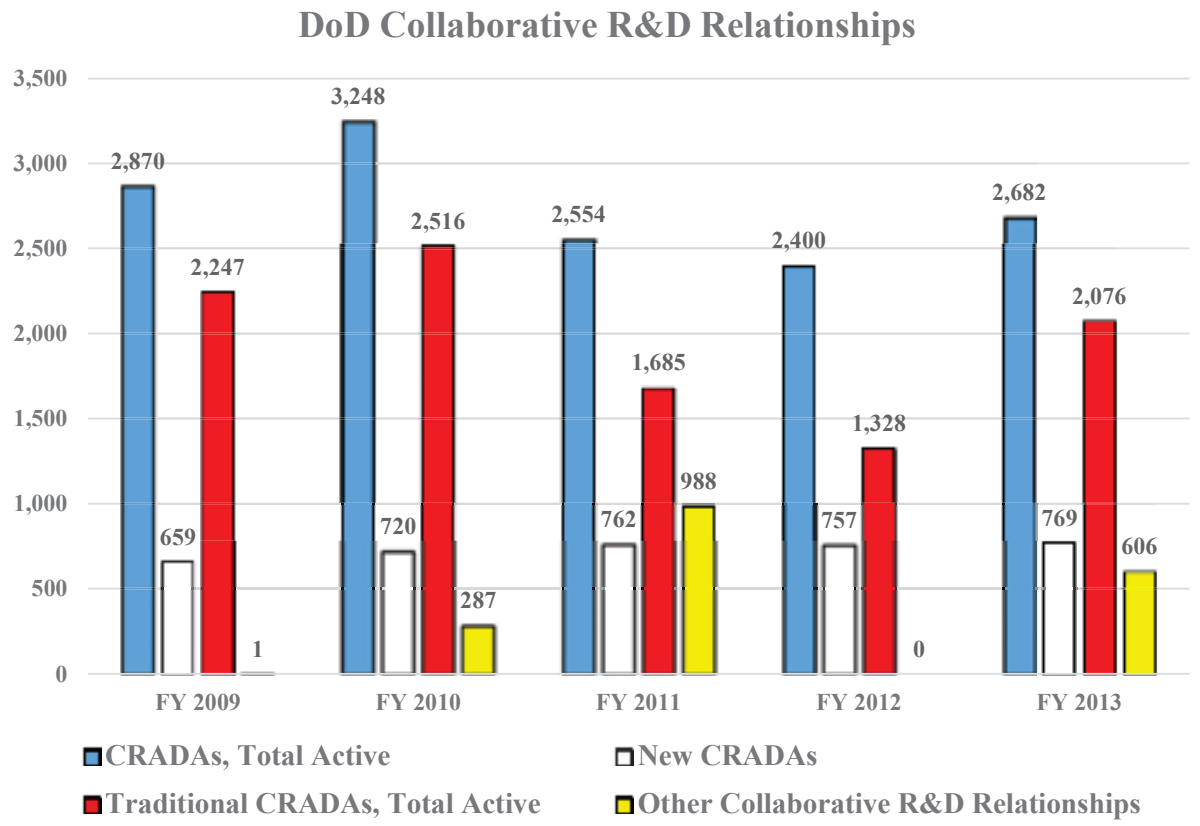


	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$16,439	$13,424	$15,682	$7,055	$21,575
Invention Licenses	$16,165	$13,026	$15,364	$6,552	$20,859
Total Earned Royalty Income	$16,240	$10,848	$7,702	$6,335	$20,438

[36] License revenues includes $7.8 million from FY12 that was paid in FY13 due to legal settlement.

DoD Collaborative R&D Relationships

The number of total active CRADAs decreased 6.55% between FY 2009 and FY 2013, and the number for total active traditional CRADAs fell by 7.61% during the same five-year period. The number of new CRADAs grew by 16.69% to 769 agreements by FY 2013. The quantity of other collaborative R&D relationships was 606 in FY 2013, compared to only one relationship in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	2,870	3,248	2,554	2,400	2,682
New CRADAs	659	720	762	757	769
Traditional CRADAs, Total Active	2,247	2,516	1,685	1,328	2,076
Other Collaborative R&D Relationships	1	287	988	0	606

DoD Downstream Success Stories

Air Force Software Technology Changing the Face of an Entire Industry

HeliusMCT™, the trademarked moniker for Helius multicontinuum technology, is a new finite element analysis software code developed specifically for predicting the behavior and failure of materials and structures composed of at least two different materials, such as fiber and resin.

The technology was tested, demonstrated and commercialized through a pivotal three-way partnership between the Air Force Research Laboratory Space Vehicles Directorate (AFRL/RV), Firehole Technologies (Laramie, WY), and LoadPath (Albuquerque, NM).

The software has been widely adopted by the multi-billion-dollar global composites industry. It is currently in use at AFRL, multiple NASA and Department of Energy facilities, and airplane, satellite, and launch vehicle (rocket) producers, in addition to the sporting goods, yachting, auto racing, and wind energy industries. The widespread adoption of the technology has led to broad economic impacts including the acquisition of Firehole Technologies by Fortune 350 software giant Autodesk.

This technology transfer partnership was initiated using a Small Business Innovative Research contract. Firehole Technologies responded to the AFRL-written topic; LoadPath, a small business CRADA partner with AFRL/RV, provided the test data that was critical to demonstrations of the capabilities of HeliusMCT.

Army System Trains Medical Staff to Save Lives in Obstetric Emergencies

LTC Shad Deering, MD, developed a life-saving technology to ensure positive outcomes in high-risk obstetric emergencies. The technology—the Mobile Obstetric Emergencies Simulator (MOES™) —was developed at the US Army Medical Department's Madigan Army Medical Center.

The Army-patented MOES courseware system integrates a full-size, full-body commercial birthing mannequin with a carefully designed obstetric (OB) training curriculum to build medical staff competencies in OB emergencies and promote patient safety.

Miami-based Gaumard Scientific, a leading healthcare simulation company, licensed the technology through the US Army Medical Research and Materiel Command ORTA, assisted by DoD partnership intermediary TechLink.

The MOES learning package is now integral to a commercial off-the-shelf product sold by Gaumard that is being used in every hospital with a labor and delivery ward across the military health system—52 Army, Navy, and Air Force hospitals in 14 countries and 41 states. Beyond the Department of Defense, the transferred cutting-edge technology is measurably advancing medical education and assuring patient safety in any labor and delivery setting.

Disruptive Multicore Processor Technology Developed by an Army R&D Lab

A processor chip so revolutionary that it's on the cusp of becoming the world's processing standard for advanced communication and image/video devices originated in hyperspectral image processing software created by Dr. Paul Willson, a now retired physicist with the U.S.

Army RDECOM/ARDEC. The HyperX multicore parallel processor was designed to meet the requirements of military field operations, where soldier-wearable and mobile communication devices need to be both programmable and capable of storing, processing, and retrieving massive amounts of data.

HyperX processing is done either serially or in parallel with multiple programs operating simultaneously. The chip handles massive amounts of data more efficiently than any multicore processor on the market. Commercial users of HyperX processors report a reduction in power consumption by a factor of 10 and a 10x improvement in performance, as well as reduced chip counts.

The transfer and commercialization of HyperX included a series of SBIR contracts between ARDEC and Coherent Logix (Austin, TX) and other T2 tools including an MOU to transition the technology into additional Department of Defense locations.

Throughout the transfer, Dr. Willson, Coherent Logix's CEO Mr. Michael Doerr, and Dr. Robert Reuss, HyperX program manager for DARPA, worked together to advance the technology and attract venture capital funding. Today the HyperX processor chip is the cornerstone of Coherent Logix's portfolio of commercial products with 29 related patents.

Among the multiple commercial products now with embedded HyperX technology are ixMax, the world's first carrier-class cognitive radio network, and small cell consumer and commercial wireless communications equipment from Public Wireless.

Navy Technology Aids First Responders on the Scene of Emergencies

"The events of 9-11-2001 revealed that the FDNY did not have a reliable method to account for all members responding to an incident."

That short but laden statement by Edward Baggott, Deputy Assistant Chief with the Fire Department of New York (FDNY), sums up one of the greatest problems for first responders. Who exactly is on a scene? Where are they? Are they safe?

With input from FDNY, the Naval Research Laboratory's Force Protection/Emergency Response (FP/ER) team developed the "EBF-4," or electronic riding list, to do precisely that. The "Active-RFID Tracking System for First Responders" is comprised of a Radio Frequency Identification (RFID) tag worn by the firefighter, a special RFID reader and mobile data terminal installed in the response vehicle, and an RFID server at headquarters, connected via cellular network. When a crew boards an RFID-equipped vehicle, the system reads the tags and transmits the list of names to headquarters. Now, a battalion chief can instantly compile a list of personnel at an incident, segregated into present and working on or near the truck, and present on the scene but out of range, presumably in the building. This puts FDNY light years ahead of where it was on 9-11.

To date, the system has been installed in 15 vehicles and 15 companies across the Department Work For Outside Parties Agreements between NRL and FDNY and a non-exclusive, royalty-free license agreement were the mechanisms used to transfer the RFID tracking system, a stellar example of the ways technology transfer returns vitally important benefits to the nation.

Improved Fuel Injectors and Consumer Electronics among Benefits of Navy Laser Technology

The Naval Surface Warfare Center (NSWC) Crane Division engaged in a highly successful transfer of ultrashort pulse laser technology that is yielding substantial commercial and military benefits.

Ultrashort pulse lasers deliver electromagnetic pulses measured in femtoseconds, a time span so brief that the pulses alter the way light interacts with matter. One of the key attributes of these pulses is that, unlike conventional lasers, they produce no heat and do not damage the targeted material beyond the intended extent. This capability enables ultrashort pulse lasers to remove material more cleanly and precisely than ever before possible.

An Education Partnership Agreement with the Rose-Hulman Institute of Technology allowed students to experiment with the laser in designated materials-processing applications. A Partnership Intermediary Agreement established Pennsylvania State University's Electro-Optics Center as a conduit through which ultrashort pulse laser technology and intellectual property moves into the Center's consortium of electro-optics companies, laboratories, and universities. Numerous CRADAs have helped outside partners gain access to lasers and other specialized expertise, equipment, and facilities at NSWC Crane. These T2 mechanisms were supported by nearly $16 million in more than 34 SBIR/STTR and other awards to support the work of small businesses engaged in the development, refinement, and productization of new ultrashort pulse laser applications.

This technology transfer activity has resulted in the start-up of two new businesses and the development of novel applications in both the commercial and military sectors. Automotive fuel injectors are now being cut so precisely that they deliver 30-percent greater fuel efficiency; more precise eye surgery is being performed with less risk; glass screens on consumer electronics are being made much stronger. Ultrashort pulse lasers also have many defense applications, most of which are classified, but include deterring enemy threats.

Licensing of NSA Technology Launches a Company and Provides Critical Network Security

The transfer of the patented NSA Wireless Intrusion Detection System (WIDS) to Baltimore-based Integrata Security stands as an excellent example of how intellectual property is moved from the lab to market.

NSA's patented WIDS is the world's most advanced cybersecurity solution for wireless local area networks (LANs). Unlike traditional WIDS, which channel-hop leaving networks periodically exposed to undetected attack, NSA's technology continuously monitors all Wi-Fi channels all of the time. This level of protection is critical given the increasing numbers of sophisticated cyber-attacks, particularly for the nation's defense, finance, energy, healthcare, and other high-risk industries. Many in these sectors had avoided any use of wireless networks due to risk exposure.

WIDS was invented by Ms. Kristen Matlock, a computer systems researcher, in response to a DoD directive that its wireless LANs had defense in depth. It was transferred to Integrata in September 2013; just months after Integrata approached the NSA Technology Transfer Program in search of Federal cybersecurity IP to commercialize.

Since the transfer, Integrata has secured $1.5 million in commercial business in wireless network security. The company has also created 10 new jobs and strengthened the regional economy through partnerships with area manufacturing companies.

Department of Energy (DOE)

The Department of Energy's 17 national laboratories and several of its facilities conduct much of its fundamental and applied research, and they license to and collaborate with industry and academia to develop and commercialize a wide spectrum of products and processes for commercial use. Technology partnering has been an important focus for DOE technology transfer, and it is a significant means for DOE laboratories and facilities to engage Federal, private, and academic entities in arrangements to advance the process of technology development and commercialization. These arrangements leverage capabilities of DOE's top-notch scientists and world-class facilities, including national user facilities, computational facilities, and science laboratories with industrial research and production facilities.

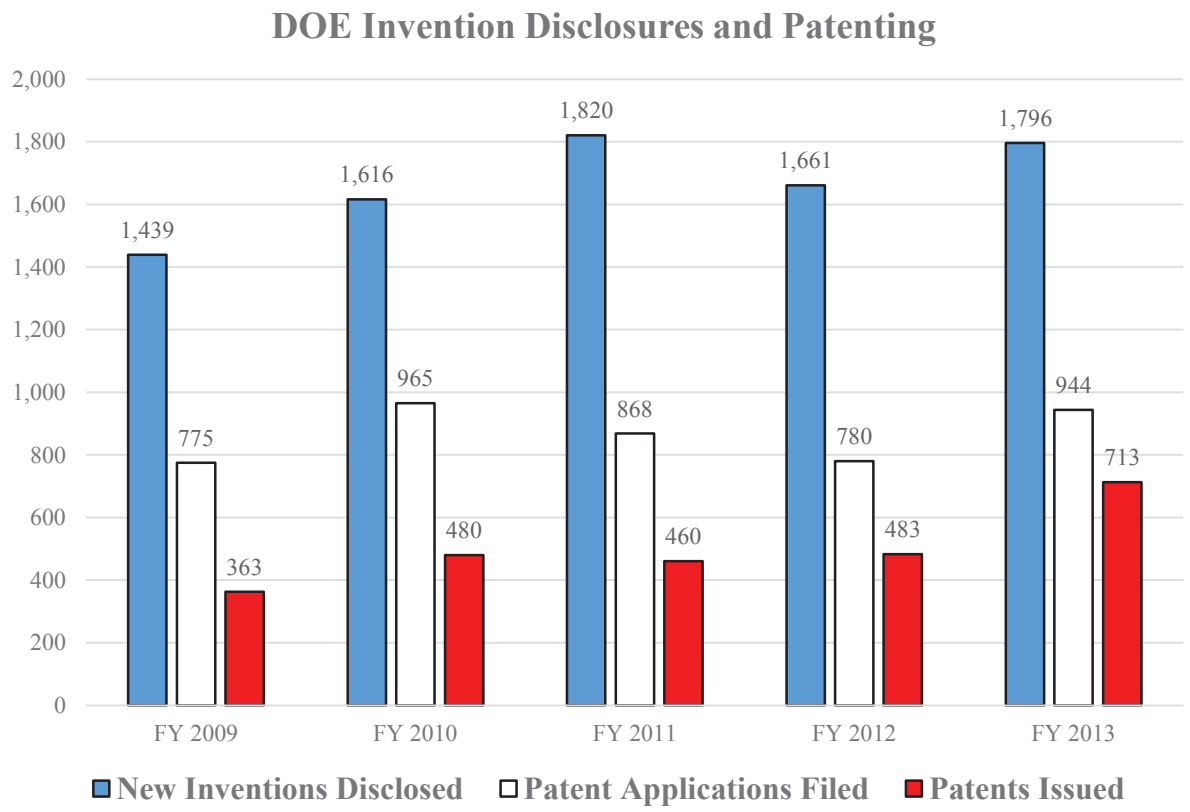
The Department oversees the construction and operation of some of the Nation's most advanced research and development user facilities, located at national laboratories and universities. These state-of-the-art facilities are shared with the science community worldwide and offer some technologies and instrumentation that are available nowhere else. In fiscal year 2013, these facilities were used by more than 17,000 researchers from universities, national laboratories, private industry, and other Federal science agencies.

More information about DOE's technology transfer activities is available on the following website:

- http://energy.gov/technologytransitions/office-technology-transitions.

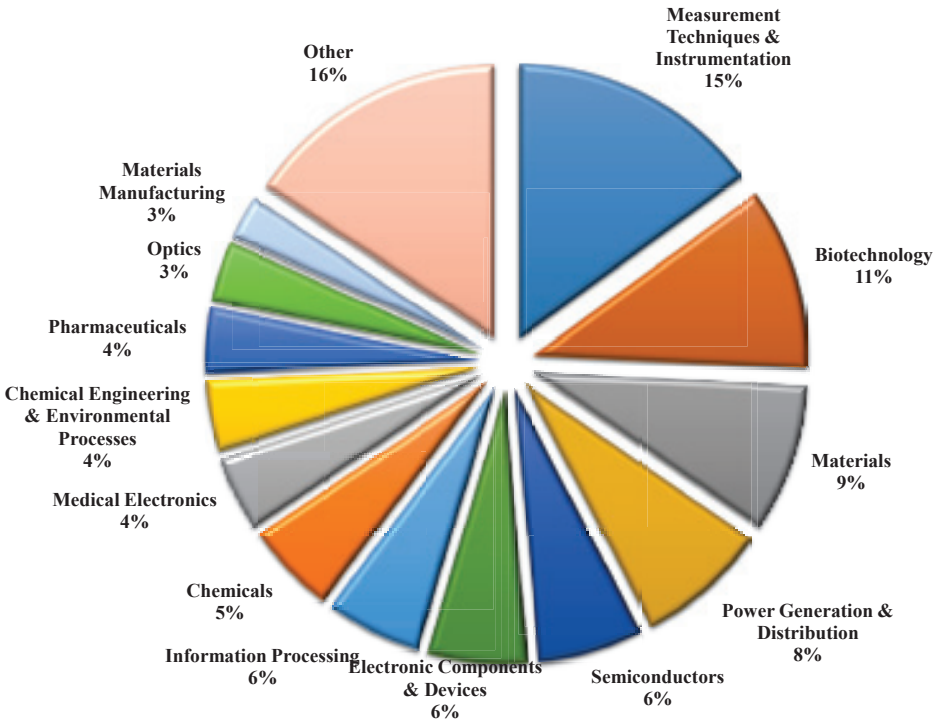
DOE Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased by 25% to 1,796. Also during this period, the number of patent applications increased 22% to 944 and the number of patents issued to the department increased by 96% to 713.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	1,439	1,616	1,820	1,661	1,796
Patent Applications Filed	775	965	868	780	944
Patents Issued	363	480	460	483	713

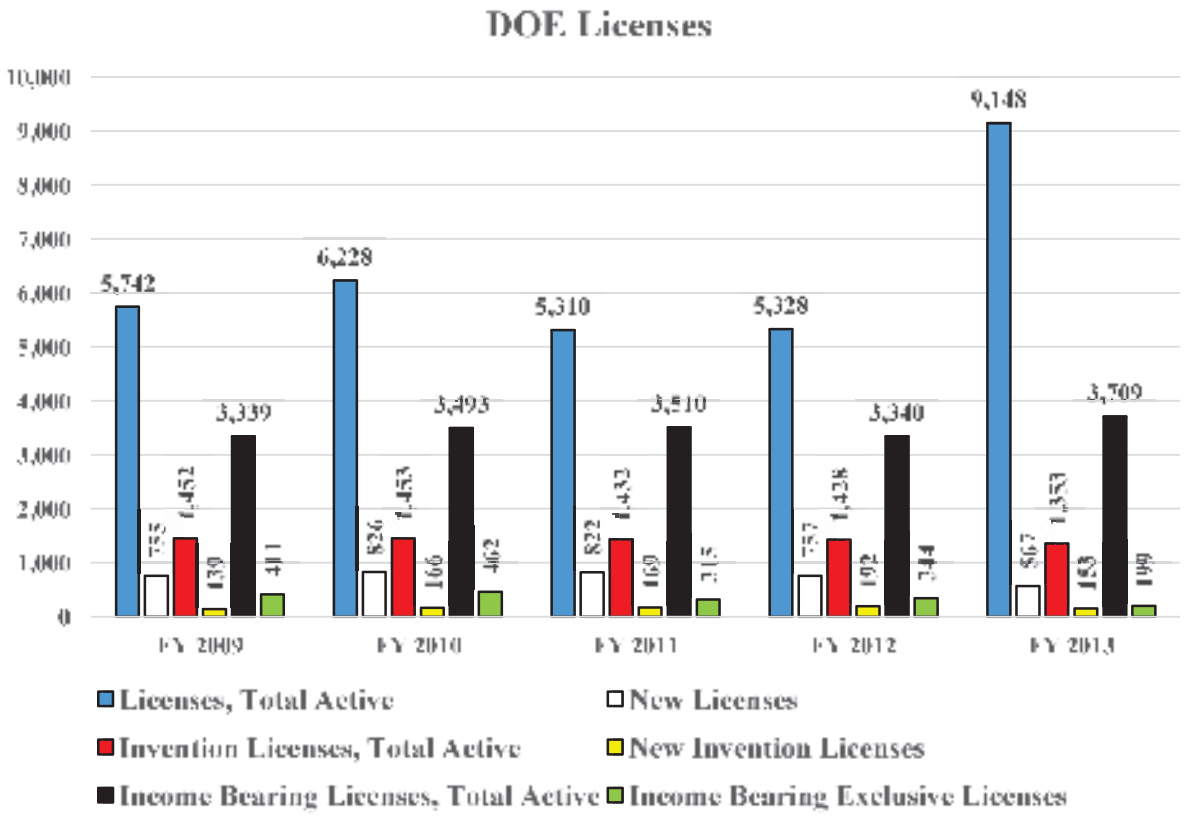
USPTO Patents Assigned to DOE by Technology Area: FY 2013[37]



[37] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DOE Licenses

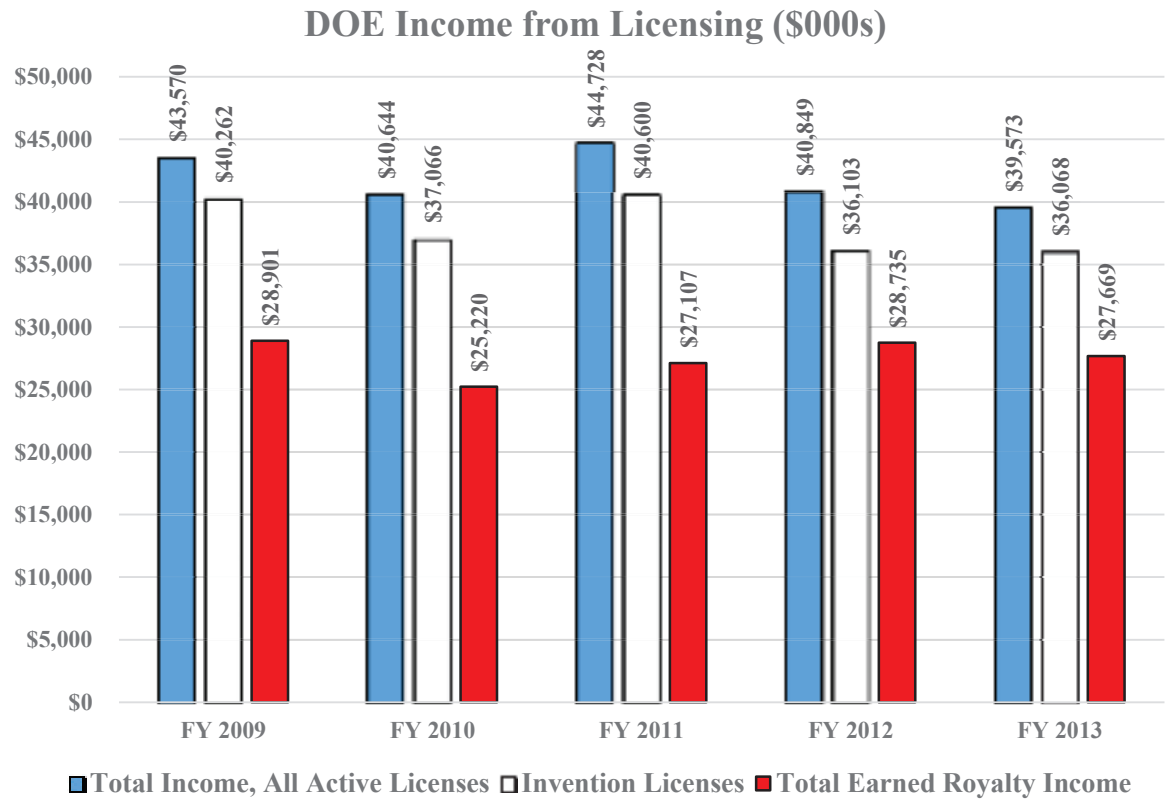
Between FY 2009 and FY 2013, the number of total active licenses grew by 59% to 9,148 licenses. Also during this period, the number of new licenses decreased by 25%. Invention licenses experienced a 7% decrease in the total number of active licenses, but a 10% increase in the number of new licenses. The total number of income bearing licenses increased by 11%, and there was a 52% decrease in the number of income bearing exclusive licenses.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	5,742	6,228	5,310	5,328	9,148
New Licenses	755	826	822	757	567
Invention Licenses, Total Active	1,452	1,453	1,432	1,428	1,353
New Invention Licenses	139	166	169	192	153
Income Bearing Licenses, Total Active	3,339	3,493	3,510	3,340	3,709
Income Bearing Exclusive Licenses	411	462	315	344	199

DOE Income from Licensing

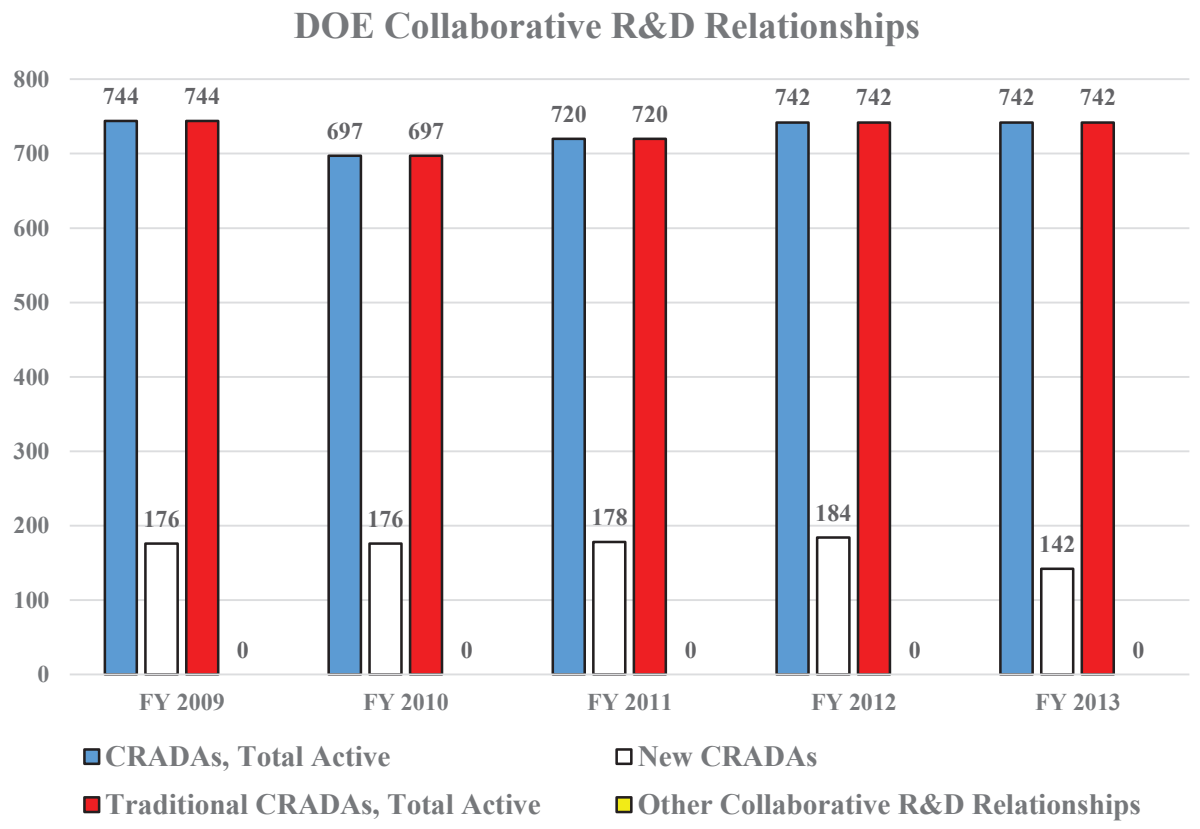
Between FY 2009 and FY 2013, the number of total income for all active licenses decreased by 9% to $39.5 million in FY 2013. Invention licensing income decreased by 10% to $36 million. Total earned royalty income decreased 4% to $27.7 million.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$43,570	$40,644	$44,728	$40,849	$39,573
Invention Licenses	$40,262	$37,066	$40,600	$36,103	$36,068
Total Earned Royalty Income	$28,901	$25,220	$27,107	$28,735	$27,669

DOE Collaborative R&D Relationships

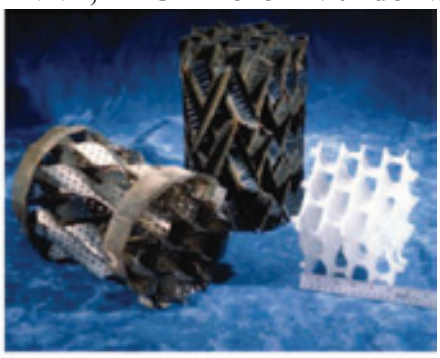
Between FY 2009 and FY 2013, the number of total active CRADAs remained practically consistent, with a decrease of 0.27% to 742. The number of new CRADAs decreased by 19.3% to 142 agreements in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	744	697	720	742	742
New CRADAs	176	176	178	184	142
Traditional CRADAs, Total Active	744	697	720	742	742
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

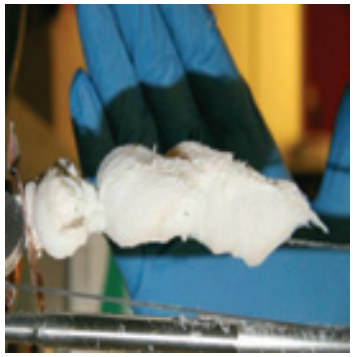
BNNT, LLC – Boron Nitride Nanotube (BNNT)



To create a better packing for geothermal condensers, NREL researchers modeled and tested a variety of structures. Credit: NREL

In May 2013, BNNT, LLC, a Newport News, Virginia start-up, began construction of the world's first commercial factory dedicated to the manufacture of Fibril Boron Nitride Nanotubes, "Fibril BNNT™." With similar commercial applications as carbon nanotubes, Boron nitride nanotubes are equally strong yet much more heat resistant and easier to synthesize.

Fibril BNNT™ is a super-strong, heat-resistant, textile-like polymer with the appearance of cotton, but a molecular backbone 100 times stronger than steel. It can withstand temperatures over 800 degrees centigrade and is expected to attract a broad range of customers in the nanotube materials sector. Applications are projected to range from aerospace heat shields to cancer therapies as well as to be used as a spray or coating. Additionally, BNNT also plans to make and sell the material for scientific investigations, commercial product R&D, and various other commercial products. Initial shipping of product is anticipated in early 2014.



The techniques for synthesizing Fibril BNNT™ were developed at the U.S. Department of Energy's Jefferson Lab in Newport News, Virginia in collaboration with NASA Langley Research Center and the National Institute of Aerospace using the Office of Naval Research funded Free-Electron Laser.

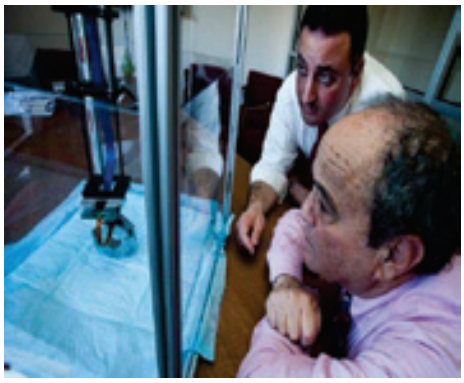
SPX Heat Transfer, LLC – Advanced Direct Contact Condenser (ADCC)

SPX Heat Transfer, LLC, is a provider of turnkey solutions to the power generation industry. Based in Tulsa, OK, SPX relies on a commercial patent license from NREL for their market leading condensers for use in the geothermal power sector.

Geothermal power plants typically generate steam from pumping underground fluids into a power plant. However, geothermal fluids typically compromise water and a variety of potential pollutants, including non-condensable gases such as ammonia, hydrogen sulfide, and methane. Because of these contaminants, vapor exhaust into the atmosphere is usually prohibited for environmental reasons.

To facilitate separation of water from the pollutants, NREL developed an improved condenser for commercial use. This condenser includes a contact medium that encourages contact between the vapor and cooling liquid, a relatively short and straight vapor flow path to minimize backpressure and pressure loss, and a separate hot well for effluents containing relatively high concentrations of non-condensable gases. Relatively inexpensive to build and easy to maintain, this design provides several desirable characteristics for commercial application. NREL licenses the technology to SPX, which uses it at several geothermal facilities nationwide.

WattJoule Corporation – Advanced Batteries for Renewable Energy Storage
WattJoule Corporation provides next generation disruptive flow batteries for use in renewable energy systems. Based in Lowell, MA, WattJoule relies on a commercial patent license from PNNL for their redox flow battery technology.



Redox flow batteries can help store large amounts of renewable energy and improve the reliability of the nation's power grid. Researchers at PNNL, which is managed by Battelle, have made significant progress in improving the performance of redox flow technologies since their development in the 1970s. PNNL developed novel vanadium electrolytes that overcome the limitations of earlier redox flow batteries, such as limited temperature range and high cost of production. The result is a dramatically improved operating temperature range, higher energy density and lower cost for vanadium redox flow batteries.

WattJoule plans to combine its own proprietary technology with PNNL's to develop an energy storage platform for a broad variety of energy companies, including those involved in wind and solar power. This is the third and final license granted for PNNL's technologies to all-vanadium, mixed acid redox flow battery developers.

SynchroPET – Medical Imaging and Diagnostics
Additional Licensees – ASICS use in Medical Devices; Cardiovascular Therapy and Diagnostics
SynchroPET, a start-up provider of medical imaging and diagnostics, licenses several technologies from BNL for use in their products. The company executed a commercial license with Brookhaven Science Associates (BSA) to commercialize BNL's Positron Emission Tomography (PET) technology. The company is BNL's first customer under a program that started last year in conjunction with the Long Island Association (LIA).

The compact modular PET detector was invented and developed by the collaborative efforts of a team of BNL researchers from the medical, instrumentation, and physics departments. The technology is covered by four patents.

SychroPET's owners, Marc Alessi and Burke Liburt, signed a commercial licensing agreement in late December with the lab. It is the first of what the lab and the LIA, Long Island's largest business and civic organization, hope will be many such deals. BNL and LIA officials see such arrangements as a prime way of creating new companies and jobs on Long Island. Alessi and Liburt took an option on RatCap, an imaging system aimed at diagnosing diseases in small animals while allowing the animals to

remain awake. Alessi said the technology could also be used to study Alzheimer's and other diseases.

In August, the Lab and LIA displayed several technologies under a program in which the cost of optioning a technology was substantially reduced. Through this effort, BNL has been able to advance discussions with other potential licensees. For example, Company A licensed several inventions related to Compositions and Methods for manufacture of High-Specific Activity and no-carrier added radionuclides for use in cardiovascular diagnostic and therapeutic applications, while Company B hopes to execute a commercial license for Application-specific integrated circuit (ASICS) technology for use in medical devices.

Department of Health and Human Services (HHS)

Research at the Department of Health and Human Services is conducted by the Centers for Disease Control and Prevention (CDC), the Food and Drug Administration (FDA), and the National Institutes of Health (NIH).

The NIH has as its mission the conduct and support of biomedical research to improve the public health. The NIH Office of Technology Transfer (OTT) is responsible for identifying, evaluating, protecting, and marketing technologies derived in NIH intramural laboratories. OTT transfers these technologies through licenses to the private sector, where they can be further developed into products used in the prevention, diagnosis, or treatment of disease.

NIH's annual technology transfer report is available online at:
http://www.ott.nih.gov/sites/default/files/documents/pdfs/AR2013.pdf.

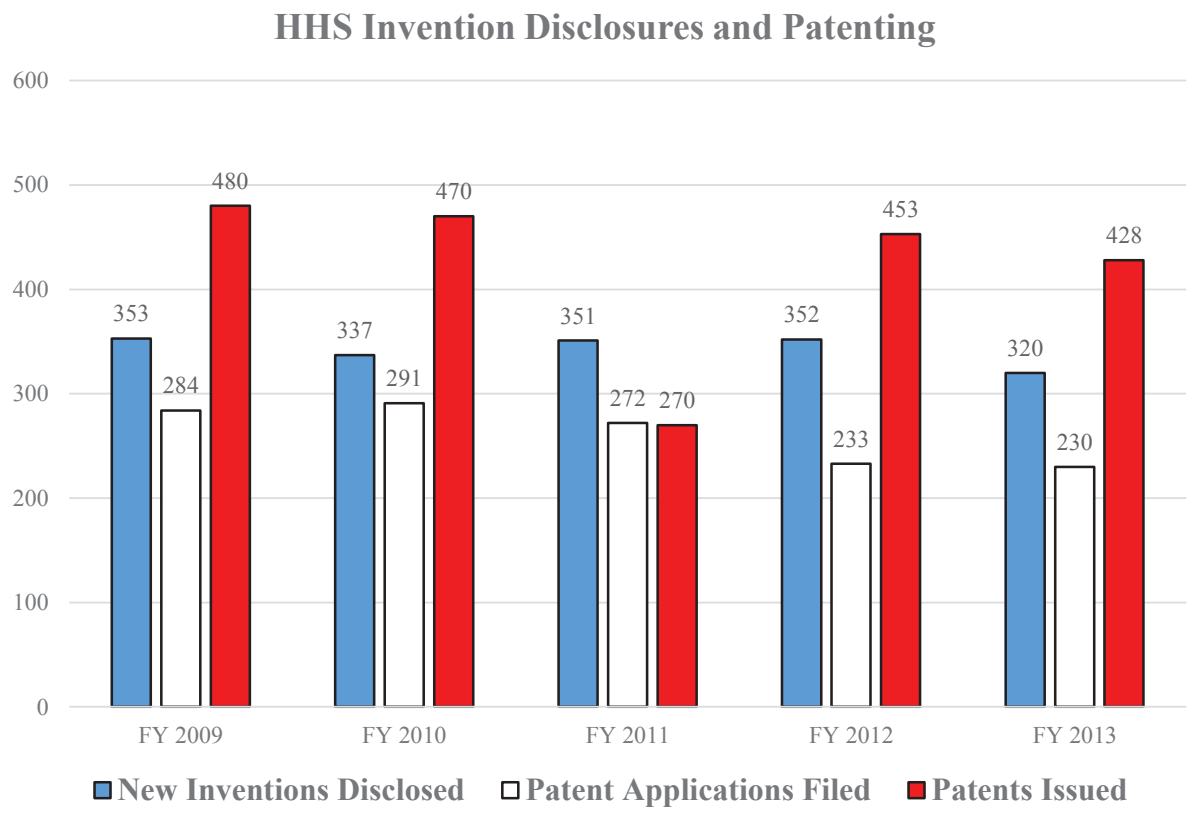
More information about HHS technology transfer activities is available on the following websites:

- CDC: http://www.cdc.gov/od/science/technology/;
- NIH: http://www.ott.nih.gov/; and
- FDA: http://www.fda.gov/ScienceResearch/CollaborativeOpportunities /default.htm.

Effectively measuring the public health outcomes that result from such technologies is challenging and complex. Traditionally, efforts to measure the effect of technology transfer activities focus on outputs such as the number of patents and licenses or the amount of royalties generated. However, this approach does not depict the full scope of activities and may distort the importance of ensuring that novel biomedical inventions are commercialized.

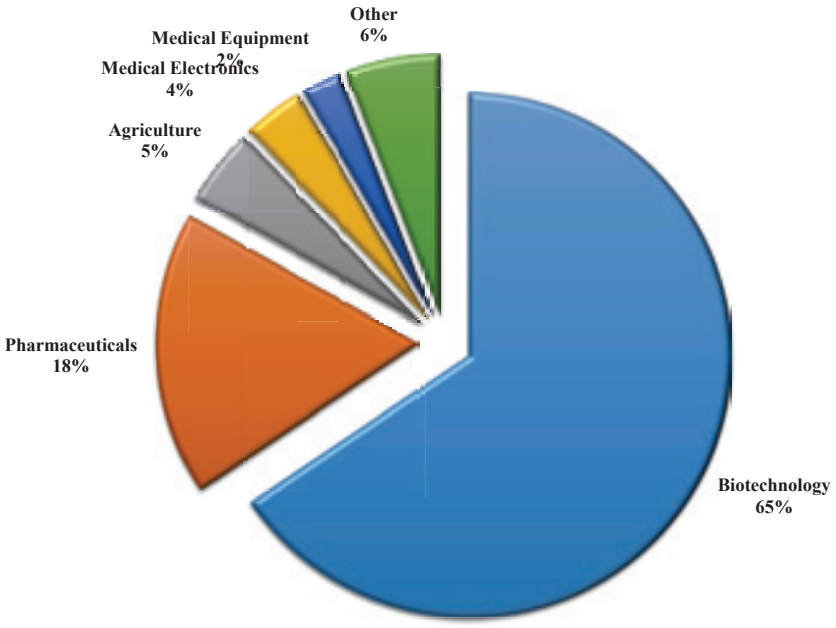
HHS Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed decreased by 9% to 320 disclosures in FY 2013. The number of patent applications filed decreased by 19% during the five-year period to 230 applications. The number of patents issued decreased by 11% to 428 patents in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	353	337	351	352	320
Patent Applications Filed	284	291	272	233	230
Patents Issued	480	470	270	453	428

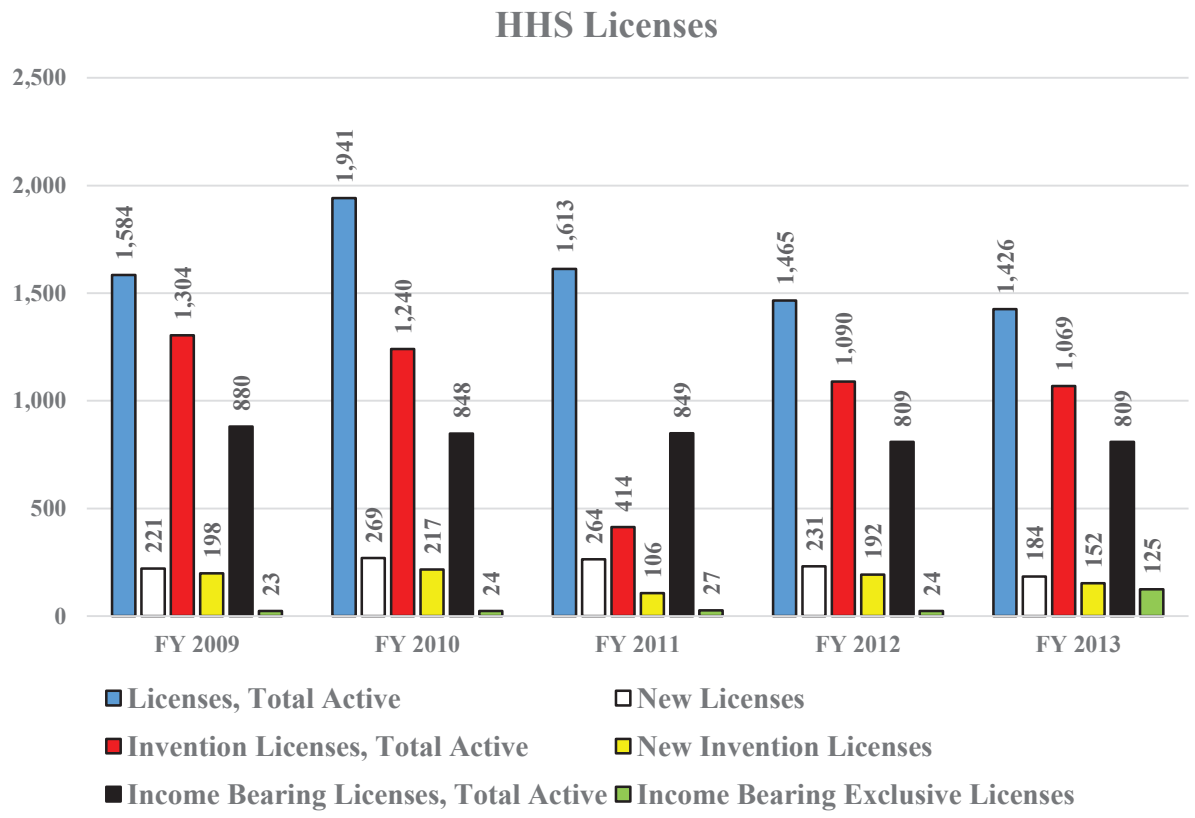
USPTO Patents Assigned to HHS by Technology Area: FY 2013[38]



[38] Source: National Science Foundation and The Patent Board™ (see footnote 5).

HHS Licenses

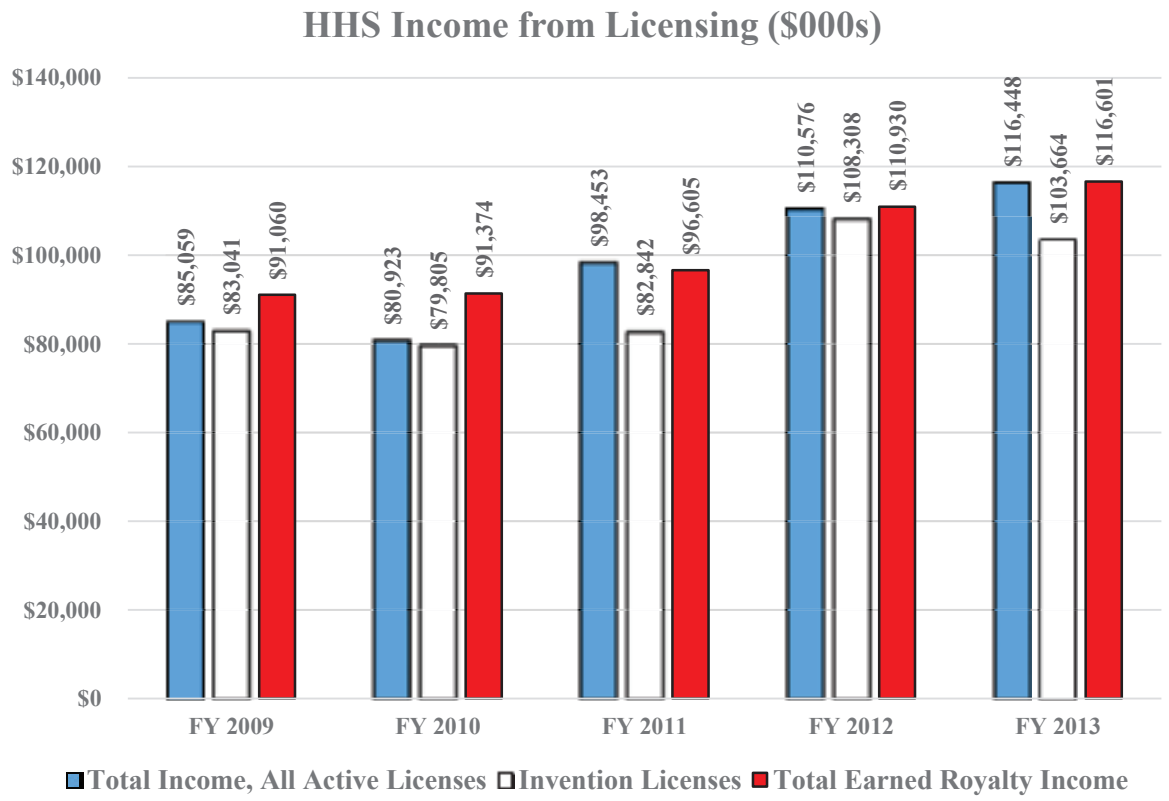
Between FY 2009 and FY 2013, the number of total active licenses decreased by 10%, totaling 1,426 licenses in FY 2013. Invention licenses experienced a decrease in total active licenses and the number of new licenses per year, with an 18% and 23% decrease, respectively. The number of income bearing exclusive licenses, on the other hand, did increase by 443%, from 23 licenses in FY 2009 to 125 licenses in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	1,584	1,941	1,613	1,465	1,426
New Licenses	221	269	264	231	184
Invention Licenses, Total Active	1,304	1,240	414	1,090	1,069
New Invention Licenses	198	217	106	192	152
Income Bearing Licenses, Total Active	880	848	849	809	809
Income Bearing Exclusive Licenses	23	24	27	24	125

HHS Income from Licensing

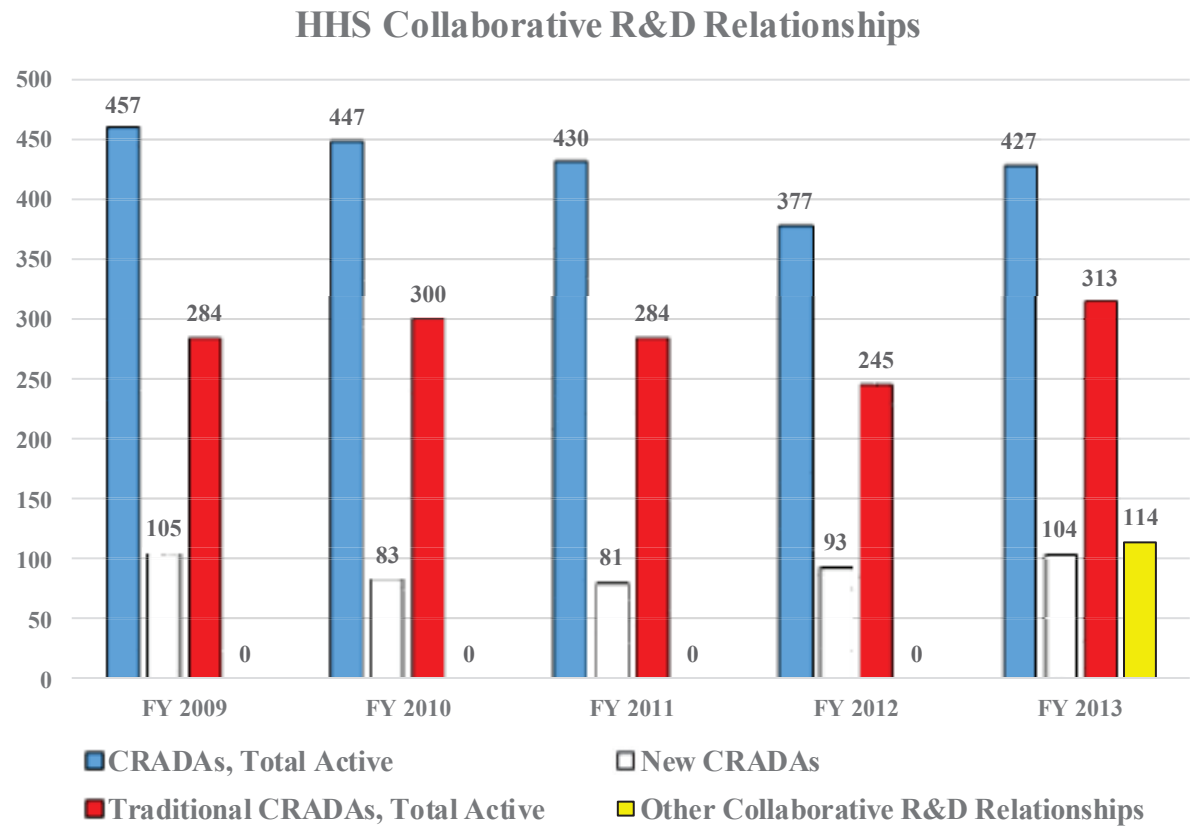
Between FY 2009 and FY 2013 the total income for all active licenses increased by 36.9% from $85 million to $116.4 million. Invention licensing income also experienced an increase, from $83 million to $103.6 million. Earned royalty income experienced a 28.05% increase, resulting in $116.6 million.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$85,059	$80,923	$98,453	$110,576	$116,448
Invention Licenses	$83,041	$79,805	$82,842	$108,308	$103,664
Total Earned Royalty Income	$91,060	$91,374	$96,605	$110,930	$116,601

HHS Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs decreased by 6.56% from 457 agreements to 427 agreements. Total active traditional CRADAs increased 10.21% during the five-year period, reaching 313 CRADAs in FY 2013, compared to 284 agreements in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	457	447	430	377	427
New CRADAs	105	83	81	93	104
Traditional CRADAs, Total Active	284	300	284	245	313
Other Collaborative R&D Relationships	0	0	0	0	114

HHS Downstream Success Stories

National Institutes of Health (NIH)

Deep Transcranial Magnetic Stimulation Coil and Therapy System for Neuropsychiatric Disease

Scientists at the National Institute of Neurological Disorders and Stroke (NINDS) and at the National Institute on Drug Abuse (NIDA) at NIH developed a new medical device utilizing transcranial magnetic stimulation (TMS) for use as a non-systemic, non-invasive, and non-surgical system for the treatment of neuropsychiatric diseases. Licensed by Brainsway, Inc., the success of the new device is in the use of a new coil design (termed the Hesed coil or H-coil) that is designed to stimulate deeper brain regions without increasing the electrical field intensity in the superficial cortical regions.

The H-coil dTMS system addresses an unmet need in medicine to treat patients suffering from depression, ADHD, and addictive disorders non-invasively without the side effects typically exhibited by pharmaceutical interventions. Brainsway continues to investigate the uses of the dTMS system for other neuropsychiatric diseases. Using the licensed technology, the company has begun a double-blind Phase II clinical trial of therapeutic dTMS stimulation of patients with schizophrenia and bi-polar disorder and on acute and maintenance treatments of drug-resistant depressive episodes.

The rapid marketing success of Brainsway's dTMS system and its current human use worldwide is evidence of successful public-private collaboration for the transfer of innovative technologies initiated at a Federal lab and developed in the marketplace to benefit improving public health.

Interleukin-2 Receptor Gamma Deficient Mice -- Widely Used Research Tools

Scientists at the National Heart, Lung, and Blood Institute (NHLBI) at NIH created an interleukin-2 receptor gamma chain (IL-2Rg) deficient mouse. IL-2 is a cytokine with broad actions on lymphocyte proliferation, differentiation, and survival. NHLBI had demonstrated that mutations in the gene encoding IL-2Rg result in X-linked severe combined immunodeficiency (XSCID) in humans and that IL-2Rg is a subunit common to multiple cytokine receptors. Patients with XSCID are immunocompromised and prone to infection. The IL2Rg-deficient mouse created at NIH provides a unique animal model, the first of its kind, to study X-linked severe combined immunodeficiency and other immune deficiencies. In addition, the mouse model can also be used as a parent to create new mutant mice harboring double or even triple mutations for the studies of a wide variety of diseases.

This mouse model provides a valuable tool for the research community to study various disease mechanisms, as well as for corporate drug discovery and development. It has been broadly disseminated to a variety of companies through non-exclusive licensing which allows wide distribution and availability of the materials for potential commercial applications.

Food and Drug Administration (FDA)

New Low-cost Meningitis Vaccine for Sub-Saharan Africa

Meningococcal meningitis, a bacterial infection of the brain that sweeps across sub-Saharan Africa in an area called the "meningitis belt", is now losing its power to inflict illness and death. Scientists and technology transfer officers from the Food and Drug Administration (FDA) along with technology transfer officers from the National Institutes of Health (NIH) made a critical contribution in developing and transferring the technology needed to manufacture a vaccine against this terrible disease and at an affordable cost for African nations like Burkina Faso, Chad, Ethiopia, and Niger. Meningitis can be prevented with vaccination, but the technology is complex and generally beyond the capacity of scientists in most developing countries.

Under a novel partnership mechanism organized by PATH (Program for Appropriate Technology in Health), NIH licensed a conjugate vaccine technology developed by Dr. Che-Hung Robert Lee and Dr. Carl Frasch of the FDA to PATH who worked with the Serum Institute of India, which agreed to produce the vaccine cheaply in exchange for technical know-how. The collaboration agreement was described in SciDev.Net as an "intriguing model" of vaccine development in developing countries, in which a vaccine with specific characteristics tailored to a particular population is developed at a modest cost and provisions to ensure sustainable access are built in from the start.

The contribution of both the FDA and the NIH to a major health care project in Africa also underscores the recognition by both agencies that infectious diseases know no borders. Protecting human health globally is linked to the FDA and NIH core mission of protecting human health in the United States.

Centers for Disease Control and Prevention (CDC)

Rapid Development of a Diagnostic Test for H1N1 Influenza for "Swine Flu" Pandemic

First described by the CDC influenza team, H1N1 was dubbed "swine flu" for its unique combination of influenza virus genes not previously identified in animals or people. By April 23, 2009, H1N1 cases increased in multiple countries and human-to-human spread of the virus was ongoing. CDC scientists helped public health laboratories rapidly identify the 2009 H1N1 virus in patient samples by developing a RT-PCR test. The diagnostic test was cleared for use by the FDA under an Emergency Use Authorization (EUA) less than two weeks after identification of the new pandemic virus. Subsequently, the CDC began shipping test kits to domestic and international public health laboratories under Material Transfer Agreements (MTAs).

As the number of cases swelled, the CDC Laboratory Support for Influenza Surveillance (CLSIS) website was launched to accommodate the volume of requests for the test kit. The SharePoint site is still used today to handle all influenza outbreaks and provide important information about site visitors.

Subsequently, the first commercial license agreements were negotiated and executed by CDC. The commercial agreements included the diagnostic oligonucleotide primer and probe sets for H1N1 as well as patented influenza panel test kits that allow for universal detection of all influenza type A and type B viruses and the identification of the HA genes for a variety of influenza A viruses.

Department of Homeland Security (DHS)

The DHS's Office of Research and Technology Applications (ORTA) is housed in the Science and Technology Directorate. The ORTA is responsible for developing and instituting policies to facilitate technology transfer in accordance with 15 USC 3710 throughout DHS and its laboratories. The ORTA's responsibilities include:

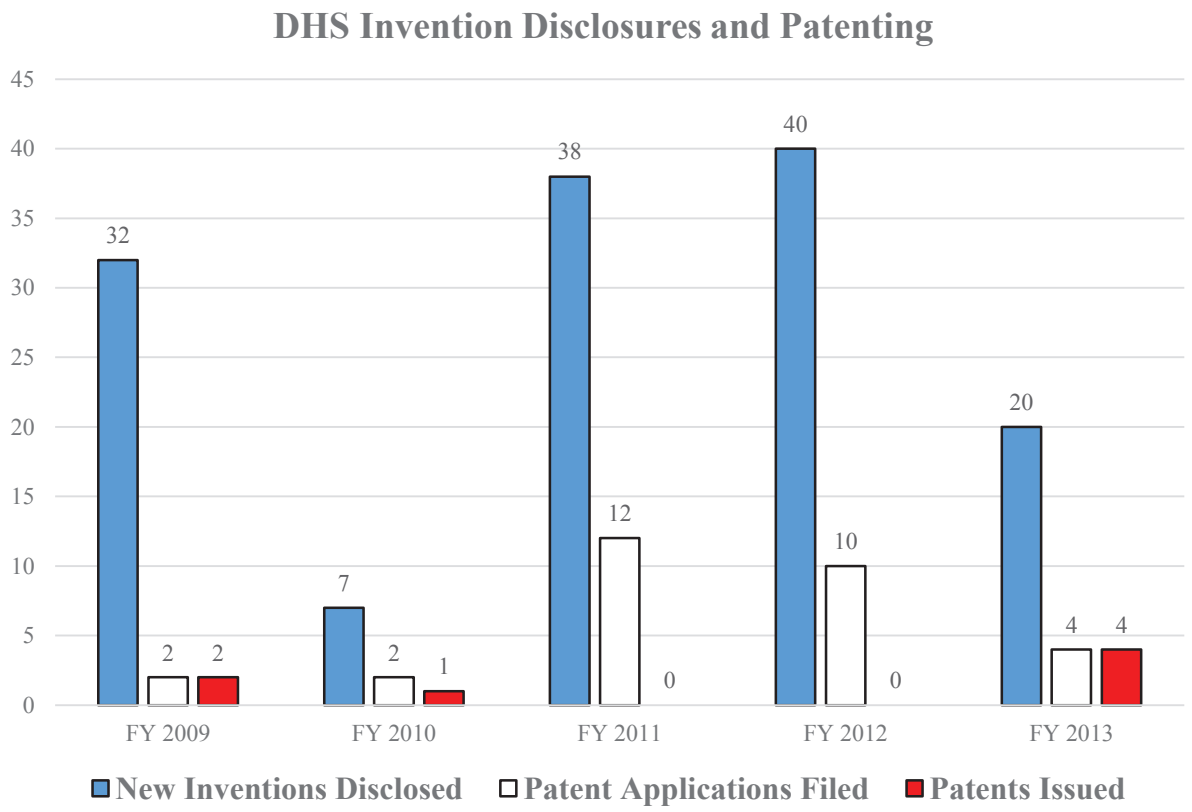
- Standardizing and approving DHS CRADAs, licensing, and other technology transfer agreements;
- Preparing application assessments for selected research and development projects in which the DHS Laboratory is involved and may have commercial applications;
- Providing and disseminating information on federally owned or originated technologies which have potential application to State and local governments and private industry;
- Preparing and providing an annual report to Congress and the President through submission to NIST;
- Developing training programs on technology transfer and intellectual property for DHS employees; and
- Establishing an intellectual property program for DHS to track and prosecute patents and other intellectual property and to develop a royalty and rewards policy.

More information about DHS technology transfer activities is available on the following website:

http://www.dhs.gov/technology-transfer-program.

DHS Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed decreased by 38% from 32 disclosures to 20 disclosures. Also during this period, the number of patent applications filed and patents issued both increased by 100%.



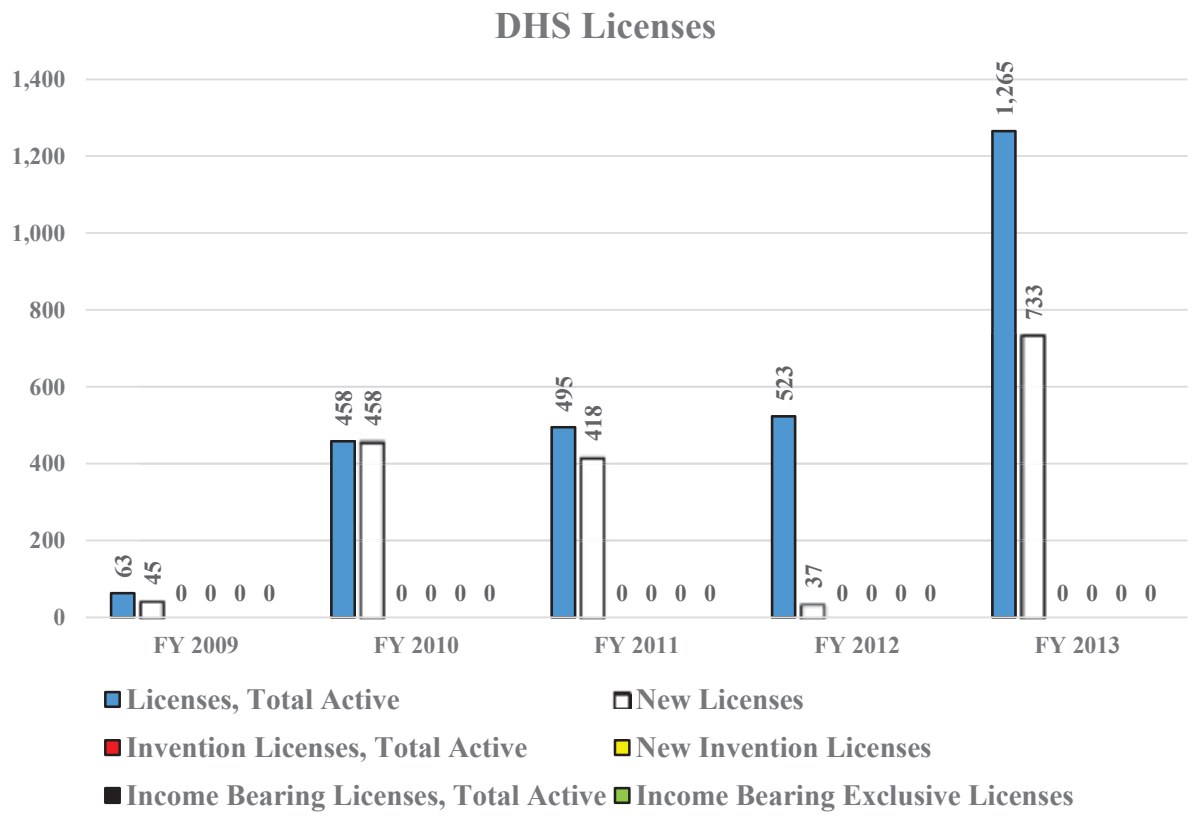
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	32	7	38	40	20
Patent Applications Filed	2	2	12	10	4
Patents Issued	2	1	0	0	4

Data from the USPTO identifies the patent(s) issued to DHS are in the technology area of Electronic Components & Devices.[39]

[39] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DHS Licenses

Between FY 2009 and FY 2013, the number of total active licenses increased by 1,908% from 63 licenses to 1,265. The number of new licenses per year also increased, from 45 new licenses in FY 2009 to 733 licenses in FY 2013.



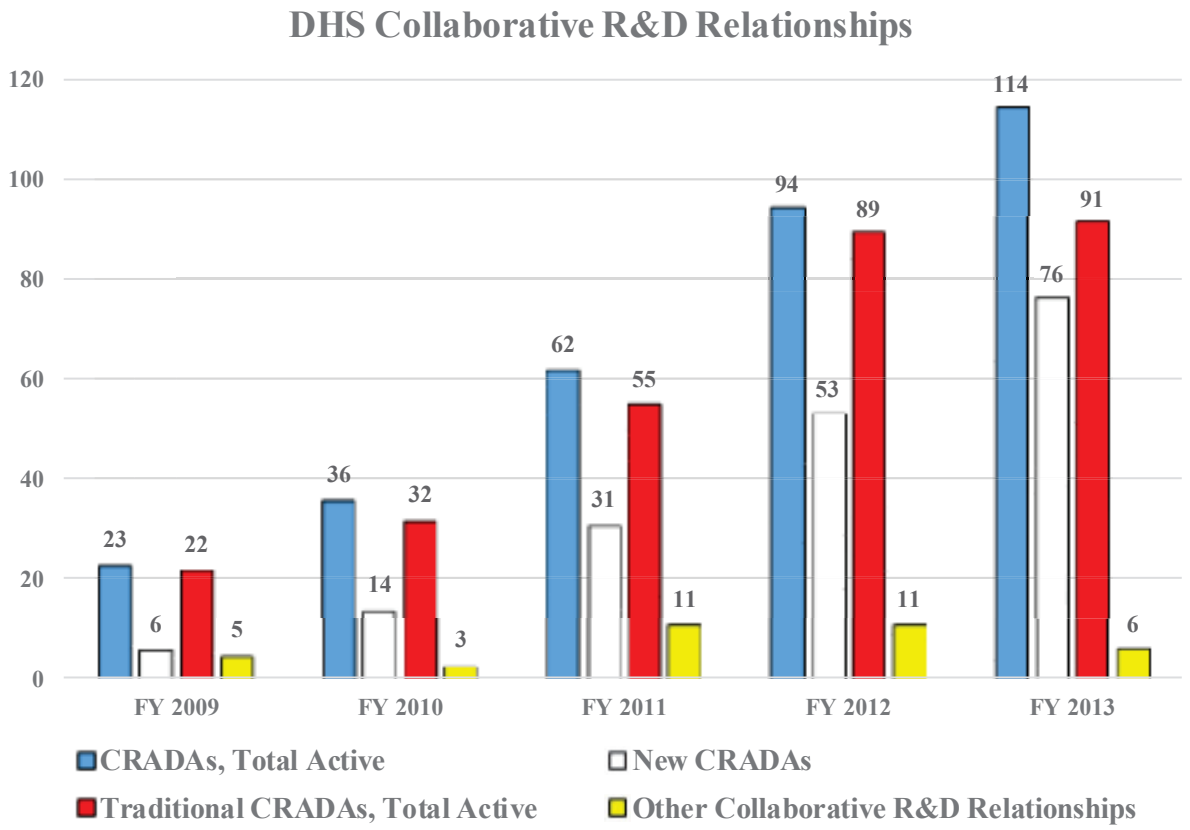
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	63	458	495	523	1,265
New Licenses	45	458	418	37	733
Invention Licenses, Total Active	0	0	0	0	0
New Invention Licenses	0	0	0	0	0
Income Bearing Licenses, Total Active	0	0	0	0	0
Income Bearing Exclusive Licenses	0	0	0	0	0

DHS Income from Licensing

DHS reports zero licensing income between FY 2009 and FY 2013.

DHS Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs increased by 396% from 23 agreements to 114 agreements. The number of new CRADAs per fiscal year increased 1,167% by FY 2013, to 76 agreements. Total active traditional CRADAs increased 314% during the five-year period, reaching 91 CRADAs in FY 2013, compared to 22 agreements in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	23	36	62	94	114
New CRADAs	6	14	31	53	76
Traditional CRADAs, Total Active	22	32	55	89	91
Other Collaborative R&D Relationships	5	3	11	11	6

DHS Downstream Success Stories

Certification Test Services for the Transportation Security Administration

The Transportation Security Administration (TSA) seeks X-ray based Explosive Detection Systems (EDSs) for checked airline baggage that can meet new, more stringent detection requirements. The Transportation Security Laboratory (TSL) provided technical assistance to six different EDS vendors to help them get their EDSs through development testing and prepare for formal certification testing. TSL conducted the certification tests that provided TSA with critical detection performance information.

EDS Certification Testing

The TSL established CRADAs with industry partners to conduct certification testing on 11 EDSs, and the results helped TSA choose systems that meet the new, more stringent explosives detection performance requirements. More certification testing will take place in FY 2014.

> *I wanted to let you know what a great job TSL does in working with the vendors to provide meaningful data in a timely manner that helps us improve product performance. I especially appreciate working with a team that understands our products in depth and can engage at a meaningful technical level. Thank you for your team's assistance in our cooperative development efforts.*
>
> - *Dawn Golden, Director, Programs, L-3 Communications*

Qualification Test Services for the Transportation Security Administration

TSL provides developmental assistance to technology developers that wish to get their checkpoint screening systems qualified for acquisition by the Transportation Security Administration (TSA). TSL helps vendors test their systems against an extensive collection of artfully concealed live explosives, and these evaluations allow vendors to refine their detection algorithm. TSL's Technology Optimization Partnerships (TOPs) process is a public-private partnership designed to expedite the maturation and deployment of technologies; in FY 2013, TSL entered into 15 new CRADAs with industry partners to help them mature their systems for checkpoint applications. TSL also conducts qualification testing that gives TSL critical system performance information.

Explosive Trace Detection Systems

The TSL established CRADAs with four explosive trace detection (ETD) system developers in FY 2013, providing developmental assistance with specialized test articles, technical feedback on system improvements, and qualification testing. Working with TSL, Implant Sciences became the first American qualified vendor with a non-radioactive source ETD system; when fielded, this system will greatly facilitate operations since it does not require radioactive-related regulatory compliance. TSL also entered into a CRADA with Safran/Morpho Detection for collaboration on improving their system performance and enabled TSA to install upgrades to thousands of fielded systems.

> *Recently, our small U.S. Company received approval for its ETD system, the QS B220, under the Air Cargo Screening Technology List (ACSTL). We are*

very proud of this accomplishment and wish to acknowledge the critical support that we received from the Transportation Security Laboratory (TSL). Their efforts and stewardship were focused by a common goal between our Company and the Laboratory to introduce new technology into the aviation security industry. We demonstrated that a true partnership between private industry and government has a potent impact on the expeditious introduction of new technology to the Department of Homeland Security (DHS). We are proud of this joint achievement and what it represents for the security technology industry and our nation.

- *Glenn Bolduc, Chief Executive Officer, Implant Sciences Corporation*

I wanted to write to thank [the TSL] for your perseverance, personal engagement, and ongoing communication throughout the past year. It was invaluable and [Morpho] is better off because of it."

- *Cameron Ritchie, VP, Technology and CTO, Safran/Morpho Detection Inc.*

Bottle Liquid Screeners

The TSL helps technology developers mature their Bottle Liquid Scanner (BLS) designed for use at checkpoints and directly provides support to TSA's mission to ease restrictions on liquids, aerosols, and gels. TSL gave developmental assistance, provided technical feedback to three BLS vendors with systems in various states of system maturity, and helped them collect detection data on explosive threats with which to refine their algorithms. TSL also conducted four qualification tests on BLSs for the TSA. Due to TSL's developmental support, the qualification of one BLS system enabled TSA to acquire and deploy nearly 400 systems in FY13.

Carry-On Bagger Scanners

The TSL performed developmental testing on multiple detection algorithms for four Advanced Technology-2 (AT2) checkpoint carry-on baggage scanners and provided feedback to the technology developers to help them meet the Transportation Security Administration's new, more stringent detection standards. The TSL subsequently conducted two qualification tests of AT2 systems. The results were provided to TSA and will help TSA deploy qualified systems that meet new, more stringent explosives detection performance requirements.

I just wanted to thank everyone for all their hard work […] which greatly contributed in getting the approval by DHS. [The] TSL for your support in testing, many times over, the vendors' submissions."

- *Jennifer Orr, Portfolio Manager: Carry-On Baggage Technologies, Passenger Screening Program (PSP), Transportation Security Administration*

Readiness assistance is fully supported and endorsed by the TSL Director [who] is a leading advocate for high-technology small businesses and has worked hard to ensure that we are aware […] of the processes necessary to successfully maneuver through the qualification process.

- *Dolan Falconer, President and CEO, Scantech Identification Beam Systems, LLC. Testimony Before U.S. House of Representatives Subcommittee on Transportation Security on Homeland Security*

Portable Signatures Library Development

The Transportation Security Laboratory Electromagnetic Study of Explosives group evaluated a cross-platform library of explosives signatures for spectroscopic-based detection systems and demonstrated the portability of the library across different fielded platforms for the Department of Defense's Joint Improvised Explosive Devices Defeat Organization. This capability gives first responders and war fighters the ability to download new signatures onto fielded detection systems.

Department of the Interior (DOI)

Technology transfer for the Department of the Interior (Department) includes a range of activities designed to disseminate scientific and technical information and knowledge between the Department and other Federal and non-Federal entities. It includes, but is not limited to, publications, exchange of scientific and technical information, protecting and licensing intellectual property rights, and sharing — or otherwise making available — for scientific or technical purposes the expertise and specialized scientific material and resources that the Department manages. In general, technology transfer activities within the Department are consistent with its mission to protect and manage the Nation's natural resources and cultural heritage; to make available scientific and other information about those resources; to honor trust responsibilities to Tribes; and to supply energy for the future.

The FY 2013 enacted budget for the Department of the Interior included $789.0 million for research and development. Much of the funding was for applied research ($629.8 million), while basic research and development received $51.4 million and $107.8 million, respectively. The programs supported through these funds generate large amounts of knowledge, information, and technology, which help the Department meet its mission objectives that are then transferred to resource managers, stakeholders, and the public.

The Department's bureaus have varying levels of involvement with scientific and technical research and innovation, and technology transfer. In FY 2013, as in previous years, the majority of technology transfer activities being reported by the Department under the Federal Technology Transfer Act of 1986 (FTTA) was undertaken by the U.S. Geological Survey (USGS). It is the largest research and development (R&D) organization within the Department, both in terms of budget and personnel, and it typically accounts for about 80% of the Department's R&D budget.

The Department's scientists, engineers and other technical personnel advance the state of knowledge related to the Department's resources and ensure that this information is accessible to resource managers, private industry, and the public. The vast majority of the Department's technology transfer activities use traditional technology transfer mechanisms such as publications of peer reviewed papers and reports, webpage postings, and presentations at meetings and conferences. In FY 2013, USGS and U.S. Fish and Wildlife Service (FWS) personnel, for example, authored or co-authored over 2,200 reports, books, fact sheets, and other publications, including over 1,400 scientific journal articles. Bureaus also use other conventional approaches to share scientific and technical resources and expertise with each other, universities, and other entities to address resource management issues. For example, several are active participants in the network of Cooperative Ecosystem Studies Units (CESUs), a collaboration among 13 Federal agencies (including six DOI bureaus) and over 300 non Federal partners (including universities, Tribes and tribal organizations, State agencies, museums, aquariums, arboretums, and conservation organizations) organized into 17 CESUs, each hosted by a university.

Bureaus that are active in research and development, or have research capabilities that complement U.S. commercial interests, may also utilize technology transfer agreements authorized by the FTTA to join forces with non-Federal partners. Such agreements allow the

Department's bureaus and private sector industries to pool their expertise and resources to create and advance technologies that could help fulfill agency missions while helping U.S. industries innovate and commercialize technologies that can strengthen our national economy and create jobs.

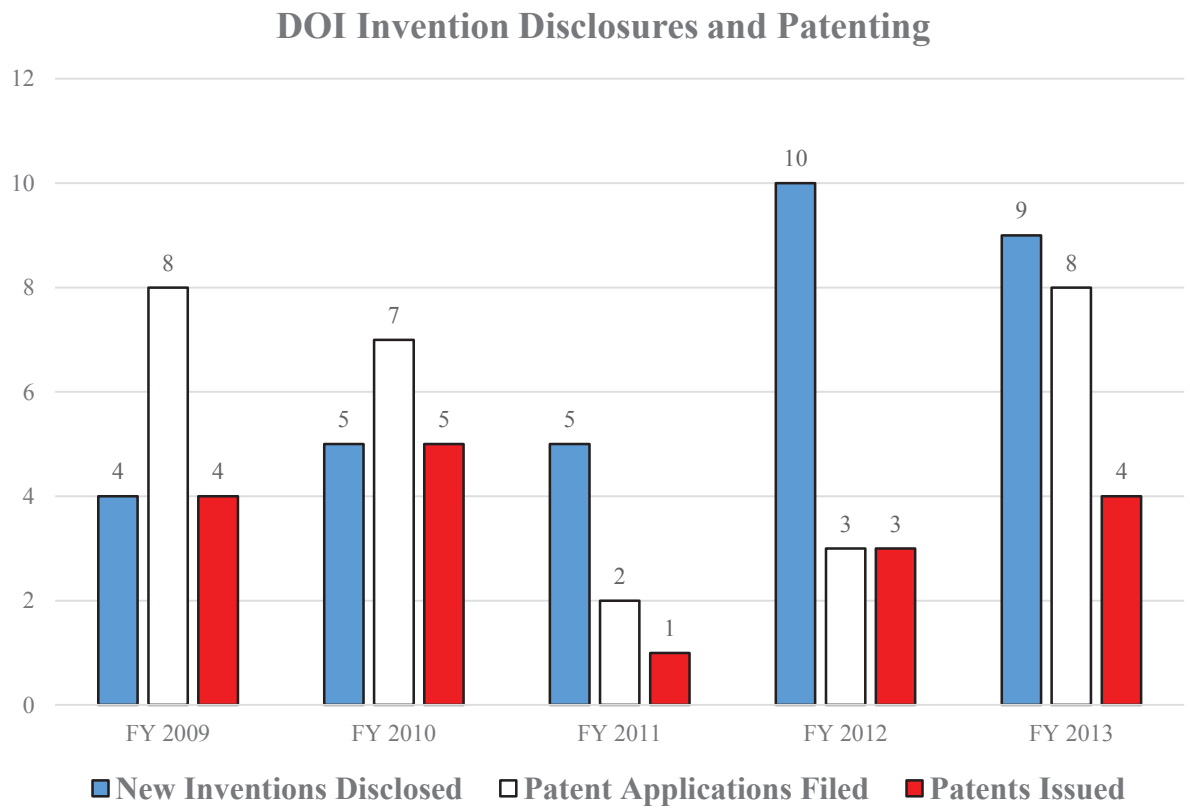
DOI's annual technology transfer report is available online at:
https://www.doi.gov/techtransfer/annual-doi-reports-on-technology-transfer

More information about DOI technology transfer activities is available on the following website:

- http://www.usgs.gov/tech-transfer/index.html.

DOI Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased by 125% to nine disclosures in FY 2013. The number of patent applications filed and patents issued remained constant at eight and four, respectively.



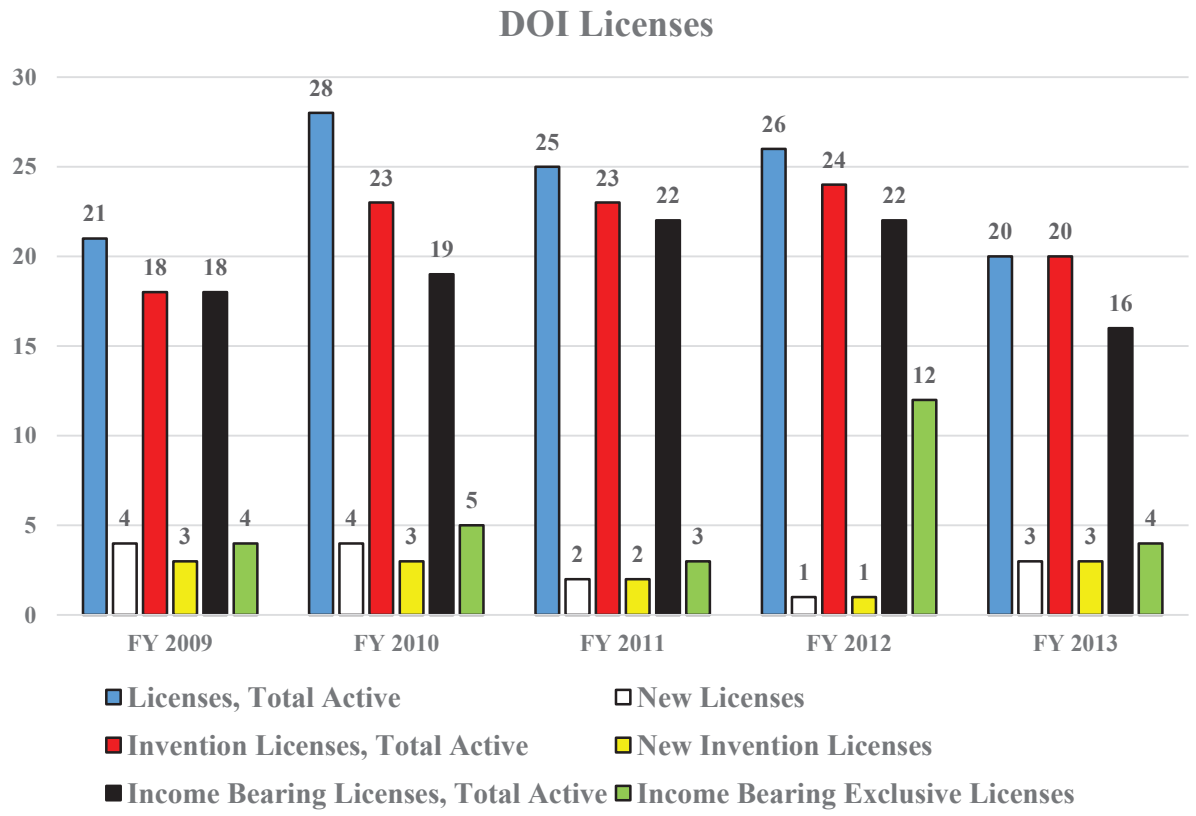
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	4	5	5	10	9
Patent Applications Filed	8	7	2	3	8
Patents Issued	4	5	1	3	4

Patents issued to DOI are in the technology areas of Measurement Techniques & Instrumentation, Electronic Components & Devices, and Agriculture.[40]

[40] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DOI Licenses

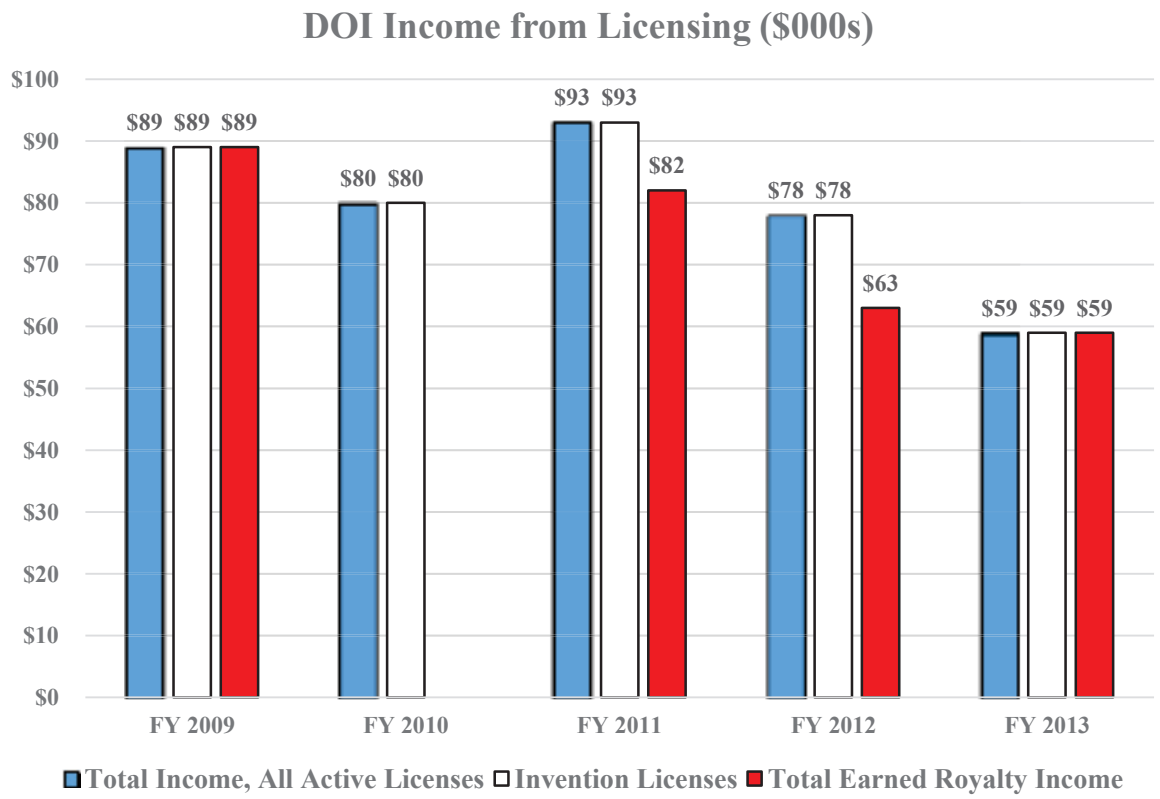
Between FY 2009 and FY 2013, the number of total active licenses decreased by 5% to 20 licenses in FY 2013. Overall, the number of total active licenses, invention licenses, and income bearing licenses remained stable.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	21	28	25	26	20
New Licenses	4	4	2	1	3
Invention Licenses, Total Active	18	23	23	24	20
New Invention Licenses	3	3	2	1	3
Income Bearing Licenses, Total Active	18	19	22	22	16
Income Bearing Exclusive Licenses	4	5	3	12	4

DOI Income from Licensing

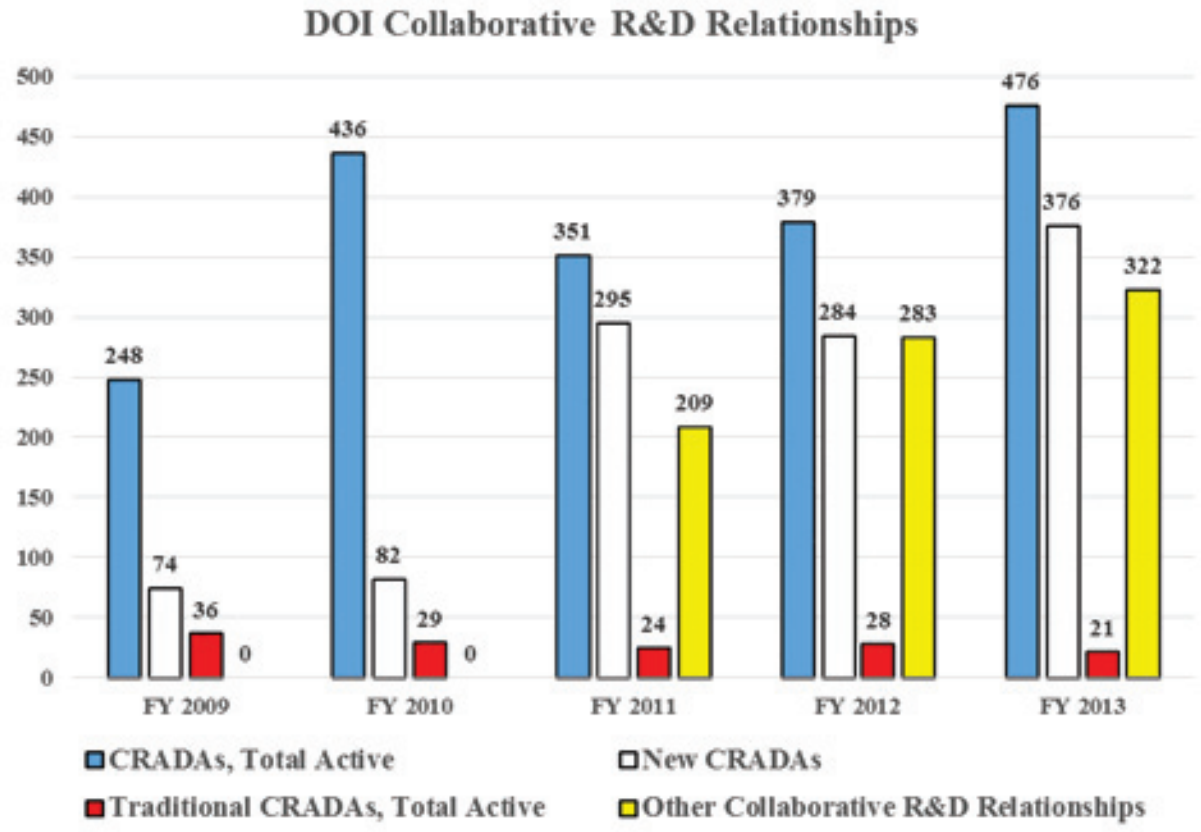
Total income from all active licenses, invention licenses' income, and total earned royalty income are the same thing. Between FY 2009 and FY 2013, income decreased by 34% to $59,000.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$89	$80	$93	$78	$59
Invention Licenses	$89	$80	$93	$78	$59
Total Earned Royalty Income	$89	n/r	$82	$63	$59

DOI Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs increased by 92% to 476 agreements. The number of new CRADAs per fiscal year increased by 408%, from 74 in FY 2009 to 376 on FY 2013. Also during this five-year period, the number of total active traditional CRADAs decreased by 41.7% to 21 agreements in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	248	436	351	379	476
New CRADAs	74	82	295	284	376
Traditional CRADAs, Total Active	36	29	24	28	21
Other Collaborative R&D Relationships	0	0	209	283	322

Efforts to Streamline Technology Transfer Operations

In response to a Presidential Memorandum, the Department has committed to a set of actions that will advance technology transfer activities within the Department. The following summarizes these commitments, and the progress toward fulfilling them:

- Developed the Departmental Manual chapter specifying general policies for implementing technology transfer (TT) activities authorized by the FTTA, and related legislation. This chapter was in the Department's clearance process at the end of the Fiscal Year.
- Commenced work on revising the current Departmental Manual chapter on patents and inventions which dates to the 1980s.
- Developed a unified website to improve public access to information related to inventions owned by the various bureaus, and other technology transfer activities. Its home page can be accessed at http://www.doi.gov/techtransfer/.
- Developed an online repository of documents and legal templates detailing best practices for TT agreements and activities from across the government and other organizations, which can be accessed via the DOI technology transfer home page.

DOI Downstream Success Stories

Reclamation's Award-Winning High Impact Research on Advancing Mussel Detection

Mussels can attach to and clog pipes, pumps, trash racks, cooling water systems, fire protection systems, and virtually any water related infrastructure surface, thereby reducing the reliability and efficiency of water and hydropower systems while simultaneously increasing maintenance costs.

Zebra and quagga mussels have recently invaded the Colorado River and other western water bodies. Detecting and preventing the spread of these mussels is, therefore, critical to Reclamation's primary mission of water and hydropower delivery. To advance the capabilities to monitor water bodies for the presence of mussels, Reclamation has entered into a CRADA with Fluid Imaging Technologies to conduct research for improving automated detection and quantification of invasive mussel larvae (also known as "veliger"). Larvae are 70 to 200 microns in size (about half the size of the period at the end of this paragraph). Detecting and monitoring invasive mussel larvae is the cornerstone of an effective strategy to manage these invasive nuisances.

Reclamation has pioneered new methods to aid early detection of quagga and zebra mussels before they become a major nuisance for water infrastructure.

It has developed a Mussel Detection and Monitoring Program to help better understand the spread of mussels. This program cooperates with States and other partners to come up with proactive measures to provide the earliest detection possible for any new mussel introductions that can reduce the need to remove mussels or interrupt Reclamation's facilities and structures. Reclamation has entered into a CRADA with a partner who specializes in developing particle analysis instruments using digital imaging technology that could help monitor mussel larvae. Under the CRADA, both parties bring together their joint interests and capabilities to monitor larvae for various water types. Reclamation's contributions include research expertise and know-how from botanists, engineers, and biologists, and the use of Reclamation's field test site and Research Laboratory. The CRADA partner's contributions include the FlowCAM® technology, research resources, and capabilities to improve its technology to better count samples with abundant organisms. The major advantage of the FlowCAM over traditional cross-polarized microscopy is that it has the potential to process samples more systematically than manual methods and provides automated photography of individual particles if additional analysis is necessary.

Under the CRADA, both parties jointly improved the FlowCAM into a specialized VeligerCAM to count abundant organisms including mussel larvae, and monitor physical larvae damage. The hardware to the FlowCAM has also been upgraded to include dual cameras that can display images of the same organism in both regular light and cross-polarized light that helps with identifying and accelerating the analysis. So far, research results conducted under the CRADA indicate the images recovered from the VeligerCAM are much brighter and sharper when compared to the standard FlowCAM. The VeligerCAM reports more accurate high number larvae counts than cross-polarized microscopy and current testing indicates that accuracy remains above 95% recovery. VeligerCAM photos are also used as a tool for evaluating the effectiveness of various mussel control interventions by photographing the pretreatment and post-treatment condition of mussel shell health.

Both parties have benefited from the CRADA. The CRADA partner has improved and validated the performance of their FlowCAM while adding the newly developed VeligerCAM capabilities into their line of product offerings for other users. Reclamation now has a specialized technology that can accurately and efficiently count abundant mussel samples. In part due to the newly developed VeligerCAM capability, Reclamation's Mussel Detection Laboratory, located in the Technical Service Center in Denver, Colorado, received the Colorado Governor's Award for High Impact Research in 2012 for its work in advancing methods to monitor for the presence of invasive quagga and zebra mussels in bodies of water.

CRADA to Develop New Coating Technologies to Protect Water Infrastructure

Reclamation is conducting research across a broad portfolio of technologies and methods to reduce fouling of infrastructure by mussels. This includes research into durable, "foul-release"

coatings that would negate mussels' ability to attach to the infrastructure. In 2013, Reclamation entered into material transfer agreements to test commercially available coatings with several U.S. companies and universities to determine the capability of existing coatings products for preventing mussel attachment and durability protection needed for Reclamation's water infrastructure. These tests indicated that commercially available coatings did not meet the desired performance standards, and that a new coating formulation is needed. Thus, in FY 2013, Reclamation launched an effort to explore a CRADA with a U.S. coating manufacturer to create new commercially available, durable, foul-release coating to protect water infrastructures.

Under the CRADA, both parties will bring together the joint interests and the complementary capabilities that are necessary to achieve the research results that neither party is capable of producing on its own. Reclamation's contributions include background intellectual property and research expertise, know-how from material engineers, chemists, and biologists, and the use of Reclamation's Parker Dam field test site and Materials Engineering and Research Laboratory. The CRADA partner's contributions also include background intellectual property, supplemented by research staff with extensive experience in formulating foul release coatings for marine environments, specialized research facilities, extensive coating scale-up and manufacturing know-how and related production facilities, and in-kind resources.

Early Stage Research Collaboration across Federal Agencies and Non-Federal Organizations

Pooling the know-how and research capacity of Federal agencies and U.S. private sector companies is vital to maintaining and growing the U.S.'s worldwide leadership positions and meeting the growing needs for water in the U.S. and abroad. In FY 2013, Reclamation started exploring an effort to create and implement Communities of Practice in areas of water resources research where industry involvement is vital to create innovations, and develop and manufacture new tools, solutions, and products that will secure water for generations to come. Communities envisioned include desalination, hydropower, water conservation, and water infrastructure technologies. During FY 2014, Reclamation plans to further develop and pilot test the concept in collaboration with the EPA and other Federal agencies before implementing a Community in partnership with the private sector. Depending on progress, capabilities, and interests, Communities would be pursued in other subject matter areas.

The Communities of Practice concept is similar to the call in the October 28, 2011, Presidential Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Business to better utilize technology innovation clusters to foster effective collaborations with industry and economic development consortia, and other entities. Developing Communities of Practice is also consistent with the Presidential Memorandum by providing new ways to engage U.S. industry at the early stages of Federal discovery.

Communities would serve as forums to foster industry-Federal partnerships to inspire and pull discoveries toward mutual industry-Federal goals at the earliest possible time. This would allow the commercial value for discoveries to be identified early in the research process. Communities of Practice will also create more awareness across U.S. industries and other non-government organizations about the specialized Federal research resources (people, lands, and facilities) that they can access through technology transfer agreements authorized by the FTTA (15 USC

3710a). Once the Communities are developed and implemented, it is envisioned that ongoing administration would become a shared responsibility of industry trade associations or similar organizations.

Assessment of Blowout Preventers and Related Technologies
A blowout preventer (BOP) is a device used to seal and control oil and gas wells to ensure safety and limit environmental harm from accidental losses of well control during operation. BSEE entered into a study with researchers from industry to investigate new designs for blind shear rams on BOP stacks, methods to detect high pressures in the well bore during the drilling process, the effects of water depth on detection, and new methods for detecting failure of BOP components.

Management of Hydrocarbon Hydrates during Production
Hydrocarbons (e.g., methane and ethane) at low temperatures and high pressures can, in the presence of water, form quasi- stable solid crystals called hydrocarbon hydrates. These hydrates can block pipes, flowlines, valves, and other equipment used for offshore drilling and production activities. Moreover, if disturbed or warmed sufficiently, these hydrates can "explode" as the hydrocarbons escape from the hydrate. Thus, they can be a safety hazard for offshore oil and gas drilling and production operations. An ongoing joint industry project with over a dozen oil and gas operating companies is investigating how hydrocarbon hydrates can be managed during the life of a producing oil and gas field and how anti-freeze and various other chemicals affect hydrate plugging. The project will also evaluate high-pressure jumper pipe design and help develop new technologies to monitor hydrates, and hydrate simulation tools. It is expected that this joint industry project will be completed in FY 2014.

Appalachian Pilot Project Geographic Information System (GeoMine)
During FY12-13 OSM partnered with the SMCRA regulatory programs in Kentucky, Tennessee, Virginia and West Virginia; and Federal agencies involved in SMCRA, Clean Water Act (CWA) and Endangered Species Act (ESA) regulation and consultation (EPA, FWS and the Army Corps of Engineers) to develop the GeoMine interactive digital map of coal mining and reclamation activities. This GeoMine Pilot Project has demonstrated the feasibility and value of sharing this mapping data between the partner agencies through the Internet. A final report of the Pilot Project findings and recommendation was reviewed and approved by all Federal, State and tribal agency executives and published in December 2013. The report recommended that GeoMine be deployed nationwide to the SMCRA, CWA, and ESA communities and the public.

Remote Sensing Pilot Project
OSM Remote Sensing Specialists in the TIPS program have been working since 2009 on a pilot project to "determine the best satellite image data, products, and services that will support effective and efficient SMCRA solutions for the regulatory program." The project explored the processes and requirements involved in acquiring image data, products, and services from the National Geospatial-Intelligence Agency (NGA) Office of Commercial Partnerships through the USGS. The President's Commercial Remote Sensing Space Policy (CRSSP), signed in 2003 and supported through President Obama's 2010 National Space Policy, tasked the NGA with sharing satellite imagery with Federal agencies. In 2009, OSM also entered into an official partnership with the NGA through the USGS to assist the goals of this pilot project. OSM is working with

the Civil Applications Committee (CAC), for which USGS is the co-chair, to obtain satellite imagery.

The OSM Remote Sensing Pilot Project Final Report is to be released in early 2014, with a finding that satellite imagery is extremely useful for SMCRA applications and may be used for virtual inspections of mines, identification of key features for ground inspection, or to locate abandoned mines. The project also revealed that there is a significant cost savings associated with using remote sensing imagery for virtual inspections.

OSM will continue to work with the NGA to improve products and services for the use of satellite imagery in SMCRA applications. In the interim, TIPS has established an annual imagery purchase process to provide images for mines where OSM is the regulatory authority and will assist States on a case-by-case basis.

Diagnosing Avian Botulism Avian botulism, a paralytic disease caused by the toxins produced by the naturally occurring bacterium, *Clostridium botulinum*, in their food supply can kill thousands of birds each year. This bacterium produces seven distinct neurotoxins (called *botulinum* neurotoxins, or BoNTs), each designated by the letters A through G. These toxins are among the deadliest substances known to man.

The USGS through its National Wildlife Health Center Diagnostic Microbiology Laboratory, with support from the Great Lakes Restoration Initiative, has had a CRADA with BioSentinel, Inc., to develop a rapid method of detecting BoNT-type E which causes mortality in fish-eating birds. The current standard method for detecting BoNTs is to test them using live mice. This assay method, in addition to raising ethical concerns, is too labor intensive and time consuming to be of utility for analyzing the large number of samples required to conduct meaningful ecological studies.

The assay method developed under the CRADA, BoTest™ Matrix E, uses a fluorescence-based bioassay to detect BoNT type E activity in avian blood and other sample types. This method, which does not involve killing mice, is faster, cheaper and has been shown to be as sensitive as the live mouse bioassay. This new assay will be used to advance both the understanding of environmental factors that contribute to outbreaks of avian botulism, and ongoing research to develop strategies to mitigate its impacts. This method may also have applications for human health since Type E botulism can occur in humans following consumption of improperly prepared fish.

Department of Transportation (DOT)

The U.S. Department of Transportation (DOT) is the Federal steward of the nation's transportation system. DOT consists of multiple modal Operating Administrations, which carry out mission-related Research, Development, and Technology (RD&T) programs in support of the DOT strategic goals: Safety, Quality of Life in Communities, Environmental Sustainability, State of Good Repair, Economic Competitiveness, and Environmental Sustainability. In 2004, the Research and Innovative Technology Administration (RITA) was charged by its enabling legislation with coordination of DOT-wide RD&T and technology transfer activities. In the Omnibus Bill of 2014, RITA was elevated to the Office of the Secretary and given a new name – the Office of the Assistant Secretary for Research and Technology.

DOT defines technology transfer as the process of transferring and disseminating transportation related scientific information to stakeholders who may apply it for public or private use. DOT's current approach to technology transfer is diverse and unique to each mode of transportation. Each modal Operating Administration conducts mission specific deployment activities tailored to its mode and type of research.

Technology Transfer activities are executed by DOT agencies and laboratories:

- Federal Aviation Administration (FAA): The FAA's Federal laboratory is the William J. Hughes Technical Center (Atlantic City International Airport, New Jersey);
- Federal Highway Administration (FHWA): Turner-Fairbank Highway Research Center (McLean, VA);
- Office of the Assistant Secretary for Research and Technology (OST-R): John A. Volpe National Transportation Systems Center (Volpe Center, Cambridge, MA);
- National Highway Traffic Safety Administration (NHTSA): Vehicle Research and Test Center (VRTC).

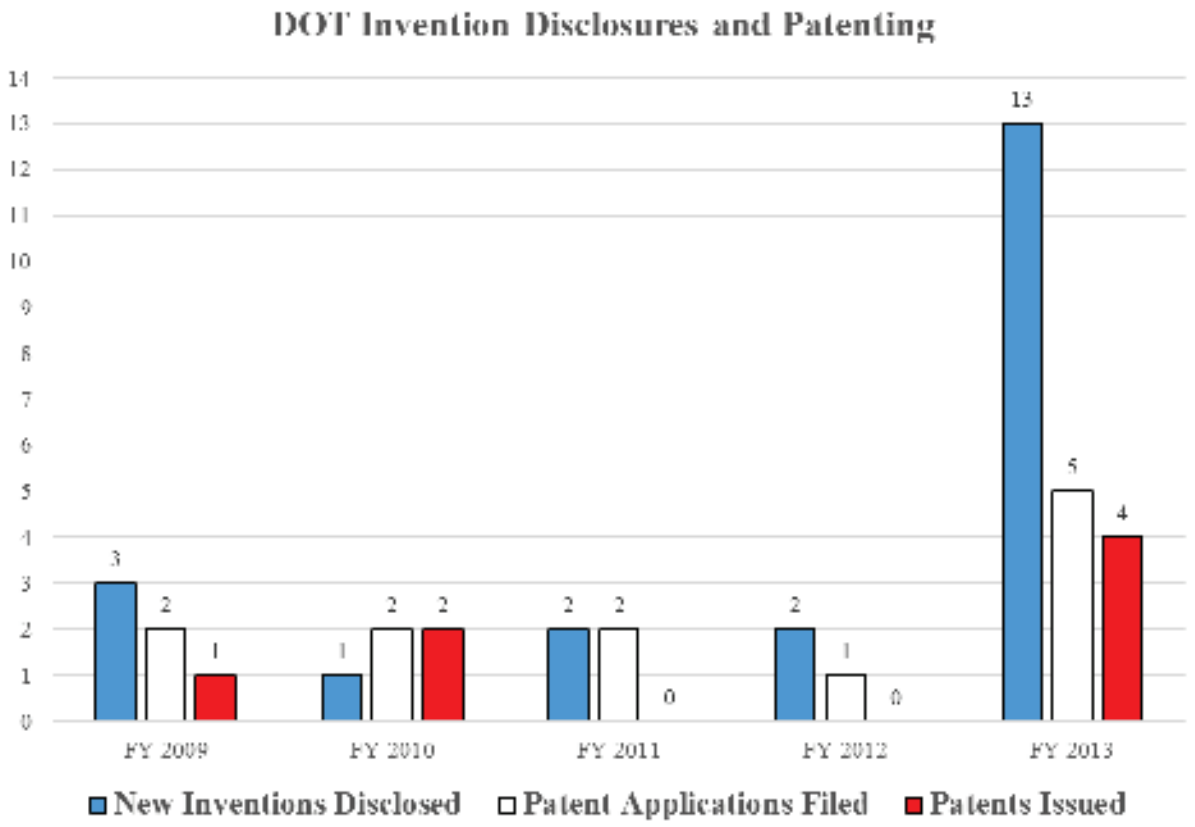
DOT's annual technology transfer report is available online at:
http://www.transportation.gov/open/research-facilities

More information about DOT technology transfer activities is available on the following websites:

- FAA: http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/initiatives/ttp/;
- FHWA: http://www.fhwa.dot.gov/everydaycounts/; and
- OST-R: http://www.volpe.dot.gov/ourwork/techtrns.html.

DOT Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased 333% to 13 disclosures in FY 2013. Patent application filing increased 150% to five filings in FY 2013. The number of issued patents increased from one in FY 2009 to four in FY 2013.



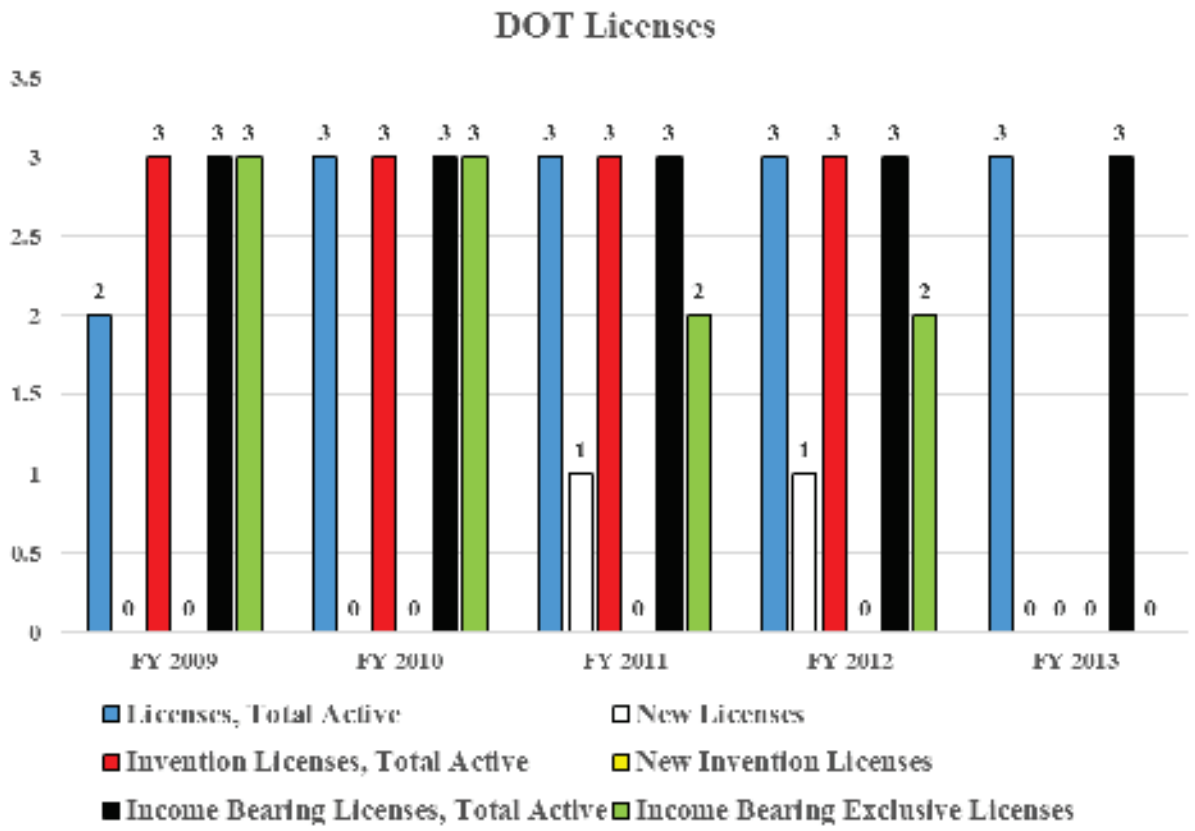
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	3	1	2	2	13
Patent Applications Filed	2	2	2	1	5
Patents Issued	1	2	0	0	4

Patent(s) issued to DHS are in the technology area of Measurement Techniques and Instrumentation.[41]

[41] Source: National Science Foundation and The Patent Board™ (see footnote 5).

DOT Licenses

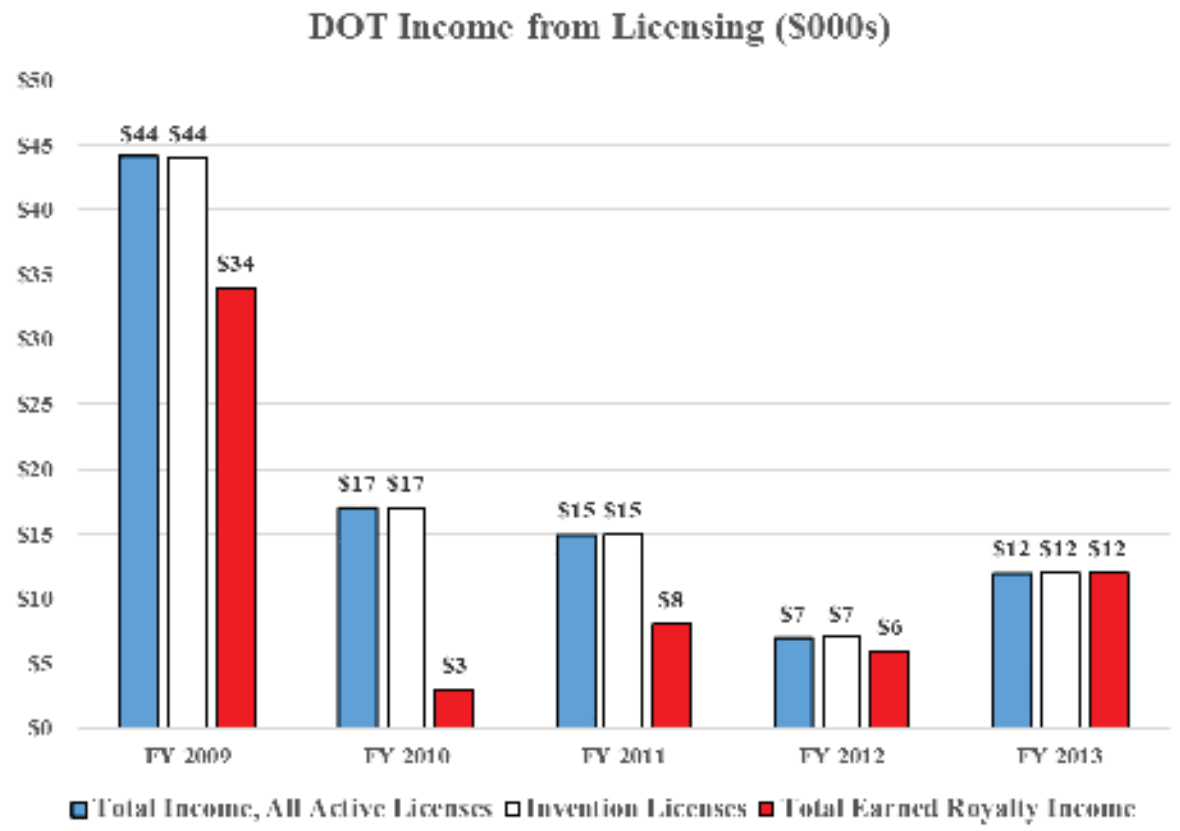
Between FY 2009 and FY 2013, the number of total active licenses increased from two licenses in FY 2009 to three licenses in FY 2013. FY 2013 active licenses, new invention licenses, and total active invention licenses remained stable.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	2	3	3	3	3
New Licenses	0	0	1	1	0
Invention Licenses, Total Active	3	3	3	3	0
New Invention Licenses	0	0	0	0	0
Income Bearing Licenses, Total Active	3	3	3	3	3
Income Bearing Exclusive Licenses	3	3	2	2	0

DOT Income from Licensing

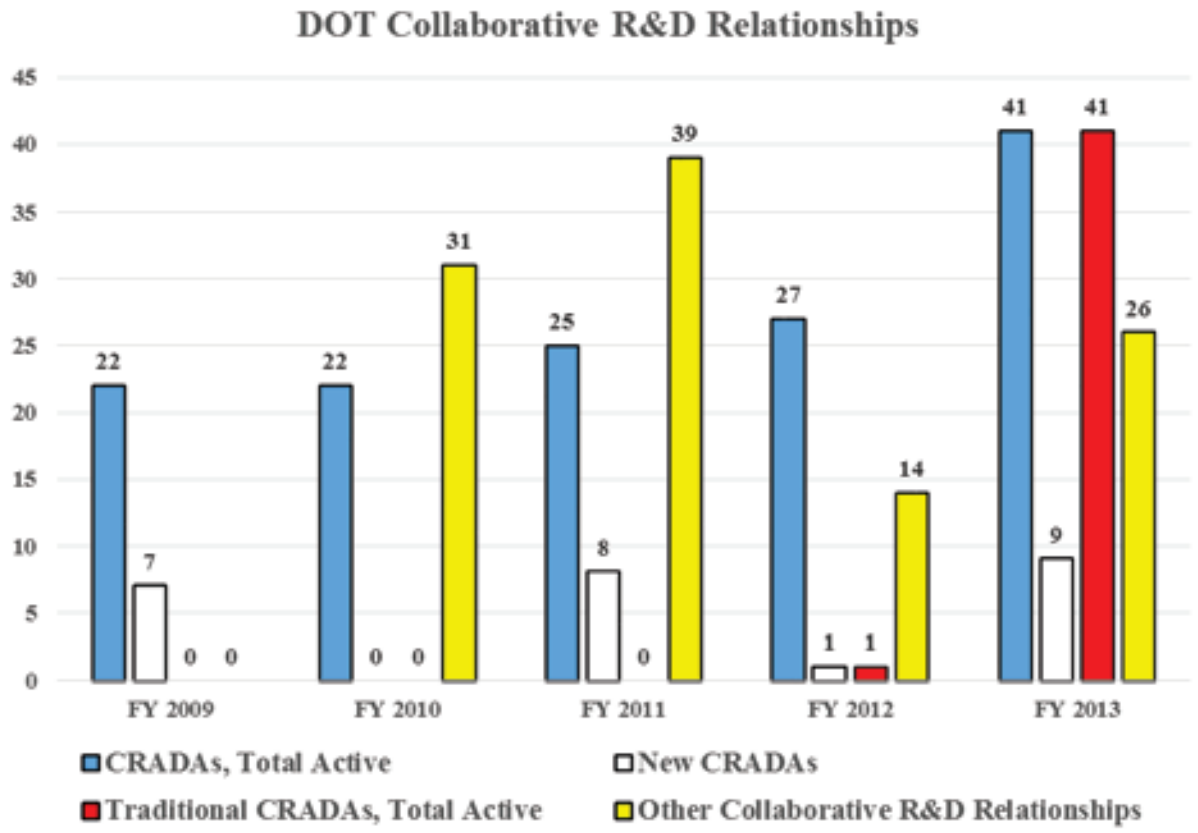
Between FY 2009 and FY 2013, all active license income decreased by 73% to $12,000 in FY 2013. Invention license income also decreased by 73%, from $44,000 in FY 2009 to $12,000 in FY 2013. Total earned royalty income decreased to $12,000 in FY 2013 from a previous high of $34,000 in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active Licenses	$44	$17	$15	$7	$12
Invention Licenses	$44	$17	$15	$7	$12
Total Earned Royalty Income	$34	$3	$8	$6	$12

DOT Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs increased by 86.4% to 41 agreements in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	22	22	25	27	41
New CRADAs	7	0	8	1	9
Traditional CRADAs, Total Active	0	0	0	1	41
Other Collaborative R&D Relationships	n/r	31	39	14	26

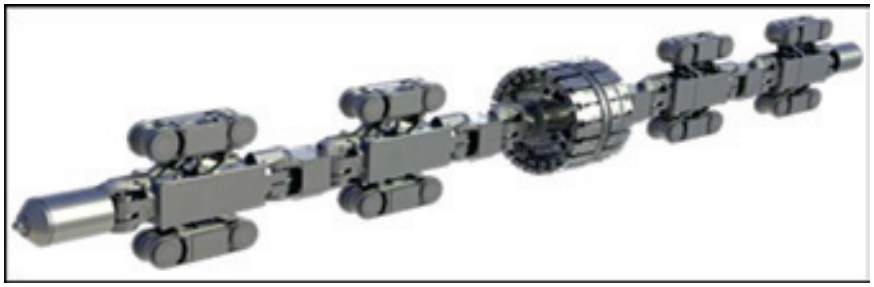
Efforts to Streamline Technology Transfer Operations
DOT is increasing coordination between Operating Administrations (OA) through the designation of identified technology transfer points of contact from each OA R&D program. These efforts are already providing enhanced efficiencies in the collection of IP and T2 information necessary for the completion of the annual Technology Transfer Performance Report submitted to the Department of Commerce. Other efforts for streamlining its operations include:

- increasing its federal laboratory participation in Lab-to-Market directives through the development of a website that will improve public awareness and access to information on the Department's technology transfer operations;
- developing training materials to assist R&D personnel to incorporate various technology transfer best practices into their research programs;
- developing a new Departmental intellectual property policy, which will include streamlined procedures for the submission and review of potential invention disclosures, as well as improving total effectiveness and reductions in cost;
- preparing simplified model agreements for use or adoption by the OAs and/or the Department's federal laboratories to reduce resources and time spent on negotiation; and
- reviewing the possibility of entering into an agreement with a third party intermediary for further improving the visibility of the Department's research facilities and equipment, its research capabilities, and the technologies available for licensing.

DOT Downstream Success Stories

Acoustic-Based Technology to Detect Buried Pipes
Collaborative research between U.S. DOT's Pipeline and Hazardous Material Safety Administration and the pipeline industry improved the Ultra-Trac® APL hand held acoustic pipe locator through multiple validation demonstrations at several urban utility sites. The research produced an algorithm that improves the process of locating pipes without using tracer wire (or broken wire). The algorithm assists pipeline operators and underground asset locators in detecting buried metallic and non-metallic pipes (Polyethylene and sewer pipes), reducing "excavation damages," and increasing the system and public safety.

Completion of Development of Robotics Systems for Inspecting Unpiggable Transmission Pipelines
Collaborative research between the U.S. DOT's Pipeline and Hazardous Material Safety Administration and the pipeline industry led to the development and commercial deployment of the first robotic inspection platform (Explorer) and integrated Magnetic Flux Leakage sensor capable of internal unpiggable gas pipeline inspection through many internal obstructions including plug valves. Explorer is an



untethered, modular, remotely controllable, self-powered inspection robot for the visual and nondestructive inspection of 20” and 26” natural gas transmission and distribution system pipelines.

Consolidated Research Program to Map, Detect, and Characterize Mechanical Damage Defects in Pipeline

This consolidated program and public/private funded research partnership between U.S. DOT’s Pipeline and Hazardous Material Safety Administration and the pipeline industry involved two distinct research project successes (Project #1 & Project # 2). Project #1 adapted JENTEK's Meandering Winding Magnetometer (MWM) Array and Magnetoresistive MWM Array for the detection and characterization of corrosion and mechanical damage characterization of pipeline damage from inside the pipe using an in-line inspection or JENTEK PIG-IT tool. Project #2 adapted JENTEK's MWM Arrays for the detection and characterization of corrosion and mechanical damage through coatings. Advancements were made in the sensor configuration, instrumentation layout, mechanical integration, and data processing algorithms. Therefore, the same technology in two different PHMSA projects brought tech transfer via in-ditch and ILI technology. This innovation began as PHMSA funded Small Business Innovative Research Phase I awards that were then competed within broader partnerships with PHMSA’s core RD&T Program.

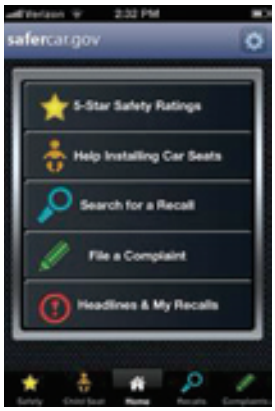
A Quantitative Non-Destructive Residual Stress Assessment Tool for Pipelines

The new eStress™ system for residual stress assessment of pipeline damage was developed, demonstrated and commercialized under a Pipeline and Hazardous Material Safety Administration (PHMSA) Small Business Innovative Research (SBIR) Phase II award. The SBIR Phase II award was supported by a successful SBIR Phase I award also funded by PHMSA. This inspection tool quantitatively measures residual stress in pipeline damage to determine the susceptibility of damaged regions to failure. The eStress™ system provide much more insight into the nature and severity of the stresses near dented and damaged regions. This new nondestructive testing technology is coupled with advanced modeling techniques to improve the capability to not just determine the difference between good and bad amounts of stress but to quantitatively measure the local stress and map the stress around the entire area. Direct stress measurements such as these were not possible before the PHMSA investment and now provide for enhanced determination of mechanical damage defect severity in pipelines.

New App Puts Vehicle Safety in Consumers’ Hands

A new iPhone application has made it easier for consumers to make important vehicle safety decisions in real time. Developed by Volpe National Transportation Systems Center for the National Highway Traffic Safety Administration (NHTSA), the SaferCar app allows users to

access information from NHTSA's SaferCar.gov site to search vehicle 5-Star Safety Ratings, locate child seat installation help, file a vehicle safety complaint, and receive automatic notices about recalls.



Volpe's team has a deep understanding of the data behind the app and how important the data are in improving transportation safety, having worked with NHTSA on vehicle recalls and safety complaints for 12 years. Volpe developed a major system of the SaferCar.gov website that handles safety complaints and recalls. Volpe's team also completed a major redesign of the website's user interface two years ago and provides all of the support for SaferCar.gov and NHTSA.gov.

With Volpe's knowledge of NHTSA's websites and systems, its team moved the app's development quickly, while working on advanced features like a function that allows users to scan VIN barcodes with their phones, making it easier to register their vehicles for safety recall notifications. The app's main features include the following:

- 5-Star Safety Ratings: Searchable crash test ratings for vehicles by make and model and compare different vehicle ratings. Easy to shop smart at a car dealership. Since the app's release in March, about 10,500 users have downloaded the app;
- Safety recalls and complaints: Users can enter information for up to 10 vehicles to be notified of safety recalls. Simple for users to submit safety complaints about vehicles, helping NHTSA investigate defects;
- Child seat installation help: Users can find directions, hours, and contact information on the nearest car seat inspection station to get help installing child seats and boosters; and
- Safety news: Consumers can receive important news and safety information from NHTSA, as well as notices on their registered vehicles.

Aircraft Braking Friction Project

The FAA has undertaken a research project for assessment of aircraft landings under contaminated runway conditions (i.e. snow, slush, and ice) in response to an NTSB recommendation issued in 2007. The objective of the project is to utilize aircraft systems data, generated during landings on contaminated runways to predict the landing performance of follow-on aircraft. The FAA has initiated CRADAs with both Team Eagle Ltd. Of Ontario, Canada and Engineered Arresting Systems Corporation (ESCO) with offices in Logan Township, NJ and Aston, PA for conducting joint research on the effects of contaminants on aircraft braking performance. The CRADAs provide FAA access to field experts of aircraft braking systems, surface condition reporting, and pilots knowledgeable with commercial aircraft operations. In addition, the

CRADAs provide FAA with use of braking performance test data generated by the CRADA partners.

The FAA has instrumented a Boeing 727 aircraft (R&D 40) for conducting testing on contaminated runway surfaces. Instruments have been installed on the R&D 40 for measurement of braking friction and associated wheel slip (Mu-Slip) during stopping under varying contamination conditions. The performance of modern aircraft Anti-Skid Brake Systems (ASBS) is based on these Mu-Slip characteristics and can be used in the assessment of braking friction.

Team Eagle has developed a Braking Availability Tester (BAT shown below) which incorporates an aircraft tire with representative aircraft braking system and ASBS, within a commercial vehicle chassis. The objective of the BAT is to provide predictive braking availability on contaminated runway surfaces toward a better understanding of actual aircraft landing distances. Joint testing with the R&D 40 and the BAT is planned under the CRADA for this winter at ACY.

Pressure transducers supplied by ESCO have been installed into the R&D 40 main landing gear braking system. ESCO has an approved patent relating to the estimation of aircraft braking friction on contaminated runways using the hydraulic system pressure differentials across the ASBS control valves. Under the CRADA, the FAA and ESCO will jointly conduct braking friction testing with R&D 40 this winter at ACY.

Automatic Speech Semantic Recognition and Verification in Air Traffic Control

The FAA's Technology Transfer Program maintains a CRADA with BrainVentions Corporation, Inc. of Los Angeles, CA. The purpose of this continued collaborative partnership is to conduct the exploration of automatic speech recognition technologies in Air Traffic Control (ATC) research.

The FAA conducts research to develop methods of measuring human performance in ATC environments with Human-in-the-Loop (HITL) simulations and the collection of data recordings from fielded ATC operations. A portion of the data collected consists of voice data that can only be analyzed once the manual process of transcription has been completed. Unfortunately, the transcription process requires many person-hours to complete – therefore, some analyses are cost prohibitive.

Under the CRADA, FAA and BrainVentions investigate the current state of the art Automatic Speech Semantic Recognition (ASSR) technology, measure its accuracy, and explore its potential applications in ATC. The ASSR system used for this study is the ValsVox (BrainVentions) web-based Software as a Service application for real-time speech recognition

and semantic parsing of ATC voice communications. Case studies are conducted using an enhanced ValsVox system with recorded audio from previously conducted ATC HITL simulations.

ValsVox speech recognition is constrained in real-time by the semantic parsing - unlike other systems in which a transcript of the utterance is first generated then semantically parsed. For the phrases that were successfully recognized, accuracy of the semantic recognition was over 80%. These findings suggest that the technology may be ready for follow-on research to incorporate ASSR into ATC decision support tools. There is also a potential to use ASSR in simulation and training environments. In addition, human transcriptionists could use ValsVox-generated transcripts to save time and costs when complete accuracy is needed.

Geosynthetic Reinforced Soil-Integrated Bridge Systems
The Federal Highway Administration's "Bridge of the Future" initiative took a wise look at the past before soaring ahead to the future. The result was the Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS), which combined cutting-edge geosynthetics with ancient building secrets. This radically simple construction method can lower costs, slash construction time, improve durability, and increase worker safety. This technology uses alternating layers of compacted granular fill material and fabric sheets of geotextile reinforcement to provide support for a bridge. The technology also affords a smooth transition from the roadway to the bridge, alleviating the bump at the start and end of the bridge caused by uneven settlement. Thirty-five States have built more than 100 bridges using the technology. The technical team continues its work as part of a group focused on accelerated bridge construction. The team is providing workshops, training, showcases, conference presentations, and white papers, as well as participating in panel discussions.

Prefabricated Bridge Elements and Systems
Prefabrication, which involves the manufacture and assembly of components or entire structures offsite, is solving many constructability challenges. The technology is revolutionizing bridge construction by greatly reducing onsite construction time, minimizing traffic disruptions, and improving work zone safety because of the reduced number of onsite workers exposed to moving traffic. State DOTs have designed or constructed more than 2,500 replacement bridges using prefabricated bridge elements and systems. In addition, nearly half of all States report that more than 25 percent of their replacement bridges have used at least one major prefabricated bridge element or system.

High Friction Surface Treatments
High friction surface treatments (HFST) are the site-specific application of very high quality, durable aggregates using a polymer binder that restores and maintains pavement friction where the need for a safer pavement surface is the greatest. Maintaining the appropriate amount of pavement friction is critical for safe driving. Vehicles traversing horizontal curves require a greater side force friction, and vehicles at intersections require greater longitudinal force friction. The increased use of HFST to improve highway safety is (in part) a result of research and evaluations conducted by FHWA, industry partners, and leveraging research conducted by foreign countries. This research has shown the use of HRST resulted in decreases in overall crashes, and in many cases, severe crashes. HFST has been tried and proven in 11 States with 23

installations as part of FHWA's Surface Enhancements at Horizontal Curves (SEAHC) demonstration program. Crash data from the U.S. sites from Pennsylvania, Kentucky, and South Carolina DOTs report a before/after total crash reduction of 100%, 90% and 57%, respectively, for their respective signature trial projects, for which the after periods equal approximately three to five years. Kentucky has gone on to install and measure 25 additional HFST applications, and after at least one year, these sites have witnessed crash reductions of 69%.

NHTSA's VRTC Strikeable Surrogate Vehicle

Researchers at NHTSA's Vehicle Research and Test Center (VRTC) created a Strikeable Surrogate Vehicle (SSV) to serve as a Principal Other Vehicle (POV) during test track evaluations of forward crash avoidance and mitigation (FCAM) technologies such as Crash Imminent Braking and Dynamic Brake Support. A surrogate vehicle must be used in the evaluation of these systems since collisions between the test vehicle (known as the Subject Vehicle, or SV) and the POV may occur during testing. While it is important for the POV to be capable of sustaining repeated impacts, it must also present itself as realistic to be physically interpreted as a vehicle when testing with a SV. Balancing these requirements has been the focus of considerable research for years.

The NHTSA SSV features four novel elements in design:

1. It presents itself as a realistic vehicle to all known sensors presently implemented by forward-looking advanced warning and automatic braking systems;
2. The rigid body shell maintains a constant presence (free from buffeting) as approached by an SV;
3. A lightweight foam bumper and carbon fiber slider/load frame allows impact forces acting on an SV to be incrementally realized, thereby decreasing the peak loads present immediately after an impact occurs; and
4. A constant SSV-to-tow vehicle distance is maintained, even during decelerating test maneuvers, using a towed rail that features skid plates designed to offer long-term durability and reduced in-the-field service.

The rear profile of NHTSA's SSV is dimensionally similar to a small high-volume hatchback. To reduce the potential for damage to the SV during an impact, the SSV is constructed from carbon fiber, Kevlar, phenolic, and Nomex honeycomb; all of which are lightweight composite materials with favorable strength-to-weight characteristics. An assessment of the SSV radar return characteristics performed by the Michigan Technical Research Institute and the University of Michigan Transportation Research Institute concluded the SSV could be a viable POV for the evaluation of FCAM technologies. Feedback from the vehicle manufacturers and automotive suppliers generally has been favorable.

NHTSA's VRTX Supports Proposed Rulemaking for Child Side Impact Test Dummy

Researchers at NHTSA's Vehicle Research and Test Center (VRTC) provided four reports in support of a Notice of Proposed Rulemaking (NPRM) regarding the Q3s side impact test dummy, a new dummy representing a 3-year old child. The NPRM looks to amend the

regulations to include specifications and qualification requirements for the Q3s Child Side Impact Test Dummy, which the Agency plans to use in testing child restraint systems for new side impact performance requirements.

The reports describe the qualities of the Q3s dummy that make it a suitable anthropomorphic test device during crash testing to improve side impact safety for children. These documents allow users of the dummy to ascertain the correct assembly, disassembly, and inspection procedures when utilizing the Q3s in their research, development, and testing. Reports are publicly available in the NPRM's docket.

Test dummies specified in Federal Motor Vehicle Safety Standards (FMVSS) are subjected to a series of qualification tests to ensure that their components are functioning properly. The Qualification Procedures report demonstrates how the dummy is prepared for this testing, how the tests themselves are conducted, and the performance requirements to which the dummy must adhere to be acceptable for use in Regulatory testing.

The final report documents the Q3s's "Repeatability, Reproducibility, and Durability." This work evaluates the Q3s production version for potential use in Federal regulatory test standards. It includes the results of the repeatability and reproducibility of the Q3s dummy's responses in qualification procedures and sled tests. High-energy component tests were conducted to assess the dummy's durability. The Q3s dummy's repeatability and reproducibility generally rated as "excellent" or "good" as defined by the NHTSA rating system. Furthermore, the dummy proved to be a durable test device.

Department of Veteran Affairs (VA)

The Department of Veterans Affairs (VA) through the Veterans Health Administration (VHA) conducts a robust research program whose fundamental mission is to advance the healthcare of Veterans. VA's Technology Transfer Program operates within the Office of Research & Development (ORD), which in turn is part of VHA. ORD aspires to discover knowledge, develop VA researchers and health care leaders, and create innovations that advance health care for our veterans and the nation. Every year, the Department of Veterans Affairs researchers develop new health care-related technologies and other inventions and engage in collaborative research and development activities that advance Veterans healthcare. VA's Technology Transfer Program (TTP) helps translate the results of those discoveries into practice and facilitates the development of collaborative research agreements that support VA's research activities.

VA's research program is different from other Federal technology transfer programs because it is highly decentralized. The TTP office is located in Washington, DC; however, the actual research is conducted at more than 100 VA Medical Centers (VAMC), all of which are Federal Laboratories.

The VA conducts basic and applied clinical research to discover new treatments and therapies for diseases that affect our nation's Veterans. These activities are often conducted in collaboration with industry partners, universities, non-profit foundations under CRADAs. The majority of VA CRADAs are clinical CRADAs. In many cases, these studies are multicenter clinical trials involving several VAMCs across the country. VA clinical trials have helped find new therapies for heart failure, high blood pressure, coronary artery disease, stroke, tuberculosis, kidney disease, and diabetes. The review and approval of these CRADAs is a joint effort by TTP and VA's Office of General Counsel (OGC).

In support of ORD's mission to develop VA researchers and health care leaders, VHA has forged unique relationships with academic medical institutions throughout the country. Currently 124 VAMCs have formal affiliations with academic institutions and many VA researchers have academic appointments. As a result, most VA inventions are jointly owned by VA and its academic affiliates, making technology transfer a collaborative effort between two entities. Affiliated academic institutions ask their employees and academic appointees to enter into agreements that give ownership of inventions to the academic affiliate. Because of this requirement, most VA inventions are jointly owned by VA and its academic affiliates. To facilitate efficient technology transfer, TTP has executed Cooperative Technology Administration Agreements (CTAA) and other invention management agreements on VA's behalf with many academic affiliates. These agreements allow the affiliate and VA to decide which party will take the lead in the management of the co-owned inventions. This includes patenting inventions, marketing, negotiating, executing, and managing licenses on behalf of the affiliate and VA. Historically, the affiliates have taken the lead in these activities for most jointly owned IP. Any royalties that the affiliate receives from licensing a jointly owned invention are shared with VA according to a formula in the CTAA or invention management agreement. VA then distributes these royalties in accordance with its royalty distribution policy. At the same

time, TTP manages the patent prosecution and marketing of inventions solely owned by VA, or inventions in which the academic affiliate declines to take the lead.

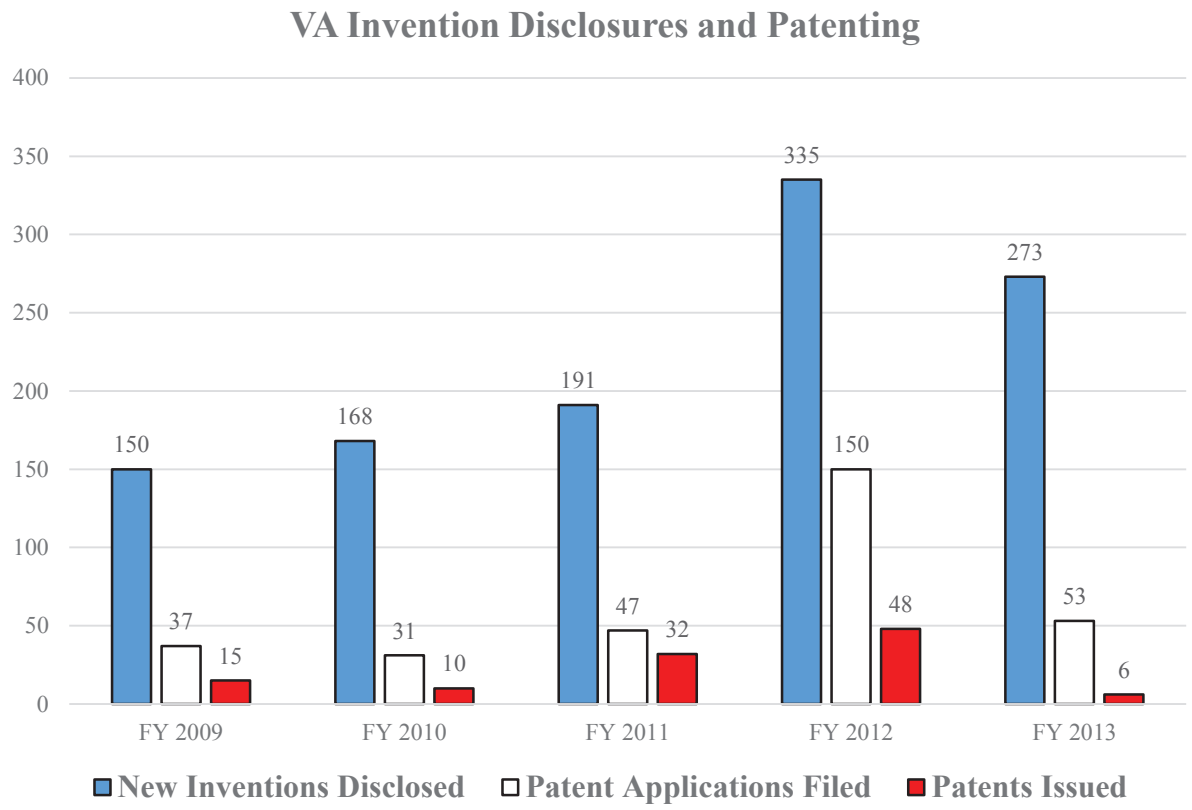
Where VA is the sole owner of an invention or lead partner in a jointly owned invention, TTP manages the patent prosecution, marketing and licensing activities. TTP, through contracts, works with selected law firms to patent inventions. Marketing activities are facilitated with an intellectual property-marketing contractor who provides TTP with technology assessments and performs initial marketing activities. VA's OGC reviews and approves licenses prior to execution by the appropriate signing authority. Successful patents licensed to manufacturers for both jointly owned and VA sole inventions provide a royalty stream to the VA. As a result, inventors, their research laboratories, and the local VA facility share in licensing royalties. The American taxpayer will gain from this return on the research investment because resources will be reinvested in the original research laboratories to further additional biomedical advances.

More information about VA technology transfer activities is available on the following website:

- http://www.research.va.gov/programs/tech_transfer/default.cfm.

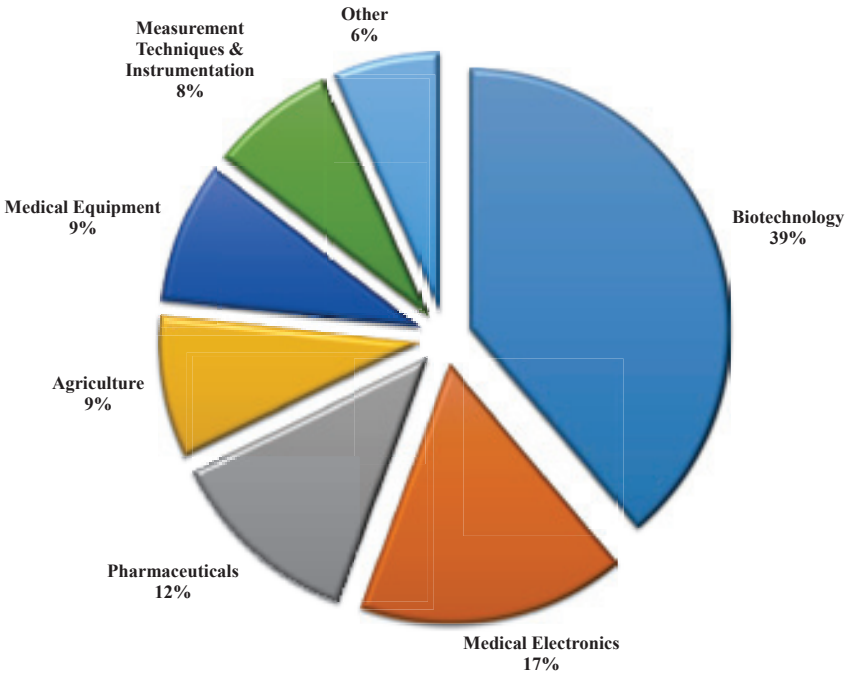
VA Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased by 82% to 273 disclosures in FY 2013. During the same period, the number of patent applications filed increased by 43% to 53 in FY 2013. The number of patents issued decreased by 60%, totaling six patents in FY 2013, compared to 15 patents in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	150	168	191	335	273
Patent Applications Filed	37	31	47	150	53
Patents Issued	15	10	32	48	6

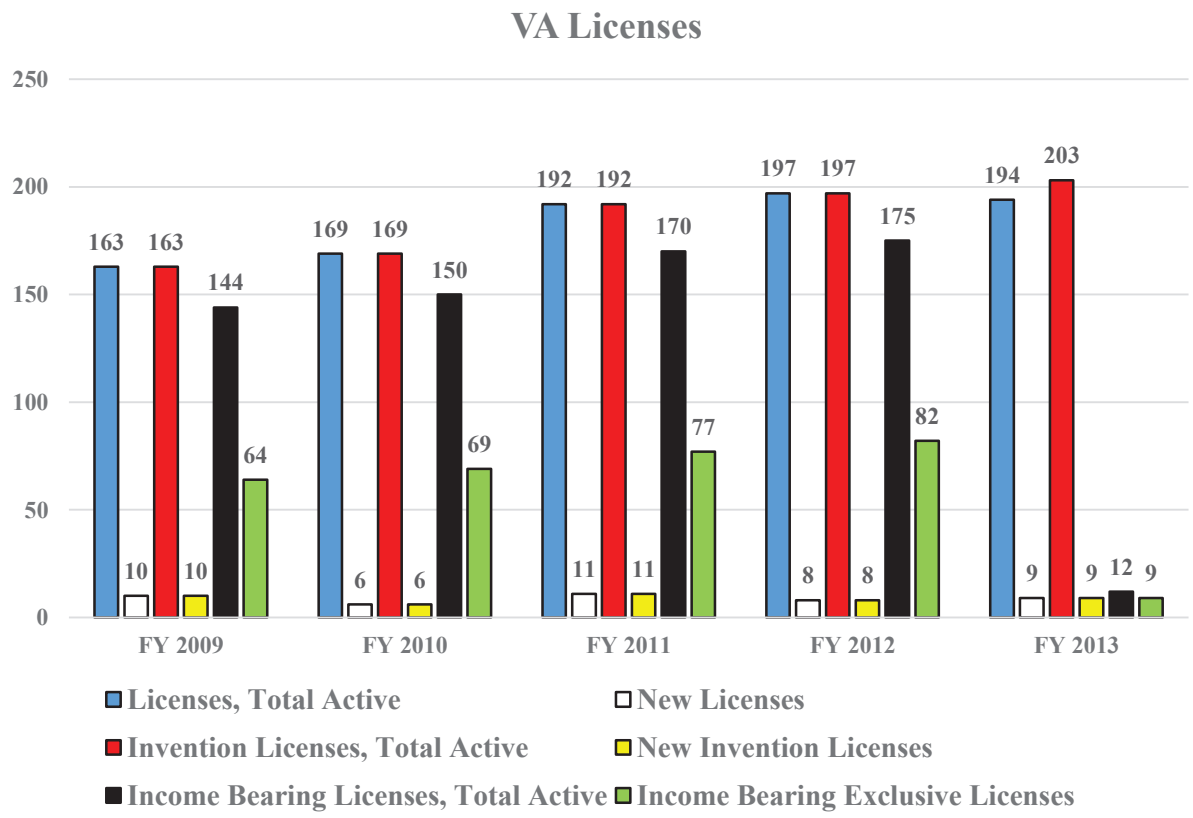
USPTO Patents Assigned to VA by Technology Area: FY 2013[42]



[42] Source: National Science Foundation and The Patent Board™ (see footnote 5.)

VA Licenses

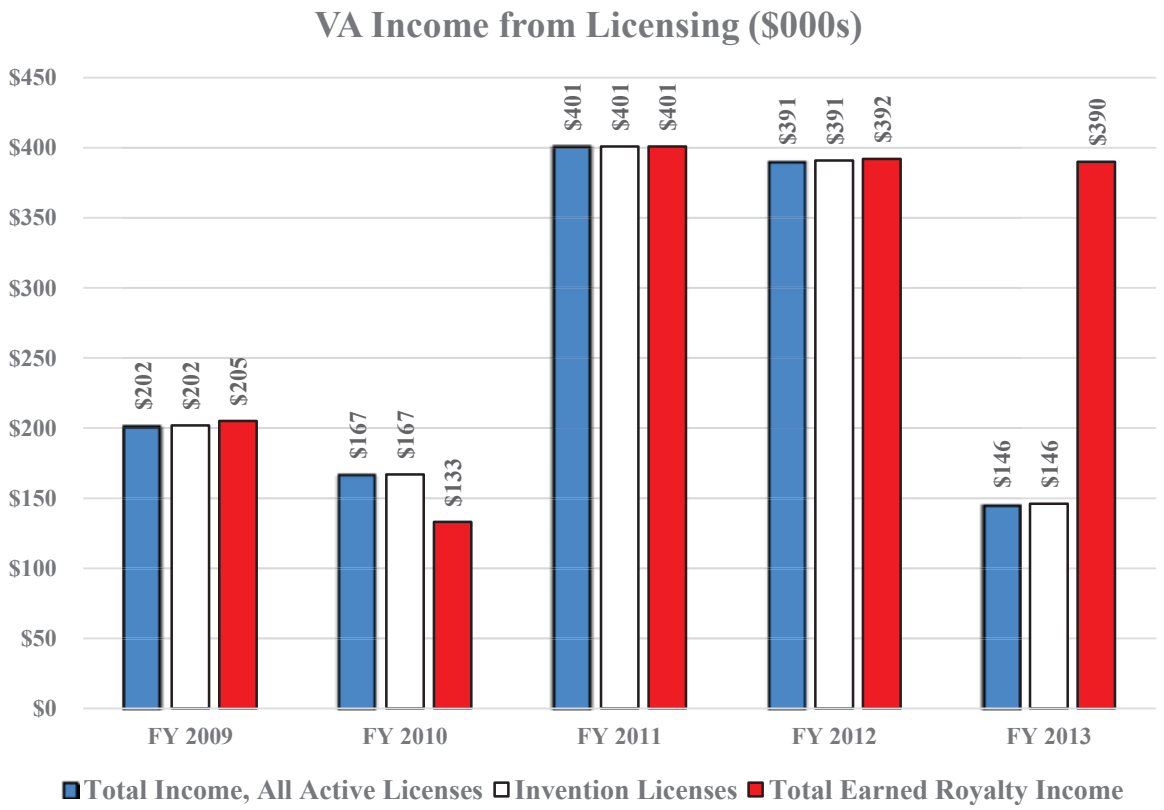
Between FY 2009 and FY 2013, total active licenses reported increased by 19%, from 163 licenses in FY 2009, to 194 licenses in FY 2013. Total active invention licenses increased by 25%, reaching 203 licenses in FY 2013. The number of income bearing licenses decreased significantly, from 144 total active income-bearing licenses in FY 2009 to 12 licenses in FY 2013. The number of exclusive income bearing licenses dropped 86%, falling to nine licenses in FY 2013, compared to 64 in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	163	169	192	197	194
New Licenses	10	6	11	8	9
Invention Licenses, Total Active	163	169	192	197	203
New Invention Licenses	10	6	11	8	9
Income Bearing Licenses, Total Active	144	150	170	175	12
Income Bearing Exclusive Licenses	64	69	77	82	9

VA Income from Licensing

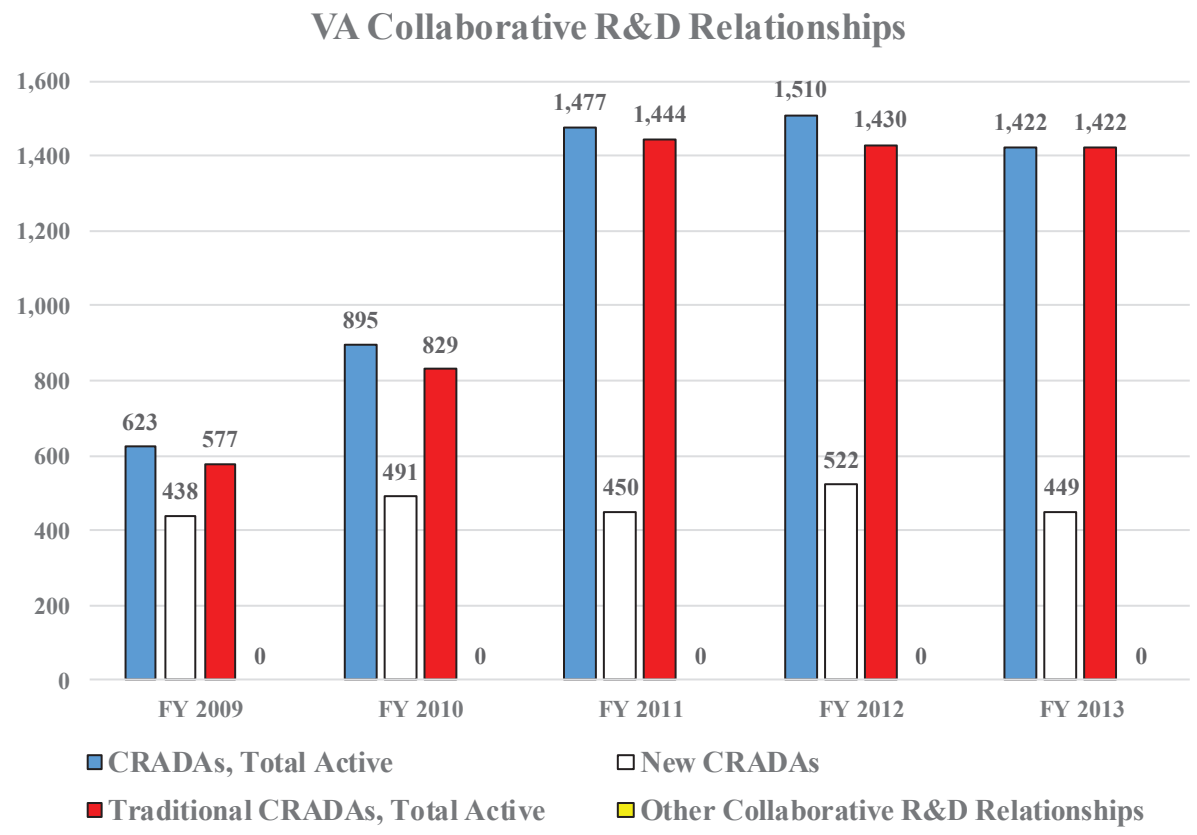
Total income from all active licenses fell 27.72% during the five-year period of FY 2009 to FY 2013, reaching $146 thousand in FY 2013. All of the income came from invention licenses. Total earned royalty income increased by 90.24%, from $205 thousand in FY 2009 to $390 thousand in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$202	$167	$401	$391	$146
Invention Licenses	$202	$167	$401	$391	$146
Total Earned Royalty Income	$205	$133	$401	$392	$390

VA Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs increased by 128.3% to 1,422 agreements in FY 2013. The number of new CRADAs per year increased by 2.5% during the same five-year period, totaling 449 new CRADAs in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	623	895	1,477	1,510	1,422
New CRADAs	438	491	450	522	449
Traditional CRADAs, Total Active	577	829	1,444	1,430	1,422
Other Collaborative R&D Relationships	0	0	0	0	0

Efforts to Streamline Technology Transfer Operations

The goal of VA's technology transfer plan is to increase the number and pace of effective technology transfer and commercialization activities in partnership with non-federal entities, including companies, academic research organizations, and nonprofit entities. In fiscal year (FY) 2012, the agency set ambitious goals for itself. However, FY 2013 became a re-building year for VAs technology transfer program with changes in personnel, and hiring of a new Director and an additional technology transfer specialist. This year, OGC, a key partner in VA's technology transfer activates, initiated a pilot program, the Specialty Team Advising Research (STAR). The STAR team consisted of eight attorneys in regional offices specifically designated to support local VAMC research activities including technology transfer activities such as the review of research agreements, such as CRADAs, and intellectual property activities, such as approval of IP licenses and inventors determination of rights.

Ultimately TTP narrowed its focus this year to addressing five key initiatives: increasing the number and quality of Invention Disclosures (ID); streamlining the determination of rights (DOR) process by which the Federal Government determines its ownership rights in any invention; evaluating existing mechanisms for coordinating IP management activities with affiliates; management of the CRADA review process; and selection and implementation of new contracts for office operations.

- **Invention Disclosure Management**
  TTP established a goal in FY 2012 of improving the number and quality of invention disclosures (IDs). One of TTP's most significant challenges is to ensure that VA inventors themselves disclose their inventions to VA. While inventors invariably disclose their inventions to VA academic affiliates, they are often not aware of their duty to disclose their inventions to VA. Academic affiliates should make VA investigators aware of this requirement, but there is no consistency in the affiliates' actions in this area. As a result, in FY 2012 TTP began to make site visits to VAMCs and academic affiliates to raise awareness of TTP itself and of the procedures and regulations inventors are required to follow regarding disclosing inventions to VA. This outreach resulted in significant increases in both our ID rate and royalty revenues. Current travel restrictions have led us to explore remote educational techniques such as webinars. The initial seminars were well received and will be continued and expanded in the FY14.

- **Streamlining the DOR Process**
  Increasing the number and quality of TTP inventions requires close cooperation with our academic affiliates. Many researchers work at both VA and an academic affiliate, making ownership determinations a more complicated process than at other Federal agencies. Because the decision to take ownership of an invention made by a Federal employee is a legal determination, TTP works with STAR, which formally issues a legal Determination of Rights memorandum, based upon an invention evaluation recommendation by TTP. Patents are then filed by the VA for those inventions that 1) VA has asserted rights 2) the academic affiliate is not taking the lead on IP management. TTP identified administrative impediments to the development of an effective invention evaluation and subsequent DOR. By working with STAR, a new process has been developed that will permit more

timely processing of IDs and lead to an increase in the number of potential VA inventions. Clarity in the government's position on ownership of jointly developed intellectual property will also support our affiliate's ability to seek licensing partners.

- **Coordination of IP management with Affiliates**
  More than 10 years ago, when VA began its technology transfer activities, TTP negotiated CTAAs with the majority of its high volume academic affiliates. The CTAAs describe a mechanism for handling jointly owned inventions, including a formula for sharing revenue and expenses from patenting and licensing activities. Over time, several significant limitations to the CTAA have become apparent, including:

  - A requirement in CTAAs that the academic affiliate report to VA any activity taking place with jointly owned technologies. These agreements are not consistent with regards to the date such report must be provided to VA and they do not describe data elements or a report format. As a result, the timing, nature, format, and quality of the data TTP receive are highly variable;
  - Under the CTAA, the affiliate always has the right to take the lead in developing an invention, except for inventions made pursuant to a VA CRADA, which are rare. TTP has found many inventions where all work was done at VA (often the case with inventions made under Center of Excellence funding), but since one of the VA researchers also has an affiliate appointment, the affiliate can, and usually does, take the lead. This leads to fragmentation of the IP estate and worse, a loss of control over IP that could complicate the successful commercialization of VA's research. Often, a commercial product is an effective way for Veterans and the public to see direct benefit from research; and
  - CTAAs currently contain a mechanism by which VA's share of patent expenses are offset against income generated by a license. Unfortunately, CTAAs give VA no voice in patenting decisions. As a result, some affiliates have undertaken expensive international patent filing campaigns to which VA would not have agreed had VA held some control over the decision.

  TTP will develop and implement a revised CTAA model to address these and other issues.

  Having identified these issues with the existing CTAAs TTP determined that development of a new invention management agreement (IMA) was necessary. Working with OGC TTP has developed a new IMA and is discussing implementation of the new agreement with various academic affiliates. This new agreement is compliant with Federal regulations and will insure VAs contribution to commercialization of new technologies is recognized.

- **CRADA Review Process**
  For the past five years, the VA has executed over 400 CRADAs per year, the majority of which are clinical CRADAs, which permit VA researchers to collaborate with pharmaceutical and biomedical companies to develop new solutions to health care challenges facing veterans. These studies ultimately lead to the development of new commercial products that benefit the public's health.

Historically the VA has relied on Model and Master agreements with selected pharmaceutical companies to manage's these cooperative studies. Model agreements are templates for general use with specific types of research activities such as basic research, principal investigator initiated clinical research, data collection studies, company sponsored clinical studies phase 1,2 and clinical studies phase 3,4 and investigational device studies. Master agreements are templates, which may not be modified and are negotiated with selected industry partners for specific types of research projects. Unmodified agreements based upon a VA Model Agreement are generally reviewed and approved by STAR without TTP review. However, increasingly these agreements are significantly modified by the industry partner resulting in more CRADAs coming to TTP for review. TTP focuses its review on those elements of the agreement involving intellectual property rights.

This year, considerable effort was spent training the new staff within TTP and STAR on Federal technology transfer policies and regulations as well as VA policies and regulations regarding the conduct of clinical studies. Since both TTP and STAR are involved in the review of these CRADAs, coordination of this review is critical. The teams have begun an evaluation of the CRADA review process based upon the past years' experience directed at streamlining the review process. In FY 2014, VA will seek to update existing Masters and negotiate new Masters with the goal of reducing the number of modified agreements that need significant review by TTP and STAR. In addition, existing model agreements will be evaluated and updated as necessary to reflect current policy and regulations.

- **Office Operations Support**
  TTP completed its analysis of workflow early in FY 2013 and determined that the existing database did not adequately support the scope of its technology transfer activities. A functional, intuitive database is critical to managing the various phases of the technology transfer lifecycle. A contract for a new database was finally awarded in September. When operational, this software will enhance the program's capabilities in portfolio management; improve our ability to track metrics and provide deliverables to academic affiliates and increase accountability and the ability to manage data.

  In FY 12 TTP was required to replace existing contracts with its outside law firms who had been managing its intellectual property portfolio with new contracts. The VA will solicit additional contractors to assist in the management of new patent applications.

  VA TTP is an important link in the process of ensuring Veterans receive access to the latest technologies developed by VA researchers. The program also helps VA and the American public to receive their fair share of royalties from patents and joint ventures with non-governmental agencies and private companies. VA is proud to support the President's goal of using technology transfer as a driver of successful innovation in the United States.

Environmental Protection Agency (EPA)

EPA's Federal Technology Transfer Act (FTTA) Program was established to promote collaboration between private sector and Federal researchers. EPA offers exceptional opportunities to develop and commercialize new technologies. Through the authority given to EPA by the Federal Technology Transfer Act of 1986 (Public Law 99-502), EPA facilitates the transfer of new technologies to the marketplace while protecting intellectual property rights of all parties.

Partners in the FTTA Program have the benefit of collaborating with world-class EPA scientists involved in leading-edge research. Collaboration enhances the quality of research projects and helps move environmental technologies into the marketplace, resulting in better protection of human health and the environment.

EPA's annual technology transfer report is available online at:

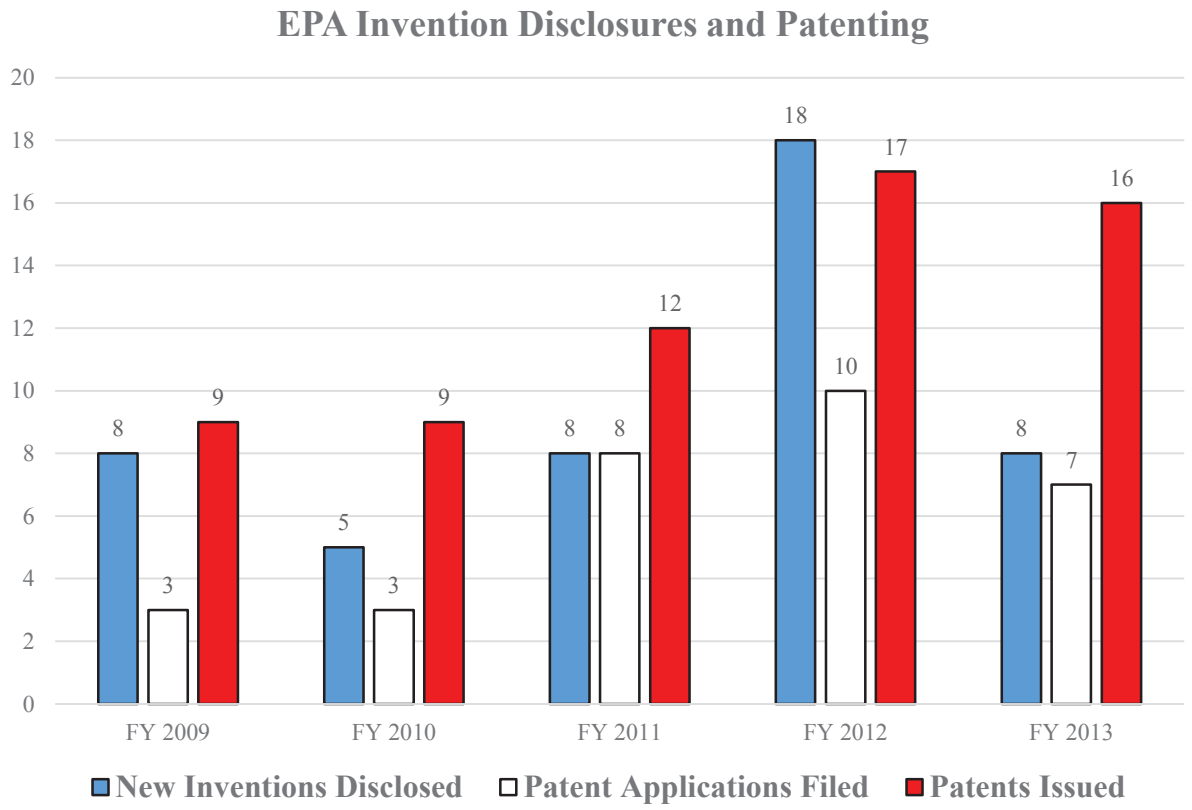
http://www2.epa.gov/ftta/epa-reports-congress-technology-transfer

More information about EPA technology transfer activities is available on the following website:

- http://www2.epa.gov/ftta.

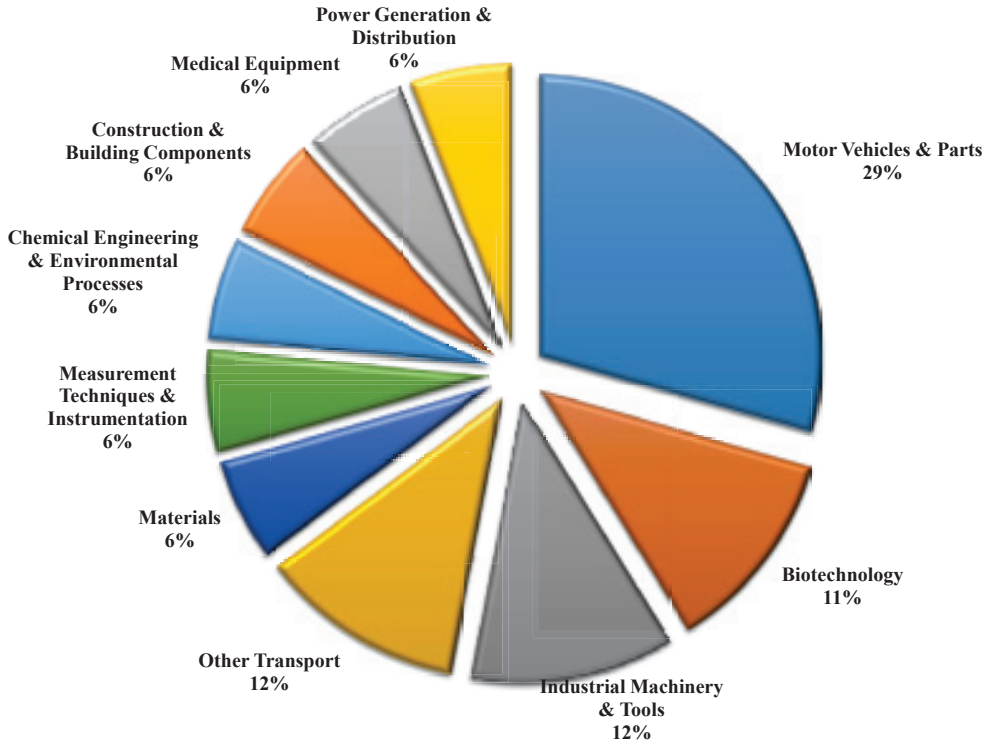
EPA Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed remained constant at eight disclosures per year. The number of patent applications filed during the same five-year period increased by 133% to seven applications in FY 2013. There was a 78% increase in the number of patents issued, reaching 16 patents in FY 2013, compared to nine patents in FY 2009.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	8	5	8	18	8
Patent Applications Filed	3	3	8	10	7
Patents Issued	9	9	12	17	16

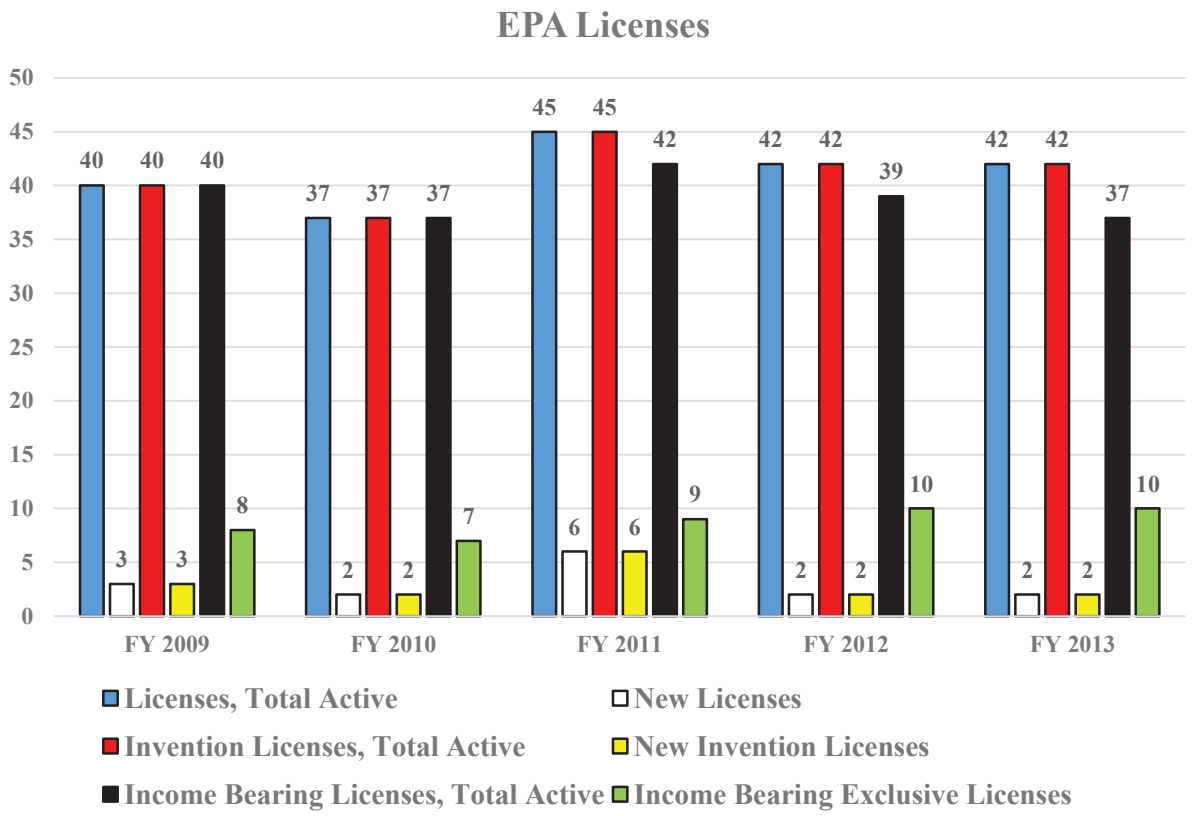
USPTO Patents Assigned to EPA by Technology Area: FY 2013[43]



[43] Source: National Science Foundation and The Patent Board™ (see footnote 5.)

EPA Licenses

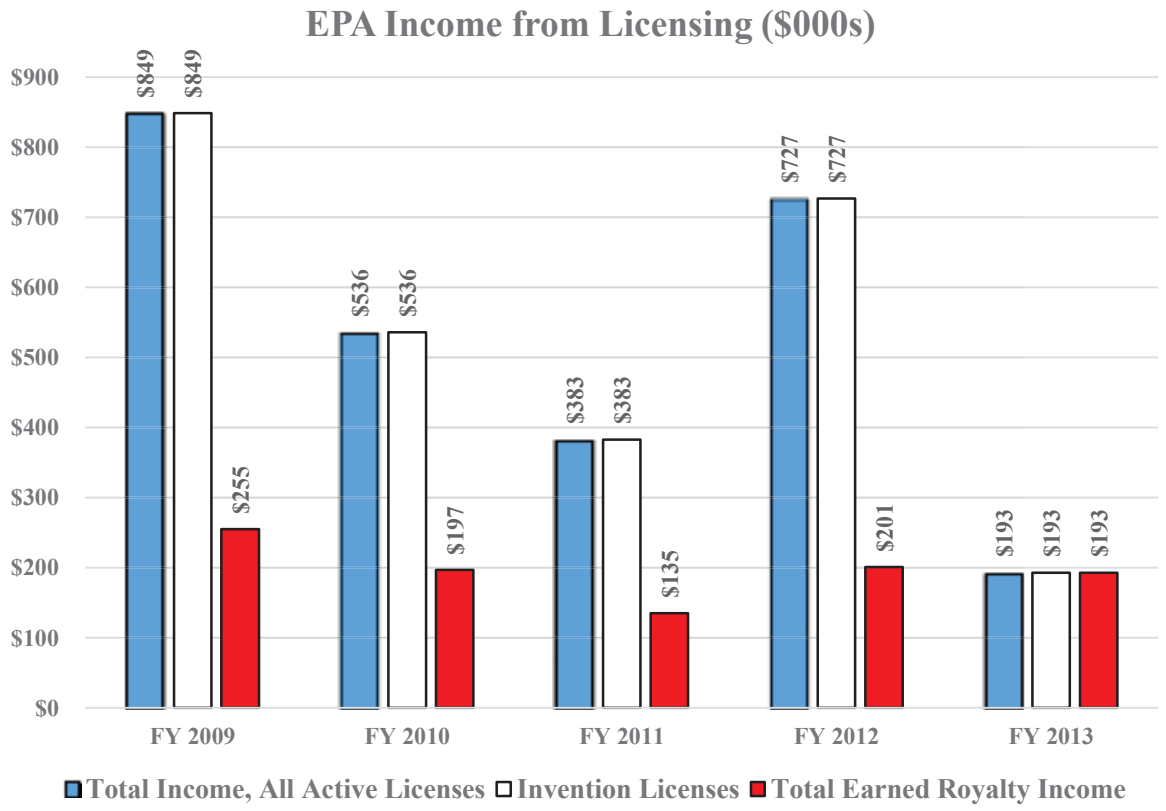
Between FY 2009 and FY 2013, the number of total active licenses, which equals the number of total active invention licenses, increased by 5% to 42 licenses in FY 2013. New licenses per year decreased by 33% to two new licenses in FY 2013. Total active income bearing licenses decreased by 8%, whereas income bearing exclusive licenses increased by 25%.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	40	37	45	42	42
New Licenses	3	2	6	2	2
Invention Licenses, Total Active	40	37	45	42	42
New Invention Licenses	3	2	6	2	2
Income Bearing Licenses, Total Active	40	37	42	39	37
Income Bearing Exclusive Licenses	8	7	9	10	10

EPA Income from Licensing

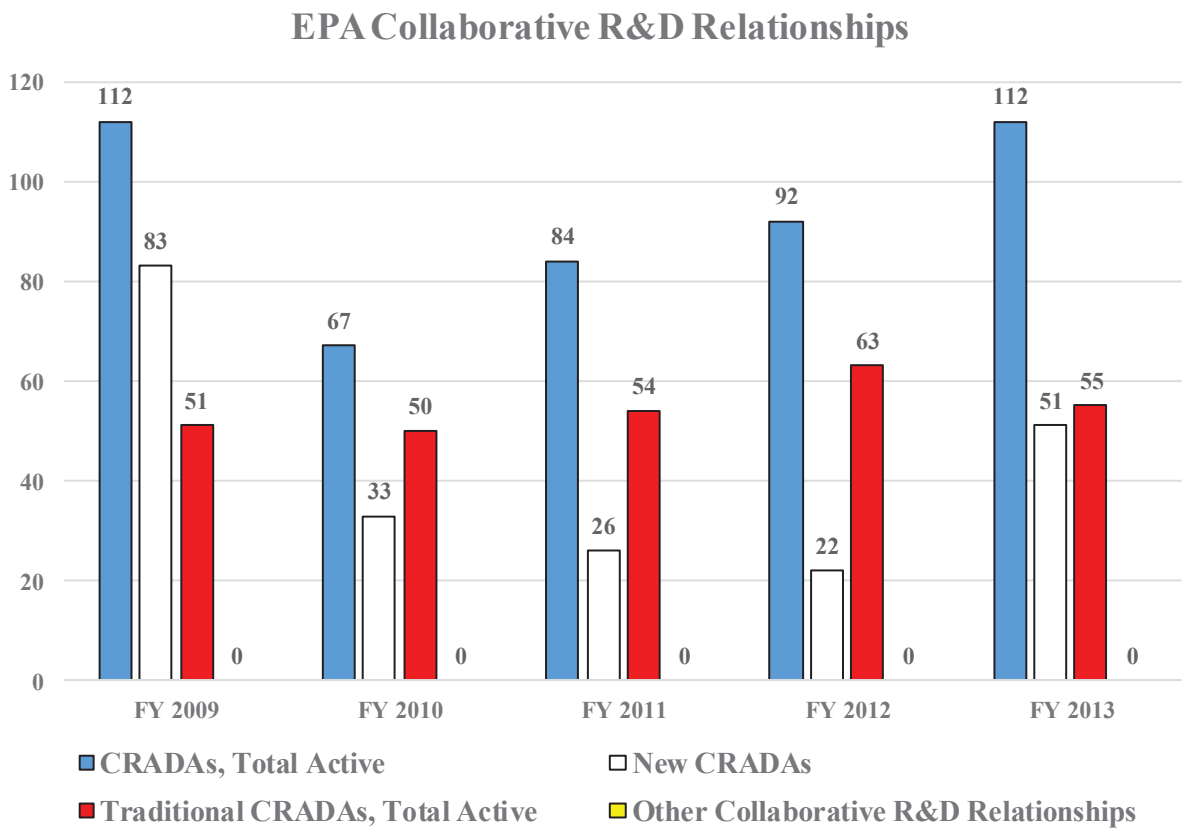
Between FY 2009 and FY 2013, total income decreased by 77% to $193,000 in FY 2013. Total earned royalty income decreased by 24% from $255,000 in FY 2009 to $193,000 in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$849	$536	$383	$727	$193
Invention Licenses	$849	$536	$383	$727	$193
Total Earned Royalty Income	$255	$197	$135	$201	$193

EPA Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of total active CRADAs remained constant at 112 agreements. The number of new CRADAs per fiscal year decreased by 38.6% to 51 new agreements in FY 2013. Total active traditional CRADAs increased by 7.8% during the five-year period, totaling 55 agreements in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	112	67	84	92	112
New CRADAs	83	33	26	22	51
Traditional CRADAs, Total Active	51	50	54	63	55
Other Collaborative R&D Relationships	0	0	0	0	0

Efforts to Streamline Technology Transfer Operations

In its response to the Presidential Memo of 2011 on Accelerating Technology Transfer, EPA committed to enhancing its training outreach, including through virtual methods. The inclusion of FTTA in the annual ethics training, conducted via the computer for nearly all staff, upheld this commitment to enhanced technology transfer training.

EPA Ethics Training for All Staff Incorporates FTTA and Protection of Intellectual Property

In the fall of 2012, EPA's annual online ethics training was released. This training meets the government-wide requirement at 5 CFR 2638.704. Each year, a different focus area is selected, around which the training is structured. For 2012, the training focused on collaborations and agreements with external parties. Recognizing that this topic intersected neatly with EPA's work under the Federal Technology Transfer Act (FTTA), the FTTA staff worked closely with the ethics staff to incorporate a module dedicated to the Federal Technology Transfer Act, development and protection of intellectual property, and patenting. This made-to-order module included information on CRADAs and other FTTA agreements, such as Materials Transfer Agreements; discussed how to identify intellectual property and established that intellectual property belongs to the Federal government if it was developed during the course of work; and highlighted protection of intellectual property through patents and licensing of patents.

EPA employees who file financial disclosure reports are required to take annual ethics training. However, at EPA, many more people take the training than are required. Typically, more than 13,000 of EPA's 16,000 employees take the training. By seizing the opportunity to insert training into the annual ethics course, FTTA staff capitalized on reaching a broad audience. While the FTTA staff conducts training every year for various EPA laboratories and offices, this was the first time that FTTA principles and mechanisms have been presented to the EPA workforce so broadly. At this critical time of diminishing budgets and an evolving research structure at the Agency, the knowledge of tools available under the FTTA statute can be very valuable to staff looking for opportunities to collaborate or leverage research dollars.

EPA Downstream Success Stories

Evaluating Small, Mobile Air Sensors to Assess Pollutants and Concentrations

A series of Materials Cooperative Research and Development Agreement (MCRADA) partnerships between EPA's National Exposure Research Laboratory (NERL) and nine partner organizations focused on personal sensor technologies and their potential for community and regulatory environmental air pollutant monitoring. The small sensor movement and focus on citizen-collected data is aimed at better gathering real-world data on air pollutant concentrations. NERL conducted a series of studies associated with nitrogen dioxide and/or ozone sensors provided by each partner.

These studies were conducted on the performance and operation of the sensors with respect to data quality, telecommunication protocols, battery operation, design issues, and ease of use features. The lab then provided iterative feedback to the sensor developers. Many of the

developers used the feedback to make significant improvements to their units related to performance, telecommunications, or design features. NERL also provided validated laboratory data describing performance characteristics.

The result of these collaborations is a better understanding of the air sensors' functionality by the laboratory, and improved functionality of these sensor technologies by the developers, based upon the testing feedback. These technologies offer significant hope in lower cost, more efficient means of environmental data collections at environmentally relevant concentrations. The sensor developers gained valuable knowledge and data on their devices and an understanding of how to improve the performance of their technologies for the next generation of air monitoring sensors.

Removing VOCs from Groundwater and Wastewater Streams by Pervaporation, and Reducing Energy Requirements for Biofuel Purification

The US Environmental Protection Agency (EPA) entered into a CRADA with Membrane Technology and Research, Inc. (MTR) in March 2000 to further the development of pervaporation membrane technology for the removal of volatile organic compounds (VOCs) from groundwater and wastewater. (In pervaporation, dense membranes are used to separate solvents and water based on sorption and diffusion differences.) In 2002, the CRADA was amended to develop membrane-based technologies for the selective recovery and dehydration of biofuel components from dilute fermentation broths as alternatives to energy-intensive distillation processes. The collaborative work has resulted in several research articles and presentations, 3 issued joint EPA-MTR patents, 1 pending EPA patent, one licensing agreement, and three additional license agreements under negotiation.

As verified by pilot-scale tests at the EPA's Test & Evaluation Facility in Cincinnati, this integrated technology reduces the energy required for ethanol and butanol purification by over 60%. Saving energy in biofuel purification directly affects the environmental impact and sustainability of renewable fuels. The Energy Independence and Security Act established standards for renewable fuels achieving 20, 50, and 60% reductions in greenhouse gas (GHG) emissions relative to conventional fuels. For corn-based ethanol, about 50% of the energy consumed in the production facility is due to the separation processes used to recover and dry ethanol from fermentation broths, leading to significant "upstream" GHG emissions. Cellulosic feedstocks produce even lower ethanol concentrations, requiring more energy for separation processes. Therefore, to deliver sustainable biofuels, energy efficient alcohol-water separation alternatives, such as those developed through the EPA-MTR collaboration, are needed.

MTR is currently in the pre-commercialization development stage of an integrated distillation-membrane technology that is directly related to the CRADA work. This enhanced research and development work with EPA has improved MTR's business offerings and allowed them to advance the speed of their commercialization while providing EPA with access to the real-world tools and know-how necessary to evaluate an emerging technology for challenging environmental separations.

National Aeronautics and Space Administration (NASA)

NASA is engaged in the technology development for missions preparing to look farther into our universe than ever before. NASA innovators are creating the next generation of satellites and rovers for deep space and planetary missions. In addition, NASA is building the new vehicles that will soon take human beings to other worlds for the first time.

To power these missions, the latest era of innovation is underway at the Space Agency. While that means unique advances in science and technology for space applications, it also means remarkable new benefits for daily life, right here on Earth.

NASA's Technology Transfer Program brings together NASA's best problem-solvers with the Nation's brightest commercial and entrepreneurial leaders, forming partnerships that transfer groundbreaking NASA technologies to the public — and providing solutions for challenges in the fields of health and medicine, transportation, consumer goods, public safety, and more.

NASA Technology Transfer Performance Measures

In response to the President's Memorandum, "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses," NASA laid out a series of objectives and is currently engaged in initiatives to accelerate the rate and effectiveness of its technology transfer activities. These initiatives contribute toward seven key objectives:

- Revise Agency policies to ensure alignment with NASA's commitment to technology transfer best practices;
- Identify strategies to build partnerships for technology development, transfer, and mutual benefit;
- Strategically acquire and manage intellectual property;
- Increase the number of new technologies reported by NASA civil servants and contractors;
- Develop and implement innovative methods for technology licensing;
- Increase Agency use of CRADA authority to accelerate licensing of resulting technologies; and
- Increase the release of NASA-developed software to new users.

Each year, NASA will set specific goals within this framework of objectives, identify milestones and, draft both plans and schedules to meet the milestones and ultimately the annual goal.

NASA's annual technology transfer report is available online at:

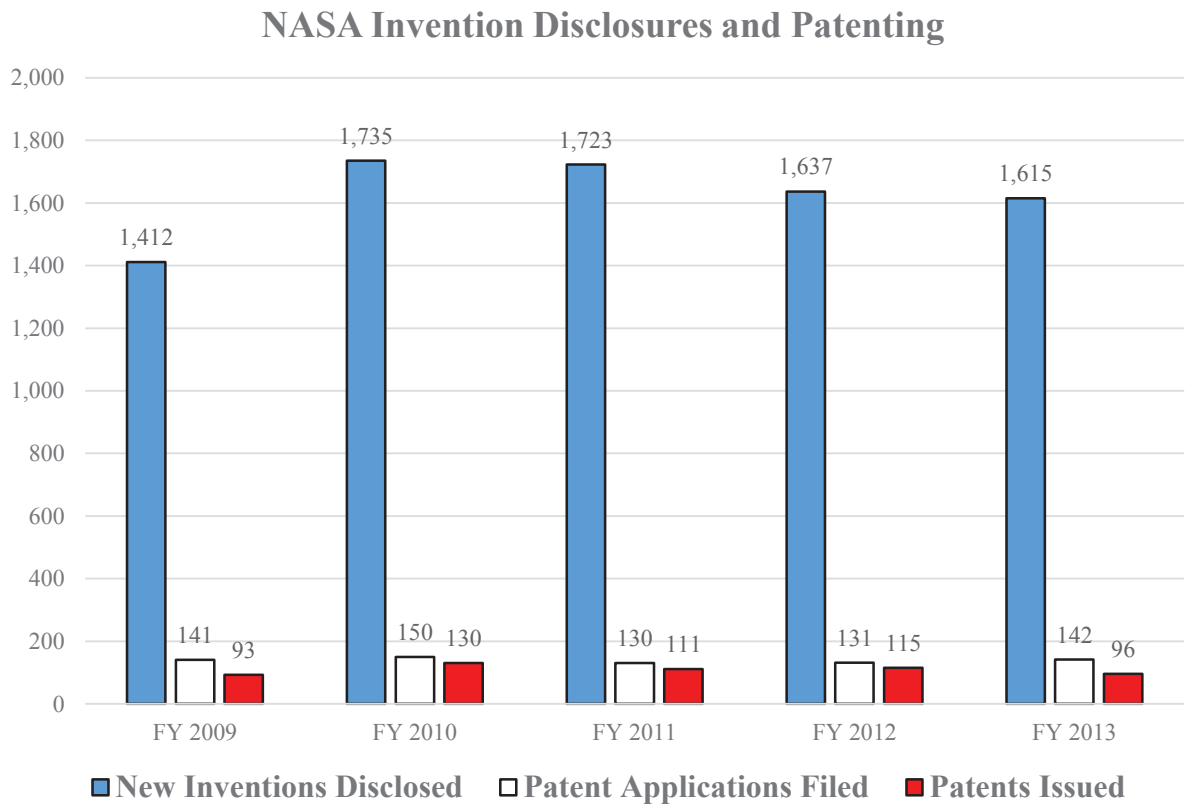
http://technology.nasa.gov/analytics/

More information about NASA technology transfer activities is available on the following website:

- http://www.nasa.gov/offices/oct/home/index.html.

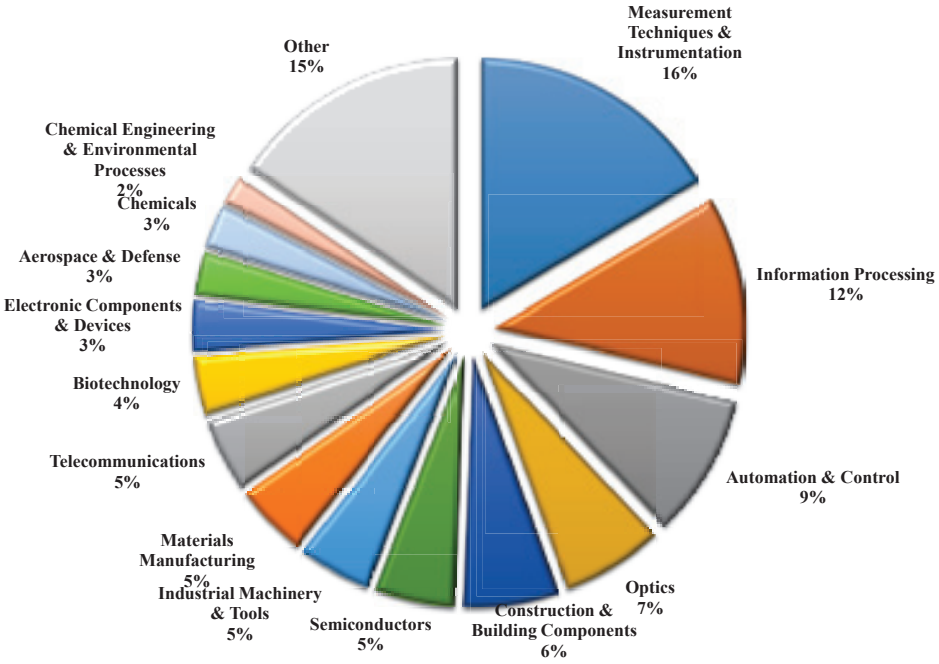
NASA Invention Disclosures and Patenting

Between FY 2009 and FY 2013, the number of new inventions disclosed increased by 14% to 1,615 disclosures in FY 2013. The number of patent applications filed experienced a 1% increase equating to one additional application filed. The number of patents issued during this five-year period increased by 3% to 96 patents in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
New Inventions Disclosed	1,412	1,735	1,723	1,637	1,615
Patent Applications Filed	141	150	130	131	142
Patents Issued	93	130	111	115	96

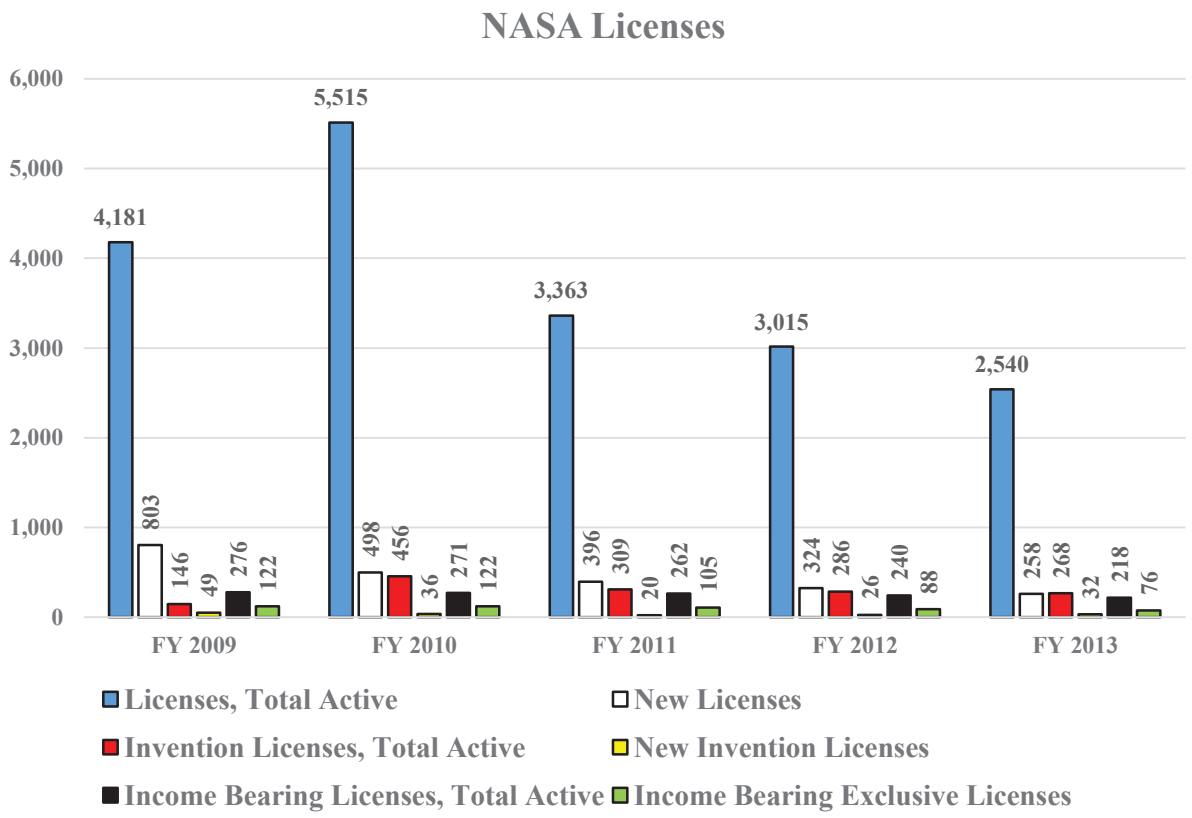
USPTO Patents Assigned to NASA by Technology Area: FY 2013[44]



[44] Source: National Science Foundation and The Patent Board™ (see footnote 5).

NASA Licenses

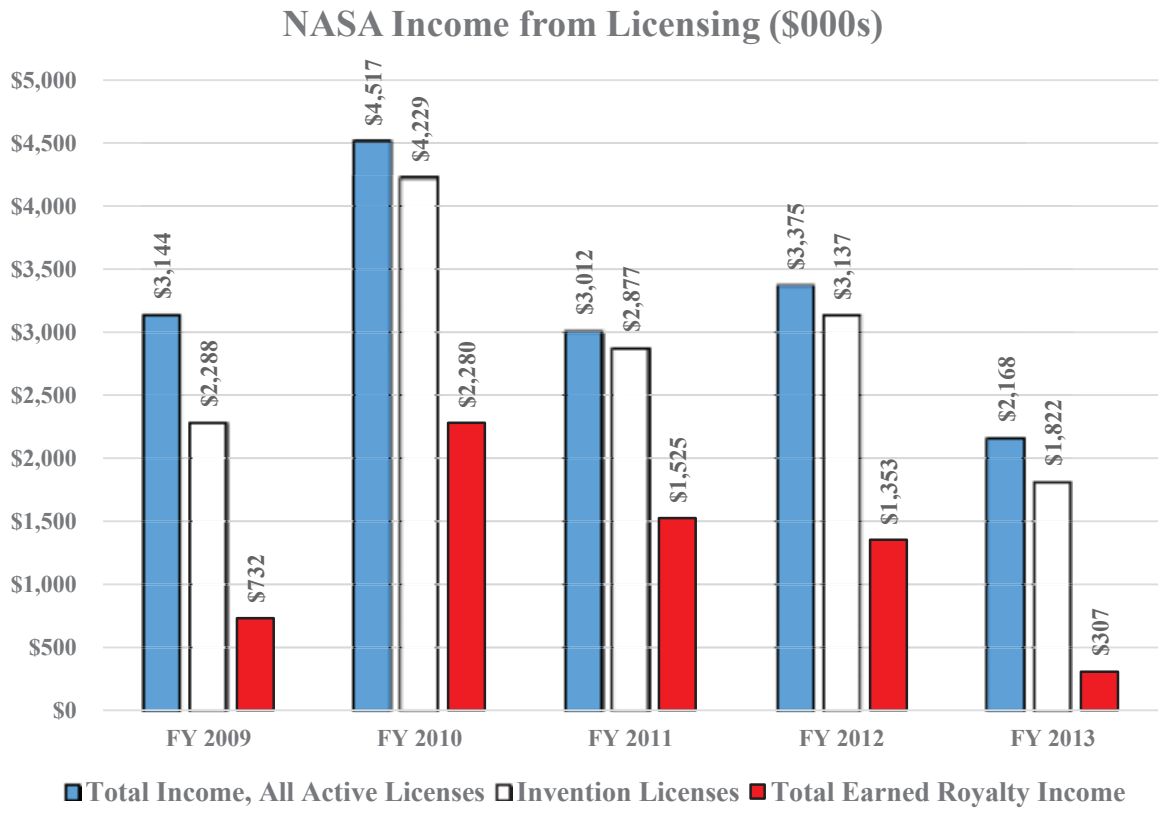
Between FY 2009 and FY 2013, the number of total active licenses decreased by 39% to 2,540 licenses in FY 2013. New licenses decreased by 68% to 258 licenses from a previous 803 in FY 2009. The number of total active invention licenses increased by 84% to 268 licenses.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Licenses, Total Active	4,181	5,515	3,363	3,015	2,540
New Licenses	803	498	396	324	258
Invention Licenses, Total Active	146	456	309	286	268
New Invention Licenses	49	36	20	26	32
Income Bearing Licenses, Total Active	276	271	262	240	218
Income Bearing Exclusive Licenses	122	122	105	88	76

NASA Income from Licensing

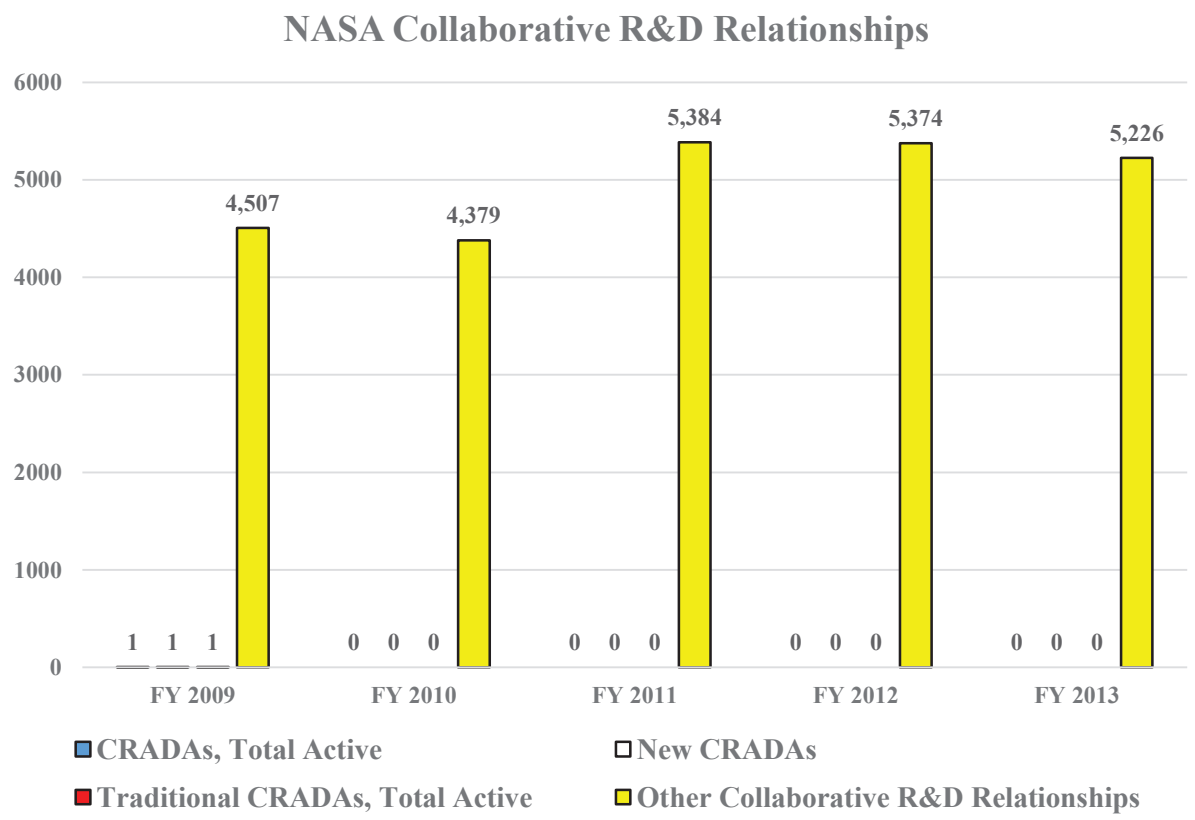
Between FY 2009 and FY 2013, the number of total income from all active licenses decreased by 31% to $2.2 million in FY 2013. The income from invention licenses decreased by 20.4% to $1.8 million. Total earned royalty income decreased 58.1% from $732,000 in FY 2009 to $307,000 in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Income, All Active	$3,144	$4,517	$3,012	$3,375	$2,168
Invention Licenses	$2,288	$4,229	$2,877	$3,137	$1,822
Total Earned Royalty Income	$732	$2,280	$1,525	$1,353	$307

NASA Collaborative R&D Relationships

Between FY 2009 and FY 2013, the number of Space Act Agreements increased 16% from 4,507 agreements in FY 2009 to 5,226 in FY 2013.



	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
CRADAs, Total Active	1	0	0	0	0
New CRADAs	1	0	0	0	0
Traditional CRADAs, Total Active	1	0	0	0	0
Other Collaborative R&D Relationships (Space Act Agreements)	4,507	4,379	5,384	5,374	5,226

Efforts to Streamline Technology Transfer Operations

In response to the President's Memorandum, "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses," NASA laid out a series of objectives and is currently engaged in initiatives to accelerate the rate and effectiveness of its technology transfer activities. These initiatives contribute toward seven key objectives:

- Revise Agency policies to ensure alignment with NASA's commitment to technology transfer best practices;
- Identify strategies to build partnerships for technology development, transfer, and mutual benefit;
- Strategically acquire and manage intellectual property;
- Increase the number of new technologies reported by NASA civil servants and contractors;
- Develop and implement innovative methods for technology licensing;
- Increase Agency use of CRADA authority to accelerate licensing of resulting technologies; and
- Increase the release of NASA-developed software to new users.

Each year, NASA will set specific goals within this framework of objectives, identify milestones and, draft both plans and schedules to meet the milestones and ultimately the annual goal. Accomplishments this year include:

- Revision, updating, and consolidation of agency technology transfer policies;
- Increased education and outreach efforts, including development of standardized training materials, a poster campaign, and revamping of the agency invention disclosure website, including a reporting "button" placed on numerous internal websites, provided promising early returns, with a 20 percent increase in the number of new technologies reported by civil servants, the highest level in 10 fiscal years;
- NASA simplified its patent licensing application for non-exclusive licenses and launched a website designed to increase licensing by further simplifying the process by offering non-negotiated licenses at low upfront fees;
- NASA Technology Transfer Offices each participated in monthly webinars geared at promoting technologies available for licensing. These webinars had, on average, over 1,000 viewers from across a wide array of industries. These were recorded and continue to be viewed;
- NASA began exploring crowdsourcing for understanding potential markets for mission-developed technologies. Two pilot programs have been used to assess the feasibility of this new approach, and each has been promising;
- NASA's Technology Transfer Program worked with the Agency's Small Business Innovation Research Program and the Agency's Procurement Office to improve the overall process by which small businesses report new technologies. This work leveraged existing processes to enhance communications internally and simplify requirements for small businesses;

- NASA published its first-ever CRADA handbook and policy. The Agency had long-relied on its Space Act Agreement authority to conduct similar work, but CRADAs provide a degree of additional flexibility with regard to intellectual property licensing. Primarily, though, NASA wanted to be able to offer industry a partnership vehicle with which they are already familiar; and
- In FY 2013, NASA also began the process of building a system for widespread sharing of its software.

NASA Downstream Success Stories

Miniaturized, Portable Sensors Monitor Metabolic Health
In order to measure astronauts' metabolic rates in space, Glenn Research Center partnered with Case Western University and the Cleveland Clinic to develop the Portable Unit for Metabolic Analysis (PUMA). Cleveland-based Orbital Research licensed and then modified PUMA to help the US Navy assess pilot oxygen problems and is now designing a device that can be used in hospitals.

Data Mining Tools Make Flights Safer, More Efficient
A small data mining team at Ames Research Center developed a set of algorithms ideal for combing through flight data to find anomalies. Dallas-based Southwest Airlines Co. signed a Space Act Agreement with Ames in 2011 to access the tools, helping the company refine its safety practices, improve its safety reviews, and increase flight efficiencies.

Heat Shield Paves the Way for Commercial Space
The Phenolic-Impregnated Carbon Ablator (PICA) heat shield, a lightweight material designed to withstand high temperatures, was used for the Stardust's reentry into Earth's atmosphere. Hawthorne, California-based SpaceX later worked with the inventors at Ames Research Center to outfit PICA on its Dragon capsule, which is now delivering cargo to and from the International Space Station through NASA's Commercial Resupply Services contracts program.

Brainwave Monitoring Software Improves Distracted Minds
Neurofeedback technology developed at Langley Research Center to monitor pilot awareness inspired Peter Freer to develop software for improving student performance. His company, Fletcher, North Carolina-based Unique Logic and Technology Inc., has gone on to develop technology for improving workplace and sports performance, monitoring drowsiness, and encouraging relaxation.

Shuttle Engine Designs Revolutionize Solar Power
The Space Shuttle Main Engine was built under contract to Marshall Space Flight Center by Rocketdyne, now part of Pratt & Whitney Rocketdyne (PWR). PWR applied its NASA experience to solar power technology and licensed the technology to Santa Monica, California-based SolarReserve. The company now develops concentrating solar power projects, including a plant in Nevada that has created 4,300 jobs during construction.

Vision Algorithms Catch Defects in Screen Displays

Andrew Watson, a senior scientist at Ames Research Center, developed a tool called the Spatial Standard Observer (SSO), which models human vision for use in robotic applications. Redmond, Washington-based Radiant Zemax LLC licensed the technology from NASA and combined it with its imaging colorimeter system, creating a powerful tool that high-volume manufacturers of flat-panel displays use to catch defects in screens.

Chapter 3 Conclusion

Technology transfer is an active and essential mission of Federal research and development laboratories. By leveraging our Nation's innovative nature and investing in science and technology, we strengthen our economy and American competitiveness in world markets. In recent years, agencies have engaged in efforts to increase the rate and efficacy of technology transfer activities and thereby improve the economic and societal impact from Federal research and development investments.

This report provides a summary of the technology transfer activities of all 11 Federal agencies that are actively involved in research and development. This summary is derived from each agency's annual technology transfer reports that are located online at http://nist.gov/tpo/publications/agency-technology-transfer-reports.cfm

Statistical data provided in this report indicate that there has been a significant increase in invention disclosures and patenting activities over the five-year span from FY 2009 through FY 2013. During this period, Federal invention disclosures increased by 19%, patent applications increased by 20% and patents issued increased by 42%. In FY 2013, the top three technical areas in which federal patents were awarded were Biotechnology (14%), Measurement Techniques and Instrumentation (13%) and Aerospace and Defense (7%).

Between FY 2009 and FY 2013, the number of total active licenses increased by 24% and the number of new licenses decreased by 5%. The number of income-bearing licenses increased by 4% and the number of exclusive licenses decreased by 25%. The number of Federal collaborative R&D relationships increased by 12%, the number of new CRADA agreements increased by 39%, and the number of non-traditional CRADA agreements increased by 44%.

In response to the September 2011 Presidential Memorandum, Federal agencies have begun gathering additional technology transfer metrics and have instigated plans to monitor and improve the overall impact of Federal technology transfer activities. Data from these efforts will also be published beginning with this report.

In FY 2013, Federal researchers published more than 44,800 papers. More than half of these papers were in the fields of biological sciences (22%), medical sciences (19%) and physics (15%). One report also identifies these three fields as involving the most cited Federal research within U.S. patents. In FY 2013, more than 78% of Federal publications cited in U.S. patents were in the fields of biological sciences (44%), medical sciences (22%), and physics (12%).

Another area of interest now being reported involves the interaction of Federal laboratories with small and young businesses. An initial effort to determine the number of small businesses involved in Federal CRADA agreements reveals that for the agencies that were able to report small business participation, 18% of the 3,095 traditional, Federal CRADA agreements involved small businesses as participants. Federal agencies also support small businesses through the licensing of technologies. For those agencies that were able to report small business participation, 7% of the 10,336 active, Federal licenses were issued to small businesses.

Finally, federally developed technologies are also transferred through interactions with young startup companies. Companies that have been in existence for five years or less and have spun off federally developed technologies or have received critical technical support for their core development areas from Federal laboratories evidence the effective transfer of Federal technologies. Preliminary data from three agencies that report interactions with young startup companies reveals that 78 companies that started between the years of 2008 and 2013, received critical technical support from Federal laboratories.

Appendix A

Federal Invention Disclosure and Patenting

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
USDA	New Inventions Disclosed	178	149	158	160	180
	Patent Applications Filed	123	113	124	122	147
	Patents Issued	24	45	49	69	51
DOC	New Inventions Disclosed	40	31	26	52	41
	Patent Applications Filed	20	20	17	21	25
	Patents Issued	7	12	16	13	20
DoD	New Inventions Disclosed	831	698	929	1,078	1,032
	Patent Applications Filed	690	436	844	1,013	942
	Patents Issued	404	304	523	1,048	648
DOE	New Inventions Disclosed	1,439	1,616	1,820	1,661	1,796
	Patent Applications Filed	775	965	868	780	944
	Patents Issued	363	480	460	483	713
HHS	New Inventions Disclosed	353	337	351	352	320
	Patent Applications Filed	284	291	272	233	230
	Patents Issued	480	470	270	453	428
DHS	New Inventions Disclosed	32	7	38	40	20
	Patent Applications Filed	2	2	12	10	4
	Patents Issued	2	1	0	0	4
DOI	New Inventions Disclosed	4	5	5	10	9
	Patent Applications Filed	8	7	2	3	8
	Patents Issued	4	5	1	3	4
DOT	New Inventions Disclosed	3	1	2	2	13
	Patent Applications Filed	2	2	2	1	5
	Patents Issued	1	2	0	0	4
VA	New Inventions Disclosed	150	168	191	335	273
	Patent Applications Filed	37	31	47	150	53
	Patents Issued	15	10	32	48	6

Federal Invention Disclosure and Patenting (continued)

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
EPA	New Inventions Disclosed	8	5	8	18	8
	Patent Applications Filed	3	3	8	10	7
	Patents Issued	9	9	12	17	16
NASA	New Inventions Disclosed	1,412	1,735	1,723	1,637	1,615
	Patent Applications Filed	141	150	130	131	142
	Patents Issued	93	130	111	115	96

Total	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
	New Inventions Disclosed	4,450	4,752	5,251	5,345	5,307
	Patent Applications Filed	2,085	2,020	2,326	2,474	2,507
	Patents Issued	1,402	1,468	1,474	2,249	1,990

Federal Licenses

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
USDA	Licenses, Total Active	330	344	358	384	400
	New Licenses	26	22	35	34	25
	Invention Licenses, Total Active	302	313	322	341	351
	New Invention Licenses	22	18	29	28	19
	Income Bearing Licenses, Total Active	327	340	354	379	397
	Income Bearing Exclusive Licenses	234	248	257	277	291
DOC	Licenses, Total Active	40	46	40	41	39
	New Licenses	12	7	5	6	5
	Invention Licenses, Total Active	40	46	40	41	39
	New Invention Licenses	11	7	5	6	5
	Income Bearing Licenses, Total Active	28	29	26	25	27
	Income Bearing Exclusive Licenses	11	12	12	12	15
DOD	Licenses, Total Active	432	397	633	520	527
	New Licenses	57	50	63	44	59
	Invention Licenses, Total Active	386	341	431	432	425
	New Invention Licenses	57	50	63	44	59
	Income Bearing Licenses, Total Active	227	134	214	356	264
	Income Bearing Exclusive Licenses	78	67	51	120	n/r
DOE	Licenses, Total Active	5,742	6,228	5,310	5,328	9,148
	New Licenses	755	826	822	757	567
	Invention Licenses, Total Active	1,452	1,453	1,432	1,428	1,353
	New Invention Licenses	139	166	169	192	153
	Income Bearing Licenses, Total Active	3,339	3,493	3,510	3,340	3,709
	Income Bearing Exclusive Licenses	411	462	315	344	199
HHS	Licenses, Total Active	1,584	1,941	1,613	1,465	1,426
	New Licenses	221	269	264	231	184
	Invention Licenses, Total Active	1,304	1,240	414	1,090	1,069
	New Invention Licenses	198	217	106	192	152
	Income Bearing Licenses, Total Active	880	848	849	809	809
	Income Bearing Exclusive Licenses	23	24	27	24	125
DHS	Licenses, Total Active	63	458	495	523	1,265
	New Licenses	45	458	418	37	733
	Invention Licenses, Total Active	0	0	0	0	0
	New Invention Licenses	0	0	0	0	0
	Income Bearing Licenses, Total Active	0	0	0	0	0
	Income Bearing Exclusive Licenses	0	0	0	0	0

Federal Licenses (continued)

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
DOI	Licenses, Total Active	21	28	25	26	20
	New Licenses	4	4	2	1	3
	Invention Licenses, Total Active	18	23	23	24	20
	New Invention Licenses	3	3	2	1	3
	Income Bearing Licenses, Total Active	18	19	22	22	16
	Income Bearing Exclusive Licenses	4	5	3	12	4
DOT	Licenses, Total Active	2	3	3	3	3
	New Licenses	0	0	1	1	0
	Invention Licenses, Total Active	3	3	3	3	0
	New Invention Licenses	0	0	0	0	0
	Income Bearing Licenses, Total Active	3	3	3	3	3
	Income Bearing Exclusive Licenses	3	3	2	2	0
VA	Licenses, Total Active	163	169	192	197	194
	New Licenses	10	6	11	8	9
	Invention Licenses, Total Active	163	169	192	197	203
	New Invention Licenses	10	6	11	8	9
	Income Bearing Licenses, Total Active	144	150	170	175	12
	Income Bearing Exclusive Licenses	64	69	77	82	9
EPA	Licenses, Total Active	40	37	45	42	42
	New Licenses	3	2	6	2	2
	Invention Licenses, Total Active	40	37	45	42	42
	New Invention Licenses	3	2	6	2	2
	Income Bearing Licenses, Total Active	40	37	42	39	37
	Income Bearing Exclusive Licenses	8	7	9	10	10
NASA	Licenses, Total Active	4,181	5,515	3,363	3,015	2,540
	New Licenses	803	498	396	324	258
	Invention Licenses, Total Active	146	456	309	286	268
	New Invention Licenses	49	36	20	26	32
	Income Bearing Licenses, Total Active	276	271	262	240	218
	Income Bearing Exclusive Licenses	122	122	105	88	76

Total	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
	Licenses, Total Active	12,598	15,166	12,077	11,544	15,604
	New Licenses	1,936	2,142	2,023	1,445	1,845
	Invention Licenses, Total Active	3,854	4,081	3,211	3,884	3,770
	New Invention Licenses	492	505	411	499	434
	Income Bearing Licenses, Total Active	5,282	5,324	5,452	5,388	5,492
	Income Bearing Exclusive Licenses	958	1,019	858	971	729

Federal Income from Licensing ($000s)

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
USDA	Total Income, All Active Licenses	$5,376	$3,641	$3,989	$3,806	$4,390
	Invention Licenses	$5,318	$3,566	$3,855	$3,671	$4,058
	Total Earned Royalty Income, (ERI)	$4,422	$3,075	$3,137	$3,060	$3,354
DOC	Total Income, All Active Licenses	$336	$237	$277	$248	$151
	Invention Licenses	$336	$237	$277	$248	$151
	Total Earned Royalty Income, (ERI)	$336	$237	$277	$248	$151
DOD	Total Income, All Active Licenses	$16,439	$13,424	$15,682	$7,055	$21,575
	Invention Licenses	$16,165	$13,026	$15,364	$6,552	$20,859
	Total Earned Royalty Income, (ERI)	$16,240	$10,848	$7,702	$6,335	$20,438
DOE	Total Income, All Active Licenses	$43,570	$40,644	$44,728	$40,849	$39,573
	Invention Licenses	$40,262	$37,066	$40,600	$36,103	$36,068
	Total Earned Royalty Income, (ERI)	$28,901	$25,220	$27,107	$28,735	$27,669
HHS	Total Income, All Active Licenses	$85,059	$80,923	$98,453	$110,576	$116,448
	Invention Licenses	$83,041	$79,805	$82,842	$108,308	$103,664
	Total Earned Royalty Income, (ERI)	$91,060	$91,374	$96,605	$110,930	$116,601
DHS	Total Income, All Active Licenses	$0	$0	$0	$0	$0
	Invention Licenses	$0	$0	$0	$0	$0
	Total Earned Royalty Income, (ERI)	$0	$0	$0	$0	$0
DOI	Total Income, All Active Licenses	$89	$80	$93	$78	$59
	Invention Licenses	$89	$80	$93	$78	$59
	Total Earned Royalty Income, (ERI)	$89	n/a	$82	$63	$59
DOT	Total Income, All Active Licenses	$44	$17	$15	$7	$12
	Invention Licenses	$44	$17	$15	$7	$12
	Total Earned Royalty Income, (ERI)	$34	$3	$8	$6	$12
VA	Total Income, All Active Licenses	$202	$167	$401	$391	$146
	Invention Licenses	$202	$167	$401	$391	$146
	Total Earned Royalty Income, (ERI)	$205	$133	$401	$392	$390
EPA	Total Income, All Active Licenses	$849	$536	$383	$727	$193
	Invention Licenses	$849	$536	$383	$727	$193
	Total Earned Royalty Income, (ERI)	$255	$197	$135	$201	$193

Federal Income from Licensing (continued) ($000s)

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
NASA	Total Income, All Active Licenses	$3,144	$4,517	$3,012	$3,375	$2,168
	Invention Licenses	$2,288	$4,229	$2,877	$3,137	$1,822
	Total Earned Royalty Income, (ERI)	$732	$2,280	$1,525	$1,353	$307

Total	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
	Total Income, All Active Licenses	$155,108	$144,186	$167,033	$167,112	$184,715
	Invention Licenses	$148,594	$138,729	$146,707	$159,222	$167,032
	Total Earned Royalty Income, (ERI)	$126,034	$122,519	$129,277	$165,426	$169,174

Federal Collaborative R&D Relationships

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
USDA	CRADAs, Total Active	243	273	292	274	259
	New CRADAs	81	92	102	65	86
	Traditional CRADAs, Total Active	201	219	207	211	211
	Other Collaborative R&D Relationships	10,306	11,570	13,458	14,351	16,102
DOC	CRADAs, Total Active	2,397	2,253	2,245	2,410	2,428
	New CRADAs	1,512	2,159	2,192	2,844	2,290
	Traditional CRADAs, Total Active	101	100	98	153	197
	Other Collaborative R&D Relationships	2,828	2,897	2,899	2,782	2,977
DoD	CRADAs, Total Active	2,870	3,248	2,554	2,400	2,682
	New CRADAs	659	720	762	757	769
	Traditional CRADAs, Total Active	2,247	2,516	1,685	1,328	2,076
	Other Collaborative R&D Relationships	1	287	988	0	606
DOE	CRADAs, Total Active	744	697	720	742	742
	New CRADAs	176	176	178	184	142
	Traditional CRADAs, Total Active	744	697	720	742	742
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	457	447	430	377	427
	New CRADAs	105	83	81	93	104
	Traditional CRADAs, Total Active	284	300	284	245	313
	Other Collaborative R&D Relationships	0	0	0	0	114
DHS	CRADAs, Total Active	23	36	62	94	114
	New CRADAs	6	14	31	53	76
	Traditional CRADAs, Total Active	22	32	55	89	91
	Other Collaborative R&D Relationships	5	3	11	11	6
DOI	CRADAs, Total Active	248	436	351	379	476
	New CRADAs	74	82	295	284	376
	Traditional CRADAs, Total Active	36	29	24	28	21
	Other Collaborative R&D Relationships	0	0	209	283	322
DOT	CRADAs, Total Active	22	22	25	27	41
	New CRADAs	7	0	8	1	9
	Traditional CRADAs, Total Active	0	0	0	1	41
	Other Collaborative R&D Relationships	n/r	31	39	14	26
VA	CRADAs, Total Active	623	895	1,477	1,510	1,422
	New CRADAs	438	491	450	522	449
	Traditional CRADAs, Total Active	577	829	1,444	1,430	1,422
	Other Collaborative R&D Relationships	0	0	0	0	0

Federal Collaborative R&D Relationships (continued)

Agency	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
EPA	CRADAs, Total Active	112	67	84	92	112
	New CRADAs	83	33	26	22	51
	Traditional CRADAs, Total Active	51	50	54	63	55
	Other Collaborative R&D Relationships	0	0	0	0	0
NASA	CRADAs, Total Active	1	0	0	0	0
	New CRADAs	1	0	0	0	0
	Traditional CRADAs, Total Active	1	0	0	0	0
	Other Collaborative R&D Relationships	4,507	4,379	5,384	5,374	5,226

Total	Metric	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
	CRADAs, Total Active	7,740	8,374	8,240	8,305	8,703
	New CRADAs	3,142	3,850	4,125	4,825	4,352
	Traditional CRADAs, Total Active	4,264	4,772	4,571	4,290	5,169
	Other Collaborative R&D Relationships	17,647	19,167	22,988	22,815	25,379

Appendix B

Technology Area Classifications
Mapping of International Patent Classifications to Technology Area[45]

Aerospace & Defense: parts and components that pertain to aircraft and spacecraft as well as defense mechanisms. This includes engines, jet propulsion, gas turbines, and fuel control related to airplanes, helicopters, spacecraft and lighter-than-air vehicles. Defense includes weapons, ammunition, explosives, warship or submarine weaponry as well as protective gear, armed vehicles and land defense devices. Note: Engines and turbines included here are primarily for aircraft, but some for locomotives and ships will appear as well.

Biotechnology: pertains to living organisms (or parts of living organism) used primarily for medicinal purposes and diagnostics, as well as genetic engineering and biotechnology research equipment. This includes vaccines, pharmaceuticals, nutraceuticals, herbal remedies, peptides, sugars, nucleic acids, micro-organisms, enzymes, genetic engineering, measuring and testing techniques, research and laboratory equipment and combinatorial chemistry.

Chemical Engineering & Environmental Processes: select processes and techniques used in chemical industrial processes, recycling, treating materials to make them safer or for safe disposal. This includes separation and filtration techniques, mixing, cryogenics, waste and water treatments, soil reclamation and solid waste disposal. Included in separation techniques are processes related to catalysts, including catalytic converters for engine exhaust gases (but not muffler/exhaust systems).

Chemicals: organic or inorganic compositions and processes involving dyes, pigments, coating, cleaning, polishing, glue, gelatin, catalysts, fatty acids, petrochemicals, natural resins, and electrolytic processes.

Electronic Components & Devices: components related to high-tech electronic equipment and devices that perform functions. This includes display technologies, capacitors, resistors, actuators, piezoelectric devices, card readers and connectors, as well as components for navigational items, spectrometers, micro-electromechanical systems (MEMS), data collectors (i.e. bar code scanners, ID card readers) and registers.

Information Processing: data or information processing, computational models, business methods. This includes image analysis, data capture and collectors, speech/audio processing, database structures, error detection/correction, security, analog to digital conversion, data transfer sequencing as well as computer software.

Materials Manufacturing: processing and treatment of materials along with their related machinery, as well as layered products. This includes metalworking, metal casting, metal rolling, foundry molding, photomechanical processes, chemical and mechanical treatments, textile

[45] Copyright ©2013, The Patent Board. Used with permission.

cleaning and dying, clothes manufacturing, electrolytic processes, paper/cardboard processes, coating processes as well as layered products comprising different materials or are of certain forms.

Materials: glass, minerals, pulp, paper, fibers, textiles, metals, and composites thereof. This includes plastics, polymers, rubber, cement, ceramics, stone, micro and nano-structures, liquid crystal materials, anti-oxidants and adhesives as well as materials that are electro chromic, photosensitive, luminescent, thermoelectric and radioactive in nature.

Measurement Techniques & Instrumentation: techniques and use of instrumentation which measures, tests, inspects or analyzes a wide variety of materials or processes. This includes measuring electric variables, distances, volume, flow, velocity, speed, force, stress, torque, temperatures, weight, length, thickness, and mechanical vibrations through tapes, levels, global-positioning devices, radar, scales, thermometers and flow meters, among other specialized devices. This also includes horology, meteorology, geophysics (e.g. earthquake detection/measurement), analyzing chemical or physical processes and associated laboratory equipment (e.g. centrifuges, beakers, test tubes, etc.), investigating or analyzing materials (includes optical means for inspection widely used in the semiconductor industry) and scanning-probe microscopy.

Optics: optical elements, materials and systems. This includes light guides, lenses, waveguides, optical fibers, electro-chromic materials, microscopes, telescopes, optical modulation, MEMS, masers, lasers, holography, optical measuring instruments and optical arrangements for controlling displays.

Pharmaceuticals: preparation and compounds of synthetic therapeutic drugs. This includes over-the-counter drugs, targeted medicinals and steroids.

Power Generation & Distribution: generation of small or large-scale power from both traditional and alternative energy sources and means for distribution. This includes batteries, fuel cells, generators, motors (motor control), fusion reactors as well as combustion, power conversion and distribution. Alternative energy includes solar, wind, wave, tidal, hydroelectricity and geothermal means as well as nuclear.

Semiconductors: semiconductor materials, manufacturing, design and processes. This includes silicon wafer manufacturing, solid-state devices and solar cells, as well as processes such as chemical-vapor deposition (CVD), coating, etching and polishing as well as computer-aided design.

Telecommunications: transmission of voice/data over landlines or wireless and the equipment necessary to deliver. This includes antennas, receivers, equipment arrangements, modulation, waveguides, resonators, multiplexing, and impedance networks.

Appendix C

Fields and Subfields of S&E Publications Data[46]

Biological sciences: general biomedical research, miscellaneous biomedical research, biophysics, botany, anatomy and morphology, cell biology, cytology, and histology, ecology, entomology, immunology, microbiology, nutrition and dietetics, parasitology, genetics and heredity, pathology, pharmacology, physiology, general zoology, miscellaneous zoology, general biology, miscellaneous biology, biochemistry and molecular biology, virology

Chemistry: analytical chemistry, organic chemistry, physical chemistry, polymers, general chemistry, applied chemistry, inorganic and nuclear chemistry

Engineering: aerospace engineering, chemical engineering, civil engineering, electrical engineering, mechanical engineering, metals and metallurgy, materials engineering, industrial engineering, operations research and management, biomedical engineering, nuclear technology, general engineering, miscellaneous engineering and technology

Geosciences: meteorology and atmospheric sciences, geology, earth and planetary sciences, oceanography and limnology, marine biology and hydrobiology, environmental sciences

Medical sciences: endocrinology, neurology and neurosurgery, dentistry, environmental and occupational health, public health, surgery, general and internal medicine, ophthalmology, pharmacy, veterinary medicine, miscellaneous clinical medicine, anesthesiology, cardiovascular system, cancer, gastroenterology, hematology, obstetrics and gynecology, otorhinolaryngology, pediatrics, psychiatry, radiology and nuclear medicine, dermatology and venereal disease, orthopedics, arthritis and rheumatism, respiratory system, urology, nephrology, allergy, fertility, geriatrics, embryology, tropical medicine, addictive diseases, microscopy

Physics: acoustics, chemical physics, nuclear and particle physics, optics, solid state physics, applied physics, fluids and plasmas, general physics, miscellaneous physics

---

[46] SOURCES: The Patent Board™, and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR) database system, http://webcaspar.nsf.gov. Science and Engineering Indicators 2012. Used with permission.

National Institute of Standards and Technology
U.S. Department of Commerce

100 Bureau Drive, Gaithersburg, MD 20899-2200 | http://www.nist.gov