Federal Laboratory Technology Transfer

Fiscal Year 2015

Summary Report to
the President and the Congress

Prepared by:
National Institute of
Standards and Technology
U.S. Department of Commerce

NIST

December 2017

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The cover image displays quantum “cat” states in which the cores of several ions all spin clockwise and counterclockwise at the same time. The image appears in, “Creation of a Six-Atom ‘Schrödinger Cat’ State” by D. Leibfried, E. Knill, S. Seidelin, J. Britton, R. B. Blakestad, J. Chiaverini, D. B. Hume, W. M. Itano, J. D. Jost, C. Langer, R. Ozeri, R. Reichle & D. J. Wineland. Nature 438, 639-342 (01 December 2005). (http://rdcu.be/A8Zz) David Wineland of the National Institute of Standards and Technology, along with Serge Haroche, won the 2012 Nobel Prize in Physics for “ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems” (https://www.nobelprize.org/nobel_prizes/physics/laureates/2012/). Picture used with permission.

FOREWORD

The Department of Commerce is pleased to submit this Fiscal Year 2015 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 (R&D) 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 cross-agency focus on the Lab-to-Market efforts have emphasized the important role that innovation plays in accelerating the development of new industries, products, and services that lead to economic growth and job creation. Agencies have engaged in efforts to accelerate technology transfer activities, improved and expanded the collection of technology transfer metrics, and established performance goals and evaluation methods to enhance the efficiency and impact of their technology transfer activities.

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. Future editions of this report will be used 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.

Dr. Walter G. Copan
Under Secretary of Commerce for Standards and Technology &
Director, National Institute of Standards and Technology

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Chapter 1

Overview of Federal Technology Transfer

Many Federal agencies conduct R&D activities that result in the creation of new technologies. In most cases, these technologies are created to support specific needs of an agency's mission. In other cases, they are spontaneous creations of ongoing research. Regardless of how they are created, Federal technologies often have significant value that goes beyond an agency's mission. It is the role of an agency's technology transfer office to identify this value and provide the most effective means to transfer it outside of the agency.

Federal legislation provides a variety of vehicles through which Federal technologies can be transferred.[1] These vehicles facilitate the potential commercialization of inventions, 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. This includes the processing of patent applications and licenses as well as Cooperative Research and Development Agreements (CRADAs) and other mechanisms that convey knowledge, ownership rights, or establish formal research agreements.

Collaborative research is particularly important to the technology transfer process and in many ways, is fundamental to every agency's mission. By bringing together thousands of highly qualified researchers and world class research facilities, collaborative research between Federal and non-federal organizations greatly enhances research capabilities, core competencies, and creativity. This in turn leads to the flow of new ideas, new tools, more efficient techniques, new processes and products, and new businesses. Collaborative research also helps agencies attract and retain talented scientific personnel through rewards and royalty sharing opportunities.

Over the last seven years, agencies have responded to the need to improve technology transfer operations to better address the needs of businesses and especially small businesses that are vulnerable to a slow-moving bureaucratic system. The inter-agency coordination of efforts has led agencies to review their operations and propose new ways to improve overall customer experience. These improvements include efforts to streamline operations to open doors to more efficient technology transfer opportunities. Other improvements target the way customers interact with the federal system.

[1] 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.

This annual report summarizes the technology transfer activities and transfer vehicles used by 11 Federal agencies that have significant Federal laboratory operations: [2]

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

Each of these agencies has established programs for promoting the transfer and commercialization of technologies developed in its R&D laboratories and has provided the data contained in this report. The DOC'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

Spending on R&D by the Federal government supports a wide variety of agency-specific missions, for instance, military objectives, health and human services issues, energy development, space exploration, and so forth. In FY 2015, the total Federal budget for R&D was $128,573 million. Of this, $82,529 million (64%) was used to support R&D activities that occurred outside of Federal laboratories. This includes funding for grants, cooperative agreements, awards, and the like. The remainder, $46,044 million (36%), supported R&D activities that occurred inside Federal laboratories. This includes $34,925 million to support intramural activities and $11,119 million to support federally funded R&D centers (FFRDCs).[3] These funds constitute the amount of Federal funds that can be used to support research that creates technologies developed in Federal laboratories and the accompanying technology transfer activities which are the focus of this report. As shown in the table below, the percent of an agency's budget that was available to support the development and transference of Federal technologies varied significantly among agencies.

[2] In this report, the term "Federal laboratory" refers to any laboratory, any federally funded research and development center, or any center established under section 7 or section 9 of 15 U.S.C. § 3705 or § 3707 that is owned, leased, or otherwise used by a Federal agency and funded by the Federal Government, whether operated by the Government or by a contractor.

[3] For a list of FFRDCs see https://www.nsf.gov/statistics/publication-series.cfm?seriesId=25

Federal Obligations for R&D
By Agency FY 2015 ($ million)[4]

	Total R&D	Intramural[(a)]	FFRDCs[(b)]	Intramural and FFRDCs	Percent of Total R&D Budget
All Agencies	$128,573	$34,925	$11,119	$46,044	36%
DoD	$61,514	$20,180	$1,914	$22,094	36%
DOE	$11,391	$1,072	$6,892	$7,964	70%
HHS	$30,272	$6,644	$469	$7,113	23%
NASA	$11,361	$1,818	$1,385	$3,203	28%
USDA	$2,341	$1,507	$0	$1,507	64%
DOC	$1,331	$995	$10	$1,005	76%
DOI	$800	$692	$0	$692	87%
VA	$662	$662	$0	$662	100%
DHS	$742	$345	$120	$465	63%
DOT	$856	$231	$67	$298	35%
EPA	$516	$261	$1	$262	51%
Other Agencies	$6,787	$518	$261	$779	11%

(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

In FY 2015, DoD spent the largest amount of funding for intramural activities and FFRDCs, $22,094 million (36% of its R&D budget). DOE was second with $7,964 million (70% of its R&D budget) and HHS was third with $7,113 million (23% of its R&D budget).

[4] National Science Foundation (NSF), National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Federal Obligations for Research and Development, by Agency and Performer: FY 2015, Table 8. https://ncsesdata.nsf.gov/fedfunds/2015/html/FFS2015_DST_008.html

Federal Technology Transfer Summary

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 as well as agency plans to use technology transfer to advance the agency's mission and to promote U.S. competitiveness.[5] The following tables summarize Federal technology transfer activities for the five-year period from FY 2011 through FY 2015.[6] 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.

Federal Invention Disclosures and Patenting

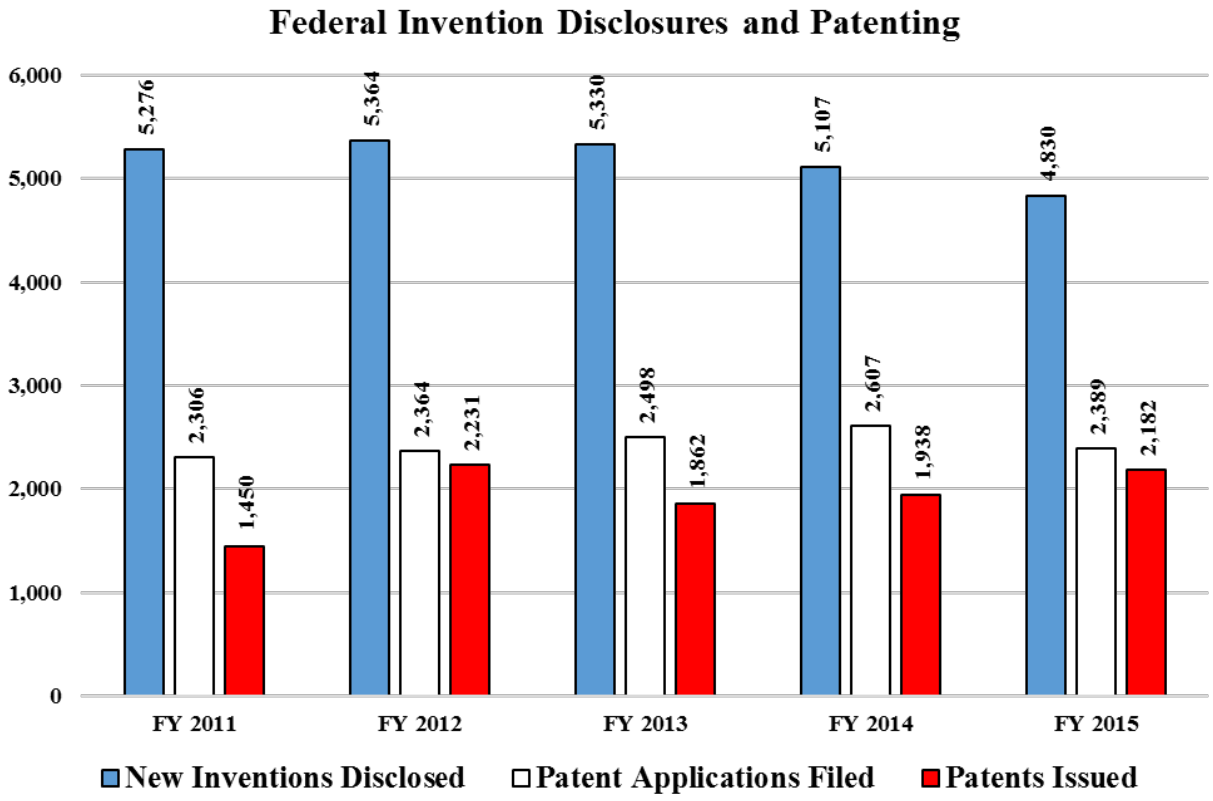
The protection of intellectual property can be vital to attracting the additional investment and product development resources necessary for early stage research products to be brought to their full commercial potential. Federal laboratory achievements in the areas of invention disclosures and patents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

Between FY 2011 and FY 2015, the number of invention disclosures reported by Federal agencies decreased by 8% to 4,830. The number of patent applications filed increased by 4% to 2,389, and the number of patents issued increased by 50% to 2,182. DOE reported the largest number of invention disclosures with 1,645 in FY 2015, followed by NASA with 1,550 and DoD with 781. These three agencies accounted for 82% of all invention disclosures reported in this fiscal year.

In FY 2015, DOE reported the largest number of patent applications with 949 and patents issued with 755. DoD was second in both categories with 884 patent applications and 623 patents issued. HHS was third with 222 patent applications and 501 patents issued. These three agencies accounted for 86% of patent applications and 86% of patents issued.

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

[6] Technology transfer data are routinely adjusted over time to account for new information resulting from changes in reporting procedures, patent decisions, programmatic changes, and other corrections. Throughout this report, data prior to FY 2015 have been adjusted where necessary, to reflect the most accurate estimates for each year reported.

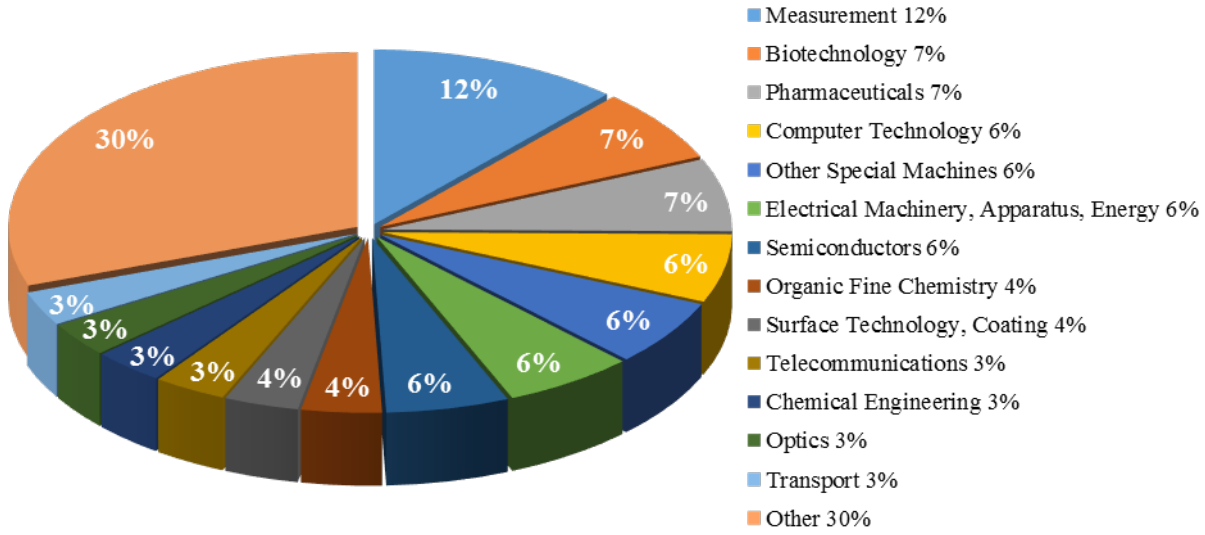


	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	5,276	5,364	5,330	5,107	4,830
Patent Applications Filed	2,306	2,364	2,498	2,607	2,389
Patents Issued	1,450	2,231	1,862	1,938	2,182

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 2015. The chart shows the percentage of patents issued to Federal agencies by technology area based on a fractional count of patents.[7] In FY 2015, the largest number of Federal patents issued involved measurements (12%) followed by biotechnology (7%), pharmaceuticals (7%), computer technology (6%), other special machines (6%), electrical machinery (6%), and semiconductors (6%).[8]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2015



Federal Licenses

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 nonfederal sector to develop and commercialize government-owned technologies helps protect federally developed innovations, which would not be further developed into commercial products or services otherwise. The terms and conditions under which Federal intellectual property is licensed varies 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.

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[7] In this summary, 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 based on the proportion of its participating institution(s)). Furthermore, fractioning is used at the level of Internal Patent Classification (IPC) codes to ensure that the sum of patents across technology areas is equal to the total number of patents as each patent can be assigned to more than one technology area. Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

[8] Definitions for all technology areas addressed are included in Appendix B.

Between FY 2011 and FY 2015, the number of total active licenses reported by Federal laboratories increased by 14% from 8,570 in FY 2011 to 9,743 in FY 2015.[9] The number of new licenses decreased by 14% from 1,239 in FY 2011 to 1,070 in FY 2015. The number of invention licenses increased by 29% to 4,119. Invention licenses refers to inventions that are patented or could be patented. The number of new invention licenses increased by 38% to 567. The number of income-bearing licenses increased by 20% to 6,349, and the number of exclusive licenses decreased by 18% to 563.

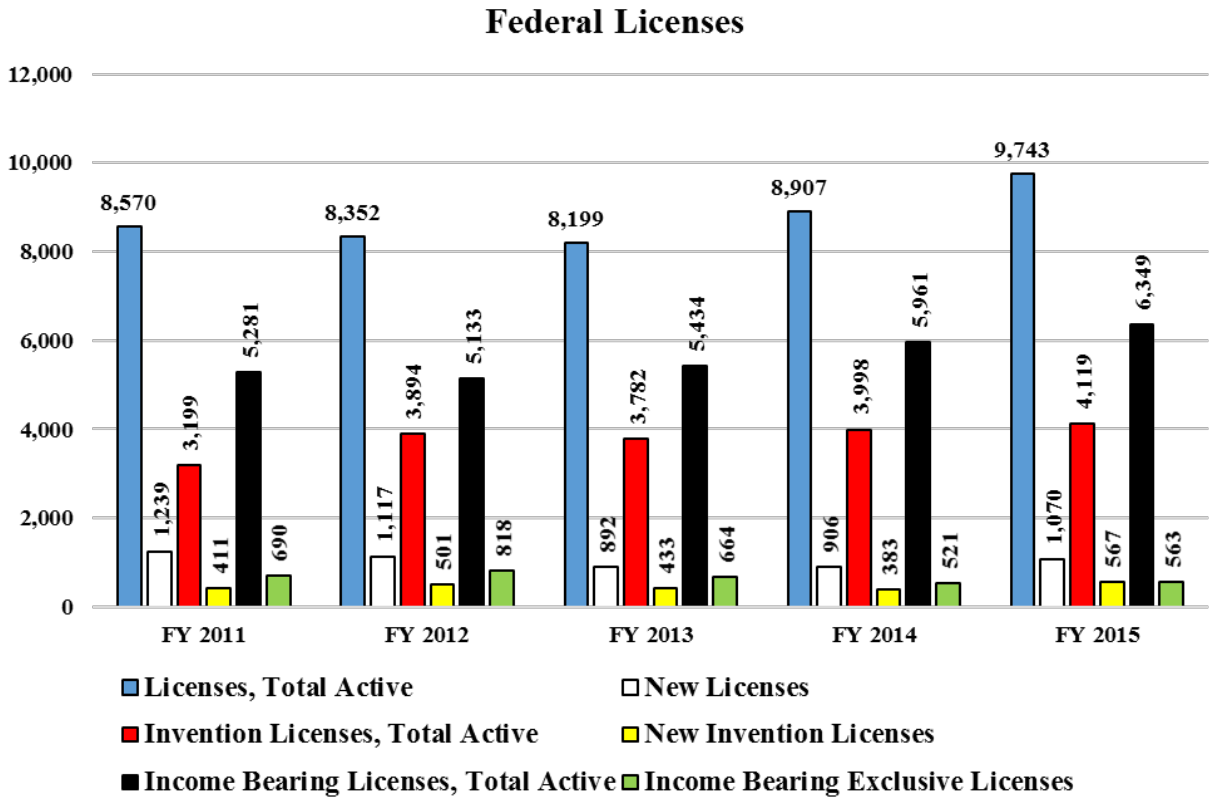
DOE reported the largest number of total active licenses with 6,310 licenses. HHS was second with 1,767 licenses and DoD was third with 560 licenses. These three agencies accounted for 89% of all licenses reported in FY 2015.

HHS reported the largest number of invention licenses with 1,354, followed by DOE with 1,336 and DoD with 446. Together these three agencies accounted for 77% of invention licenses.

DOE reported the largest number of income-bearing licenses 4,577, which was significantly higher than all other agencies combined. HHS was second with 843 followed by USDA with 421. Together these three agencies accounted for 92% of income-bearing licenses.

USDA reported the largest number of income-bearing exclusive licenses with 292, followed by HHS with 119, and DOE with 98. Together these three agencies accounted for 83% of income-bearing exclusive licenses.[10]

[9] In FY 2015, DHS revised their reporting procedure to exclude Trademark licenses for FY 2011 to FY 2015.
[10] DoD did not report "Income Bearing Exclusive Licenses" in FY 2013, FY 2014, and FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	8,570	8,352	8,199	8,907	9,743
New Licenses	1,239	1,117	892	906	1,070
Invention Licenses, Total Active	3,199	3,894	3,782	3,998	4,119
New Invention Licenses	411	501	433	383	567
Income Bearing Licenses, Total Active	5,281	5,133	5,434	5,961	6,349
Income Bearing Exclusive Licenses	690	818	664	521	563

Federal Income from Licenses

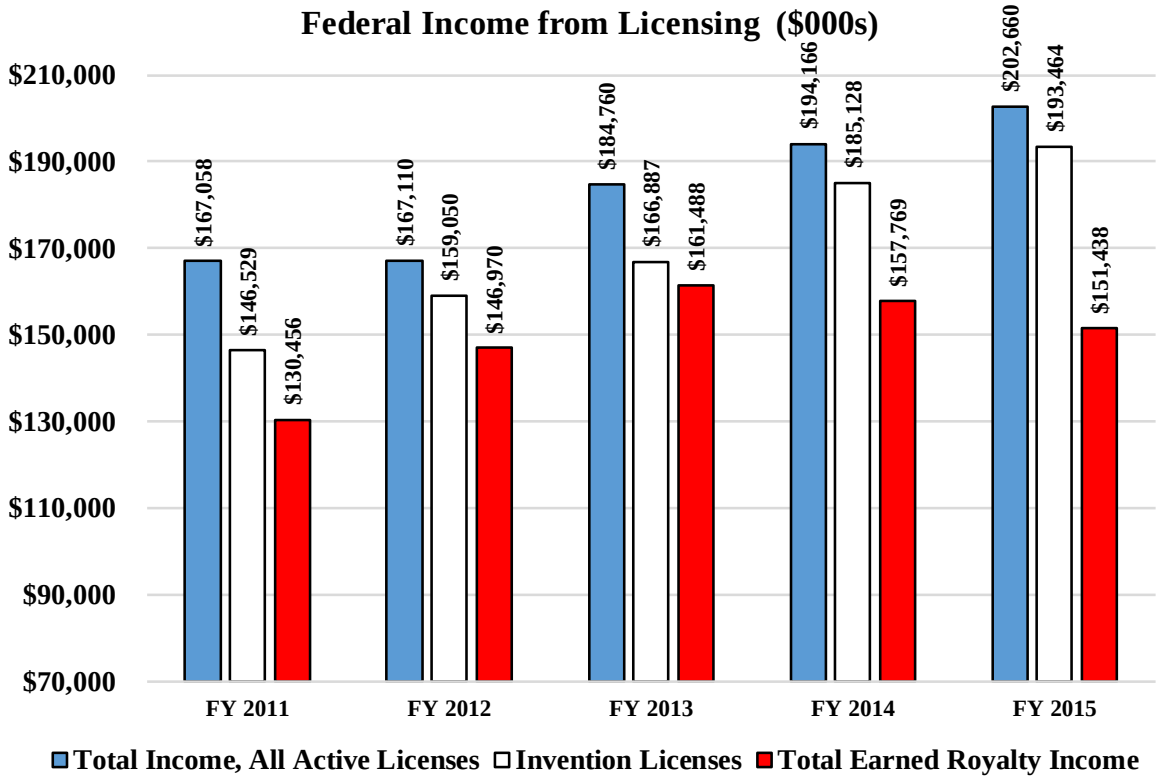
Licensing income includes income received for earned royalties from partners, license issue fees, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee, including patent costs. Between FY 2011 and FY 2015, income from all licensing increased by 21% to $202.7 million. Income from invention licenses increased by 32% to $193.5 million and total earned royalty income increased by 10% to $151.4 million.

HHS accounted for the most licensing income in FY 2015 with $151.7 million, followed by DOE with $33.1 million, and DoD with $8.5 million. Together these three agencies accounted for 95% of reported licensing income.

HHS accounted for the most Invention License Income in FY 2015 with $147.5 million,

followed by DOE with $29.0 million, and DoD with $8.5 million. Together these three agencies accounted for 96% of Invention License Income.

HHS accounted for the most Earned Royalty Income in FY 2015 with $114.1 million, followed by DOE with $21.2 million, and DoD with $8.5 million. Together these three agencies accounted for 95% of Earned Royalty Income.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$167,058	$167,110	$184,760	$194,166	$202,660
Invention Licenses	$146,529	$159,050	$166,887	$185,128	$193,464
Total Earned Royalty Income	$130,456	$146,970	$161,488	$157,769	$151,438

Federal Collaborative R&D Relationships

Collaborative R&D 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 to provide avenues for both the collaborator and the Federal laboratory to gain new competencies and develop new skills.

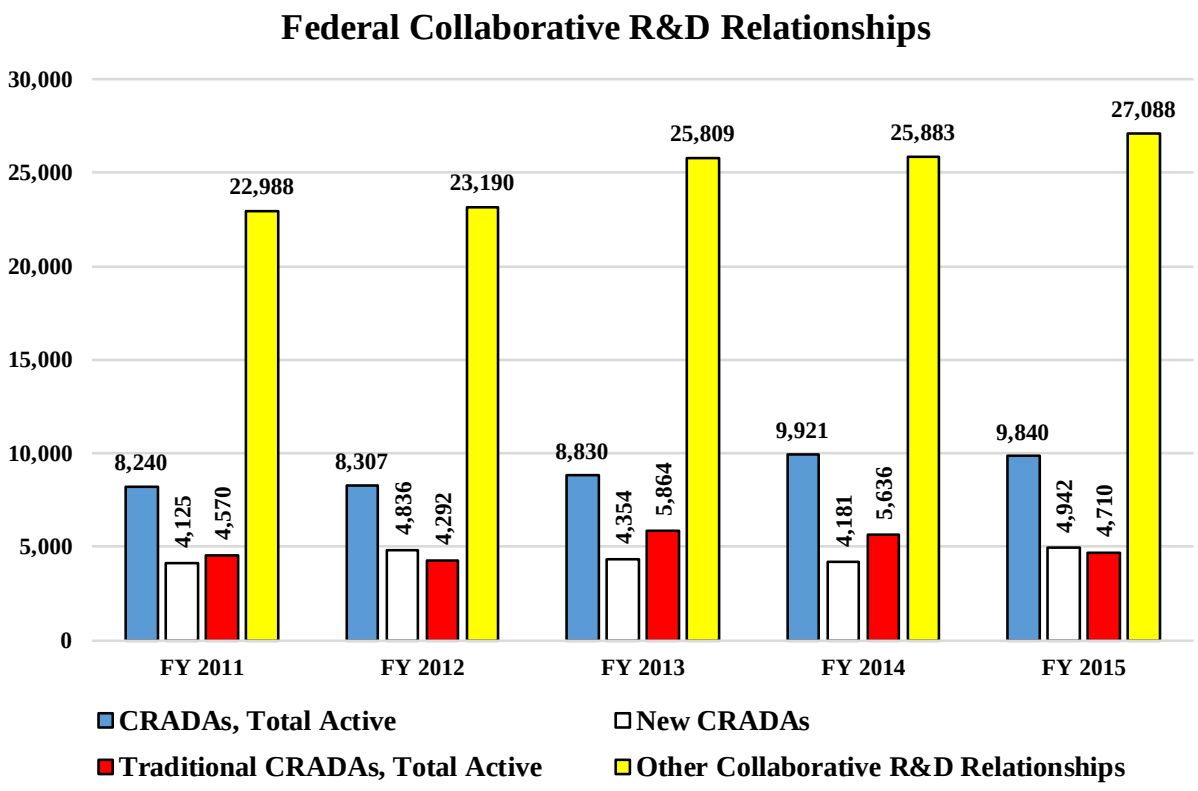
One frequently used mechanism for establishing joint research relationships is the Cooperative Research and Development Agreement (CRADA). The CRADA is a multifaceted mechanism

that can be used to address several kinds of partnership needs. A “traditional CRADA” refers to formal collaborative R&D agreements between a Federal laboratory and nonfederal 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 2011 and FY 2015, the number of active CRADAs increased by 19% to 9,840. The number of new CRADA agreements increased by 20% to 4,942. The number of traditional CRADAs increased by 3% to 4,710, while other collaborative R&D relationships increased by 17% to 22,646.

In FY 2015, DOC reported the largest number of CRADAs with 2,751, followed by VA with 2,305 and DoD with 2,148. DoD reported the largest number of traditional CRADAs with 1,601, followed by VA with 1,334 and DOE with 734. USDA reported the largest number of other collaborative R&D relationships with 15,439, DOC was second with 3,172, and NASA was third with 2,113.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	8,240	8,307	8,830	9,921	9,840
New CRADAs	4,125	4,836	4,354	4,181	4,942
Traditional CRADAs, Total Active	4,570	4,292	5,864	5,636	4,710
Other Collaborative R&D Relationships	22,988	23,190	25,809	25,883	27,088

Trends in Federal Technology Transfer Activities

Technology transfer activities are not spontaneous events. Inventions typically require years, if not decades of research effort before they are disclosed. A review of a patent application may take five years or more before the patent is awarded. It may also take several years to license a Federal patent or form the collaborative commitment behind a CRADA. To get an understanding of how technology transfer activities are performing over time, it is helpful to view the trends in key metrics. Unfortunately, it is not always easy to isolate trends from raw data because technology transfer metrics fluctuate widely. However, by converting metric values to a common scale or index, we can develop a simple tool to illustrate trends.

Index values are calculated by dividing the value of a metric in a given year (year "t"), by its value in a base year (year "i"), and then multiplying by 100.

$$Index\ Value_t = \frac{Value_t}{Base\ Value_i}\ x\ 100$$

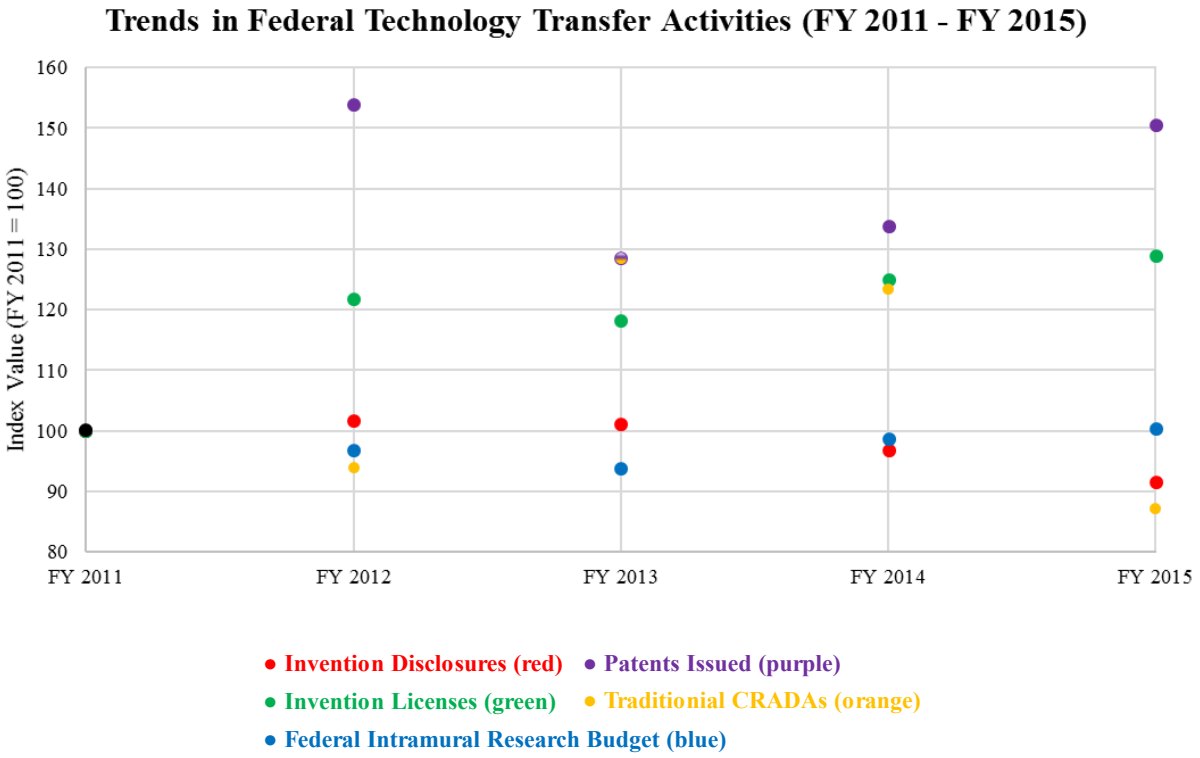
The base year chosen for this report is FY 2011. The index value for each metric in the base year would therefore be equal to 100. In the years that follow, index values change as the value of the metric in year "t" changes and the value in the base year, "i" remains the same.

For example, to calculate the index value for patents issued in FY 2012, we divide the number of patents issued in FY 2012 by the number of patents issued in the base year (FY 2011) and then multiply by 100. Using data from the table on page 11 of this report, the index value for patents issued in FY 2012 is 154.

$$Index\ Value_{FY2012} = \frac{2{,}231}{1{,}450}\ x\ 100 = 154$$

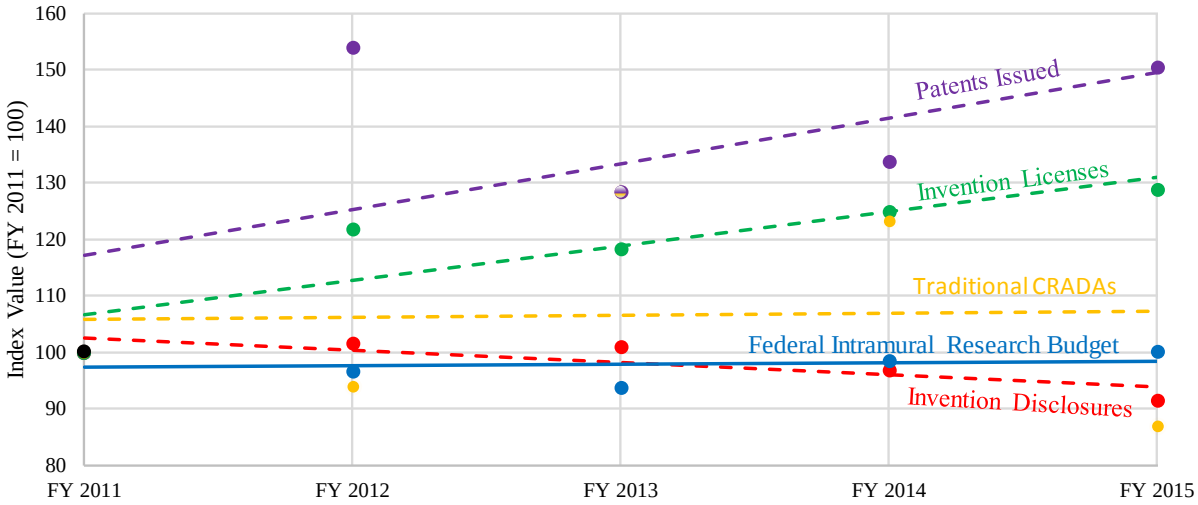
Because the index value of 154 is greater than 100, we can interpret this as a 54% increase in the number of patents issued between FY2011 and FY2012. In FY 2013, the index value for patents issued is 128 which we can interpret as a 28% increase between FY 2011 and FY 2013.

We then calculate index values for key metrics (e.g., invention disclosures, patents issued, invention licenses, and CRADAs) and plot the values in the chart below. For illustrative purposes, we also calculate index values for the Federal Intramural Research Budget using data from page 3 of this report. Note that all index values have a value of 100 in the base year, FY 2011.



To show the trend for a given metric, a straight line is positioned in the middle of the plotted values for that metric.[11] For example, in the chart below, index values for patents issued are show in purple and the trend line for patents issued is positioned in the middle of the purple points. It is important to note that each trend line is drawn independently of other measures; they do not suggest causal relationships, nor do they forecast future trends. A trend line is a simple tool that illustrates the general tendency of a measure over a given period.

Trends in Federal Technology Transfer Activities (FY 2011 - FY 2015)



Trend lines plotted for patents issued, invention licenses, and traditional CRADAs all have a positive slope which means that technology transfer activities have been increasing during this period. The trend line for invention disclosures is relatively flat indicating that during this period, the reporting of new inventions has been consistent with no significant increases or decreases. The trend line for the Federal Intramural Research Budget, which includes the budget for intramural programs as well as the budget for FFRDCs, has also been relatively consistent over these years.

Science and Engineering (S&E) Articles

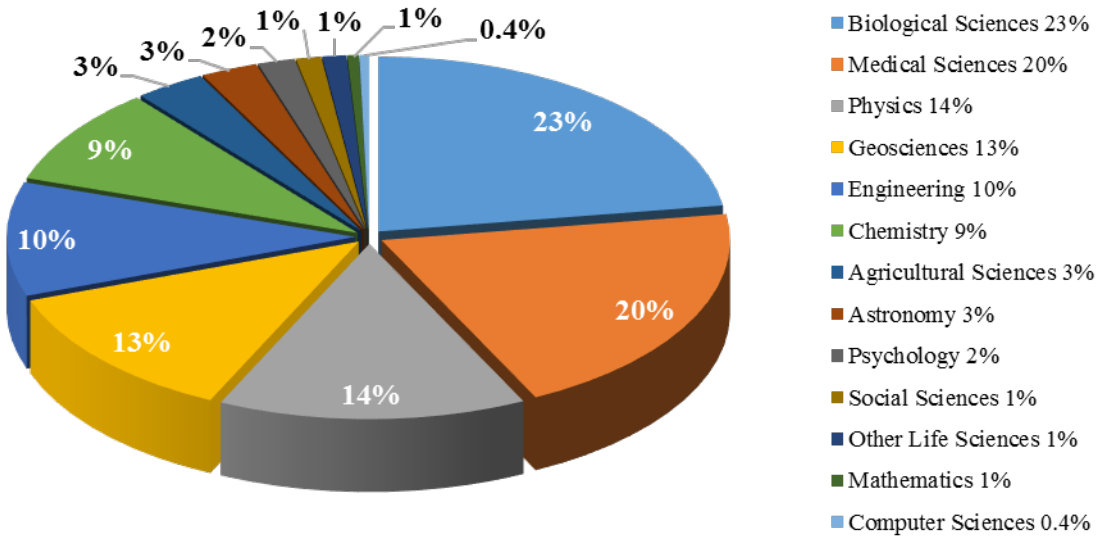
Although intellectual property has traditionally been tracked in terms of the number of patents, licenses, and collaborative efforts, most Federal research results are transferred through publication of S&E articles. Unfortunately, a uniform tracking system for S&E articles across all Federal agencies does not exist; however, data from Thomson Reuters' Web of Science database 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 2015, Thomson Reuters reports that Federal researchers authored or coauthored 36,476 articles using a whole-count basis (where each agency gets full credit for

[11] Trend lines in this report are plotted using Microsoft Excel.

each article even if the article has co-authors from different agencies). [12] By using additional data provided by agencies in their annual reports on technology transfer activities that considers publications not included in the Thomson Reuters' databases, the number of publications increases to 44,483.

The Thomson Reuters' databases provide the additional benefit of identifying publications by federal researchers according to science and engineering categories. Using this data, the greatest percentage of articles addressed research in Biological Sciences (23%), Medical Sciences (20%), Physics (14%), Geosciences (13%), Engineering (11%), and Chemistry (9%).[13]

S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: FY 2015



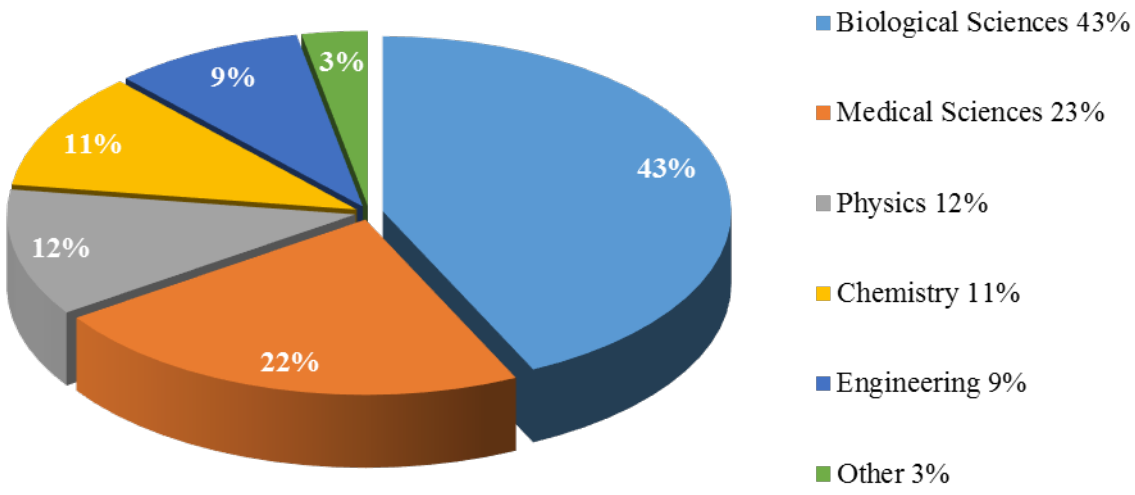
Citations within U.S. Patents

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 2015, more than 14,470 articles authored or coauthored by Federal researchers were cited in U.S. patents. Of these, the greatest number of articles addressed research in Biological Sciences (43%), Medical Sciences (22%), Physics (12%), Chemistry (11%), and Engineering (9%).

[12] Data prepared by Science-Metrix using the Web of Science (Thomson Reuters), PATSTAT (European Patent Office) and PatentsView databases under the direction of NSF. Used with permission.

[13] 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. Source: Prepared by Science-Metrix using Thomson Reuters' Web of Science database.

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2015



Small Businesses Involved in Active Traditional CRADAs

The Federal Technology Transfer Act, codified under 15 USC 3710a(c)(4)(A), requires Federal agencies 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 this study, we use a 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 eight agencies. This data reveals that out of 4,710 traditional CRADA agreements with these agencies, 770 (16%) involve small businesses as participants.

Agency	Number of Active CRADAs Involving Small Businesses FY 2015
DHS	36
DOC	68
DoD	57
DOE	254
DOT	11
EPA	23
HHS	215
USDA	106
Total	770

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 eight agencies are available at the time of this report. This data reveals that out of 9,146 active licenses granted by these agencies in FY 2015, 676 (7%) were issued to small businesses.

Agency	Number of Active Licenses Granted to Small Businesses FY 2015
DHS	1
DOC	4
DoD	43
DOE	354
DOT	1
EPA	23
HHS	100
USDA	150
Total	676

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.

Although 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 five agencies identifies 121 companies that started between the years of 2011 and 2015, and have received critical technical support from Federal laboratories.

Agency	Number of Startups Supported FY 2015 (Preliminary Data)
DOC	25
DoD	14
DOE	31
HHS	23
NASA	28
Total	121

Technology Transfer Metrics and Impact Studies

There are two types of metrics that are used to monitor and manage technology transfer programs. The first type, **activity metrics**, measures the activities or outcomes of a program, that is, efforts made to transfer technologies outside of the agency. Activity metrics are basic counts of the number of times transfer mechanisms are used during a fiscal year, for example, the number of patents, licenses, or CRADAs that are transferred. Activity metrics help characterize technology transfer operations and show the trends in various activities over time.[14]

The second type, **impact metrics**, measures the things that happen outside of an agency because of the technologies transferred. Impact metrics are used to assess the performance of technologies by quantifying the resulting benefits or net benefits that includes development costs. Impact metrics are derived from careful studies of a technology's use and demand environment. The demand environment is the environment where the need for the transferred technology is formed, where the technology is utilized, and where economic and societal impacts are generated. It can refer to any number of consumers, end-users, research laboratories, institutes, companies, markets, industries, economic regions, and so forth.

There are many types of impact studies and the appropriate one to use will depend on a variety of issues such as the objective of the study, the mechanism(s) used to transfer the technology, the nature of the impacts being assessed, the demand environment, and the quality and quantity of available research data.

Economic impact studies are typically used when technologies are transferred to commercial enterprises. These studies focus on 1) efforts to measure the agency's return on funds invested to develop the technologies (e.g., benefit to cost ratios, net present values, internal rates of return); 2) efforts to measure the net benefits that accrue to commercial developers and consumers of goods or services who use the technologies; or 3) efforts to measure the resulting change in economic activity that takes place in an industry, market or economy (e.g. changes in revenues, costs, employment, tax revenues, etc.).[15]

Impacts derived from technologies that are not directly transferred to commercial enterprises, have noncommercial applications, or are transferred in an open access manner (i.e., publications), typically focus on efforts to measure changes in technical or physical performance. For example, performance impact studies can be used to measure how technologies improve fuel efficiency, drug delivery, cyber security, highway safety and navigation, food production and food safety, pollution control, traffic congestion, and similar measurable activities. For technologies that provide societal impacts, impact studies can be used to measure improvements in behavior, training activities, crime enforcement, safety, security, and quality of life.

[14] It is important to note that because each Federal agency has a different mission, addresses the needs of different stakeholders, customers and consumers, and pursues the development of different technologies, activity metrics are not effective measures to use when comparing the performance of agencies.

[15] For a discussion of how these measures are defined and calculated see "NIST Planning Report 03-1, Methods for Assessing the Economic Impacts of Government R&D", https://www.nist.gov/document-17651

The following examples illustrate how the complexities of impact studies can lead to different measures of impact and how it is important to fully understand the nature and context of each study before accepting the results.

NIST Impact Studies

In 2002, NIST contracted with Research Triangle Institute International (RTI) to provide an *ex ante* study of the potential economic impacts from of a set international standards.[16] These standards addressed interoperability problems encountered in the exchange of digital product information in the transportation equipment industries and were based on the Standard for Exchange of Product model data (STEP) that provided a suite of standards used by a variety of industries.

Along with other institutions, companies, and academic researchers, NIST made significant contributions to the development of the STEP model, the STEP standard, the integration of STEP functionality into applications, and the adoption of STEP functionality by end users. NIST also participated in several public-private partnerships involving demonstrations and development projects with software developers, industry, and other federal agencies.

The RTI study found that STEP's benefits would accrue to end users through increased interoperability of computer-aided design, engineering, manufacturing, and product data management systems used in the product design supply chain. Using data collected from industry surveys and case studies, RTI prepared an *ex ante* study of STEP's likely impact as well as NIST's contribution.

The 2002 study estimated that the present value of benefits that would accrue to the development and use of STEP between the years 2002 and 2010 would be $1,186 million and the present value of costs would be $104 million. The net present value was therefore estimated to be $1,082 million and the benefit-to-cost ratio would be 11.4 to 1. This indicated that each dollar invested in STEP would likely yield $11.40 in return. For NIST's involvement, the RTI study estimated that in 2002, the present value of benefits would be $206 million and the present value of costs would be $26 million. The net present value would be $180 million and the benefit-to-cost ratio would be 7.9 to 1. So, for each dollar invested in STEP, NIST could expect $7.10 in return.

In 2013, NIST revisited this assessment by contracting with Robert D. Neihus, Inc. (RDN), to reassess the economic impact of the STEP standard.[17] This study provided an *ex post* assessment of STEP's benefits to the U.S. as well as NIST's contribution. The present value of benefits that had accrued due to the development and use of STEP between 2002 and 2010 was estimated to be $901 million and the present value of costs was estimated to be $83 million. The net present value was therefore $812 million and the benefit-to-cost ratio was 10.9 to 1. This means that each dollar invested in STEP yielded $10.90 in return. For NIST's involvement, the RDN study

[16] "NIST Planning Report 02-5, Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries." Prepared by RTI International. December 2002. https://www.nist.gov/document-17639

[17] Reassessing the Economic Impacts of the International Standard for the Exchange of Product Model Data (STEP) on the U.S. Transportation Equipment Manufacturing Industry. Prepared by: Robert D. Niehaus, Inc. November 2014. http://www.rdniehaus.com/rdn/wp-content/uploads/2015/07/Economic-Impact-of-STEP-on-the-Transportation-Industry.pdf

estimated the present value of benefits was $89 million and the present value of costs was $15 million. The net present value was estimated to be $74 million and the benefit-to-cost ratio was estimated to be 5.9 to 1. So, for each dollar invested in STEP, NIST received $5.90 in return.

To compare results from the RTI and RDN studies, it is first necessary to convert the annual dollar values from each period to reflect the same purchasing power of the dollar. This is done by adjusting the dollar estimates from the 2001 RTI study to 2013 dollars using the Consumer Price Index[18] so that estimates from both studies are expressed in terms of 2013 dollars. As shown in the table below, the earlier, *ex ante* RTI study estimated net present value for the overall development and use of STEP would be $1,432 million in 2013 dollars. The later, *ex post* RDN study estimated net benefits were $818, a difference of $614 million. The benefit to cost ratios for each study were close, with the RTI study forecasting 11.4 to 1 and the RDN study estimating 10.9 to 1.

Economic Returns to STEP ($ million)

	2001 RTI Study (Adjusted 2013 Dollars)	2013 RDN Study	Difference
Present Value of Benefits	$1,560	$901	($659)
Present Value of Costs	$137	$83	($54)
Net Present Value	$1,432	$818	($614)
Benefit-to-Cost Ratio	11.4	10.9	(0.50)

The two studies also differed in their estimates of the economic returns from NIST's investment in STEP. The earlier RTI study forecasted a net present value of $237 million when converted into 2013 dollars. The later RDN study estimated the net present value was $74 million, a difference of $163 million. The benefit to cost ratios also differed, with the earlier RTI study forecasting a 7.9 to 1 ratio and the later RDN study estimating a 5.9 to 1 ratio.

Economic Returns to NIST ($ million)

	2001 RTI Study (Adjusted 2013 Dollars)	2013 RDN Study	Difference
Present Value of Benefits	$271	$89	($182)
Present Value of Costs	$34	$15	($19)
Net Present Value	$237	$74	($163)
Benefit-to-Cost Ratio	7.9	5.9	(2.0)

It is easy to see that the 2013 study provides a more comprehensive assessment because it includes more information on the actual adoption rate of STEP, includes estimates for unexpected costs (e.g., avoidance costs, mitigation costs, and delay costs), and accounts for the 2008 recession which obviously was not included in the 2001 study. However, this does not

[18] See https://www.bls.gov/data/inflation_calculator.htm

mean that the 2001 study was inappropriate. Indeed, both studies provide valid estimates of impact (both potential and real), *given the conditions and assumptions under which the studies were performed.*

DoD Impact Studies

In 2012, DoD contracted with TechLink and the University of Colorado to assess the economic impacts of 602 DoD licensing agreements that were active between 2000 and 2011.[19] The primary purpose of this study was to determine the extent to which these license agreements contributed to new economic activity and job creation in the United States. The study simulated changes in the demand environment for these licenses using an economic-impact assessment software program called IMPLAN. The simulation estimated that the 602 licensing agreements generated 163,067 jobs with an average wage of $65,000, $10.6 billion in labor income, $13.4 billion in sales, $2.3 billion in federal tax revenues and $1.3 billion in state and local tax revenues.

Nationwide Economic Impacts from DoD License Agreements, 2000-2011

	Output ($ billions)	Value-Added ($ billions)	Employment	Labor Income ($ billions)	Average Wage (US = $52,000)	Tax Revenue ($ billions)
Direct Impact	$13.40	$4.50	27,128	$2.70	$100,926.00	
Indirect Impact	$11.60	$6.40	56,728	$4.20	$74,339.00	
Induced Impact	$11.30	$6.50	79,210	$3.70	$46,093.00	
Federal Tax Revenues						$2.30
State and Local Tax Revenues						$1.30
Total Economy-Wide Impact	$36.30	$17.40	163,067	$10.60	$65,041.00	$3.70

In 2015, another study of the economic impacts of DoD licenses was made. This study expanded the 2012 study by extending the assessment period to an additional three-year timeframe and increased the number of licensing agreements from 602 to 663.[20] The methodology used in the two studies was essentially the same and once again the IMPLAN software program was used to simulate impacts. The study found that the 668 licensing agreements generated $20.4 billion in total sales of new products and services, $3.4 billion in sales of new products to the U.S. military, $48.8 billion in total economic output nationwide, $1.6 billion in new tax revenues (federal, state, and local), and 182,985 full-time jobs created or retained, with 12,199 of these jobs having an average salary of $71,337.

Nationwide Economic Impacts from DoD License Agreements, 2000-2014

Impact Type	Output $ Billions	Value-Added $ Billions	Employment	Labor Income $ Billions	Average Wage (US=$46,482)	Tax Revenue $ Billions
Direct Impact	$20.4	$9.2	$41,753	$4.3	$104,058	
Indirect Impact	$15.2	$7.6	$61,185	$4.6	$75,890	
Induced Impact	$13.1	$7.1	$80,047	$4.1	$50,789	
Federal Tax Revenues						$1.2
State and Local Tax Revenues						$0.4
Total Economy-Wide Impact	$48.8	$23.9	$182,985	$13.1	$71,337	$1.6

[19] National Economic Impacts from DoD License Agreements with U.S. Industry 2000-2011. https://www.nist.gov/document-2339

[20] National Economic Impacts from DoD License Agreements with U.S. Industry 2000-2014. https://techlinkcenter.org/wp-content/uploads/2017/01/2016-DoD-Licensing-Study-E-Publication.pdf

Once again, using the Consumer Price Index to adjust estimates of the 2012 study to reflect 2015 dollars, we see significant variations in impact results from relatively small changes in inputs and the assessment period.

	2012 Economic Impact Study (Adjusted 2015 dollars)	2015 Economic Impact Study	% Increase
Total Sales, New Products and Services	$13.83 billion	$20.4 billion	48%
Sales to US Military	$1.34 billion	$3.4 billion	154%
Value Added	$17.96 billion	$23.9 billion	33%
Total Economic Output Nationwide	$37.58 billion	$48.8 billion	30%
Full-Time Jobs Created or Retained	163,067	182,985	12%

The two studies differ in terms of the number of licenses assessed and the period of assessment. It would therefore be wrong to assume that one study provides a better estimate of impact than the other. Indeed, both studies provide valid estimates of impact *given the conditions and assumptions under which each study was performed.* Therefore, when reporting impact results, it is critical to convey a clear understanding of the context in which the measures of impact were derived.

In summary, there is no definitive approach to measuring impacts from transferred technologies. Impacts are complex, interwoven, dynamic relationships that are difficult to measure and are sensitive to the approach used to assess them. Furthermore, no single measure of impact will adequately capture the true impact of a given technology which will likely continue to change over time.

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.

The Innovation Corps Program

In 2011, the National Science Foundation (NSF) established the Innovation Corps (I-Corps™)[21] 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.

In 2014, 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

[21] See http://sbir.cancer.gov/resource/icorps/

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,[22] 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 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 Transfer began its first EIR program in 2012. The EIRs are charged with three key activities: 1) review NIH technologies to assess commercial relevance; 2)

[22] See http://energy.gov/articles/energy-department-announces-new-lab-program-accelerate-commercialization-clean-energy

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 (ARS) 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 affect 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. Through this initiative experienced EIRs and NIST researchers come together to identify commercial opportunities for technologies emerging from NIST's laboratories. 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

In 2015, the Lab-to-Market initiative was being coordinated as a Cross Agency Priority goal under the Government Performance and Results Act (GPRA) Modernization Act (P.L. #111-352). Through this effort, Federal agencies proposed a number of actions to accelerate and improve the transfer of new technologies from the laboratory to the commercial marketplace.

Developing Human Capital

Research agencies will develop the Nation's human capital assets for promoting technology transfer, including:

1. 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 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 to remove barriers to collaboration with external entities, as appropriate, including efficient CRADA authorities, updated intellectual property policies, effective Laboratory-Directed R&D 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 intellectual property and (b) R&D facilities, equipment, use policies, and agency contact information as open and machine-readable, available to third parties through application programming interfaces, and tagged with concise summaries and other relevant metadata;
2. Reducing the time, cost, and complexity of executing intellectual property 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 SBIR and STTR programs will work with the Small Business Administration (SBA) and the Presidential Innovation Fellows program 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

Evaluating Impact

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

1. Working with agencies to develop new metrics to track technology transfer activities (e.g., number of intellectual property 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 intellectual property licensing agreements, increasing the number of federally-funded researchers who receive experiential entrepreneurship education, and increasing the percentage of federally funded intellectual property 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 2015

Each Federal 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.[23]

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., cooperative R&D relationships, invention disclosure and patenting, and intellectual property licensing) for the most recently closed fiscal year (FY 2015) and several prior years (chiefly, FY 2011-2015);
- 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.

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

Department of Agriculture (USDA)

President Abraham Lincoln coined the phrase "the People's Department" acknowledging the role of USDA in solving problems 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 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. A seemingly simple statement, the 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 and enhancement of research outcomes 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.

Private sector involvement in technology transfer adds the benefits of creating new or expanded businesses, jobs, and economic prosperity. Science-based innovations from USDA intramural research – often developed through public-private partnerships (PPPs) – 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 job creation and sustainable economic development.

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

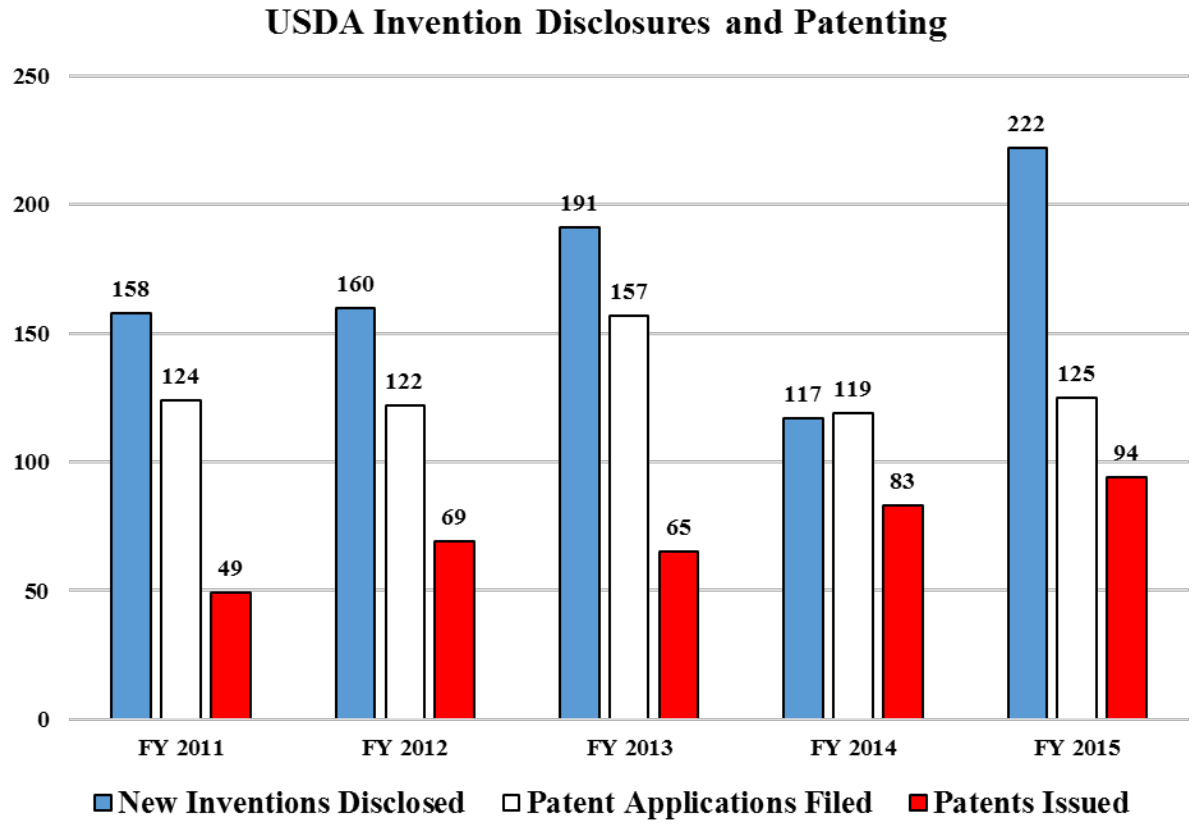
USDA's annual technology transfer report is available online at:
https://www.ars.usda.gov/business/Docs.htm?docid=24718.

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

Agricultural Research Service: https://www.ars.usda.gov/;
Animal and Plant Health Inspection Service: https://www.aphis.usda.gov/aphis/home/; and
Forest Service: http://www.fs.fed.us.

USDA Invention Disclosures and Patenting

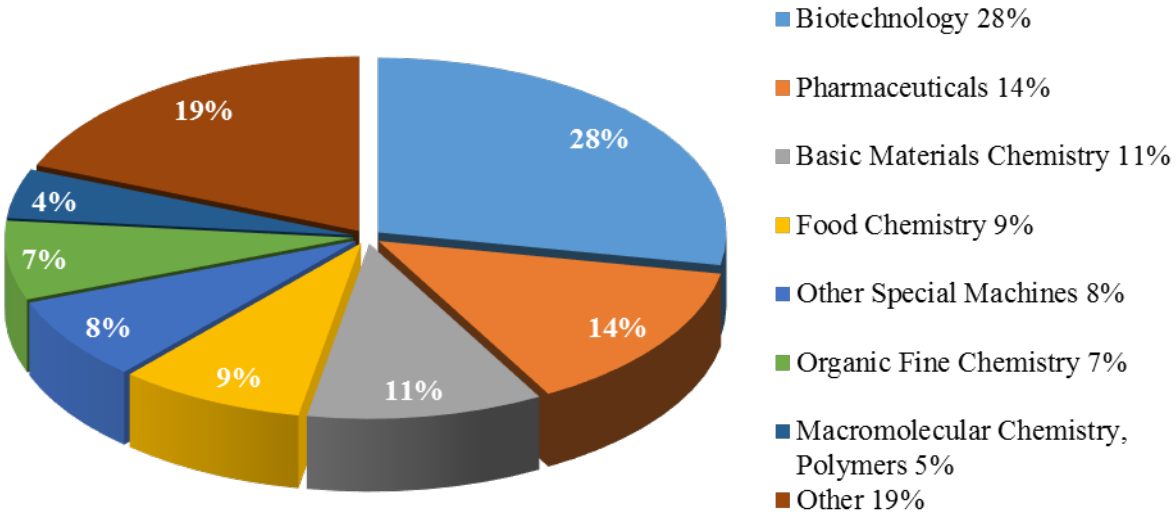
Between FY 2011 and FY 2015, the number of invention disclosures received increased by 41%, from 158 to 222. The number of patent applications filed fluctuated over the five-year period. The number of new patents issued increased by 92% from 49 to 94 in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	158	160	191	117	222
Patent Applications Filed	124	122	157	119	125
Patents Issued	49	69	65	83	94

Patents issued to USDA in FY 2015 covered many technology areas including biotechnology (28%), pharmaceuticals (14%), basic materials chemistry (11%), and food chemistry (9%).[24]

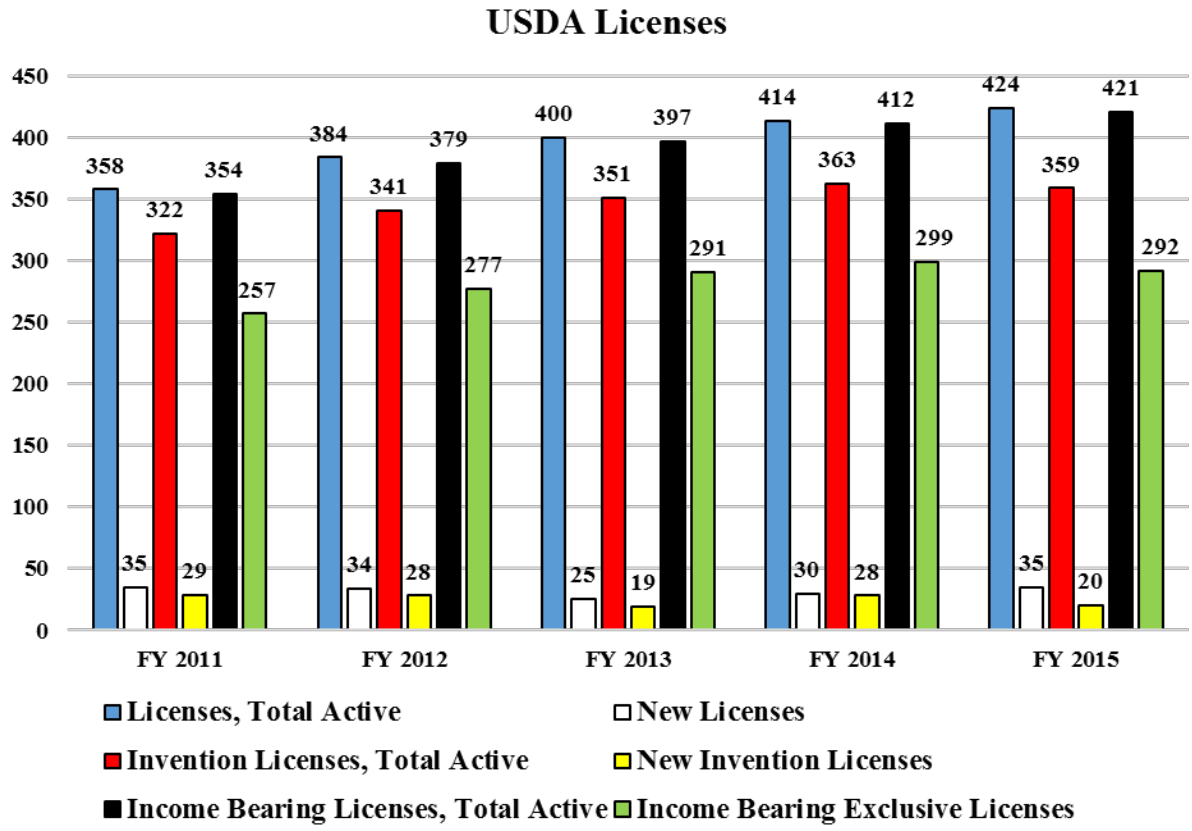
USPTO Patents Assigned to USDA by Technology Area: FY 2015



[24] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

USDA Licenses

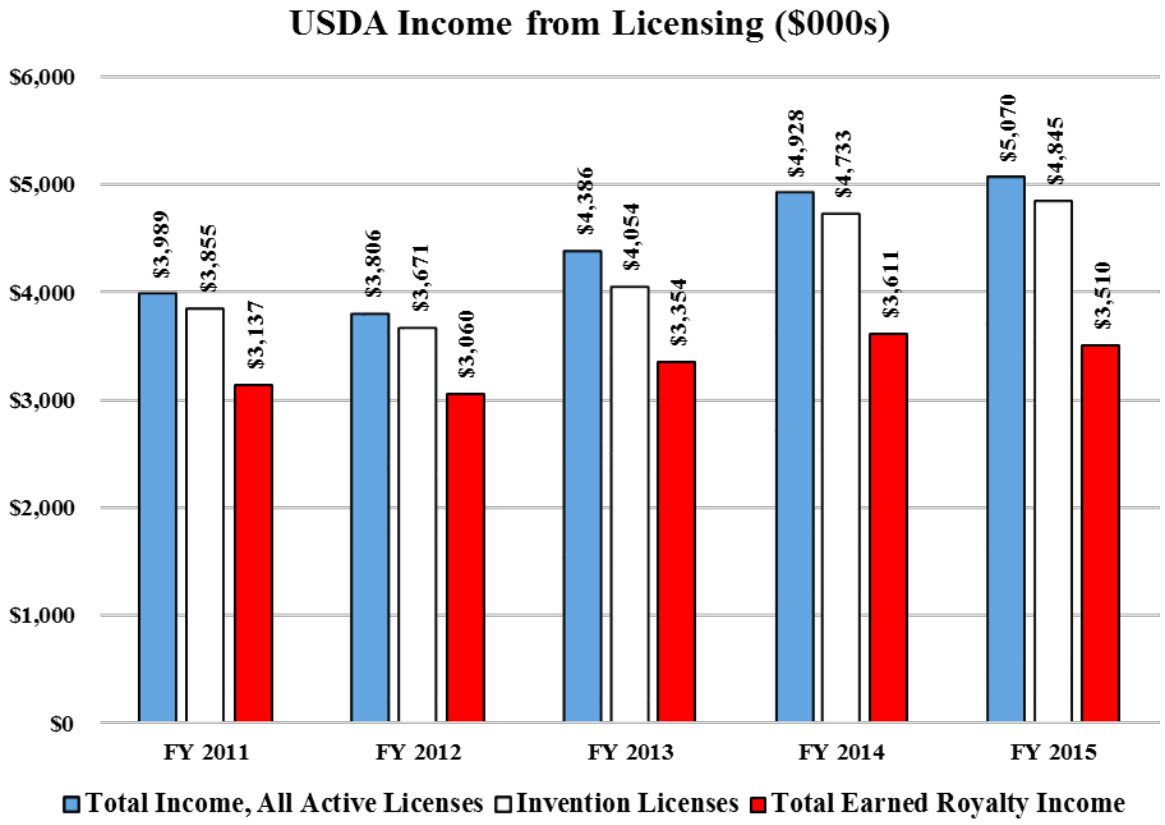
Between FY 2011 and FY 2015, the number of total active licenses increased by 18% to 424 licenses in FY 2015. The number of total active invention licenses increased by 11% to 359 licenses. Total active income bearing licenses increased 19%, from 354 in FY 2011 to 421 in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	358	384	400	414	424
New Licenses	35	34	25	30	35
Invention Licenses, Total Active	322	341	351	363	359
New Invention Licenses	29	28	19	28	20
Income Bearing Licenses, Total Active	354	379	397	412	421
Income Bearing Exclusive Licenses	257	277	291	299	292

USDA Income from Licensing

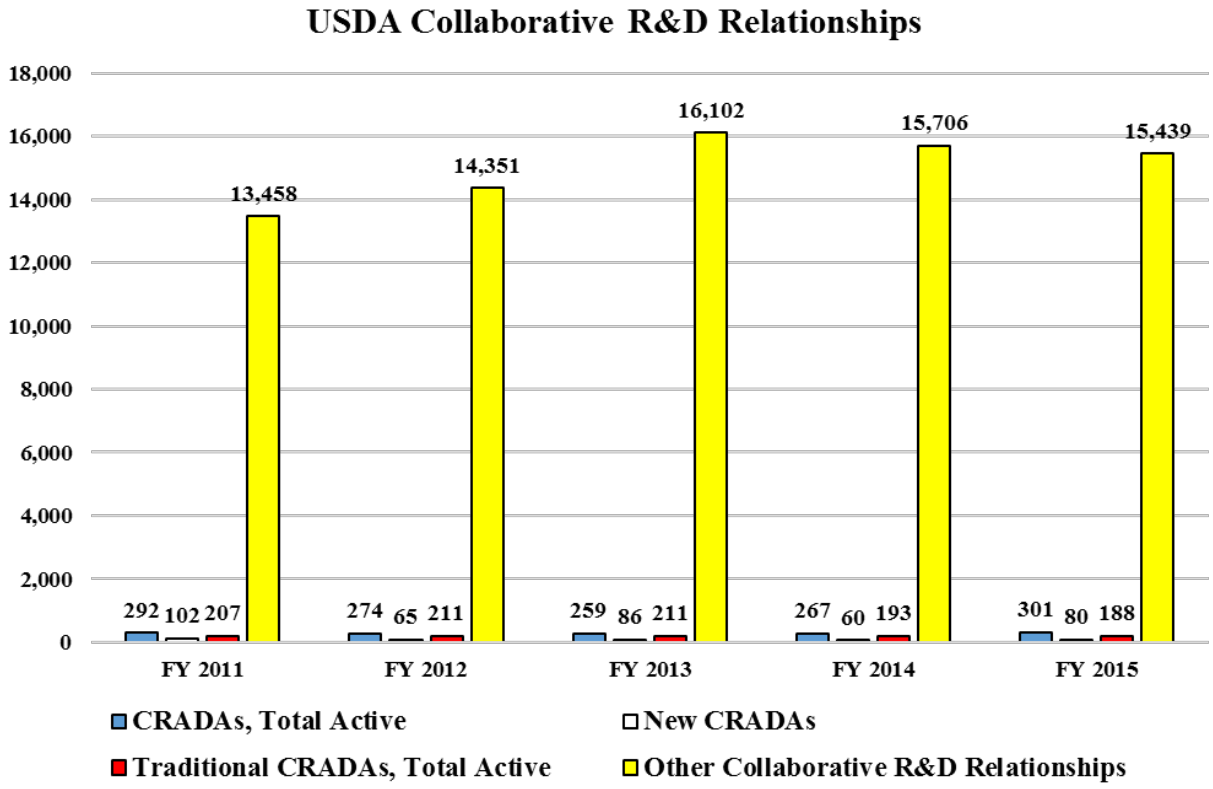
Between FY 2011 and FY 2015, the number of total income from all active licenses increased by 27% to just over $5 million in FY 2015. The income from invention licenses increased by 26% to $4.8 million. Total earned royalty income increased 12% from $3.1 million in FY 2011 to $3.5 million in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$3,989	$3,806	$4,386	$4,928	$5,070
Invention Licenses	$3,855	$3,671	$4,054	$4,733	$4,845
Total Earned Royalty Income	$3,137	$3,060	$3,354	$3,611	$3,510

USDA Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased by 3% to 301 agreements. The number of new CRADAs per fiscal year decreased by 22% to 80 new agreements in FY 2015. Total active traditional CRADAs decreased by 9% during the five-year period, totaling 188 agreements in FY 2015. Other collaborative R&D relationships increased by 15%, totaling 15,439 relationships in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	292	274	259	267	301
New CRADAs	102	65	86	60	80
Traditional CRADAs, Total Active	207	211	211	193	188
Other Collaborative R&D Relationships	13,458	14,351	16,102	15,706	15,439

USDA Efforts to Streamline Technology Transfer Operations

Update Policy and Procedure (P&P)

In FY 2015, policies and procedures were updated and streamlined to reflect statutory changes since 2000 as well as changes in the structure and operations of National Patent Committees. These changes addressed efforts to license biological materials, the use of the Agricultural Research Partnerships (ARP) network, changes in the invention disclosure review process, and efforts to determine strategic and tactic technology transfer plans for research projects.

Expand Outreach Efforts in Technology Transfer to Scientists in ARS
OTT worked with Office of National Programs to connect ARS scientists' research capabilities and technologies with a number of different companies. This was done through the ARP Network, responding to public solicitations, responding to industry scouting, and through webinars conducted by Federal Laboratory Consortium. This outreach effort is now an ongoing activity in OTT.

Encourage Other S&T Agencies to Adopt OTT's Approach to Technology Transfer
In the past, OTT has provided technology transfer services (policy advice, agreement review, patenting / licensing services, etc.) to the USDA-Animal and Plant Health Inspection Service (APHIS) Wildlife Services, USDA Forest Service (FS), DOI's Bureau of Reclamation (BoR). In FY 2015, these services were expanded through interagency agreements to include APHIS's Wildlife Services, Plant Protection and Quarantine, and Veterinary Services, as well as the FS's Forest Products Laboratory. In addition, the BoR agreement was modified to include DOI's U.S. Fish and Wildlife Service.

USDA has a role in helping to develop Federal government technology transfer policy through OTT's active participation on the Interagency Working Group on Technology Transfer and the Lab-to-Market Working Group. Through these ongoing activities, OTT is taking an active role in promoting activities which support the enhanced adoption of research outcomes.

Establishment of the "Branded Food Products Database for Public Health" Public-Private Partnership
In FY 2013, ARS, the Agricultural Technology Innovation Partnership (ATIP) Foundation, and the International Life Science Institute North America (ILSI North America) established a public-private partnership to enhance the public's health through increased knowledge of the nutritional content of the nation's food supply. This was accomplished by obtaining comprehensive food composition data from the food industry and making it available to government, industry, the scientific community, and the general public through an enhanced USDA National Nutrient Database, developed and maintained by the ARS Nutrient Data Laboratory in Beltsville, MD.

In FY2015, the public-private partnership successfully beta tested a branded food products database. Five food manufacturers participated in a beta-test by providing product label data and nutrition information on 245 products through a GS1 certified data pool provider, FSEnet. These data were then passed to ARS for incorporation into the USDA National Nutrient Database.

USDA Downstream Success Stories

National Wildlife Research Center: Federal Laboratory Consortium's Award for Excellence in Technology Transfer

On April 29, 2015, the National Wildlife Research Center (NWRC) received the Federal Laboratory Consortium's (FLC) 2015 Award for Excellence in Technology Transfer for its role in the development of an automated bait cartridge and delivery system to control invasive brown tree snakes. The automated bait cartridge and delivery system was first conceived in 2009 when NWRC researchers entered into a series of cooperative agreements with Applied Design Corporation – a private engineering and design firm in Boulder, Colorado – to develop a cost-effective, environmentally-safe, and efficient system for distributing toxicant baits to invasive brown tree snakes (BTS) in remote and inaccessible areas on Guam. Three patents are being pursued as a result of this collaboration. The system includes a biodegradable bait cartridge containing acetaminophen (a registered toxicant for BTS) and an automated delivery system that can disperse up to 4 bait cartridges per second via helicopter or fixed wing aircraft. The delivery system allows for the cartridges to open and become entangled in the forest canopy as they fall. Since the BTS is an arboreal species, entanglement in the canopy is crucial for baiting. This technology is adaptable to the delivery of other payloads and could have significant benefits for other invasive species management efforts. Obvious uses would include delivery of rodenticides or vaccines to arboreal animal populations. The award recognizes Federal laboratories that have accomplished outstanding work in the process of transferring a technology to the commercial marketplace. The NWRC is one of fifteen Federal laboratories receiving the award in 2015. The Center also received FLC's Mid-Continent Chapter award for the development of "Notable Technology" on August 26, 2015 for the same technology.

Development of Chemical Repellents for Birds

NWRC scientists have been working for decades towards developing chemical-based bird repellents for alleviating crop depredation and other nuisance situations. Many useful tools have resulted from those efforts. On September 15, 2015, the U.S. Patent and Trademark Office issued a patent to APHIS and Dr. Scott Werner for an 'Ultraviolet Strategy for Avian Repellency' (US 9,131,678 B1). This method for repelling birds from a crop or other resource is unique. First, a bird repellent is applied to the target crop in sufficient quantities to repel birds. Then, one or two subsequent treatments are applied to the crop that include not only the repellent, but also a visual cue that exhibits an ultraviolet absorbance spectrum or color similar to that of the repellent. This allows

for future repellent treatments to be applied at significantly lower amounts than the initial treatment. Because of the potential cost savings to applicators and the opportunity to develop a unique bird management tool, interest is high among private businesses to license this technology from APHIS. A license is expected to be issued by the end of 2015.

APHIS Wildlife Service (WS): Licensing of GonaCon-Equine

GonaCon-Equine is a contraceptive vaccine developed by APHIS and registered with the U.S. Environmental Protection Agency for use in wild and feral horses and burros. The technology for this vaccine was issued under patent by the U.S. Patent and Trademark Office in 2010 under the title 'Vaccine Composition and Adjuvant' (U.S. 7.731,939, B2). Humane Breakthrough, a newly established public benefit company (PBC), recently finalized a license under this patent and will begin production and sales of GonaCon-Equine in early 2016. This license allows Humane Breakthrough PBC to market GonaCon-Equine within the United States and internationally. In addition, the license and registration set the groundwork for Humane Breakthrough PBC in partnership with SpayFIRST! to develop other applications and markets for GonaCon.

International Services (IS): International Technical and Regulatory Capacity Building (ITRCB)

The ITRCB, a unit of APHIS International Services, acts as a clearinghouse to review requests for APHIS technical assistance and when appropriate, supports agency efforts facilitating technical cooperation activities with trading partners and developing countries. Training of foreign counterparts comprises a significant level of effort of the ITRCB unit. Technology transfer when it occurs is limited. One area where APHIS-IS is an active leader is developing new methods to support the Agency's control and eradication efforts of quarantine pests. In FY 2015, two activities were conducted which support larger international efforts to combat invasive pests.

The Emerald Ash Borer (EAB) – *Agrilus planipennis* is native to eastern Asia and feeds on ash species. Outside its native range, which now includes North America, it is an invasive species and is highly destructive to ash trees native to North America. Research on its biology is in progress and APHIS is attempting to control it using several methods including the use of biological control. APHIS has reared colonies of parasitoid insects that feed on EAB larvae and represent a possible control method for EAB. In 2015, APHIS transferred colonies of *Tetrasstichus planipenisi,* one of the species of biological control parasitoids, to counterparts in Canada who released them in Ontario and Quebec.

In addition, IS has coordinated technology transfer activities relating to the control of invasive pests, for example *Lobesia botrana,* the European Grapevine Moth (EGVM). This invasive moth that is a major vineyard pest was detected in California in 2009. APHIS scientists have developed methods to mass rear EGVM in order to use sterile insect technique (SIT) to control

and irradiate this invasive pest. International organizations such as the International Atomic Energy Agency (IAEA) have also supported the methods development efforts related to EGVM. In 2015 the IAEA supported an APHIS expert who provided technical assistance to Chilean plant health authorities who seek to develop their own SIT program for *Lobesia botrana.*

Plant Protection and Quarantine (PPQ): Remotely Piloted Vehicle Technology to Protect American Agriculture

The PPQ S&T Phoenix Lab has successfully deployed a Remotely Piloted Vehicle (RPV) in support of the Pink Bollworm Eradication Program. The RPV was designed to effectively release sterile pink bollworm over cotton in Arizona as an Integrated Pest Management (IPM) component. The RPV was compared to traditional Cessna 206 and hand release methods and results concluded that the RPV was just as effective as the other two methods and at a fraction of the cost. Pink bollworm has not been detected within the U.S. PBW Eradication Zone since May of 2012. There is potential for incursion from pink bollworm in central Mexican states. The development of rapid response techniques such as RPVs is critical to the long-term success of the Pink Bollworm Eradication Program. The development of the RPV was in response to the National Cotton Council's request that such technology be explored.

We recently developed a small, Vertical Takeoff and Landing (VTOL) Remotely Piloted Vehicle (VTOL-RPV) with assistance from an industry cooperator to visually detect Asian Longhorned Beetle (ALB) damage in forests. ALB presents a significant environmental and financial risk to the forests of the United States and if left unchecked, estimates of total urban canopy destruction reach upwards of 34.9% at a value loss of $699 Billion USD. ALB can survive and reproduce in any location within the lower 48 States, which contain host trees. Because of this threat, PPQ launched the ALB Eradication Program, which intends to respond to ALB's incursion by eradicating this invasive exotic species from the U.S. RPV proof of concept took place in a forest near Bethel, OH. Current survey and detection methods include spotting, ground assessments and climbing or bucket truck assessments. These methods require great human input and are costly. RPVs are launched near potential infestation zones and are visually surveyed by ground crews via live streaming video which is faster and safer than current processes. VTOL-RPVs are also being developed to visually detect Asian Gypsy Moth (AGM) egg masses on the superstructure of vessels arriving at U.S. ports of call. The proposed method for survey and detection was presented to DHS' Customs and Border Protection (CBP) office in an internal white paper written by the Center for Plant Health Science and Technology (CPHST S&T) and described as a means of aiding CBP officers in detecting AGM egg masses by utilizing RPV's and their remote sensing abilities. Current detection methods involve visually scanning the superstructure of vessels. This method, however, is limited to regions safely accessible or visible from the deck of the ship. The RPV may provide surveyors with the ability to safely detect egg masses in the higher reaches of the ship, such as masts and light fixtures, as well as along the outer hull. The continued development of this technique supports PPQ's mission to safeguard U.S. agriculture and natural resources against the entry, establishment, and spread of

economically and environmentally significant pests and directly supports CPHST's efforts in the areas of Pest Detection and Pest Management.

Foreign Agricultural Service (FAS): Norman E. Borlaug International Agricultural Science and Technology Fellows Program

In 2015, the Norman E. Borlaug International Agricultural Science and Technology Fellowship Program (BFP) supported 45 Fellows to help transfer new science and agricultural technologies to eligible developing countries. Since the program's inception in 2004, BFP has provided training to more than 750 Fellows from 64 countries and facilitated ongoing relationships between Fellows and their U.S. mentors to promote the adoption or commercialization of U.S. technologies in their respective countries.

For example, this year FAS learned that the citrus industry in the Rio Grande Valley of Texas was positively impacted as a result of training a Moroccan Fellow at Texas A & M University (TAMU) at Kingsville, a Hispanic Serving Institution. In 2011, Mr. Lhou Beniken conducted research there on improved irrigation and water management techniques for citrus orchards. His mentor, Dr. G. Rasmussen, visited Mr. Beniken at the National Agricultural Research Institute in Morocco and saw firsthand the success in orchards utilizing an improved border flood technique instead of conventional flood irrigation. This method utilizes 36 percent less water while still meeting the water needs of citrus trees. Dr. Rasmussen, along with other TAMU-Kingsville colleagues, brought this technique back to Texas, where it was introduced to the citrus industry through field demonstrations and farmer trainings. Many orchards in the Rio Grande Valley adopted this improved method and have seen measurable success. The reciprocal visit of a host university mentor to the Fellow's home country to see their research application is a unique feature of the BFP and leads to many examples of two-way knowledge sharing and learning.

Dr. Abdul Islam, a 2010 Borlaug Fellow from the Indian Council of Agricultural Research (ICAR), conducted climate change research at Colorado State University (CSU) under the Global Research Alliance Initiative. After his time in the United States under the BFP, he continued to collaborate with his mentors at CSU and USDA's Agricultural Research Service (ARS) facility in Fort Collins, Colorado. The focus was on generation of resilient agriculture scenarios, using the projection model learned during his Fellowship, to evaluate corn cultivars for adaptation to climate warming. Realizing the importance of the project, ICAR initiated a program on Integrated Agricultural Systems Analysis for preparing an adaptation strategy, with suggested policy interventions. Dr. Islam is coordinating those research activities and was recently promoted to Principal Scientist at ICAR in New Delhi. He has published four scientific journal articles about the research at CSU, has applied climate change models for two case studies in India, and has presented his findings at four seminars.

These exemplary Fellows, their U.S. mentors, and other BFP participants are continuing to learn, disseminate, and apply U.S. technologies to improve agricultural sciences, trade, and food security throughout the developing world.

Grain Inspection, Packers and Stockyards Administration (GIPSA): Harmonizing Biotech Reference Methods

There is a need for highly specific and accurate tests for the various genetically-engineered (GE) crops grown in the United States. GIPSA has developed intra-laboratory validated real-time polymerase chain reaction (PCR) methods and has evaluated the accuracy, reliability, and proficiency of publicly available methods used to detect and identify GE grains and oilseeds. GIPSA participated on a scientific panel of experts engaging U.S. stakeholders and influencing outcomes on issues related to testing of GE traits in grains with the goal of developing global scientific consensus regarding the analysis of transgenic events. GIPSA continues to collaborate with international organizations such as Codex Alimentarius, International Organization for Standardization, American Association of Cereal Chemists, and the Canadian Grain Commission to harmonize testing technologies for GE grains and oilseeds.

National Institute of Food and Agriculture (NIFA): Food Safety

Agricultural Research Service and collaborating university scientists recently completed an SCRI project that provides food safety advances for fresh-cut leafy greens. Their groundbreaking research is used by the FDA and industry to reset food safety standards. They are the first to show that the industry-standard "Control Limit" chlorine concentration does not prevent pathogen cross-contamination, and that rewashing of contaminated product is an ineffective "Corrective Action" to rectify process failures. This work overturned historical industry practices by documenting the risks associated with operating practices previously considered safe. They also determined the necessary and sufficient sanitizer concentration to prevent pathogen cross-contamination and spread. These results are now incorporated into an interagency and industry task force document supporting Food Safety Modernization Act implementation. Canadian researchers have used our findings to develop mathematical models to predict contamination, and the U.S. Department of Homeland Security have incorporated these results into anti-terrorism programs. The project also identified a cost-effective mechanism to improve cold chain integrity and fully implement food safety preventive controls during retail display. Open refrigerated display cases typically have significant temperature nonuniformity, presenting technical challenges for maintaining temperature below 5 °C at the front, without freezing damage at the rear. Their research found that retrofitting open cases with doors achieved Food Code compliance, with nearly-uniform product temperatures below 5 °C throughout the case. Moreover, energy costs were 69% less than for open cases, allowing retrofit cost recovery in less than two years. Reduced costs for product rotation and savings from reduced spoilage are also expected. Based on outreach to retailers detailing these results, use of doors on fresh-cut produce retail cases has substantially increased in the last two years.

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 research and development (R&D) in areas of science and technology at the laboratory facilities of NIST, NOAA, and NTIA's 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 the facilitation by NIST of interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency transfer programs. [25] NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer (FLC), which provides a forum for federal labs to develop strategies and opportunities for linking technologies and expertise with the marketplace.

NTIA within the DOC is a founding co-chair for the Wireless Spectrum R&D (WSRD) Interagency Working Group (IWG) that was formed in late 2010 to coordinate spectrum-related research and development activities both across the Federal government and with academia and the private sector. Through WSRD, NTIA has been helping to coordinate and inform ongoing activities across Federal agencies and to facilitate efficient and effective investment in spectrum sharing technologies and systems. These activities are consistent with the guiding principles of WSRD, which are transparency, smart investment, and the solicitation of opportunities for technology transfer across and beyond the Federal government.

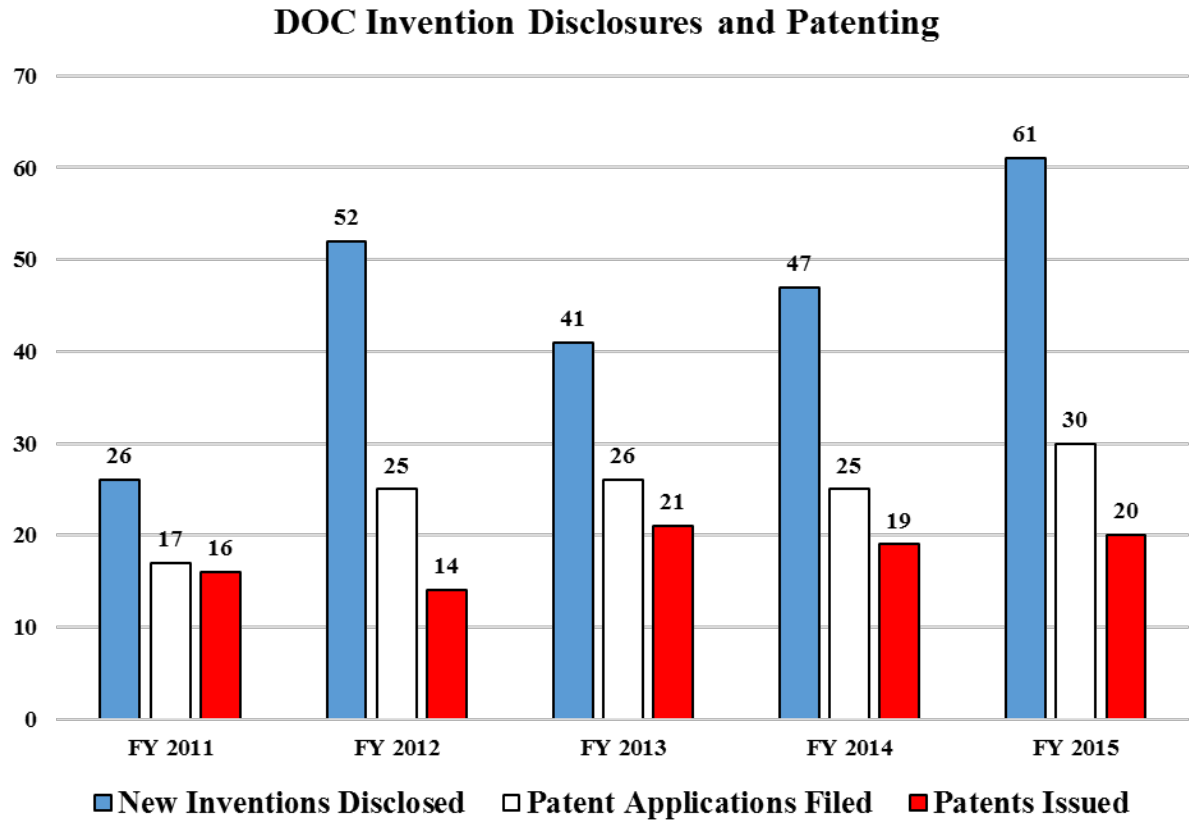
More information about DOC technology transfer is available on the following websites:

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

[25] 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 the Interior, Department of Transportation, Department of Veterans Affairs, Environmental Protection Agency, and National Aeronautics and Space Administration.

DOC Invention Disclosures and Patenting

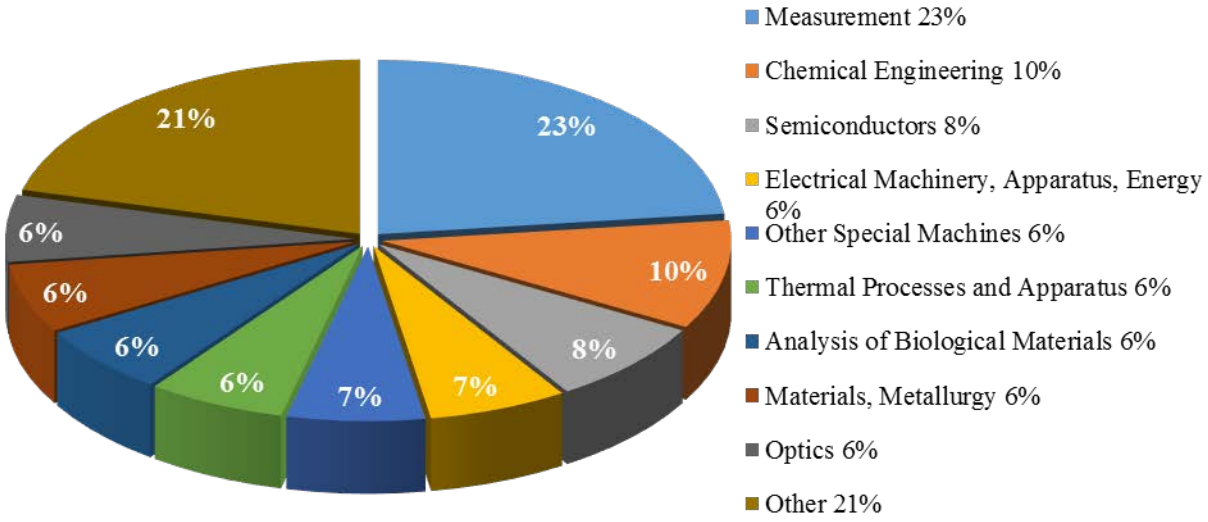
Between FY 2011 and FY 2015, the number of new inventions disclosed increased by 135% to 61 disclosures in FY 2015. The number of patent applications filed experienced a 76% increase to 30 applications filed. The number of patents issued during this five-year period increased by 25% to 20 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	26	52	41	47	61
Patent Applications Filed	17	25	26	25	30
Patents Issued	16	14	21	19	20

Patents issued to DOC in FY 2015 covered many technology areas including measurement (23%), chemical engineering (10%), semiconductors (8%), and electrical machinery, apparatus, energy (6%).[26]

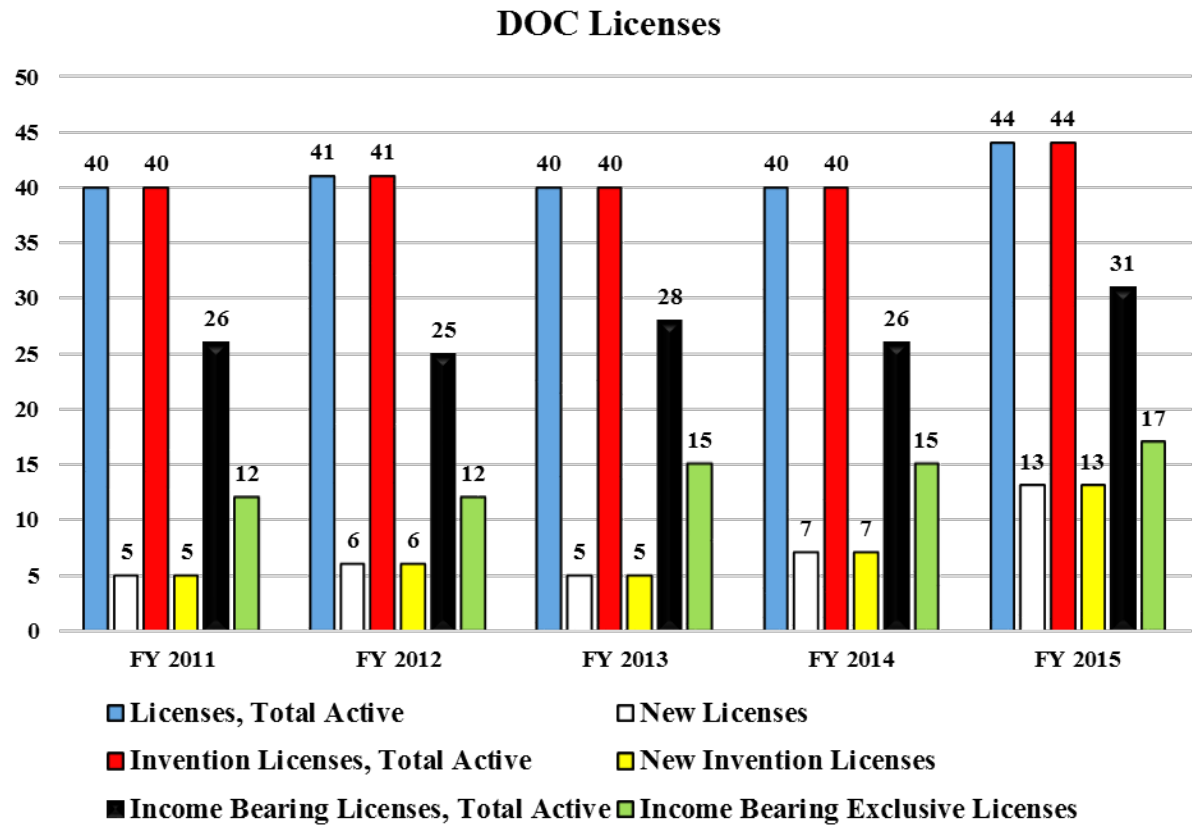
USPTO Patents Assigned to DOC by Technology Area: FY 2015



[26] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

DOC Licenses

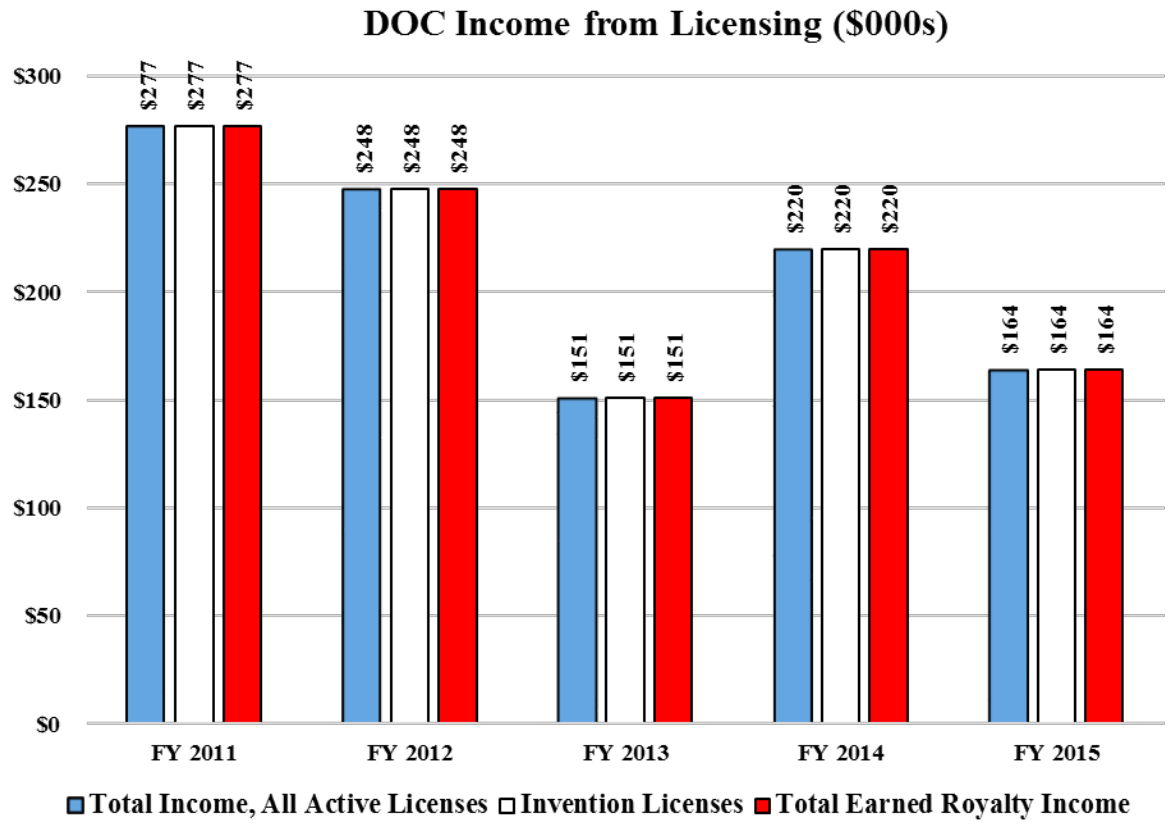
Between FY 2011 and FY 2015, the number of total active licenses increased by 10% to 44 licenses in FY 2015. All licenses were invention licenses. Total active income bearing licenses increased 19% to 31 licenses in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	40	41	40	40	44
New Licenses	5	6	5	7	13
Invention Licenses, Total Active	40	41	40	40	44
New Invention Licenses	5	6	5	7	13
Income Bearing Licenses, Total Active	26	25	28	26	31
Income Bearing Exclusive Licenses	12	12	15	15	17

DOC Income from Licensing

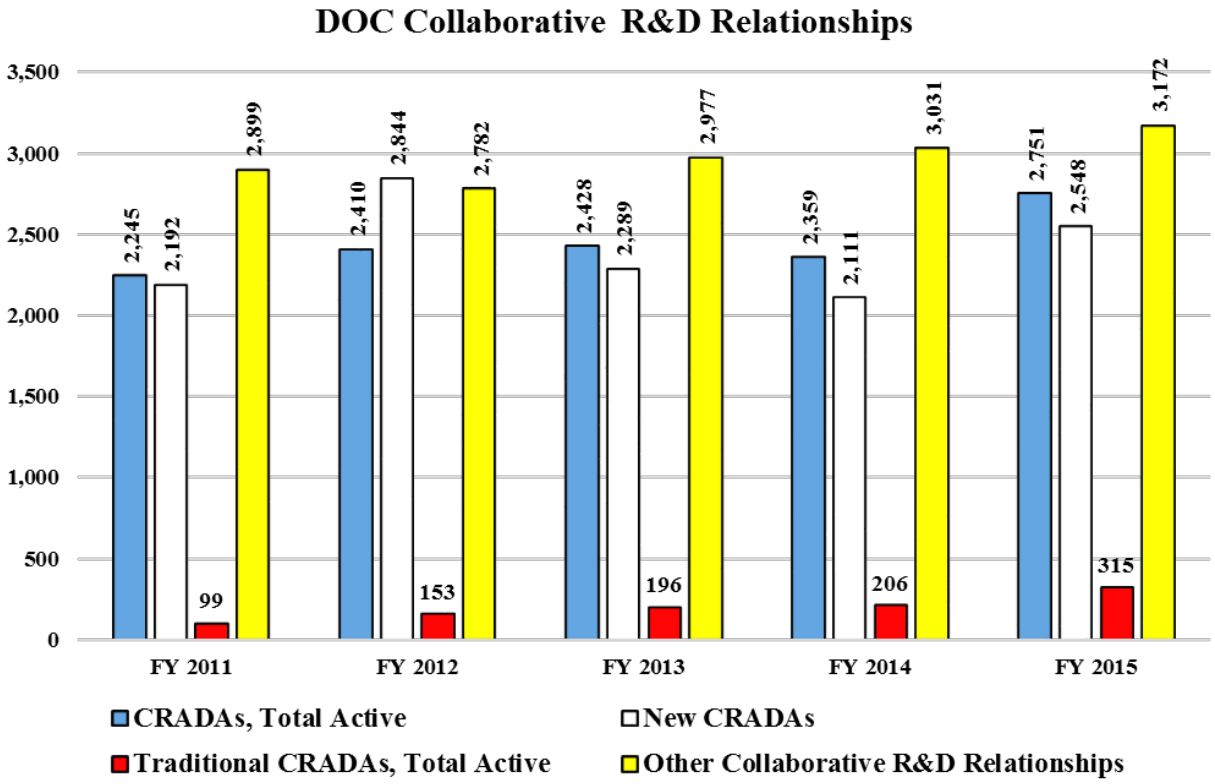
All income from licensing comes from invention licenses. During the five-year period, from FY 2011 to FY 2015, there was a 41% decrease in total income from all active licenses, from $277 thousand in FY 2011 to $164 thousand in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$277	$248	$151	$220	$164
Invention Licenses	$277	$248	$151	$220	$164
Total Earned Royalty Income	$277	$248	$151	$220	$164

DOC Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased by 23% to 2,751 agreements. The number of new CRADAs per fiscal year increased by 16% to 2,548 new agreements in FY 2015. Total active traditional CRADAs increased by 218% during the five-year period, totaling 315 traditional agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	2,245	2,410	2,428	2,359	2,751
New CRADAs	2,192	2,844	2,289	2,111	2,548
Traditional CRADAs, Total Active	99	153	196	206	315
Other Collaborative R&D Relationships	2,899	2,782	2,977	3,031	3,172

DOC Efforts to Streamline Technology Transfer Operations

In response to the PM, NIST has undertaken several efforts to streamline and simplify the technology transfer process. NIST revised its standard CRADA to expedite review of these documents and reduce the overall size of these documents by approximately one third. NIST also implemented several new licensing programs to encourage small businesses to participate. These programs lay out terms in advance to ease concerns by small businesses about overall costs. NIST is conducting detailed analysis of the flow of documents to understand where significant delays occur within the system. In many cases, these delays are with the partner and NIST does not have direct control;

however, by continued efforts to identify and understand issues experienced by partners, NIST expects to identify new ways to simplify and streamline technology transfer practices. In FY 2015, NIST experienced a 46-day reduction in the average number of days to prepare a patent application and a 45-day reduction in the average CRADA approval time.

DOC Downstream Success Stories

NIST: Combating Cyber Terrorism

NIST has granted an exclusive license for a technology used to determine network safety against unknown attacks (zero-day attacks) to George Mason Research Foundation which then sublicensed the technology to CyVision, a spin-off George Mason University (GMU). CyVision is dedicated to combating cyber terrorism and helping government and private enterprise improve their security posture. Based on this patented technology and other inventions licensed from GMU, CyVision is commercializing cybersecurity vulnerability analysis solutions.

NIST: Differentiating Biogenic and Geologic Methane Sources

NIST has granted the University of Colorado Boulder a research license for a Frequency Comb-based Spectrometer for use in an Advanced Research Projects Agency-Energy (ARPA-E) funded research project titled Frequency Comb-based Methane Sensing. NIST, NOAA and CU Boulder are working together to develop frequency comb-based technologies for methane leak detection. A licensed Patent Application from NIST and another patent application jointly owned by CU Boulder will be the basis for the planned dual frequency comb spectrometer. The technology currently in development will be able to distinguish methane, ethane, and propane, as well as methane with different carbon isotopes for differentiating biogenic and geologic methane sources. When employed as a remote methane observation network, this technology will enable significant reductions in the cost associated with identifying, quantifying, and locating methane leaks compared to currently available technologies.

NIST: Leads Development of ASTM Standard Practice for Testing Trace Explosive Detectors

Researchers in NIST's Materials Measurement Laboratory (MML) have recently completed development of a soon-to-be promulgated ASTM Standard Practice for testing and scoring the performance of trace explosive detection systems. Instrument developers and manufacturers, testing laboratories, and international agencies responsible for enabling effective deterrents to terrorism will use this standard. The revised Standard Practice goes far in increasing chemical scope, testing levels, realism, and practical aspects of explosive screening. MML distributed a white paper to outline the expanded tests and metrics and to elicit feedback regarding the performance criteria most important to trace detection. Interactions with Explosive Trace Detection (ETD) manufacturers, domestic and international agencies, subject matter experts, and stakeholder communities to better define the criteria and formulate a mechanism for scoring ETD performance that was fair and reasonable, technologically agnostic, and reflects the most important aspects of trace detection followed this. The revised standard also relaxes the requirement that an instrument identify a specific target compound, since some innovative screening technologies, such as thermo-energetic detectors and canines, cannot do this, but technologies that can provide identification get extra credit. The revision requires the use of a standard background challenge material, identified from NIST natural matrix Standard Reference

Materials (SRMs), such as a natural dust or dirt ("standard schmutz") that represents the matter co-collected on swabs during the process of sampling. Because sample throughput is important at security checkpoints, the measurement of average throughput rate for background-loaded samples is required. Lastly, the revised Standard Practice provides a means to calculate a numerical performance score based upon all the mandated tests. There is no maximum score but a minimum score is specified based upon criteria from the original E2520-07. The scores will provide tangible measures of instrumental detection performance, useful for comparing systems worldwide and for enabling targeted improvements in next-generation detection systems.

NIST: A New NIST Tool for Evaluating Sustainability Performance of Buildings

NIST's newly released database and software tools, called BIRDS (Building Industry Reporting and Design for Sustainability), enable building owners to assess three major factors contributing to building sustainability: energy, environment, and cost performance. Building professionals in more than 200 U.S. cities are using BIRDS to evaluate whether it pays to exceed code requirements for energy efficiency by tallying expected costs, kilowatts expended, carbon emissions, and other impacts over a commercial building's lifetime. Focusing initially on 11 building prototypes that account for about half of new U.S. commercial construction annually, the online data package features an innovative "whole building measurement system." An integrated set of metrics gauges, sustainability of materials and energy usage, assesses carbon footprints and 11 other indicators of environmental performance, and tabulates economic costs over nine different investment horizons. BIRDS complements NIST's popular tool known as BEES (Building for Environmental and Economic Sustainability) that allows a user to measure economic and environmental impacts of building products, ranging from concretes to roof coverings to floor coverings.

NIST: STEP File Analyzer Significantly Accelerates the Industrial Deployment of Key Manufacturing 3D CAD Standards

Computer-aided Design (CAD) has become ubiquitous throughout the modern manufacturing industry, and efforts are currently underway to base all product design and manufacturing activities on digital three-dimensional (3D) CAD master models. ISO 10303, the de facto worldwide standard for digital exchange of data for the design and manufacture of products, enables the sharing of a 3D master model among various design, analysis, and manufacturing applications. NIST has recently developed a software tool, the Standard for the Exchange of Product (STEP) File Analyzer that is critical to the industrial deployment of ISO 10303. This software is widely used in collaborative, pre-commercial testing to reduce errors in the use of ISO 10303. The STEP File Analyzer has served to accelerate the commercial delivery of ISO 10303 implementations, with more robust manufacturing information that supports geometric validation, long-term data archiving, machining, and coordinates measuring machine applications. Additionally, this software tool provides a feedback loop to the standardization community for continuous improvement of ISO 10303. Detailed analysis of these 3D CAD files has taken on greater significance since the expansion of the scope of the standard to support advanced manufacturing that use digital product models throughout the product life cycle.

NIST: PET Phantoms Bring New Accuracy to Medical Scans

Teaming with a medical equipment company, researchers at NIST have demonstrated the first calibration system for positron emission tomography (PET) scanners directly tied to national

measurement standards. Better calibrations of the machines can potentially increase the accuracy of their diagnostic images by several times, according to NIST scientists.

The new calibration capability can help to fine-tune PET scanners that find cancers and track the progress of treatments, among other diagnostic applications. It can help to ensure the accuracy of some of the newest scanners on the market.

NIST's technique, developed over the past few years, calibrates devices called "phantoms," built specifically for PET scanners to check medical imaging devices such as X-ray scanners. Typically, they are simply blocks of materials known to respond to—for example—X-rays in a consistent, known manner that is similar to the way human tissues respond. PET phantoms are more complicated because the scanners work by detecting radioactive materials injected in the patient.

The phantoms will be the first ones commercially available for PET that can trace calibration directly to NIST standards. NIST developed the calibration method partly in response to a request by Sanders Medical Products, which supplies the phantoms to GE Healthcare, a manufacturer of combination PET-MRI scanners.

NIST: New Reference Material Provides a Silver Lining for NanoEHS Research
NIST has issued a new silver nanoparticle reference material to support researchers studying potential environmental, health, and safety risks associated with the nanoparticles, known for their antimicrobial properties, found in a growing number of consumer and industrial products. The new NIST test material may be the first of its kind to stabilize the highly reactive silver particles in a freeze-dried, polymer coated, nanoparticle cake for long-term storage.

Nanoparticulate silver is a highly effective bactericide. It is, by some estimates, the most widely used nanomaterial in consumer products. These include socks and shoe liners (it combats foot odor), stain-resistant fabrics, coatings for handrails and keyboards, and a plethora of other applications. A coating and freeze-drying technique, commonly used in the pharmaceutical industry to preserve blood products and protein-based drugs, stabilizes this new NIST product.

NIST: Measuring Stick Standard for Gene Sequencing Now Available from NIST
The world's first reference material to help ensure laboratories accurately "map" DNA for genetic testing, medical diagnoses, and future customized drug therapies is now available from NIST. The new reference material, NIST RM 8398, is a "measuring stick" for the human genome, the coded blueprints of a person's genetic traits. It provides a well-characterized standard that can tell a laboratory how well its processes for determining the patterns in a person's DNA (called DNA or gene sequencing) are working by measuring the performance of the equipment, chemistry, and data analysis involved.

NIST created RM 8398 with its partners in the Genome in a Bottle consortium, a group that includes stakeholders from industry, academia, and the Federal government. Scientists from NIST and the U.S. Food and Drug Administration (FDA) helped organize the collaborative effort to provide the technical benchmarks (reference standards, reference methods, and reference data)

needed to enable widespread clinical applications of whole genome sequencing and science-based regulatory oversight of the technology by the FDA.

The new reference material marks a significant step forward in addressing FDA's regulatory needs for evaluating next-generation gene sequencing and genetic testing. The reference material is the first complete human genome to have been extensively sequenced and re-sequenced by multiple techniques, with the results weighted and analyzed to eliminate as much variation and error as possible.

NOAA: Risk Management Solutions (RMS) Acquires NOAA T2 spin-off, HWind Scientific, Plans to Integrate Team and Products

In 2014, the NOAA Technology Partnerships Office released a hurricane and storm surge modeling technology called H*Wind back to its original inventor, Dr. Mark Powell, to allow him to pursue his own startup company based on the technology. Dr. Powell, formerly of the NOAA Atlantic Oceanographic and Meteorological Laboratory, retired from Federal service and successfully created the startup – HWIND Scientific – to deliver real-time hurricane field assessments to industry and government. In 2015, just one year after Dr. Powell founded the company, Risk Management Solutions, a noted catastrophe risk-modeling firm, acquired HWIND Scientific and will integrate its capabilities into their suite of products and services.

NOAA: Survey 'Amazingly Intact' Historic WWII-Era Aircraft Carrier

As part of its Cooperative Research and Development Agreement with the Boeing Corporation, NOAA scientists gathered in Half Moon Bay to use state of the art technology to survey the wreckage of the aircraft carrier the USS Independence, scuttled by the U.S. Navy in 1951.

"After 64 years on the seafloor, Independence sits on the bottom as if ready to launch its planes," said James Delgado, chief scientist on the Independence mission and maritime heritage director for NOAA's Office of National Marine Sanctuaries. "This ship fought a long, hard war in the Pacific and after the war was subjected to two atomic blasts that ripped through the ship. It is a reminder of the industrial might and skill of the 'greatest generation' that sent not only this ship, but their loved ones to war."

NOAA's interest in Independence is part of a mandated and ongoing two-year mission to locate, map, and study historic shipwrecks in Gulf of the Farallones National Marine Sanctuary and nearby waters. The carrier is one of an estimated 300 wrecks in the waters off San Francisco, and the deepest known shipwreck in the sanctuary.

The Echo Ranger, an 18.5-foot-long autonomous underwater vehicle (AUV), provided by The Boeing Company through a cooperative research and development agreement with NOAA's Office of Oceanic and Atmospheric Research, conducted the mission. Boeing also collaborated with technology company Coda Octopus to integrate its 3D-imaging sonar system, Echoscope, into the AUV.

"Boeing is excited for the opportunity to partner with NOAA to utilize this state of the art technology," said Fred Sheldon, Boeing project manager for AUVs. "The Echo Ranger is uniquely suited for this type of mission and performed perfectly allowing us to conduct a thorough survey of the USS Independence."

NOAA: Science on a Sphere® Animations Coming to your Desktop
NOAA released a free, downloadable flat screen version of its popular Science on a Sphere® (SOS), SOS Explorer™. This new way to display the dynamics of Earth's weather and climate, plate tectonics, and more will help teachers bring these stunning science visualizations, usually found at museums and science centers, into the classroom, where students can learn by exploring.

"Bringing SOS Explorer™ into the classroom and having it as a visual tool is a huge help because students can see numbers and they don't make much sense," said Jayme Margolin-Sneider, a middle school science teacher at Westview Middle School in Longmont, Colorado. "But when we show it to them in an animation or a simulation, the lightbulb goes on."

SOS Explorer™ uses off-the shelf video gaming technology. "The gaming industry is a multi-billion-dollar industry. It surpassed Hollywood in terms of revenue and it's really using cutting-edge technology," said Eric Hackathorn, lead SOS Explorer developer at NOAA's Earth System Research Laboratory (ESRL) Global Systems Division in Boulder, Colorado. "By leveraging that technology, we can create very effective visualizations."

Future versions of SOS Explorer™ will include the entire SOS® library—hundreds of visualizations of earthquakes, hurricanes, climate change, and much more. Users will even be able to add their own content and write their own tours. The current version of SOS Explorer™ is available free of charge to everyone.

NOAA: Arctic Shield 2015: Autonomous and Piloted Aircraft Fly Search and Rescue Exercise
NOAA's Unmanned Aircraft Systems (UAS) Program Office, working together with representatives of AeroVironment Inc., conducted a Search and Rescue Exercise, called Arctic Shield, in the waters north of Alaska to test the utility of integrating unmanned aircraft into a simulated response incident.

Working from the deck of the U.S. Coast Guard Cutter HEALY, the research team launched a small, unmanned aircraft, the AeroVironment Puma, to search for a simulated missing person stranded in the icy waters. Following the launch, the Puma used both its electro-optical and infrared cameras to locate the simulated victim, affectionately named Thermal Oscar, floating in a survival raft on the water approximately one nautical mile away from the ship.

The Puma was able to relay the coordinates to the test control center on board the HEALY, which then directed a Coast Guard H-60 and ERA Helicopter to the scene. Both helicopters deployed rescue swimmers to simulate recovery and then returned safely to shore. The exercise concluded with a successful net capture of the Puma UAS and a recovery of the survival raft by the HEALY.

Much of this mission occurred under the auspices of a CRADA between NOAA and AeroVironment, Inc. The CRADA in this case allows NOAA and Aerovironment to test UAS capabilities in a series of real-life mission-based scenarios. Both NOAA and Aerovironment will analyze the results from these tests in order to improve NOAA's operational capabilities and AeroVironment's products.

NOAA: Hollings Lab and Algaeventure Systems
The NOAA Ocean Service Hollings Marine Laboratory CRADA, with Algaeventure Systems (dba Biosortia Pharmaceuticals), originally signed in 2012 and recently amended in 2014, has resulted in a wide array of successful outcomes for NOAA and for its CRADA partners. Under the CRADA, NOAA is working with academia, industry, and government entities that wish to screen toxic substances present in algal blooms for use in pharmaceuticals and other commercial applications, while also producing mission-based data products for water quality managers and homeland security applications.

"The technology that Algaeventure Systems (AVS) brings to bloom analysis is incredible," says Dr. Peter Moeller, the PI on the CRADA at NOAA's Hollings facility. "It has changed and will continue to change the way we assess blooms and their secondary metabolites (i.e., toxins and other bioactive molecules). The cool part of this program is that many of the organisms we assess are non-culturable in the lab, yet produce highly toxic compounds. AVS/Biosortia is tapping into a huge, completely novel source of natural products."

According to Moeller, NOAA has "submitted over 4,600 discrete biologically active extracts or purified fractions to our partners for testing and commercial development. We already have one patent (euglenophycin) based on this work, which is a compound being tested to capitalize on its angiogenic properties (e.g., to treat leukemia)."

In support of NOAA's mission, the research generates analytical detection method(s) for each toxin/metabolite of interest. Any water quality platform can incorporate the method/data to aid managers and decision makers. The research has also led to rapid toxin ID methods used in combating bioterrorism. These methods include mass spectrometry, liquid chromatography-mass spectrometry (HPLC/MS), and nuclear magnetic resonance spectroscopy (NMR).

"We currently have both national and international requests for toxin standards, an area we are just beginning to look into," says Moeller. "The CRADA allows us to freely access tons of microbial biomass within hours/days – biomass on a scale unattainable prior to Algaeventure Systems developing their harvesting technology. This has obviated the need for historically time consuming and expensive mass cultures. It also allows us to assess the microbial consortia in a given bloom rather than a single selected organism. This is very important, as all blooms are a mixture of microbes (algae, fungi, bacteria) that play off each other, generating secondary metabolites that could potentially be used as chemical warfare agents. These metabolites are frequently toxic to mammals, so they are of great concern to water quality managers."

NOAA: Patent for Novel Feeder for Juvenile and Larval Fishes
In 2015, the U.S. Patent and Trademark Office awarded a patent to Thomas Scott for his innovative fish feeder that allows fish farmers to feed young fish on a recurrent basis while protecting the feed from oxidation and clumping. NOAA's Northwest Fisheries Science Center in Seattle developed this feeder.

The device combines off-the-shelf solenoids and controller software with an innovative dispensing unit that uses forced nitrogen gas to both deliver the feed and keep the environment free from oxygen and moisture. The feeder can deliver small (ca. 20mg), precise doses of microparticulate (ca. 100 µm diameter) feed to selected locations.

Gravity carries feed into a firing chamber from the hopper above. A small vibrating device aids in settling the feed into the chamber. The precision of the feeder allows for very small doses, as well as adjustments for specific diet characteristics such as dry weight equivalence and particle density. Moreover, the basic controller software allows the operator to control the system and receive any warnings directly on their cell phone.

NOAA: Aerosol Measurement Devices
The NOAA Technology Partnerships Office successfully negotiated two license agreements for two atmospheric sensors developed at the Earth System Research Laboratory, Chemical Sciences Division (CSD) in Boulder, CO. The first technology, a Printed Optical Spectrometer, measures aerosol particle sizes, which are important for determining the interactions of the particles with light and hence their effects on climate.

Principal Investigator Ru-Shan Gao used CSD's three-dimensional printing capability to produce the structural components from the plastic raw starting material, and added new inexpensive lasers, optical detectors, electronics, and a miniaturized pump. Innovations of the design and fabrication approach led not only to the small size of the instrument, but also to its relatively low cost; the device is about a tenth the size – and a fifth of the price tag – of currently available instruments in its performance class.

The second instrument, a Portable Aerosol Generator, generates aerosol for particle instrument characterizations and calibrations. Using a small compressor and a medical nebulizer, the PAG can generate a continuous flow of air/particle mixture. The device is portable, simple, and quiet to operate.

Handix, LLC, a company based in Boulder, Colorado, with strong capabilities in the Chinese market, licensed both devices.

NTIA: Telecommunication Standards
ITS authored six of the eleven technical contributions on various engineering issues and subject areas submitted by the U.S. during the 2015 ITU-R SG3 meetings. ITS engineers led the Correspondence Group on Building Entry Loss, which is critical to Long Term Evolution (LTE) deployment across the world and represents millions, if not billions, of dollars in potential commercial development. ITS researchers also presented four U.S. technical contributions at the 2015 ITU-T Study Group 9 meeting.

Intense participation by ITS staff in the Third Generation Partnership Project (3GPP) standards development process on behalf of FirstNet resulted in Proximity Services and Group Communications requirements being included in 3GPP Release 12 and Mission Critical Push to Talk being included in the final agenda for 3GPP Release 13. These features are critical to ensuring that LTE can meet public safety's requirements and will be a prerequisite for FirstNet to offer mission-critical voice (MCV) on the new Band Class 14 nationwide interoperable public safety communications network when these capabilities become available.

NTIA: Table Mountain Research
The ITS Table Mountain Field Site and Radio Quiet Zone in Colorado supports fundamental research in the nature, interaction, and evaluation of telecommunication devices, systems, and

services. Each year, private companies, universities, and other organizations conduct research at Table Mountain under CRADAs.

In FY 2015, several companies used the Table Mountain site under a CRADA to test safely and demonstrate Laser Detection and Ranging (LADAR) technologies under development in atmospheric conditions and at distances relevant to potential applications and to test fully the functionality of new antenna designs during product development. Additionally, the site allowed for safe and accurate tests of an Adaptive Tactical Laser System (ATLAS) compensated beacon adaptive optics (CBAO) system under development.

For the past nine years, the University of Colorado's Research and Engineering Center for Unmanned Vehicles safely and accurately tested collective and autonomous sensing and communication technologies for small unmanned aircraft at Table Mountain.

Lockheed Martin Coherent Technologies is in its fifteenth year of field-testing and characterizing components, subsystems, and systems for eye-safe coherent laser radar. This has benefited NTIA and the Department of Defense.

NTIA: Video Quality Research

Industry and academia both use CDVL and the VQM tools for research into new techniques for transmitting video. The research tests codes, evaluates new display technologies, or validates new standards. For example, ITU-T Study Group 12 has used CDVL clips for research into the development of parametric models and tools for multimedia quality assessment and the MPEG committee opened a conversation with ITS about using the CDVL video clips for validation testing of new video coding standards.

NTIA: Public Safety Broadband Demonstration Network

The PSCR Public Safety Broadband (PSBB) Demonstration Network, established in the ITS labs in FY 2010 by the Public Safety Communications Research program, facilitates accelerated development of testing for emerging LTE broadband equipment specific to public safety. This network provides a central and independent test bed/laboratory to help public safety organizations understand 3GPP Band 14 LTE. Through CRADAs that protect their intellectual property, manufacturers and carriers test the deployment of 700 MHz systems under development in this multi-vendor environment and execute public-safety specific test cases to provide proof of concepts and improve the quality of future systems. This cooperative program provides ITS with guidance to develop technical contributions toward LTE standards to support public safety and FirstNet requirements. This work advances the development of new public safety communications equipment that will eventually operate on the nationwide public safety broadband network.

Department of Defense (DoD)

The Defense Laboratory Office (DLO) provides overall policy guidance for and oversight of Department-wide technology transfer efforts. DLO ensures, to the maximum extent practicable, that DoD developed technologies demonstrating commercial viability are integrated into the private sector; that technologies developed outside of the DoD that demonstrate national security utility are transferred into the Defense acquisition process; and that those technologies demonstrating both commercial and national security applications are made available to the DoD as well as industry and academia.

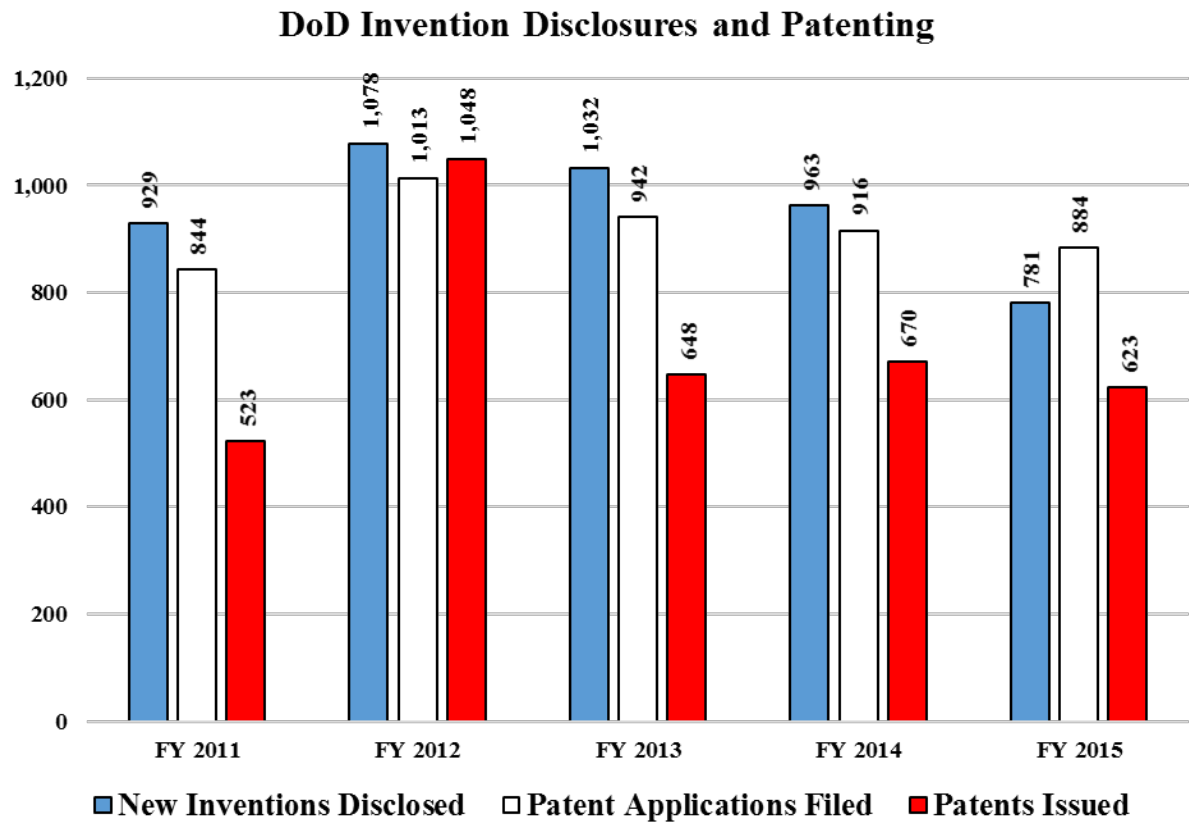
DoD is unique in applying the principles, practices, and tools of technology transfer in the execution of its mission. DoD funds and develops mission-focused technology, and technology transfer statutory authorities enable it to promote and facilitate the commercialization of that technology for both 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

DoD Invention Disclosures and Patenting

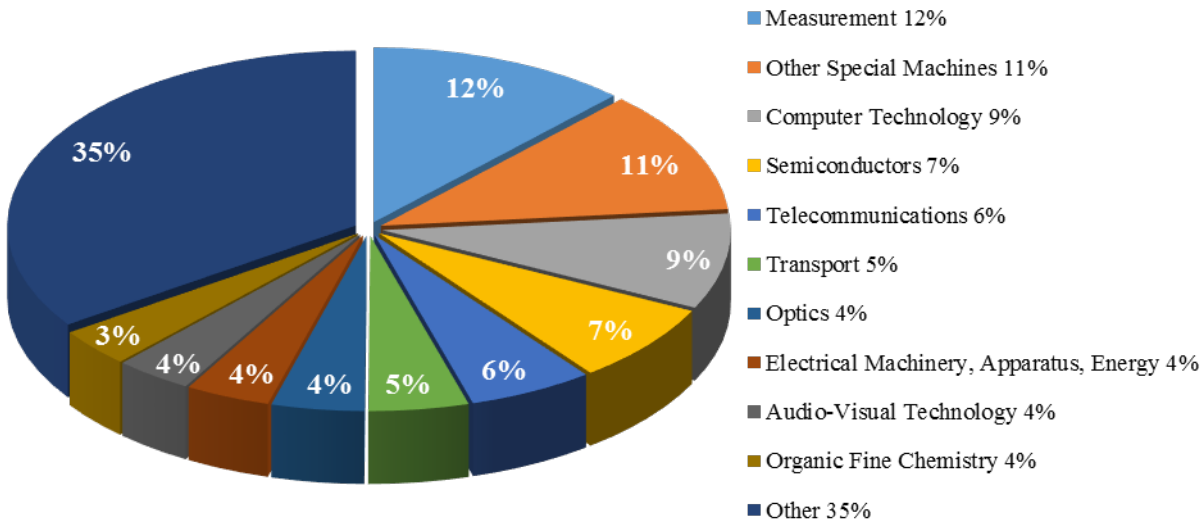
Between FY 2011 and FY 2015, the number of new inventions disclosed decreased by 16% to 781 disclosures in FY 2015. The number of patent applications filed experienced a 5% increase. The number of patents issued during this five-year period increased by 19% to 623 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	929	1,078	1,032	963	781
Patent Applications Filed	844	1,013	942	916	884
Patents Issued	523	1,048	648	670	623

Patents issued to DoD in FY 2015 covered many technology areas including measurement (12%), other special machines (11%), computer technology (9%), semiconductors (7%), telecommunications (6%).[27]

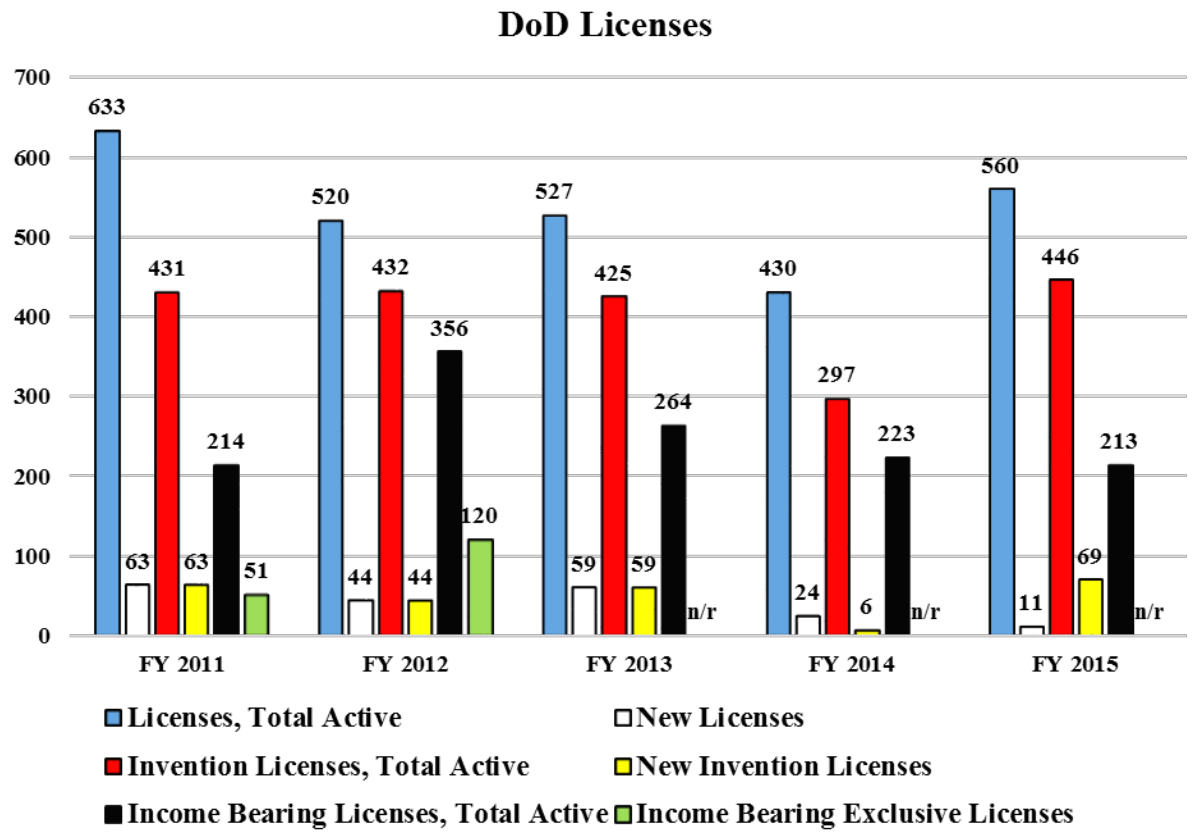
USPTO Patents Assigned to DoD by Technology Area: FY 2015



[27] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

DoD Licenses

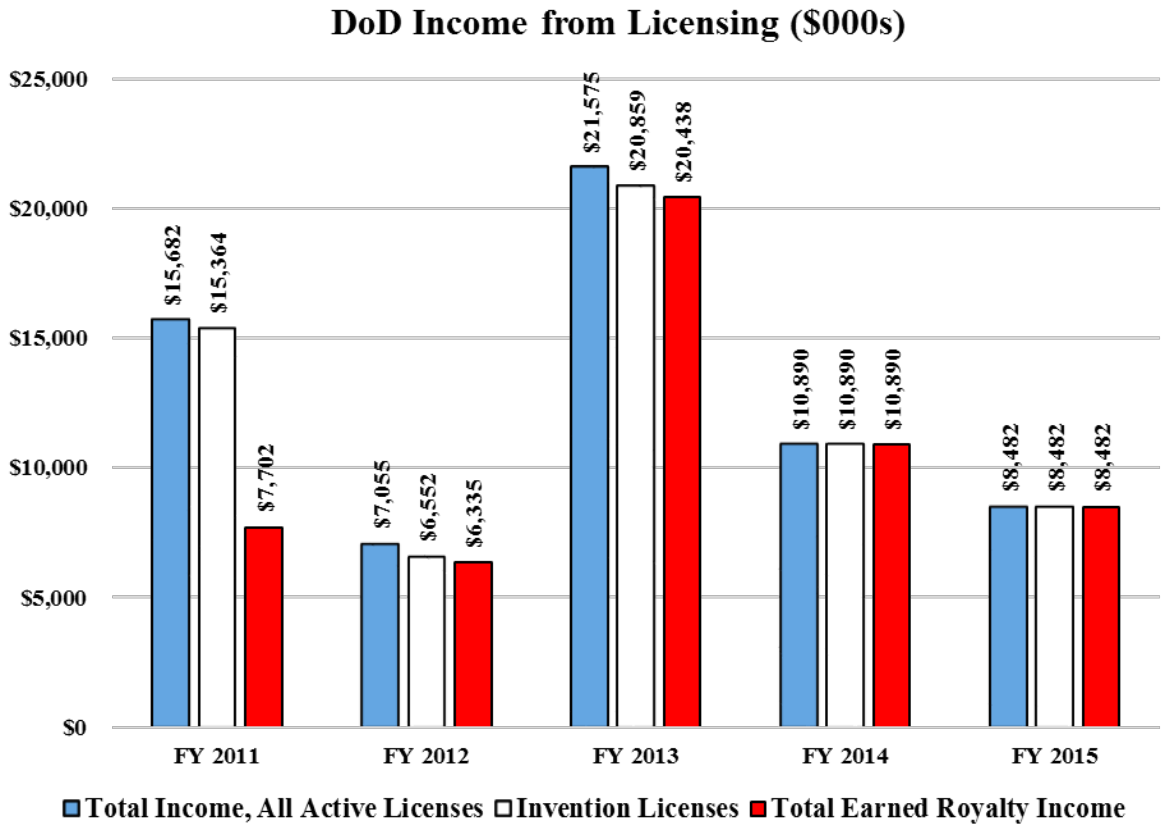
Total active licenses decreased by 12% over the five-year period, from 633 licenses in FY 2011 to 560 licenses in FY 2015. New licenses decreased by 83% to 11 licenses from a previous 63 in FY 2011. The number of total active invention licenses increased by 3% to 446 licenses. New invention licenses increased by 10% to 69 licenses in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	633	520	527	430	560
New Licenses	63	44	59	24	11
Invention Licenses, Total Active	431	432	425	297	446
New Invention Licenses	63	44	59	6	69
Income Bearing Licenses, Total Active	214	356	264	223	213
Income Bearing Exclusive Licenses	51	120	n/r	n/r	n/r

DoD Income from Licensing

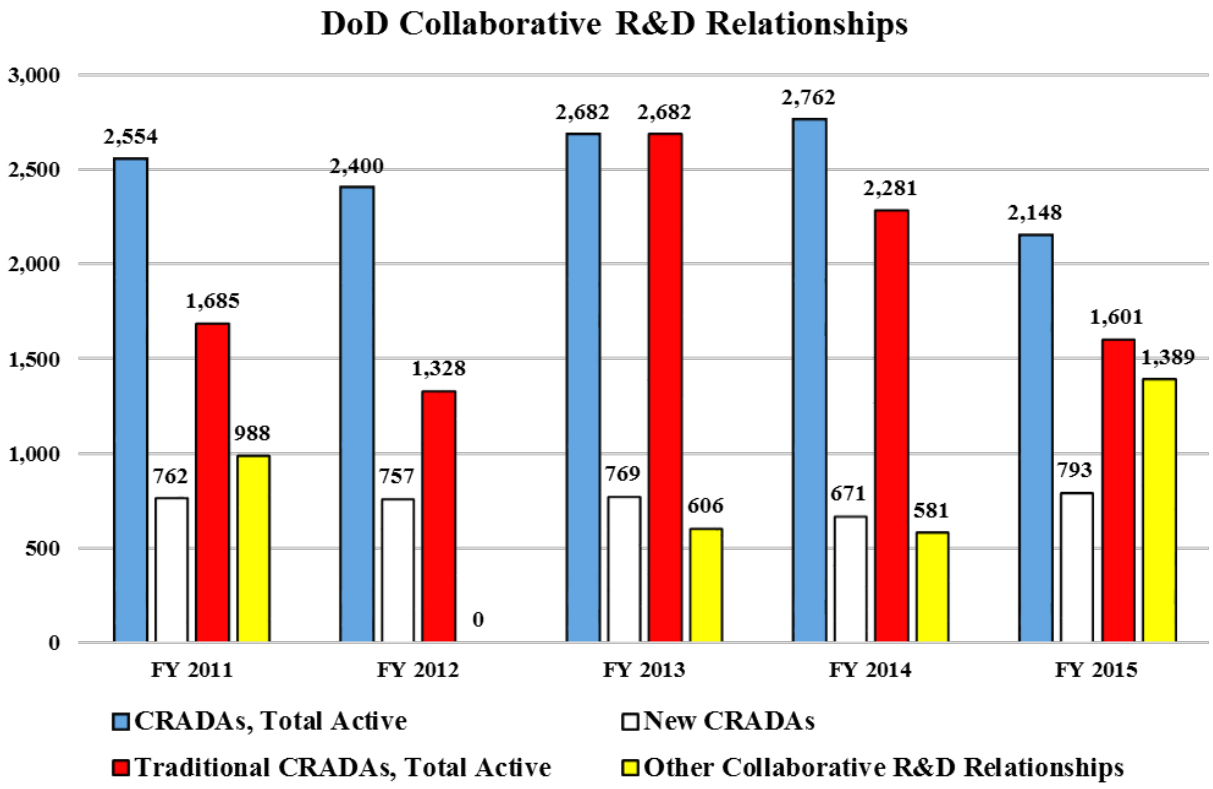
All income from licensing comes from invention licenses. Between FY 2011 and FY 2015, the number of total income from all active licenses decreased by 46% to $8.5 million in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$15,682	$7,055	$21,575	$10,890	$8,482
Invention Licenses	$15,364	$6,552	$20,859	$10,890	$8,482
Total Earned Royalty Income	$7,702	$6,335	$20,438	$10,890	$8,482

DoD Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs decreased by 16% to 2,148 agreements. The number of new CRADAs per fiscal year increased by 4% to 793 new agreements in FY 2015. Total active traditional CRADAs decreased by 5% during the five-year period, totaling 1,601 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	2,554	2,400	2,682	2,762	2,148
New CRADAs	762	757	769	671	793
Traditional CRADAs, Total Active	1,685	1,328	2,682	2,281	1,601
Other Collaborative R&D Relationships	988	0	606	581	1,389

DoD Downstream Success Stories

Air Force Research Laboratory: Roll-Out Solar Array (ROSA)

Spacecraft are primarily powered by solar energy. Due to the enormous energy requirements, the solar panels that fly in space are many times larger than the satellite or payload itself. The wingspan of geostationary communication satellites is about 150 feet; however, the launch vehicle that carries the satellite to orbit has an internal diameter less than 15 feet. This causes challenges for launching solar arrays into space since they must be stowed in the narrow confines of launch vehicle fairings and then deployed on-orbit. Additionally, launching a satellite into space is exorbitantly expensive. Currently, the approximate cost to launch satellites is $10,000 per pound. These two factors result in the limited total power available to spacecraft payloads.

Since all spacecraft require power to operate, reducing the weight and stowed volume of the solar array greatly reduces overall system cost and increases the total power for the mission. To tackle these challenges, the Air Force Research Laboratory (AFRL) Space Vehicles Directorate in partnership with NASA, Deployable Space Systems, Inc., LoadPath, LLC., and Hall Composites developed the Roll-Out Solar Array (ROSA), which uses novel, passively-deployed, composite structural booms, and a flexible solar cell blanket. ROSA's innovative architecture bests the current state-of-practice rigid solar arrays in all areas of performance including 6x improvement in stowed power density, 3x higher specific power, and 4x higher stiffness, all while lowering the array cost by 25%. The outstanding improvement in performance enables ROSA to shatter spacecraft on-orbit power limits, which enables substantially higher communication bandwidth for commercial applications, and opens up new classes of DoD missions while offering substantial cost savings for conventional missions including an estimated $1.4B in savings for U.S. Air Force communication and navigation programs.

The multi-partner effort formed by the AFRL/RV Advanced Space Power and Integrated Structural Systems teams, NASA, Deployable Space Systems, LoadPath, and Hall Composites led directly to the testing, demonstration, and commercialization of ROSA; the widespread adoption of the technology led to broad economic impacts and transitioned to Space Systems Loral to replace their existing arrays for 37 GEO/LEO CommSats in production. This technology has the potential to change the face of an entire industry, and its huge success is because of the AFRL team.

U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC): Integrated Body Armor Garment

In 2012, Protect the Force, Inc. (PTF), a strategic consulting firm specializing in providing manufacturers with relationship management, product development, acquisition and contracting expertise, and sales and marketing support geared towards Government sales, was awarded a contract to develop the next generation of enhanced torso and extremity protective equipment.

Through collaboration with various partners, including Natick Soldier RD&E Center employees, PTF introduced a prototype, later demonstrated in an Army human factors evaluation. Feedback was overwhelmingly positive with 100% of the Soldiers testing the prototypes expressing their desire for the integrated body armor garment (Garment) to become their issued protective system. Given the enthusiasm for the Garment, Mission Ready Services, Inc., the parent

company of PTF, desired to seek patent protection. As a result of the collaborative development effort between PTF and NSRDEC employees, Robert DiLalla, an NSRDEC Team Leader in the Warfighter Directorate, was named an inventor on the patent applications claiming the Garment.

The Garment is based around the concept of biomimetics, the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. Key features of the Garment are described below:

- Significant weight reduction due to the innovative design resembling the anatomy of the wearer.
- Conformal protection to the neck, upper back, upper torso, and deltoid regions.
- All protective technology is integrated into a single athletic blouse, reducing the "Christmas Tree Effect" as seen in many current systems, including the Army-issue body armor vests, where snaps, hooks, and loops are utilized to attached protective components.
- Balanced weight distribution with an integrated elastic network that aids in correct posture and facilitates the donning and doffing of body armor vests with plate carriers.
- Enhanced effectiveness and reduced risk of fatal injury due to fewer individual components and seams that can limit mobility due to snagging or dragging.
- The Garment is fabricated with stretchable, highly durable materials with flame and thermal protective properties, as well as comfort features, including moisture vapor transmission.

Though it was initially developed with the Soldier in mind, the Garment has garnered enthusiastic recognition within other areas of the military and law enforcement agencies. In the United States and European countries, there is an increasing trend to provide body armor to first responders, such as emergency medical services personnel and firefighters. This trend has been stimulated by the need to upgrade the capabilities of personnel who must respond to casualties during a terrorist attack, mass shooting event, or other situations where the responder may encounter gunfire. As a result, as of 2013, the personal protection market had an estimated value of USD$2.4 billion, and is expected to grow to USD$3.7 billion by 2023.

Navy: Modular Advanced Technologies – Marksmanship Proficiency (MAT-MP)
The Modular Advanced Technologies – Marksmanship Proficiency (MAT-MP) toolkit is a reconfigurable small arms instrumentation kit of patent-pending assessment and diagnostic tools for use on the live-fire range by marksmanship instructors and coaches. The MAT-MP toolkit provides instructors with additional direct measures of marksmanship performance to assist in assessment and diagnosis of problem shooter performance. Under sponsorship by the ONR, the Mk1 version of the MAT-MP was successfully developed and demonstrated as an advanced prototype in FY 2014. In FY 2015, the DoD's Domestic Preparedness Initiative sponsored the production of the Mk3 version of the MAT-MP for transition to the Federal Law Enforcement Training Center (FLETC). In early FY 2016, FLETC instructors will be testing the MAT-MP for use in its rifle training courses.

Department of Energy (DOE)

The Department of Energy (DOE) plays a key role in moving innovative technologies developed in research labs across the country into the commercial marketplace, fueling the innovation engine that powers the U.S. economy. Bridging the gap between research and development (R&D) and commercial deployment is crucial to the Department's mission, because it creates globally competitive industries in the United States, enables significant cost-savings for industries and consumers, and creates good jobs for Americans.

The DOE's National Laboratories tackle the critical scientific challenges of our time – from combating climate change to discovering the origins of our universe -- and possess unique instruments and facilities, many of which are found nowhere else in the world. They address large scale, complex R&D challenges with a multidisciplinary approach that places an emphasis on translating basic science into innovation. Specifically, the National Laboratories:

- Conduct research of the highest caliber in physical, chemical, biological, and computational and information sciences that advances our understanding of the world around us;
- Advance U.S. energy independence and leadership in energy technologies to ensure the ready availability of clean, reliable, and affordable energy;
- Enhance global, national, and homeland security by ensuring the safety and reliability of the U.S. nuclear deterrent, helping to prevent the proliferation of weapons of mass destruction, and securing the nation's borders; and
- Design, build, and operate distinctive scientific instrumentation and facilities, and make these resources available to the research community.

DOE oversees the construction and operation of some of the Nation's most advanced R&D 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 2015, these facilities were used by over 32,000 researchers from universities, national laboratories, private industry, and other federal science agencies.[28]

Science and engineering are not linear, nor are they uniform, but the DOE's system of National Labs, user facilities, research centers and shared research facilities, makes the pursuit of discovery – and the many solutions that result – both a collaborative enterprise and a shared national resource. Collaboration with industry and academia is essential to develop, demonstrate, deploy and commercialize the output from DOE's broad R&D investments.

In February of 2015, DOE's Office of Technology Transitions (OTT) was established to expand the commercial impact of DOE's portfolio of research, development, demonstration and deployment (RDD&D) activities over the short, medium, and long term. The new Office works closely with the National Laboratories and engages with the public and private sectors to promote scientific and technological innovation to advance the economic, energy, and national

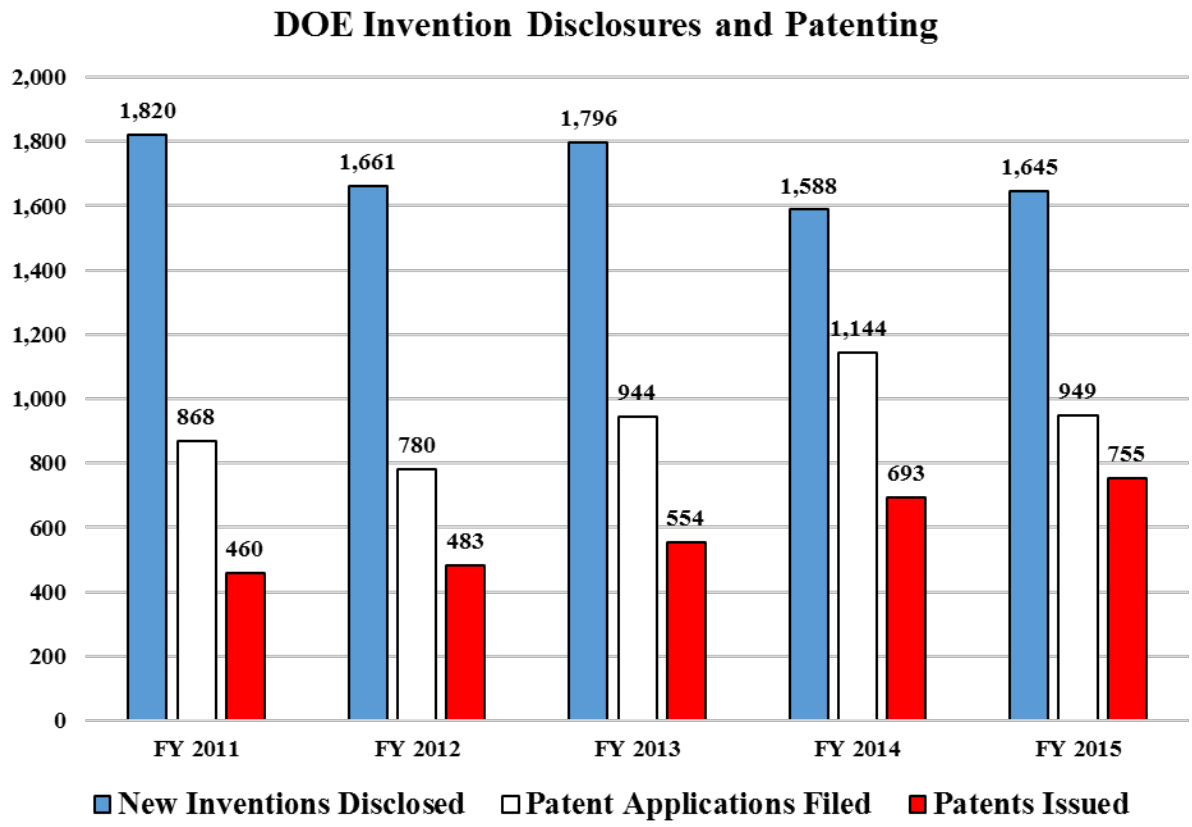
[28] Department of Energy, Office of Science. *User Facilities.* http://science.energy.gov/user-facilities/

security interests of United States. In doing so, OTT coordinates and encourages more effective technology transitions across the RDD&D spectrum from its National Laboratories.

More information about DOE's technology transfer activities are available on the following website: https://energy.gov/technologytransitions/office-technology-transitions.

DOE Invention Disclosures and Patenting

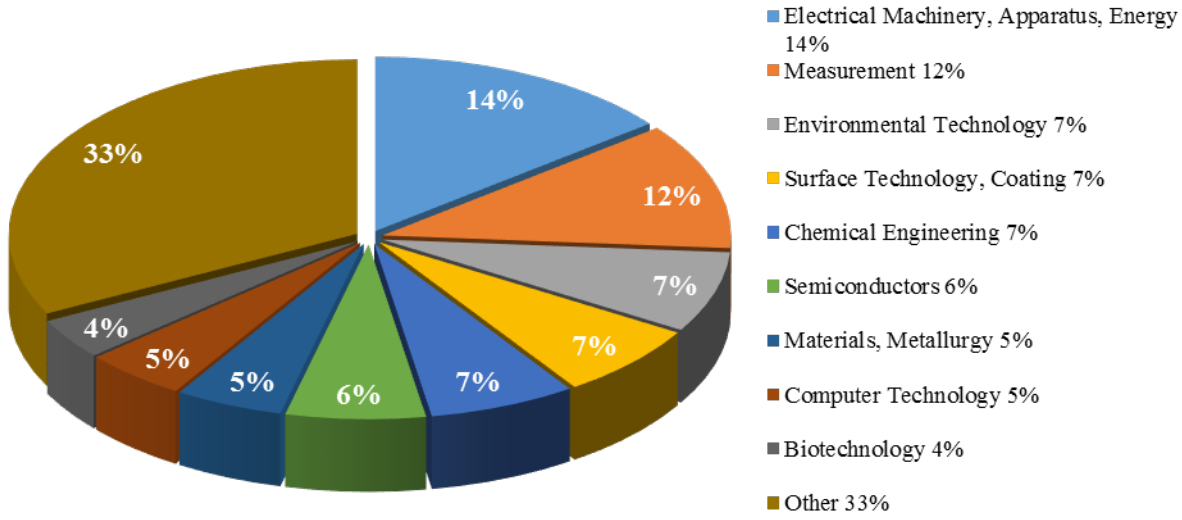
Between FY 2011 and FY 2015, the number of new inventions disclosed decreased by 10% to 1,645 disclosures in FY 2015. The number of patent applications filed experienced a 9% increase. The number of patents issued during this five-year period increased by 64% to 755 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	1,820	1,661	1,796	1,588	1,645
Patent Applications Filed	868	780	944	1,144	949
Patents Issued	460	483	554	693	755

Patents issued to DOE in FY 2015 covered many technology areas including electrical machinery, apparatus, energy (14%), measurement (12%), environmental technology (7%), surface Technology, coating (7%), semiconductors (6%), and in materials, metallurgy (5%).[29]

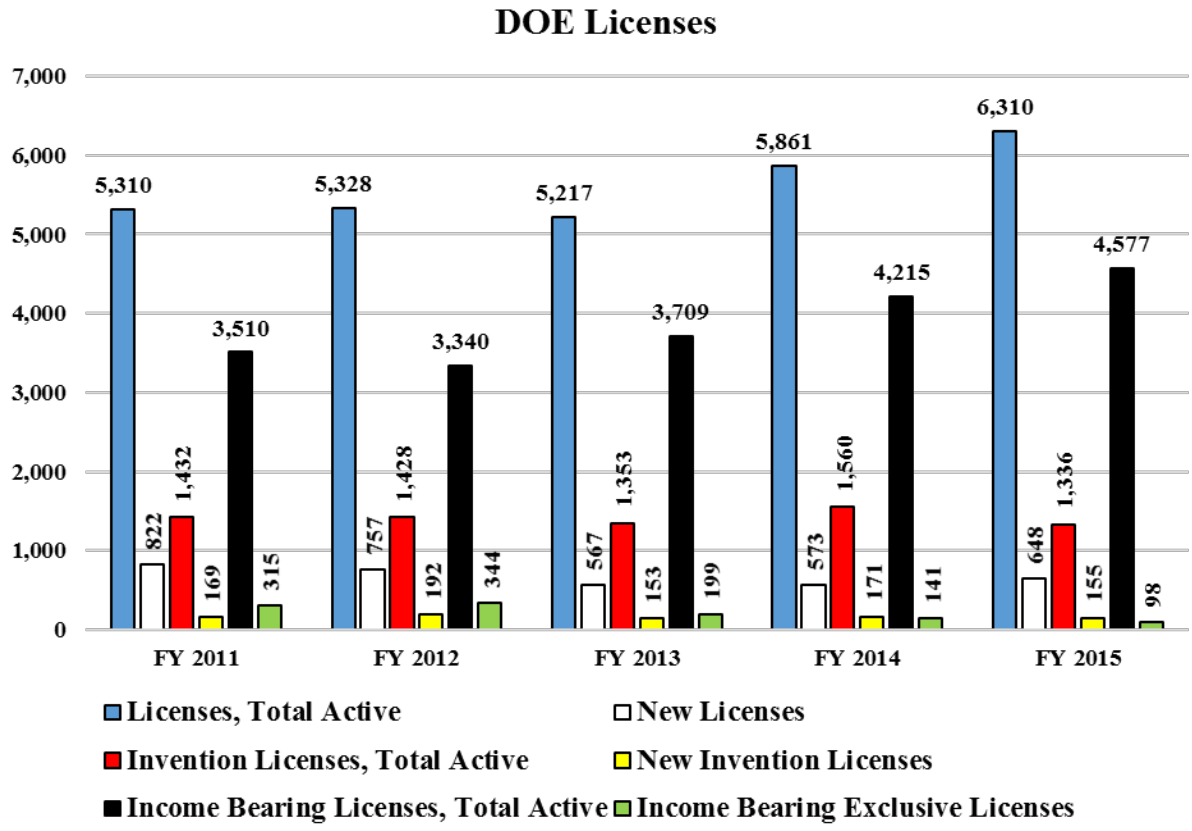
USPTO Patents Assigned to DOE by Technology Area: FY 2015



[29] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

DOE Licenses

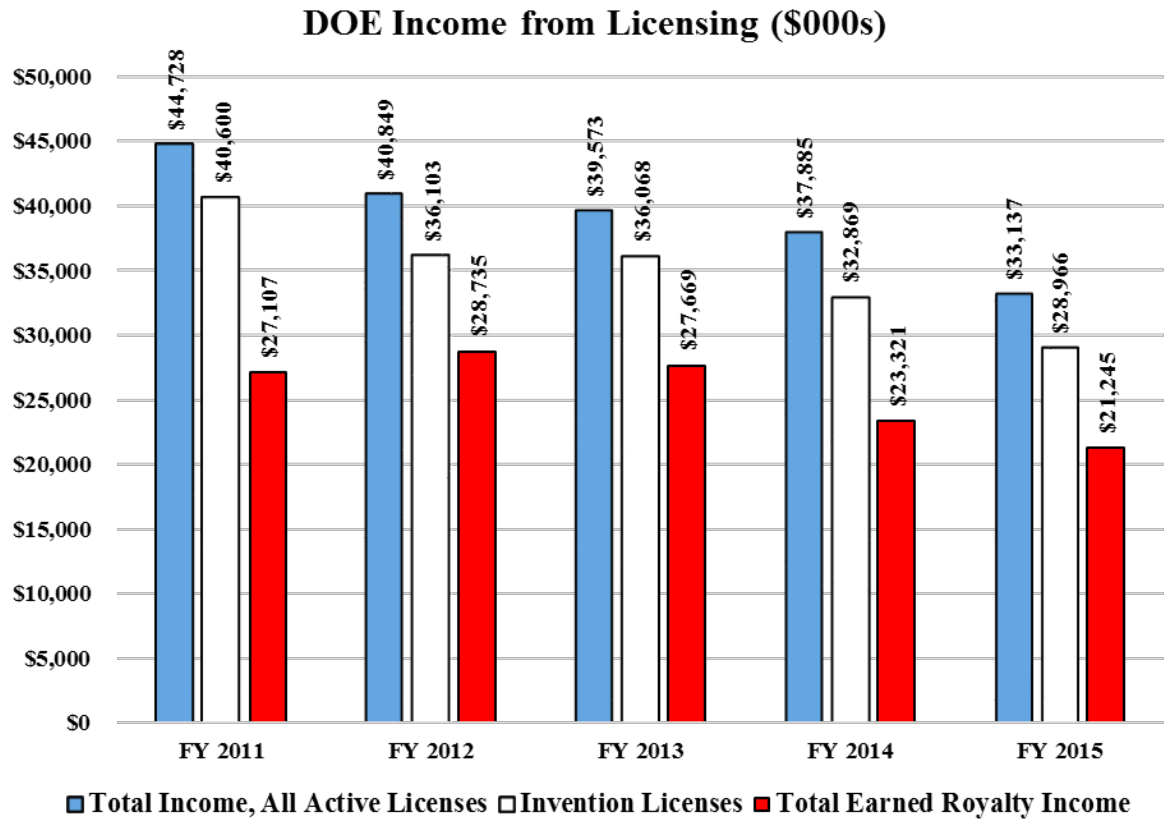
Between FY 2011 and FY 2015, the number of total active licenses increased by 19% to 6,310 licenses in FY 2015. New licenses decreased by 21% to 648 licenses from a previous 822 in FY 2011. The number of total active invention licenses decreased by 7% to 1,336 licenses.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	5,310	5,328	5,217	5,861	6,310
New Licenses	822	757	567	573	648
Invention Licenses, Total Active	1,432	1,428	1,353	1,560	1,336
New Invention Licenses	169	192	153	171	155
Income Bearing Licenses, Total Active	3,510	3,340	3,709	4,215	4,577
Income Bearing Exclusive Licenses	315	344	199	141	98

DOE Income from Licensing

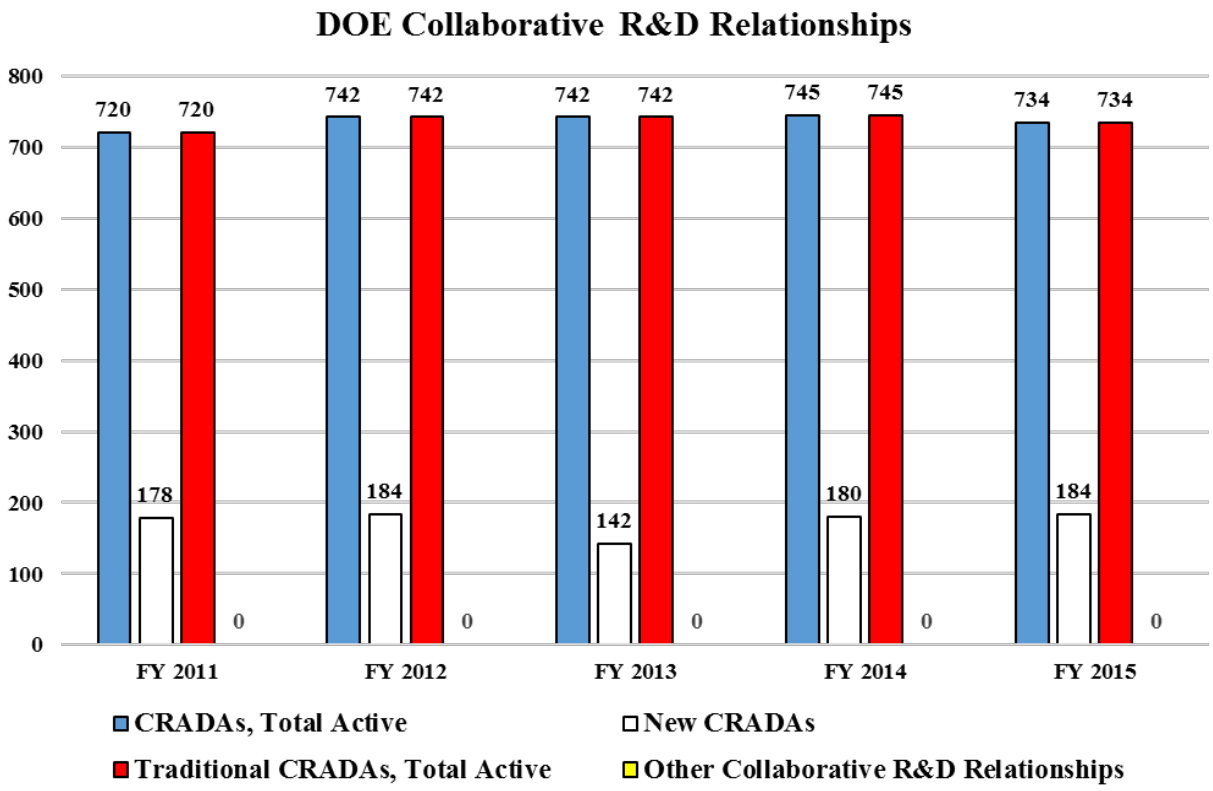
Between FY 2011 and FY 2015, total income from all active licenses decreased by 26% to $33.1 million in FY 2015. The income from invention licenses decreased by 29% to $29 million. Total earned royalty income decreased 22% from $27.1 million in FY 2011 to $21.2 million in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$44,728	$40,849	$39,573	$37,885	$33,137
Invention Licenses	$40,600	$36,103	$36,068	$32,869	$28,966
Total Earned Royalty Income	$27,107	$28,735	$27,669	$23,321	$21,245

DOE Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased by 2% to 734 agreements. The number of new CRADAs per fiscal year increased by 3% to 184 new agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	720	742	742	745	734
New CRADAs	178	184	142	180	184
Traditional CRADAs, Total Active	720	742	742	745	734
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

Argonne National Laboratory: Next Generation of Energy Storage Materials
Argonne National Laboratory has teamed up with Strem Chemicals, Inc. (Newburyport, Mass.) to provide industry and the battery research community with next-generation materials that could revolutionize energy storage.

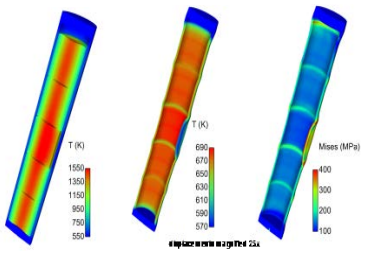
Strem, a manufacturer and distributor of specialty chemicals founded in 1964, licensed 23 separate pieces of intellectual property from Argonne in 2015 and will distribute nine battery solvents and Redox Shuttles via its extensive marketing and global distribution networks.

The materials were all invented at Argonne's Electrochemical Energy Storage Center and scaled up at the laboratory's Materials Engineering Research Facility (MERF) – all with funding from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). Since its founding, MERF has scaled up and distributed more than 27 kilograms of materials in the form of 125 different samples.

MERF was established because the U.S. Department of Energy recognized the need for a facility that could help expedite the transfer of advanced battery materials from the bench to industry. Though current projects in the facility are focused on the development of advanced batteries for vehicle and grid storage applications, the MERF can support scale-up projects for any type of material. The agreement with Strem both funds and exemplifies successful technology transfer across the research spectrum: from invention at the bench to scale-up to use by industry.

Idaho National Laboratory: Nuclear Fuel Performance Evaluation Software

Abnormalities during nuclear reactor operation can change the way fuel performs, and conversely, fuel impacts the way reactors function. Researchers are interested in the many variables that affect both. BISON is a computer code used for analysis of normal operation and potential anomalies when fuel is irradiated. Idaho National Laboratory (INL), in Idaho Falls, ID, began development of BISON in 2009 and was given permission by the Department of Energy to assert copyright in February 2015. The complex software improves upon existing simple models by operating in three spatial dimensions and processing several parameters at once, for example, temperature changes, fuel deformation, and fuel cladding stresses. BISON has been developed using laboratory research and development funds and with the support of multiple DOE Nuclear Energy programs.



Plots showing BISON's calculated temperature and stress resulting from a defective fuel pellet.

Although there are other fuel models available, they cannot be directly applied to many new fuel concepts and operating conditions. With BISON's capabilities, researchers can investigate fuel behavior in fine detail and model behavior over fractions of a second or over the course of years. This allows engineers to investigate fuel properties before experimenting on prototypes, saving time and resources.

After only six years from commencement, INL has executed 35 nonexclusive BISON software license agreements to domestic and foreign entities. A representative sample includes Bechtel Marine Propulsion Corporation, Canadian Nuclear Laboratories, Hungarian Academy of Sciences, Royal Military College of Canada, Electric Power Research Institute, Kansas State University, Massachusetts Institute of Technology, The Ohio State University, Oregon State University, Texas Engineering Experiment Station of the Texas A&M University System, Pennsylvania State University, University of South Carolina, University of Tennessee, University of Wisconsin – Madison, University of Wyoming, and Virginia Commonwealth University.

Los Alamos National Laboratory: PathScan
On August 25, 2015, Ernst & Young LLP (EY) and Los Alamos National Laboratory announced they had formed a strategic alliance to deliver some of the most advanced behavioral cybersecurity tools available to the commercial market. The alliance comes at a watershed moment when increasingly sophisticated cyberattacks are inflicting significant economic, social, and even political damage to U.S. organizations.

The tools developed by Los Alamos and delivered to the private sector exclusively by EY can help counter these threats by detecting them before they do deep and lasting damage. The first product to be introduced through the alliance was PathScan®, a network anomaly-detection tool that searches for deviations from normal patterns of communication that might be indicative of an intrusion. Until now, PathScan has been exclusively used in the government sector, but it is now being made available to private companies. The project was initially funded through Laboratory Directed Research and Development funding, then later supported by the National Nuclear Security Administration. The Department of Homeland Security's Transition to Practice program within the department's Science and Technology Directorate helped bring the technology to market.

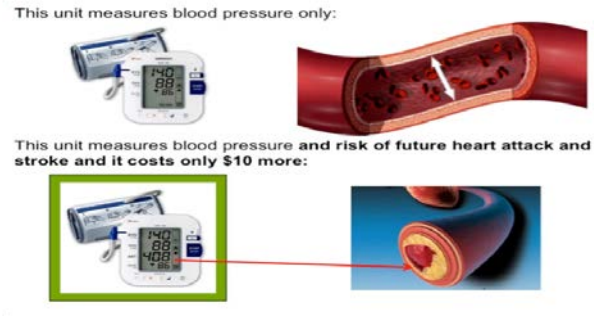
By its introduction to the marketplace, PathScan immediately becomes one of the most advanced cybersecurity tools available based on its behavioral analysis approach to detecting threats. The tool is designed to detect threat actors once they have breached an organization's perimeter, before they can inflict serious damage.

Traditional network defense tools continually prove to be insufficient for protecting enterprises from expensive data breaches. The prevailing signature-based systems are easily avoided by attackers. But mitigating cybersecurity threats is no longer about deterring and detecting something that "looks" like a threat. It is now about being able to identify and anticipate something that "acts" like a threat. PathScan represents this new way of tackling this problem by looking at behavioral anomalies that indicate an attack and allowing enterprises to be proactive in their defense.

The EY alliance demonstrates how national labs can leverage private investment in technology for mutual benefit. The Laboratory develops the technology; industry deploys it; and then the Laboratory does the next generation of analytics. The collaboration allows the Laboratory to see how industry is addressing its cyber issues and then put that technology to work for the government. Already being deployed by major Fortune® 500 companies, PathScan is the first network-security tool that enables network managers to have and sustain an advantage over attackers.

Lawrence Berkeley National Laboratory: The Missing Link in Heart Disease Prevention
Cardiovascular disease and stroke are the number one causes of death worldwide, according to the World Health Organization, and one in four deaths in the United States is attributed to heart disease. Early assessment and monitoring of blood vessel health to inform preventative care and lifestyle modification is an important step towards reducing risk. Research developed at Lawrence Berkeley National Laboratory (LBNL) will give patients a more complete view of the state of their blood vessels, potentially saving lives.

LBNL developed a device to evaluate arterial lining health to assess plaque buildup and atherosclerosis quickly and easily, outside a clinical setting. Routine blood pressure and cholesterol testing do not evaluate arterial lining health. Yet plaque deposits break away from inner artery walls, ultimately blocking blood flow downstream. Prior to this technology, plaque buildup and atherosclerosis – hardening of the arteries – could only be measured with expensive, time consuming, in-clinic ultrasound testing.



LBNL's technology measures endothelial function to assess plaque buildup and atherosclerosis, outside a clinical setting, for a more complete assessment of heart disease risk.

Using a LBNL Innovation Grant, researchers developed advanced prototype devices for clinical testing to prove the device's superior sensitivity compared to ultrasound results. Over 130 studies have been performed at University of California San Francisco (UCSF) Cardiology, UCSF Pediatric Cardiology, and Kaiser Permanente, and over 30,000 subjects are enrolled in the Health eHeart study for further endothelial function evaluation.

Startup Lexington Biosciences licensed the technology in 2015 with funding from Oxygen Capital Corporation. Lexington Biosciences will further refine the device, named the Enegevity Cuff, and complete clinical testing before initiating the Food and Drug Administration (FDA) approval process in the coming year.

National Energy Technology Laboratory: Safer, Cleaner Coatings to Protect Metals from Corrosion

Corrosion-related issues cost the U.S. economy $276 billion a year. The Energy Department's National Energy Technology Laboratory (NETL) teamed up with Carnegie Mellon University (CMU), both located in Pittsburgh, PA, to create a revolutionary and cost-effective technology to reduce that impact. The work resulted in the creation of a new CMU/NETL spin-off called LumiShield, which signed a licensing agreement with the laboratory in June 2015.

The "Ionic Liquid Solvent for Aluminum Electroplating Process" electrodeposits aluminum, replacing coatings based on heavy metals that are expensive, heavily regulated, and environmentally harmful.

The new process, which electrodeposits aluminum using standard equipment available in most electroplating shops, is set to make its mark on the industry by replacing coatings based on heavy metals, such as cadmium and chromium, which are expensive and toxic. Electroplating is the process of depositing a metal coating onto an object by putting a negative charge on it and immersing it in a

solution. The technology holds great potential for reducing the costs of protecting products from corrosion while eliminating some difficult environmental hazards.

The new electroplating technology licensed from NETL by LumiShield uses a plating solution containing ionic liquids (salts in liquid state) in open vessels without creating toxic vapors. The result is a more cost-efficient, environmentally responsible process. In addition, the process can be altered to produce a variety of properties and finishes to meet specifications for a range of applications.

LumiShield, which has created three jobs to date, was created based on the new technology and specializes in corrosion-resistant metal products that are less expensive and less environmentally harmful than existing approaches. Corrosion-resistant coatings like the LumiShield electroplating technology are in demand as a way of reducing costs. The new technology could have a significant positive impact in the fight against corrosion on a wide range of products, resulting in decreased costs and reduced impacts to the environment.

National Renewable Energy Laboratory: Battery Life Prediction Model

Companies that rely on batteries for enhanced energy efficiency – including electric vehicle (EV) manufacturers, solar and wind energy generation companies, and utilities – need to know how to use batteries most effectively. As investment in large-scale battery energy storage grows, it is also vital to know how long batteries will last in the field.

An example of a stationary, grid-connected battery is the NREL project from Erigo/EaglePicher Technologies, LLC Technologies.

In spring 2015, the National Renewable Energy Laboratory (NREL) licensed its Battery Life Predictive Model to two leading utility providers in the United States: Southern California Edison (SCE), one of the nation's largest investor-owned utilities serving 14 million customers, and Next Era Energy, a leading clean energy company with revenues totaling around $17 billion. The utilities will use the NREL model to select long-lasting energy storage systems most capable of reliably balancing grid electricity demands.

The model's origins began in 2010, when the U.S. Department of Energy (DOE) Vehicle Technology Office supported NREL researchers to analyze tradeoffs in EV battery systems design. Kandler Smith, a senior engineer in NREL's Transportation and Hydrogen Systems Center, said the research focused on issues such as examining the costs and benefits of using active thermal management systems that provide longer life versus less expensive passive cooling systems.

The model has been licensed to a variety of automotive manufactures, EV service providers, and university and laboratory research groups, and there are various ways it is being applied. NREL researchers can take client's usage data and run them in the predictive model; companies can

license the software code and do their own analyses; or NREL can conduct the battery aging tests in its labs, analyze the results and develop specific models for the client. The Battery Life Predictive Model is also an integral part of the Battery Lifetime Analysis and Simulation Tool (BLAST) and Computer-Aided Engineering for Electric-Drive Vehicle Batteries (CAEBAT) activities at NREL.

Pacific Northwest National Laboratory: Software Helps Thwart Cyber Attacks
Hackers beware. Consumers' credit card information and large retail companies' databases will be better protected from security breaches thanks to analytical software developed at Pacific Northwest National Laboratory (PNNL) and commercialized by Champion Technology Company Inc., based in Richland, Washington. Columnar Hierarchical Auto-associative Memory Processing in Ontological Networks (CHAMPION) has the knowledge to sort through data like an analyst, but on a much greater scale.

The software addresses a growing problem facing industry and government: how to analyze big data efficiently and effectively to detect cyber threats. Compared with existing solutions that rely on statistical analysis, CHAMPION combines analyst-specific subject matter expertise and conceptual modeling to identify potential threats in near real-time. CHAMPION first uses human analysts and contextual data to learn about the company it's protecting. Then it reasons whether activity on the company's network is suspicious. When threats are identified, the software alerts an analyst of the potential breach—in time to potentially thwart an attack.

PNNL funded initial development of the software as part of a multi-year internal investment—known as Laboratory Directed Research and Development funding—aimed at developing innovations for large-scale digital computer and control infrastructure. CHAMPION then was brought to industry through a unique collaboration between PNNL and EarlyX Foundation, a nonprofit intellectual property monetization organization. In addition, a startup company (Champion Technology Company, Inc.) was created to spin out the technology from PNNL. The company now has 11 employees including one of the original PNNL developers who now serves as the company's Chief Technology Officer.

Pacific Northwest National Laboratory: Salty Mist Kills Pathogens
Watertech Equipment and Sales LLC of Mount Pleasant, South Carolina, is nearing its first sale of an easy-to-use, inexpensive, and highly effective disinfection technology based on nearly a decade of research and development at PNNL in Richland, Washington. Watertech's NebuPure product is based on the micro aerosol disinfection system, which turns a salt solution into a fine mist that kills 99.9999 percent of health-harming microorganisms, including those that cause ailments such as the common flu and Ebola hemorrhagic fever.

The system is significantly less expensive, easier to use, and more environmentally friendly than existing disinfection technologies. It has successfully disinfected a variety of locations, including large research facilities, a medical center, gyms, and a chicken farm. It could also be used to decontaminate sites exposed to biological threat agents such as the bacteria that causes anthrax.

PNNL initially developed a prototype of the technology through a now-concluded DOE program that supported former weapons scientists in non-weapons research and development across the

former Soviet Union. The technology was further developed with internal PNNL funding and support from the Defense Threat Reduction Agency. It was licensed to Watertech in 2015. The company is developing efficient manufacturing methods for its NebuPure product and expects to sell it for about half as much as competing vapor- and gas-based disinfection technologies.

Sandia National Laboratory: LiDAR Technologies for Automobile Applications

The current revolution in the automotive world is all about driver assistance. Today's vehicles require numerous sensors and TriLumina Corporation's semiconductor lasers help make exciting new car features possible. TriLumina's laser arrays are critical components of Light Detection and Ranging (LiDAR) for Advanced Driver Assistance Systems, bringing the company recent recognition and funding.

TriLumina took part in the New Mexico Small Business Assistance (NMSBA) Program to help optimize an existing laser array submount assembly. NMSBA gave the company access to the expertise and facilities it required, but that were only available at Sandia National Laboratories. The project led to the invention of a new way to connect the small lasers to the submounts by the two Sandia inventors, with the technology assigned to TriLumina.

Since the completion of the NMSBA project, the company won an award from the Los Angeles Auto Show's Connected Car Expo as one of its Top Ten Automotive Startups. It was also listed in EE Times Silicon 60: 2015's Startups to Watch. Plus, TriLumina closed on $8.5 million in Series A funding from investors Stage 1 Ventures, Sun Mountain Technology Fund, and Cottonwood Capital; it also received an investment from Caterpillar Ventures.

Department of Health and Human Services (HHS)

Research at HHS 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 to conduct and support 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.

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.

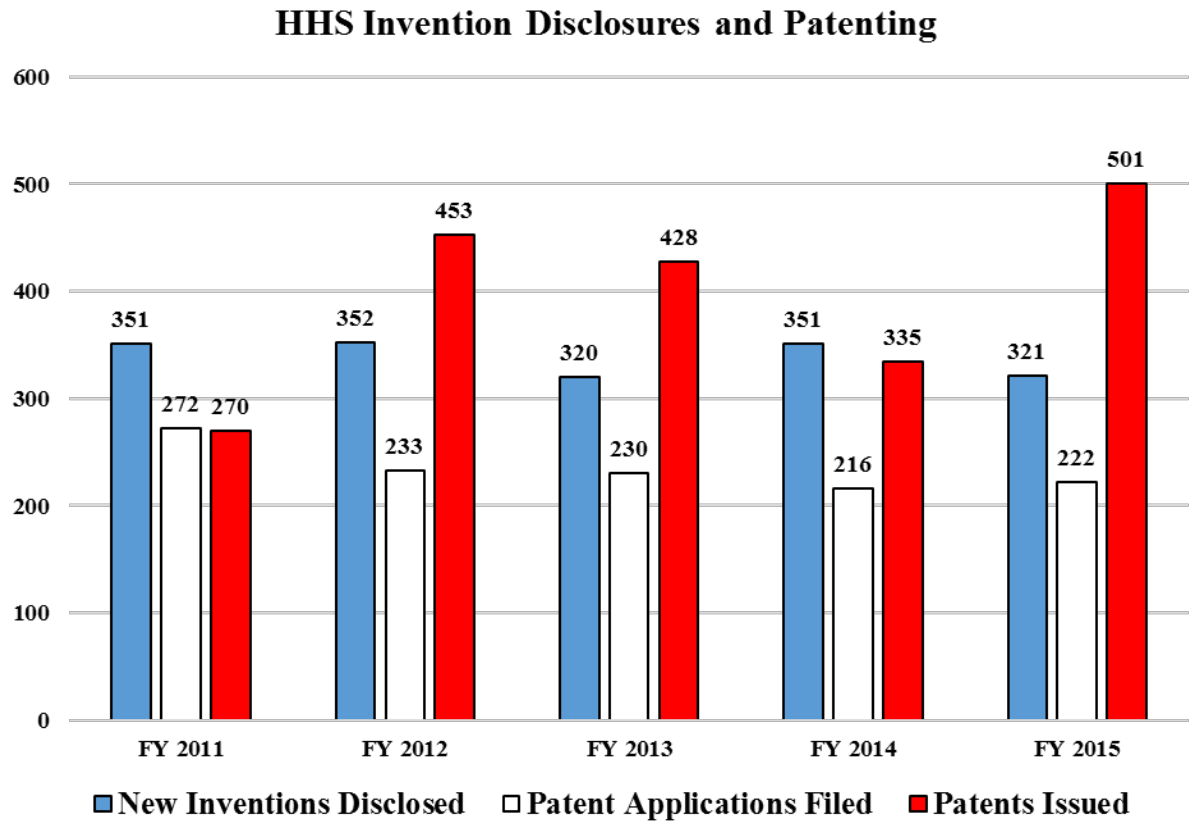
NIH's annual technology transfer report is available online at: https://www.ott.nih.gov/sites/default/files/documents/pdfs/AR2015.pdf.

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/
- FDA: http://www.fda.gov/techtransfer

HHS Invention Disclosures and Patenting

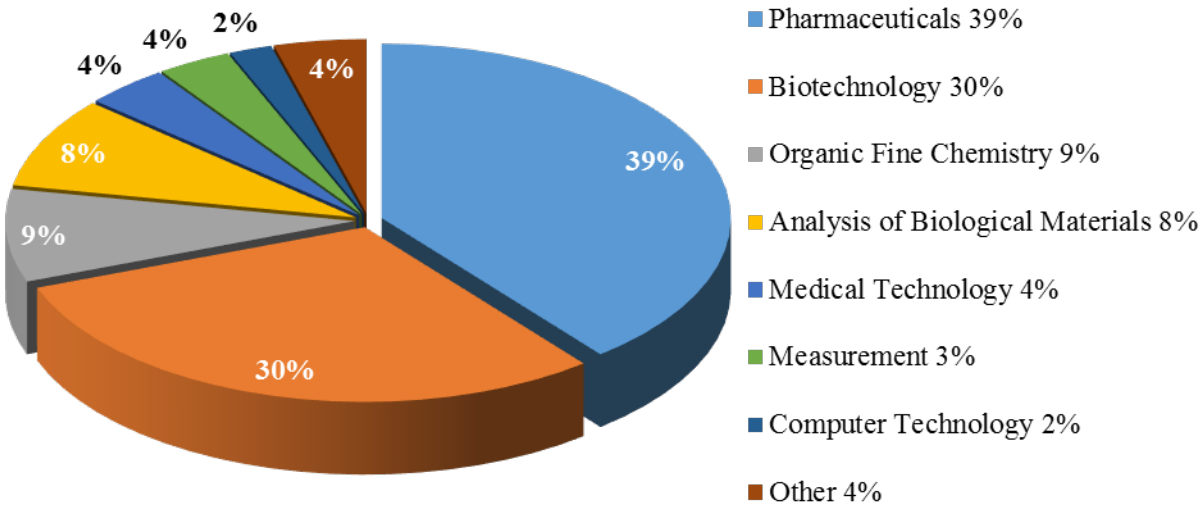
Between FY 2011 and FY 2015, the number of new inventions disclosed decreased by 9% to 321 disclosures in FY 2015. The number of patent applications filed experienced a 18% decrease. The number of patents issued during this five-year period increased by 86% to 501 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	351	352	320	351	321
Patent Applications Filed	272	233	230	216	222
Patents Issued	270	453	428	335	501

Patents issued to HHS in FY 2015 covered many technology areas including pharmaceuticals (39%), biotechnology (30%), organic fine chemistry (9%), analysis of biological materials (8%), medical technology (4%), and measurement (3%).[30]

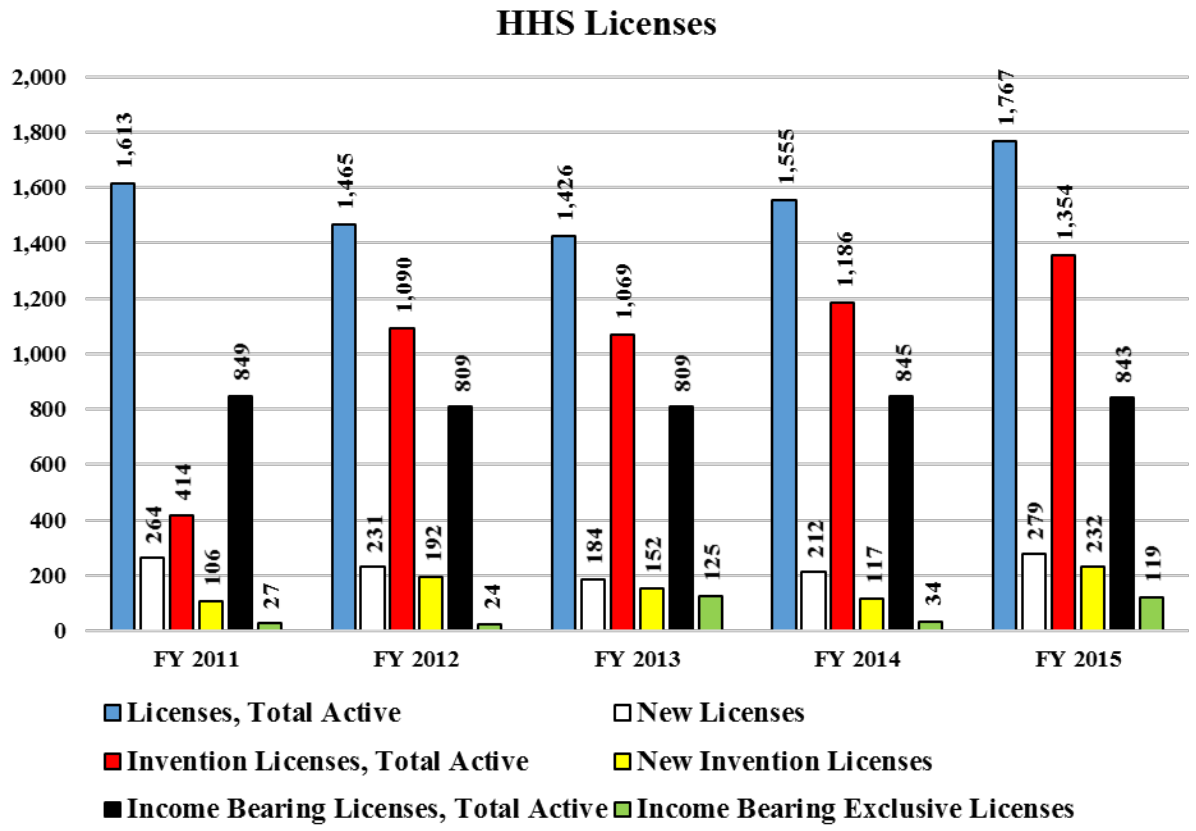
USPTO Patents Assigned to HHS by Technology Area: FY 2015



[30] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

HHS Licenses

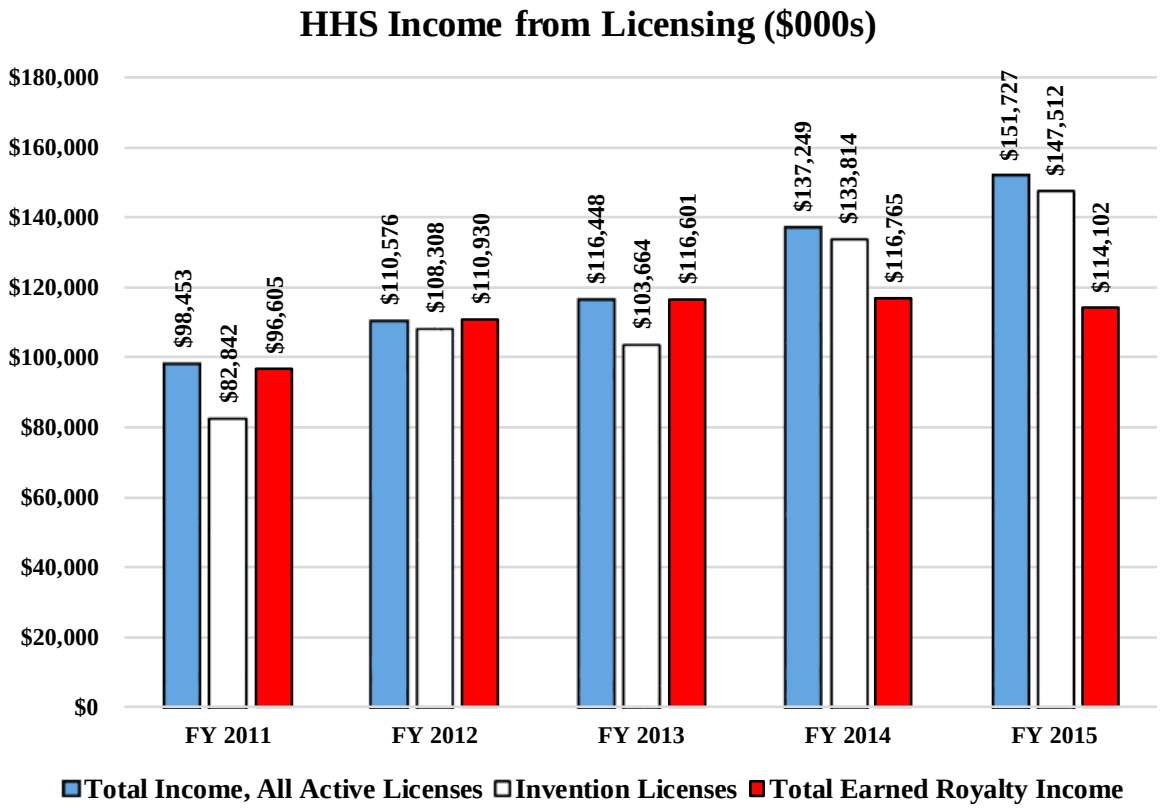
Between FY 2011 and FY 2015, the number of total active licenses increased by 10% to 1,767 licenses in FY 2015. For FY 2015, new licenses increased by 6% to 279 licenses from a previous 264 in FY 2011. The number of total active invention licenses increased by 227% to 1,354 licenses.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	1,613	1,465	1,426	1,555	1,767
New Licenses	264	231	184	212	279
Invention Licenses, Total Active	414	1,090	1,069	1,186	1,354
New Invention Licenses	106	192	152	117	232
Income Bearing Licenses, Total Active	849	809	809	845	843
Income Bearing Exclusive Licenses	27	24	125	34	119

HHS Income from Licensing

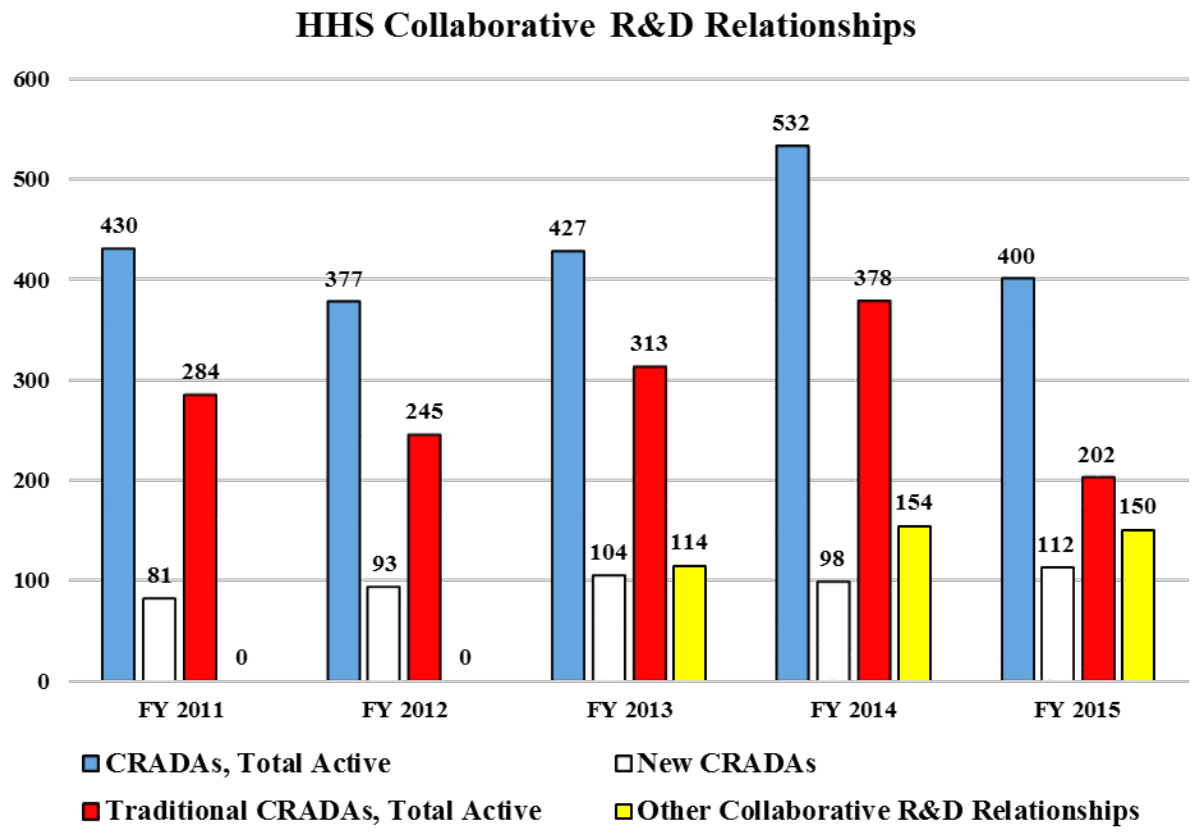
Between FY 2011 and FY 2015, the number of total income from all active licenses increased by 54% to $152 million in FY 2015. The income from invention licenses increased by 78% to $148 million. Total earned royalty income increased 18% from $97 million in FY 2011 to $114 million in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active	$98,453	$110,576	$116,448	$137,249	$151,727
Invention Licenses	$82,842	$108,308	$103,664	$133,814	$147,512
Total Earned Royalty Income	$96,605	$110,930	$116,601	$116,765	$114,102

HHS Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs decreased by 7% to 400 agreements. The number of new CRADAs per fiscal year increased by 38% to 112 new agreements in FY 2015. Total active traditional CRADAs decreased by 29% during the five-year period, totaling 202 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	430	377	427	532	400
New CRADAs	81	93	104	98	112
Traditional CRADAs, Total Active	284	245	313	378	202
Other Collaborative R&D Relationships	0	0	114	154	150

HHS Efforts to Streamline Technology Transfer Operations

In FY 2014, the NIH Technology Transfer Steering Committee recommended that authority and responsibility for the implementation and execution of patenting and licensing should shift from the centralized NIH Office of Technology Transfer (OTT) to the NIH Institutes and Centers (ICs). The Technology Transfer Steering Committee concluded that the reorganization would provide an opportunity to more closely align technology transfer expertise and decisions with the Institutes, Labs, and Programs generating research materials and new scientific discoveries. This recommendation was accepted by the NIH Steering Committee and went into effect in October 2015. Throughout FY 2015, a great deal of work took place behind the scenes to prepare for and enable the reorganization of patenting and licensing at the NIH. For example, the NIH Technology Transfer Working Group was established and has been actively guiding the transition from a centralized to decentralized Technology Transfer (TT) program at NIH.

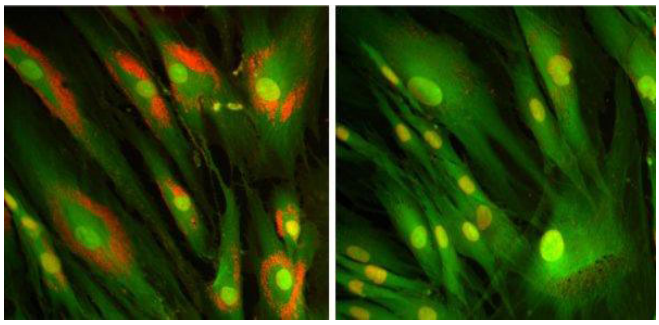
The reorganization of TT functions at the NIH called for the community to assess and redesign the processes in-place. The OTT started the process of switching from playing a central role in licensing and patenting to a more advisory one. In addition, the office opened the central database (called NIH TechTracS) to the ICs and made sure that the various staff at the ICs could effectively use this important tool. Extensive training was provided to the technology transfer community in preparation for the reorganization. During FY 2015, the OTT also began preparations to transition to a service and support role to the ICs. Continued OTT administration of royalties, monitoring and enforcement, marketing, patent docketing, and technology transfer information systems function to foster more efficient and effective commercialization of NIH, FDA, and CDC inventions.

In addition, the National Cancer Institute's (NCI) commitment to speed-up the CRADA process resulted in streamlining changes that went into effect in the fall of 2015. NIH has eliminated some internal clearance steps resulting in time savings for these agreements.

HHS Downstream Success Stories

Treating Niemann-Pick Disease

Lysosomal storage diseases comprise about 50 rare inherited disorders that usually affect children, and are often fatal. Fatty materials accumulate in the cells and tissues of the body, which can damage the brain, peripheral nervous system, liver, and other organs and tissues. A three-way collaboration between National Center for Advancing Translational Sciences (NCATS), NICHD, and a newly launched biotechnology company, Vtesse, Inc., aims to develop treatments for Niemann-Pick Type C1 (NPC) and other lysosomal storage disorders. Under the CRADA,

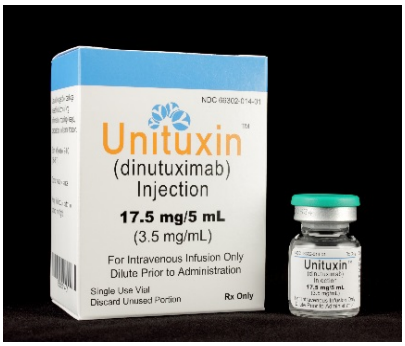


In the image above, fibroblasts homozygous for mutations in NPC1 demonstrate an increased accumulation of red Lysotracker staining indicative of the storage disease. On the right, addition of cyclodextran rescues this lysosomal storage defect. (Image courtesy NIH Image Library)

Vtesse is supporting the ongoing phase I clinical trial for NPC at the NIH CC, led by NICHD researchers who have been evaluating the safety of the drug cyclodextrin. NIH's orphan drug designations in the United States and Europe for the use of cyclodextrin for NPC1 have been transferred to Vtesse under the agreement. Vtesse is currently in the process of enrolling a total of 51 patients at approximately 20 sites throughout the United States, Europe and other locations. In addition to its Orphan Drug status in both the United States and European Union, cyclodextrin has received a Breakthrough Therapy designation status from the US FDA. In other studies, the NCATS team will optimize delta-tocopherol compounds for further testing as potential single treatments or as combination therapies with cyclodextrin. Vtesse has exclusively licensed several NCATS patent applications specifically for their use as new therapies for the treatment of lysosomal storage disorders, and will fund pre-clinical studies at NCATS to further optimize and develop these treatment options. NICHD will operate a site and participate in data analysis from all U.S. and foreign sites. This trial may advance this compound type as the first FDA approved treatment for NPC. The basic research component is being conducted at NCATS and is directed to follow on indications.

FDA Approval of Immunotherapy to Treat Rare Childhood Cancer

In March 2015, the FDA approved dinutuximab (Unituxin) as part of treatment for children with high-risk neuroblastoma. The approval was based on the results of two major Children's Oncology Group (COG) research trials and culminates a remarkable collaborative research effort that spanned more than two decades of research. The search for a National Cancer Institute (NCI) CRADA partner for the commercial marketing of Unituxin began in April 2009. The search and selection effort was orchestrated by NCI TTC. In July 2010, NCI and United Therapeutics Corporation (UTC) entered into a CRADA to conduct Phase 3 clinical studies (COG and UTC sponsored), and to transfer Unituxin manufacturing technology from NCI's Biopharmaceutical Development Program to UTC. Additional studies of Unituxin, a chimeric monoclonal antibody composed of a combination of mouse and human DNA will continue under the NCI/UTC CRADA.



Unituxin Injection
(Image courtesy NCI)

Furthering Development of Brachyury Vaccines

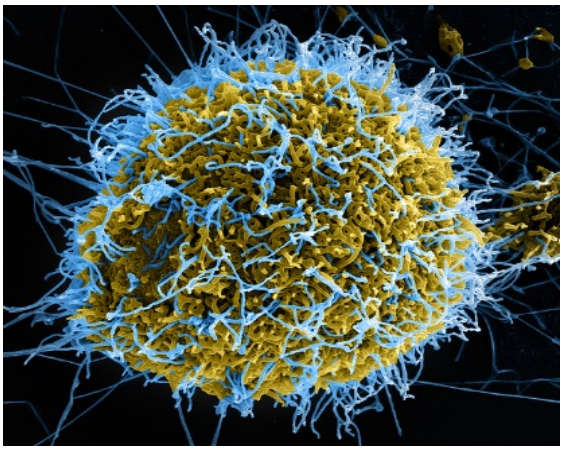
Presence of the brachyury gene has been identified as a diagnostic marker of certain malignant tumors. A Clinical Trial (CT) CRADA executed between NCI and Etubics Corporation in May 2015 allows NCI's Laboratory of Tumor Immunology and Biology (LTIB) to collaborate with Etubics in preclinical and clinical studies to develop Etubics' proprietary adenovirus platform for the treatment or prevention of human cancers.

This particular CT CRADA with Etubics is one of many agreements involving the development of brachyury vaccines, and it is representative of a larger technology transfer effort. Beginning in 2007, NCI developed investigational cancer vaccines that induce a specific, targeted immune response against cancer cells expressing the brachyury protein. Currently, NCI is collaborating with three commercial partners, including Etubics, to develop brachyury vaccines. These collaborations led to the rapid translation of these investigational therapeutic vaccines into the

clinic, and these vaccines have the potential to revolutionize how researchers and physicians treat a wide range of cancers. In addition to the CT CRADA with Etubics Corp., NCI has executed CRADAs with Celgene Corporation and Bavarian Nordic, the other two commercial partners collaborating with NCI to develop brachyury vaccines with unique, proprietary, vector technology platforms.

Fighting Ebola

In FY 2015, the NIAID Technology Transfer and Intellectual Property Office (TTIPO) continued to actively support NIAID in its fight against Ebola. Seventy-seven Ebola-related agreements were executed in FY 2015. These agreements included 1 CRADA, 17 Clinical Trial Agreements (CTAs), 5 Research Collaboration Agreements (RCAs), 7 Memorandum of Understanding Agreements (MOUs), 24 Material Transfer Agreements (MTAs) and 23 Confidentiality Disclosure Agreements (CDAs), providing wide ranged support for NIAID's research activities on Ebola. For example, 7 CTAs, 1 MOU, and 1 CDA were signed in FY 2015 to support NIAID's research and collaboration on Chimpanzee Adenovirus vector (cAd3) Ebola vaccines. The cAd3 Ebola vaccines were co-invented by Dr. Gary Nable, Dr. Nancy Sullivan and their staff in Vaccine Research Center (VRC), NIAID, as well as inventors from U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) and GlaxoSmithKline. These agreements were instrumental for the initiation of phase 1 and phase 1b clinical trials in Mali, United Kingdom and Uganda.



Ebola virus particle
(Image courtesy NIH Image library)

Due to the Ebola outbreak in West Africa, the NIH Director requested that NCATS help coordinate a drug screening project called the Ebola Global Call for Action in collaboration with organizations such as the European Federation of Pharmaceutical Industries and Associations, Biotechnology Industry Organization (BIO), and Pharmaceutical Research and Manufacturer's Association (PhRMA). The purpose of the project is to determine if there are any industry-owned drugs (either under development or already on the market) that could be used to treat Ebola. NCATS served as the lead and coordinated the implementation of CDAs between 10 pharma and biotech companies, NCATS, NIAID, and the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID). NCATS, NIAID, and USAMRIID Technology Transfer Office colleagues helped develop a common template that was used for early discussions between them and the joining pharma and biotech partners. After the CDAs were executed, subject matter experts from the NCATS, NIAID, and/or USAMRIID initiated conversations with the pharma and industry partners to determine next steps. All the CDAs were negotiated and executed in a record 7-week period even as they required coordination with three other organizations.

Vaccine against Dengue virus

Dengue is a mosquito-borne flavivirus present worldwide in tropical and semitropical regions. It is estimated that 500 million infections occur annually, resulting in more than 2 million cases of severe dengue and 21,000 deaths. An effective vaccine is a public health priority. TTIPO has negotiated and executed a CRADA between NIAID and Merck Sharp & Dohme Corp. to collaborate to evaluate the safety and efficacy of prime-boost strategies for dengue vaccines, employing NIAID's tetravalent live attenuated Dengue virus TV- 003 and/or TV-005 vaccine formulation, and Merck Sharp & Dohme Corp.'s tetravalent subunit Vl80 vaccine formulation.

Detecting Filaria

Lymphatic filariasis (LF), commonly known as elephantiasis, is a devastating infectious disease. Filariasis is an infection caused by *Wuchereria bancrofti* (Wb123), a parasitic worm transmitted by mosquito bites. Current antibody tests used for monitoring in LF elimination programs suffer from poor specificity because of considerable geographical overlap with other filarial infections. Dr. Thomas Nutman and his staff in NIAID have found Wb123, an antigen specifically reacting with Wb with no cross reactivity against other closely related filariae. In addition, Wb123 is expressed primarily by the infective stage larvae of Wb so that it may detect the presence of filariae in the prepatent period, that is, after infection, but before microfilariae are present in the blood and before clinical symptoms appear. InBios International, Inc. licensed this patented technology in FY 2014. Its Research Use Only (RUO) product, Filaria Detect™ system, is being used by researchers in more than 9 countries across 6 continents. Its In-Vitro Diagnostic (IVD) application is still under development.

***Wuchereria bancrofti* microfilaria in a thick blood smear (Image courtesy CDC)**

CDC Highlights

In winter 2015 the CDC Technology Transfer Office (CDC TTO) was selected as one of 13 project teams for the HHS Ignites Accelerator program. Operating out of the HHS IDEA Lab, the Ignites Accelerator is an internal innovation startup program for HHS departmental staff and provides methodological coaching and technical guidance within a fast-paced, entrepreneurial framework.

Through collaboration with the NIH Office of Technology Transfer, CDC TTO worked to identify the value in developing a technology transfer portal to facilitate invention review and tracking. Work continues on portal development and testing, estimated for completion and deployment in FY 2016.

Department of Homeland Security (DHS)

The DHS's Office of Research and Technology Applications (ORTA) resides within the Science and Technology Directorate. The ORTA develops and institutes policies to facilitate technology transfer in accordance with 15 U.S.C. § 3710 in consultation with and assisted by the Office of the General Counsel's Technology Programs Law Division supporting S&T and the Department. These policies are applicable throughout the Department and its laboratories. The ORTA's responsibilities include the following:

- Standardizes, reviews, negotiates, and approves DHS CRADAs, licensing, and other technology transfer agreements;
- Prepares application assessments for selected R&D projects in which the DHS Laboratory is involved and may have commercial applications;
- Provides and disseminates information on federally owned or originated technologies which have potential application to State and local governments and private industry;
- Prepares and provides an annual report to Congress and the President through submission to NIST;
- Develops training programs on technology transfer and intellectual property for DHS employees; and
- Establishes and implements 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.

Transition to Practice (TTP)

The DHS Science and Technology Directorate also administers the Transition to Practice Program (TTP). Established in 2012, the program bridges the gap between federally funded research and the marketplace, addressing the Valley of Death problem. TTP is unique in that the program selects technologies from various federal laboratories, including the Department of Energy National Laboratories, Department of Defense affiliated laboratories, Federally Funded Research and Development Centers (FFRDC), University Affiliated Research Centers (UARC), and universities receiving federal funding for R&D activities (such as through the National Science Foundation). This enables TTP to leverage prior R&D funding that these technologies have received from various federal agencies and ensure that the products of this R&D are commercialized and reach the users who need them, rather than "sit on the shelf".

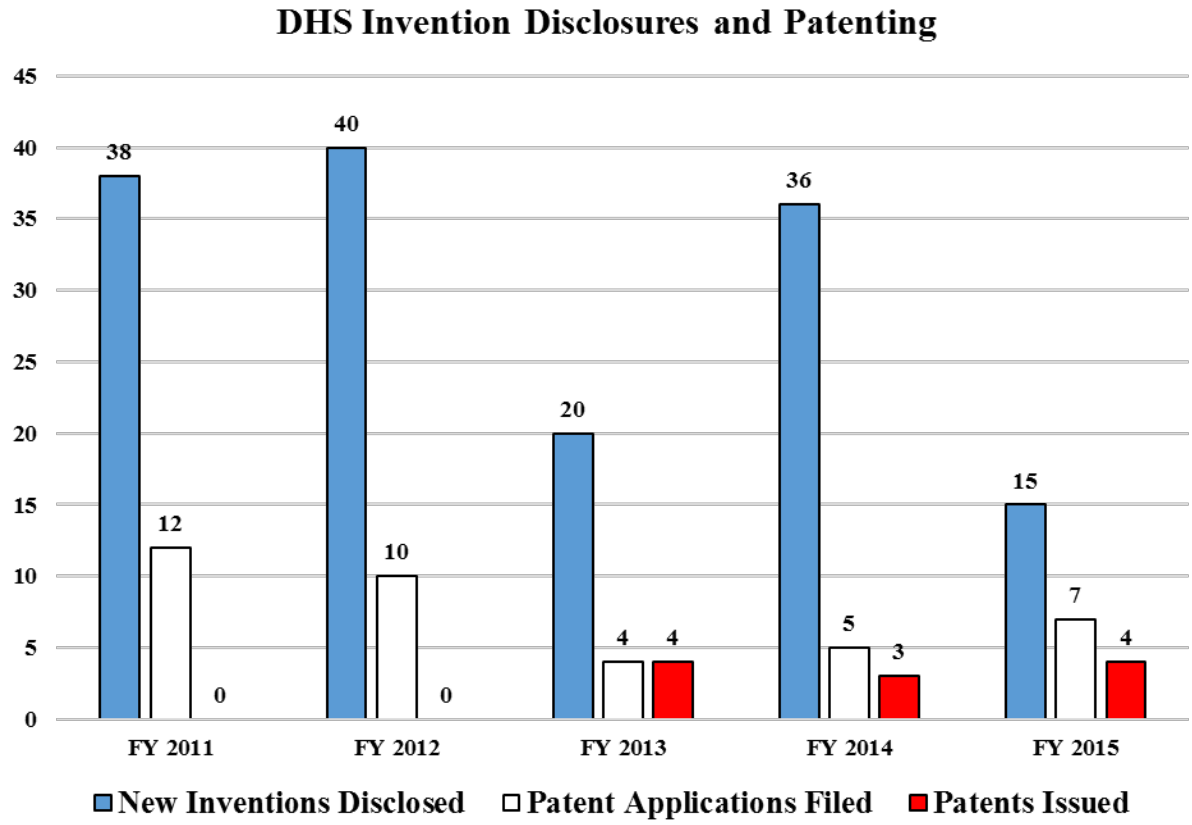
TTP technologies go through a structured technology transfer process designed to increase the technology maturity and market readiness. In addition to providing funding specifically intended for transition activities, TTP offers researchers training and resources on commercialization and entrepreneurship, access to a large network of investors, private sector companies, and government operators, and opportunities to collaborate with these potential partners and users to pilot the technologies. The program also includes technical assessments and evaluation of the technologies as well as market validation and targeting. Through outreach efforts, including multiple Technology Demo Days a year across the country, the TTP program then introduces

these technologies to investors, developers, and integrators who can license the technologies and turn them into commercially viable products.

More information about the TTP activities is available on the following webpage: https://www.dhs.gov/science-and-technology/csd-ttp

DHS Invention Disclosures and Patenting

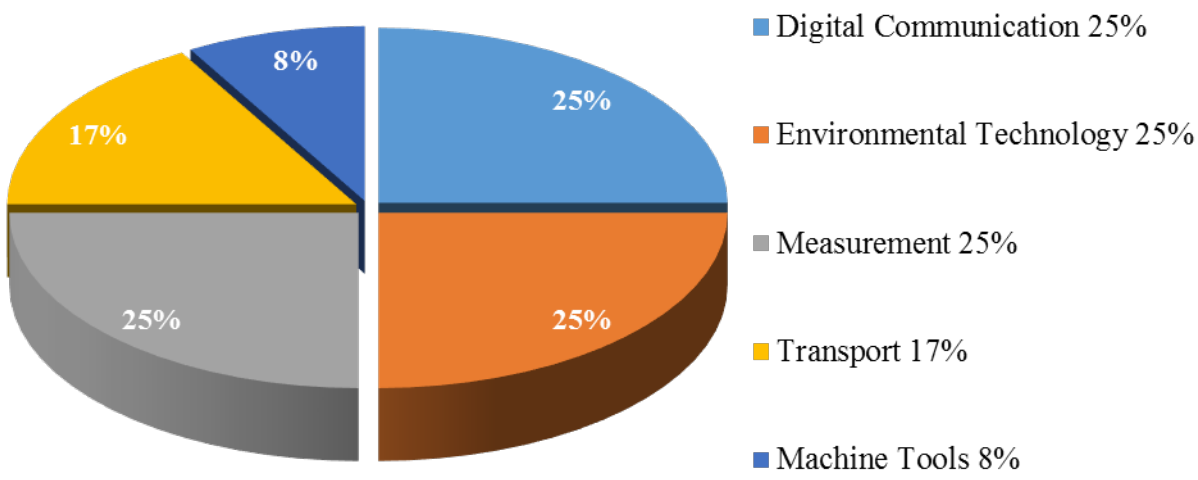
Between FY 2011 and FY 2015, the number of new inventions disclosed decreased by 61% from 38 disclosures to 15 disclosures in FY 2015. The number of patent applications filed experienced a 42% decrease. Four patents were issued in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	38	40	20	36	15
Patent Applications Filed	12	10	4	5	7
Patents Issued	0	0	4	3	4

Patents issued to DHS in FY 2015 covered many technology areas including digital communications (25%), environmental technology (25%), measurement (25%), transportation (17%) and machine tools (8%).[31]

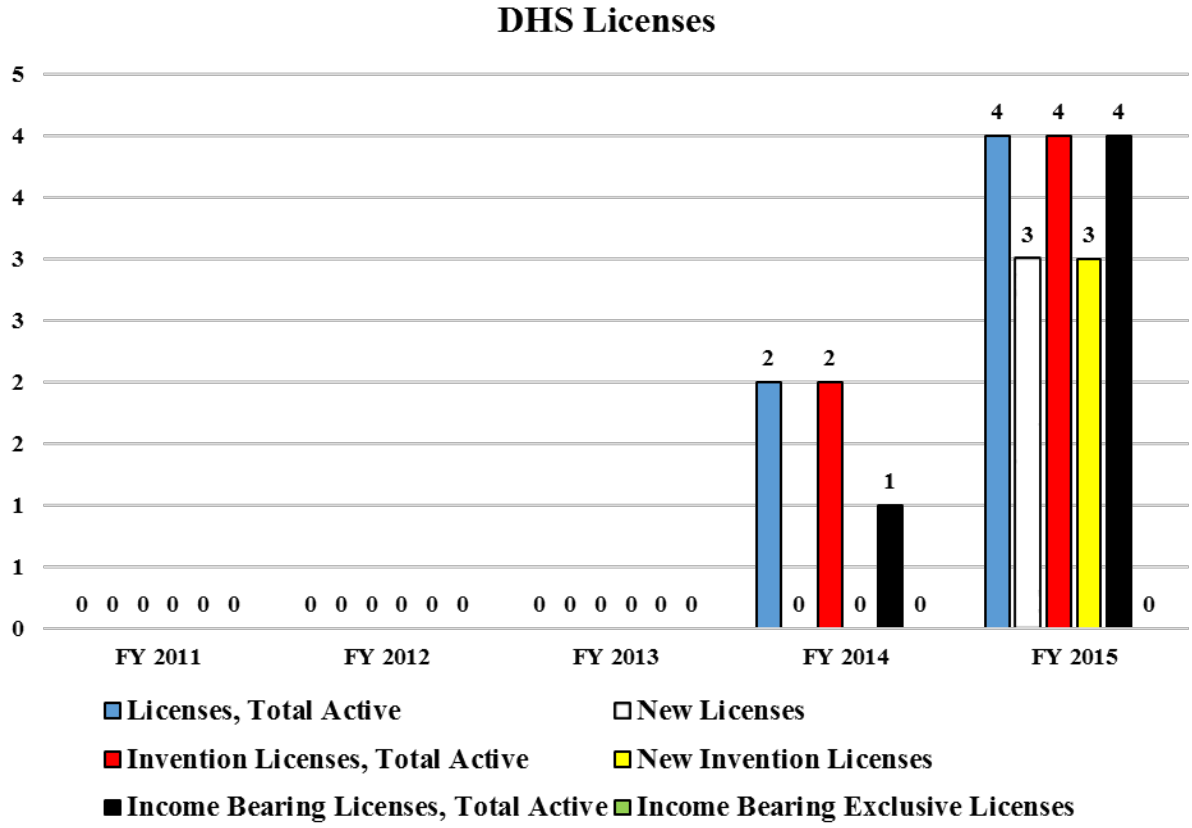
USPTO Patents Assigned to DHS by Technology Area: FY 2015



[31] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

DHS Licenses[32]

In FY15, DHS executed three new patent license agreements and managed four active license agreements. The four patent license agreements earned a total of $6,000 in royalties and license fees.

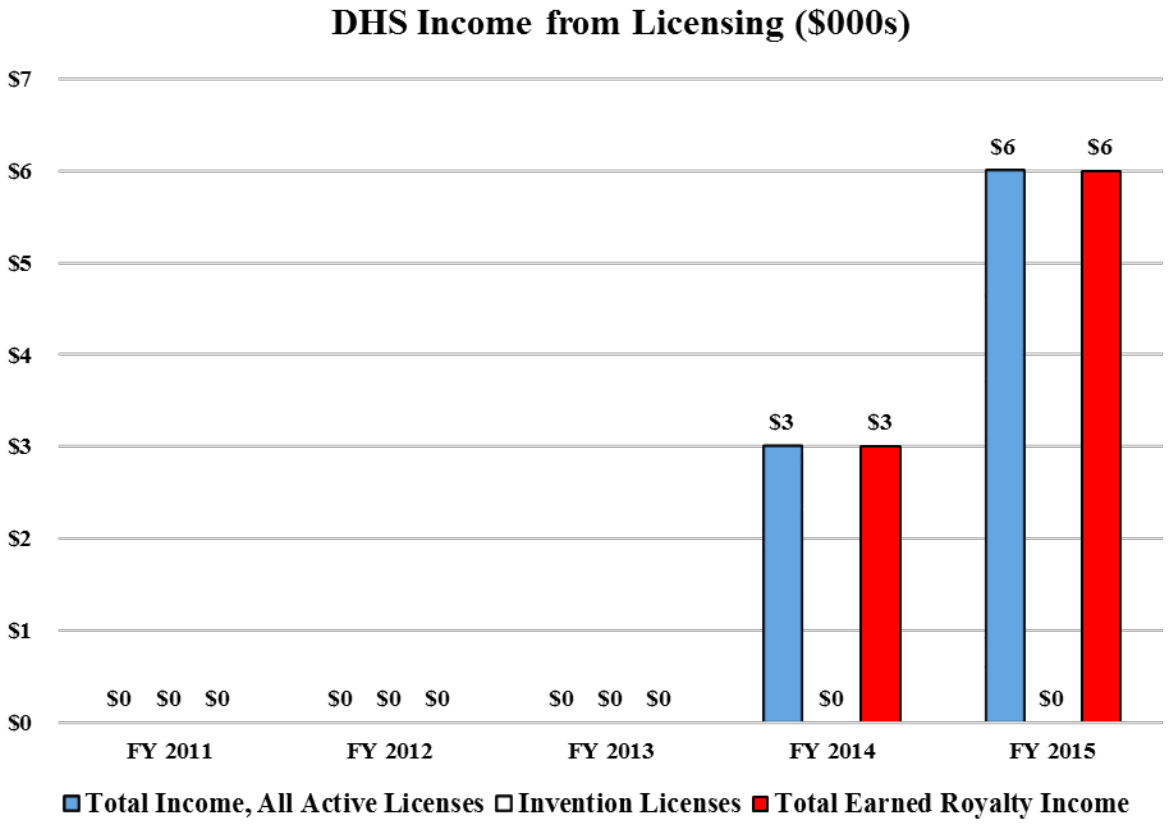


	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	0	0	0	2	4
New Licenses	0	0	0	0	3
Invention Licenses, Total Active	0	0	0	2	4
New Invention Licenses	0	0	0	0	3
Income Bearing Licenses, Total Active	0	0	0	1	4
Income Bearing Exclusive Licenses	0	0	0	0	0

[32] Licensing data for DHS were revised for the FY 2011 through FY 2015 period due to a change in reporting procedures at DHS. Trademark licenses which were included previously have been removed to follow the reporting guidance for this report.

DHS Income from Licensing

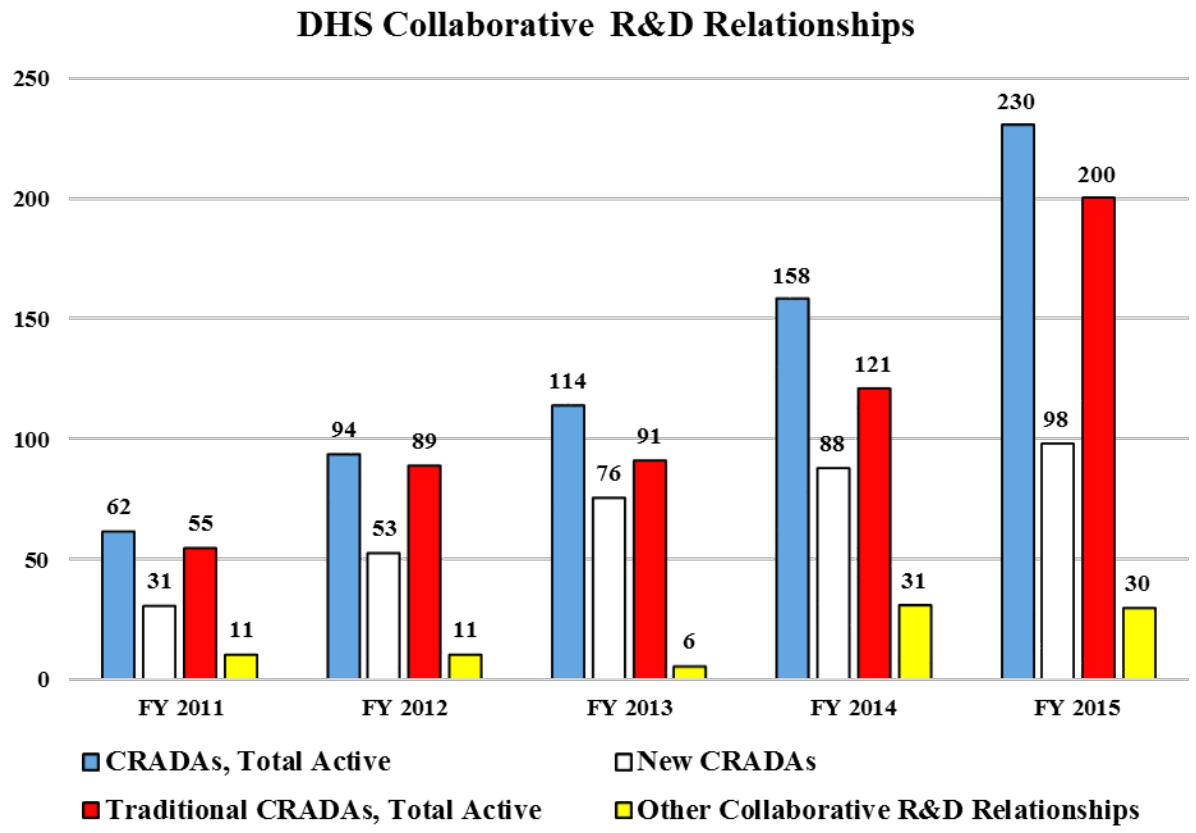
Licensing income increased from $3,000 in FY 2014 to $6,000 in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$0	$0	$0	$3	$6
Invention Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income	$0	$0	$0	$3	$6

DHS Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased by 271% from 62 to 230 agreements. The number of new CRADAs per fiscal year increased by 216% to 98 new agreements in FY 2015. Total active traditional CRADAs increased by 264% during the five-year period, totaling 200 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	62	94	114	158	230
New CRADAs	31	53	76	88	98
Traditional CRADAs, Total Active	55	89	91	121	200
Other Collaborative R&D Relationships	11	11	6	31	30

DHS Downstream Success Stories

Science and Technology Directorate, First Responders Group: Radio Internet-Protocol Communications Module

A new low-cost interoperability solution developed by DHS's Science and Technology Directorate (S&T) could save the first responder community millions of dollars.

The Radio Internet-Protocol Communications Module (RIC-M), used by local, state, and federal responders, is a low-cost, external, stand-alone, interface device that connects radio frequency (RF) system base stations, consoles, and other RF equipment—regardless of brand—over the Internet or Private Internet Protocol (IP) network. The RIC-M converts from a commonly used V.24 serial communications protocol to an open-standard Voice-Over-Internet-Protocol (VoIP). Both encrypted and unencrypted Project 25 (P25) digital communications are supported, and it can also operate with analog communication equipment.

In the past, legacy systems were not interoperable. If you bought one brand of base station, you had to buy the same brand for all the other components even if other brands offered more economical choices or better options. RIC-M allows first responder organizations to be free from dependence on expensive, single-vendor communication solutions, offering cost savings and wider variety.

Base stations are used by law enforcement, medical, and other agency dispatchers to communicate with first responders and agents in the field. Using the RIC-M, agencies can easily upgrade and reconfigure legacy systems at a low cost. Instead of having to replace an entire system which can cost as much as $15,000 when one component breaks or becomes obsolete, organizations can use any RIC-M compatible product to extend the system's life for another 10 to 20 years. Since its conception in 2012, RIC-M has been successfully field tested with various state and federal response agencies including Montgomery County, Maryland; U.S. Customs and Border Protection; Federal Protective Service; the Federal Bureau of Investigation; the U.S. Marshals Service; the Department of Justice; and the Department of the Interior, Office of Law Enforcement and Security.

The biggest benefit of the RIC-M is that it will allow agencies to continue to use current stock pile and installed legacy equipment. DHS owns the RICM patent and issued a first commercial license in 2015 with more expected in 2016.

Science and Technology Directorate, Transition to Practice: Fighting Malware with Hyperion

In February 2015, Hyperion, a technology that completed the TTP program was licensed to R&K Cyber Solutions LLC, a Manassas, Va. based application development and cyber solutions company to commercialize the technology and make it available to enterprise and government customers.

Hyperion is a malware forensics, detection, and software assurance technology that can quickly detect malicious behavior in software not previously identified as a threat. The unique feature of Hyperion is that it calculates the behavior of software to detect the presence of malware.

Hyperion was selected from among thousands of nominations and named an R&D 100 Award honoree in 2015. Since 1963, the R&D 100 Awards have celebrated the greatest R&D developments of the previous year.

Hyperion was developed by researchers at the Department of Energy's (DOE) Oak Ridge National Laboratory and selected into TTP's inaugural cohort of technologies based on its potential to address an existing cybersecurity gap. Through the TTP program, Hyperion was piloted within several organizations and was introduced to private sector industry partners, quickly generating interest from R&K to make the technology commercially available.

R&K Cyber Solutions later spun off the Hyperion technology into a new cybersecurity company, Lenvio Inc., and further expanded it into a product suite that is commercially available to users to protect their environments and improve their cybersecurity posture.

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 which 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.

This section draws on DOI's annual technology transfer report for FY 2015, which describes the actions DOI took in FY 2015 to advance technology transfer. These range from developing and helping commercialize new technologies to reduce the discharge of invasive non-indigenous species in cargo ballast waters into U.S. waters to testing and demonstrating earthquake early warning systems, and to developing new chlorine-resistant desalination membranes to enhance water supplies.

The FY 2015 enacted budget for the Department of the Interior included $935.9 million for research and development. Much of the funding was for applied research ($754.4 million), while basic research and basic development received $53.3 million and $128.1 million, respectively. The programs supported through these funds generate large amounts of knowledge, information, and technology, which help the Department meet its mission objectives and are transferred to resource managers, stakeholders, and the general public.

The Department's bureaus have varying levels of involvement with scientific and technical research and innovation, and technology transfer. In FY 2015, as in previous years, the majority of technology transfer activities reported by the Department under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS) because it is the largest research and development (R&D) organization within the Department, both in terms of budget and personnel, and, therefore, generally has greater involvement with technology transfer. Typically, USGS accounts for over 70 percent 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 general public. The clear majority of the Department's technology transfer activities use traditional technology transfer mechanisms such as publications of peer reviewed papers and reports, webpage postings, fact sheets, and presentations at meetings and conferences. In 2015, USGS and U.S. Fish and Wildlife Service (FWS) personnel authored or co-authored over 8,900 reports, books, fact sheets, and other publications, including over 3,500 scientific publications. The other bureaus, while also active in publishing and distributing scientific, technical and engineering results, however, do not systematically track these products, so their contributions are not included in these counts.

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, six bureaus are active participants in the network of seventeen Cooperative Ecosystem Studies Units (CESUs), a collaboration among 373 partners, including 15 Federal Agencies, and over 350 non-federal partners (including universities, Tribes and tribal organizations, State agencies, museums, aquariums, arboretums, and conservation organizations). Each CESU is hosted by a university.

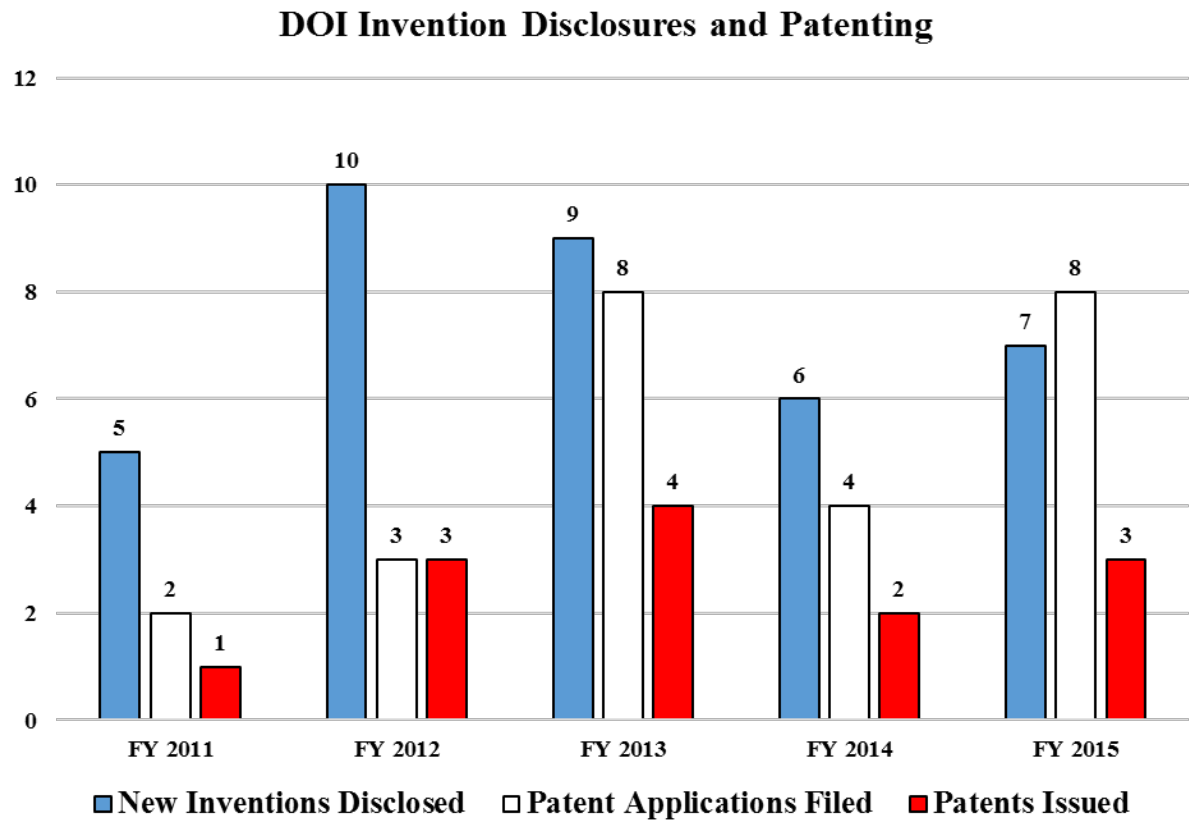
Bureaus that are active in research and development, or have research capabilities that complement U.S. commercial interests, may also utilize technology transfer agreements authorized by the FTTA to join forces with non-federal partners. Such agreements allow the Department's bureaus and private sector industries to pool their expertise and resources to jointly 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:
https://www.doi.gov/techtransfer/.

DOI Invention Disclosures and Patenting

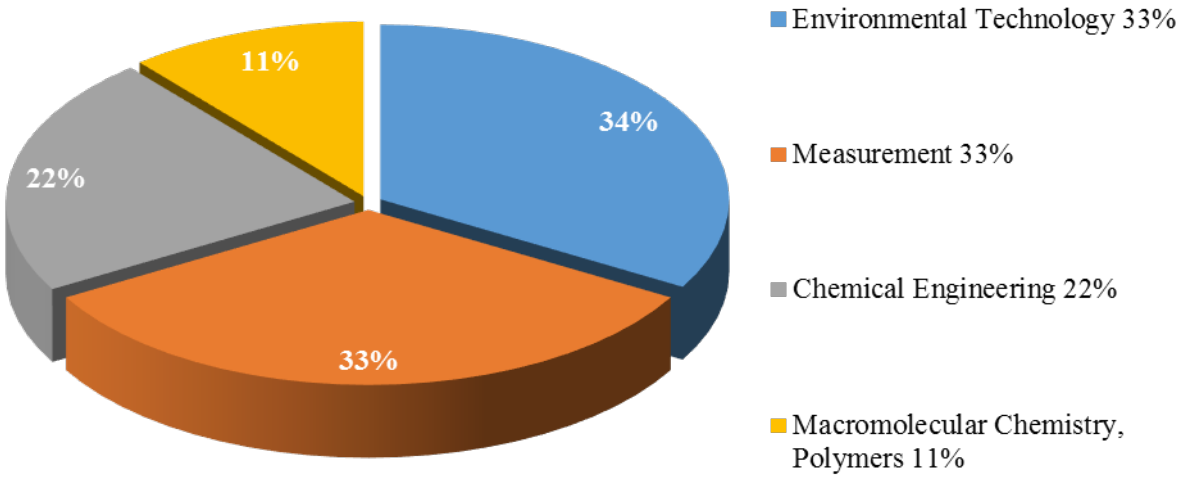
From FY 2011 to FY 2015, the number of new inventions disclosed increased to seven disclosures. The number of patent applications filed increased to eight, up from two in FY 2011. Three patents were issued in FY 2015, up from one in FY 2011. DOI's technology transfer focus has been on acquiring and spreading knowledge and information rather than inventions and patents.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	5	10	9	6	7
Patent Applications Filed	2	3	8	4	8
Patents Issued	1	3	4	2	3

Patents issued to DOI in FY 2015 covered many technology areas including environmental technology (33%), measurement (33%), chemical engineering (22%), and molecular chemistry, polymers (11%).[33]

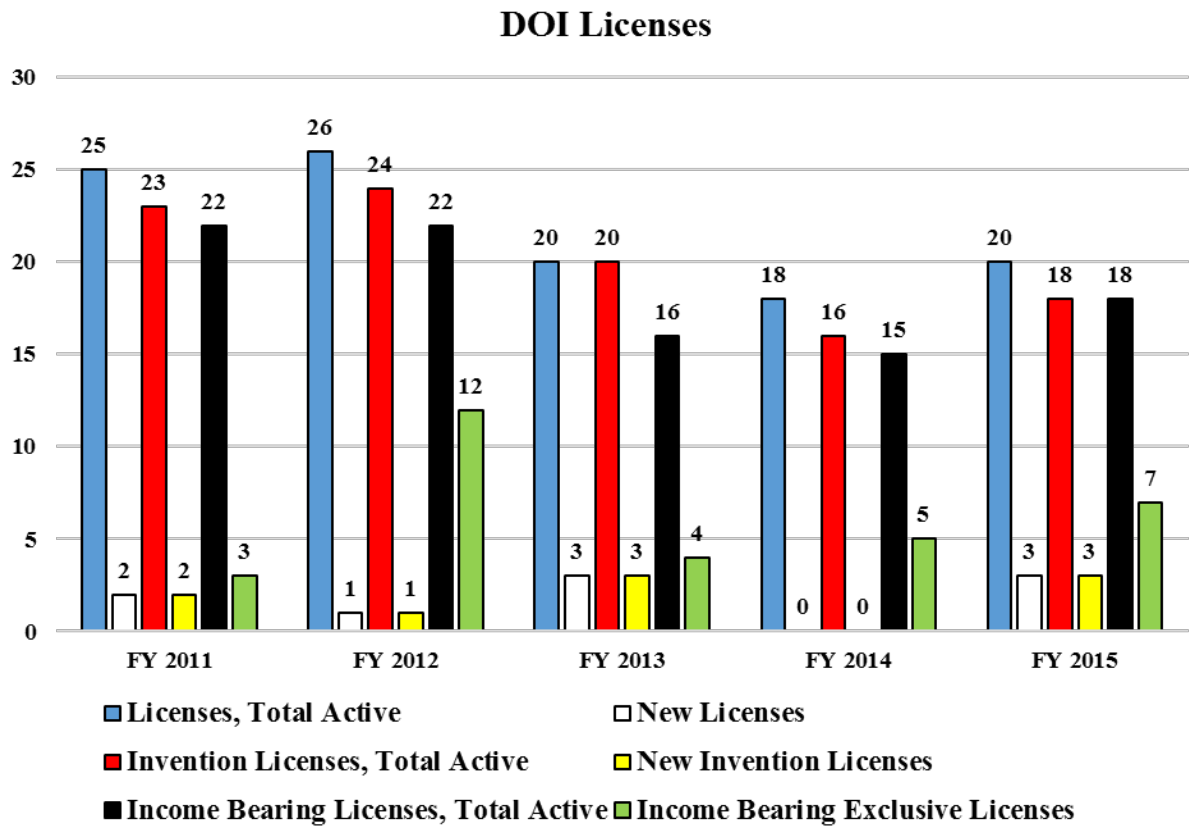
USPTO Patents Assigned to DOI by Technology Area: FY 2015



[33] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

DOI Licenses

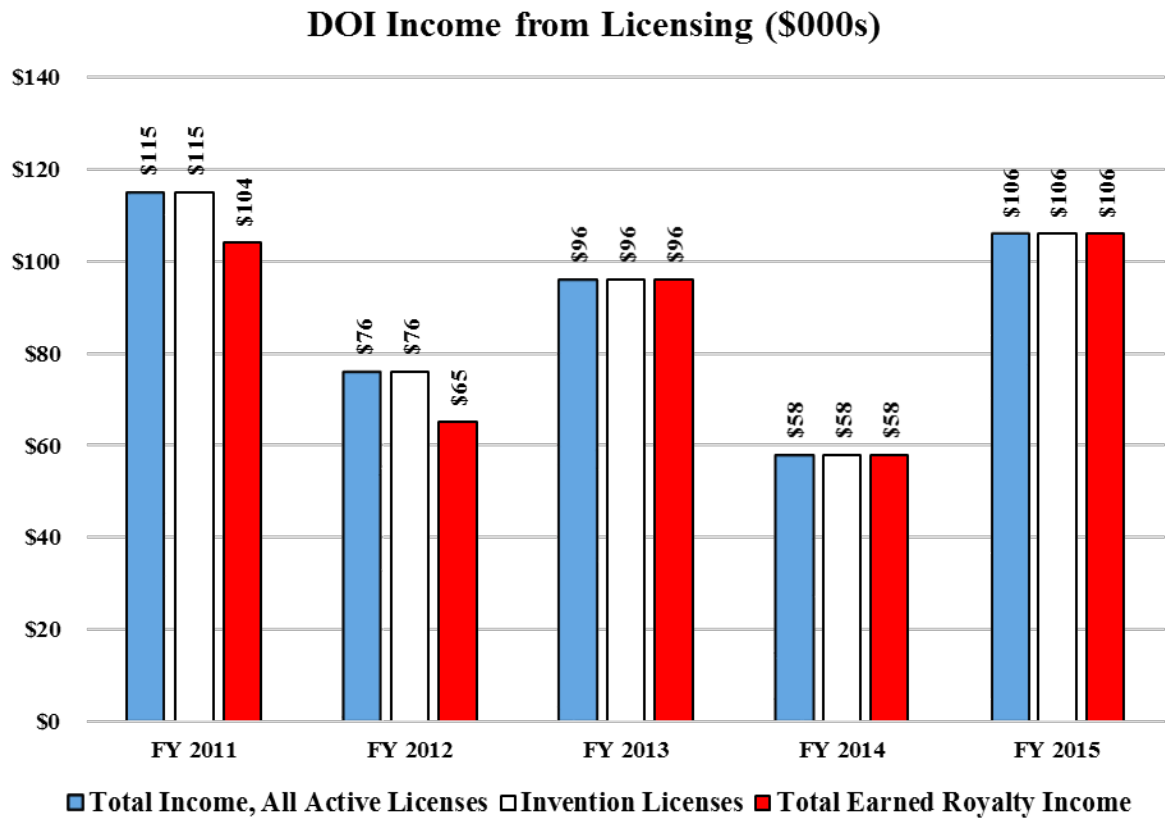
From FY 2011 to FY 2015, the number of total active licenses decreased by 20% to 20 licenses in FY 2015. There were three new licenses in FY 2015. The number of total active invention licenses decreased by 22% to 18 licenses; however, there were three new invention licenses in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	25	26	20	18	20
New Licenses	2	1	3	0	3
Invention Licenses, Total Active	23	24	20	16	18
New Invention Licenses	2	1	3	0	3
Income Bearing Licenses, Total Active	22	22	16	15	18
Income Bearing Exclusive Licenses	3	12	4	5	7

DOI Income from Licensing

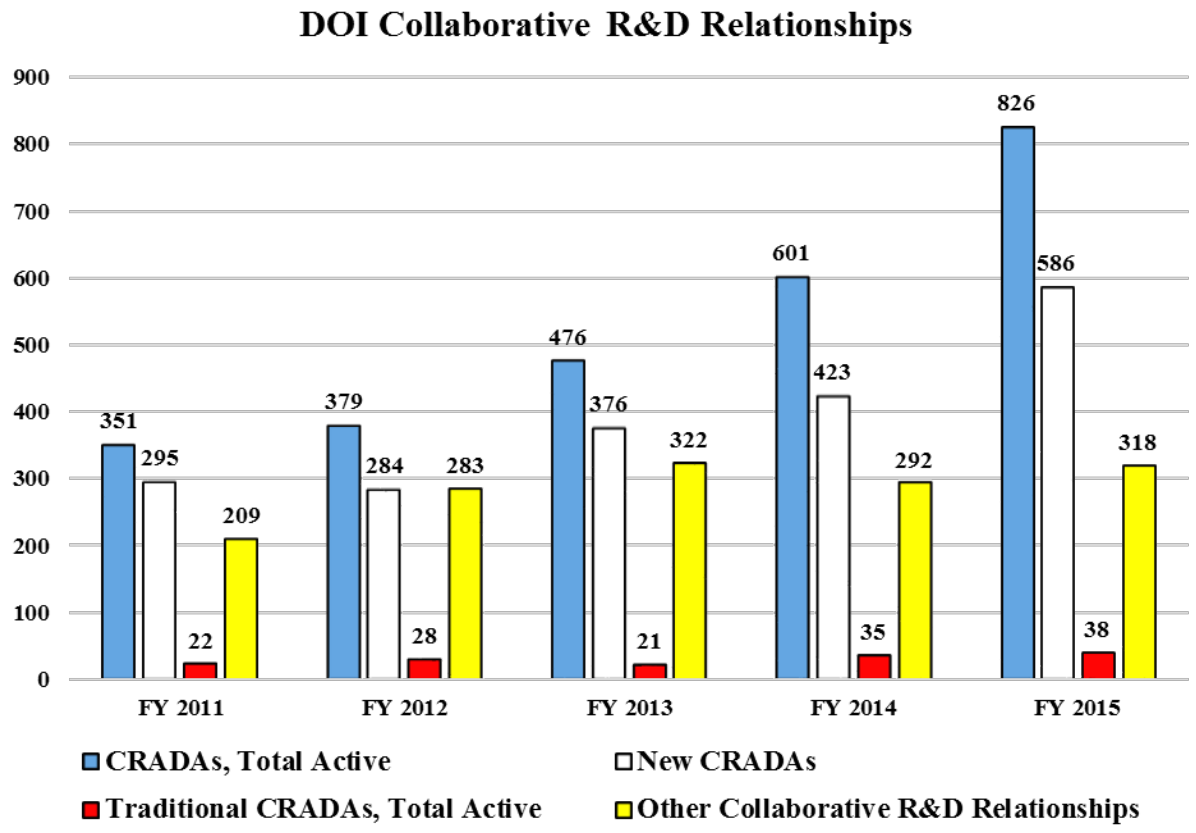
Between FY 2011 and FY 2015, the number of total income from all active licenses decreased by 8% to $106 thousand in FY 2015. The income from invention licenses decreased by the same amount, as all income received came from invention licenses. Total earned royalty income was $106 thousand in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$115	$76	$96	$58	$106
Invention Licenses	$115	$76	$96	$58	$106
Total Earned Royalty Income	$104	$65	$96	$58	$106

DOI Collaborative R&D Relationships

From FY 2011 to FY 2015, the number of total active CRADAs increased by 135% from 351 to 826 agreements. The number of new CRADAs per fiscal year increased by 99% to 586 new agreements in FY 2015. Total active traditional CRADAs increased by 73% during the five-year period, totaling 38 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	351	379	476	601	826
New CRADAs	295	284	376	423	586
Traditional CRADAs, Total Active	22	28	21	35	38
Other Collaborative R&D Relationships	209	283	322	292	318

DOI Efforts to Streamline Technology Transfer Operations

In FY 2015, the Department continued to build on actions initiated in FY 2011 and the successful implementation of the Departmental Plan on Technology Transfer submitted to OMB in FY 2012, to institutionalize technology transfer programs within the Department. These actions also enable all bureaus to more effectively and efficiently implement the FTTA and related legislation while maintaining focus on their missions. These actions included:

- Increased coordination and cooperation amongst Department bureaus through presentations, where bureaus with greater experience with instruments made available through the Federal Technology Transfer Act, shared their knowledge with bureaus with less experience. These also illustrated the benefits of using these instruments to augment appropriated resources made available to bureaus to pursue their mission;

- Increased accessibility to resources to advance technology transfer through improvements to the Department's technology transfer website. This site, which is updated continually, provides information on relevant bureau programs and activities; opportunities for other agencies, and private and nonprofit institutions to cooperate with the Department's scientists, engineers and technical personnel; links to information on best practices related to technology transfer for novice and experienced practitioners; and other training related information; and

- Development of Departmental policy and procedural guidance for offering and administering prize competitions, following intense interest within bureaus to use prize competition authority under the America COMPETES Reauthorization Act of 2010 to advance innovations to fulfill mission goals.

DOI Downstream Success Stories

U.S. Geological Survey: Ballast Nozzle Mixing Methods

The USGS invented a novel nozzle-mixing method to reduce the discharge of invasive non-indigenous species into U.S. waters during the release of ballast waters from cargo ships. It entered into an exclusive license agreement with Glosten, Inc., to commercialize and make the nozzle mixing methods publicly available as part of Glosten's proprietary Ballast Responder.

Cargo ships that transport goods around the world can carry nonindigenous species in the ballast water that is used to stabilize and balance the vessel. The release of the ballast water from the ships is a major transport mechanism for the nonindigenous aquatic organisms. When the ships enter port, the ballasts are released which may introduce nonindigenous species to local waters. These species can have a dramatic negative effect on marine, estuarine, and freshwater ecosystems in the United States and abroad. These effects can range from altering the structure and dynamics of the ecosystem to killing native species. Therefore, it is important to reduce, if not eliminate, nonindigenous species that may be in the ballast water prior to discharging it in any U.S. waters. This can be accomplished through mixing a biocide in the ballast water. Complicating this process is the fact that cargo ships have a wide variety of ballast tank configurations. The USGS has invented a system, which when paired with Glosten's products,

circulates the ballast water with a biocide without removing the ballast water from the ballast tank. This novel method overcomes the challenges of mixing within different ballast tank configurations and is a cost-effective solution to combating the introduction of exotic aquatic species.

U.S. Geological Survey: Improved Device to Measure Ground Temperature
USGS and Alpha Mach, Inc., have entered into an exclusive license agreement to commercialize and make publicly available the temperature probe co-invented by both parties to continuously measure temperature in soils and riverbed sediments at multiple depths. This allows the rate and direction of seepage to be estimated. This device has many practical applications to those interested in collecting temperature data for hydrological and ecological investigations. The new temperature probe was designed to overcome the challenges of current methods, using microchip thermistors and internal data storage, with a focus on employing heat as a tracer in surface water investigations.

U.S. Geological Survey: Test of Earthquake Early Warning Notifications
USGS and Global Security Systems, LLC (GSS) have established a collaboration to test the use of the latter's ALERT FM system to broadcast earthquake early warnings generated by the USGS ShakeAlert System. The USGS ShakeAlert System in California consists of sensors placed strategically throughout the state that detect seismic vibrations. If these vibrations exceed a pre-determined level, that would trigger an alert, and send out warnings. These warnings could be distributed across outdoor sirens, ALERT FM receivers, smartphone apps, and other notification pathways such as radio and TV broadcasts.

ALERT FM is unique since it operates a dedicated emergency notification system that is satellite-based and is not reliant on potentially vulnerable Internet connectivity. It is already being used in many southern states for tornados and hurricane notification. ALERT FM uses the digital data subcarrier of local FM radio stations, including Univision station in southern California and public radio station KQED in northern California, to distribute critical alerts in as little as 6 seconds.

An objective of the partnership is to have ShakeAlert earthquake early warning alerts posted to GSS alert software and broadcast to a set of GSS receivers. In addition, the USGS and GSS will collaborate on system design and best practices for alerting different sectors, including emergency response personnel, utilities, and other industries. Early warning of earthquakes will allow businesses to take actions to protect their employees, customers, and critical infrastructure from strong shaking. Even a few seconds of warning is enough notice to shutdown vulnerable processes, move people from unsafe places, and for people to drop, take cover, and hold on.

Information would be received on portable or fixed receivers that can be programmed for specific groups, counties, or areas. ALERT FM receivers automatically tune to and lock on to the strongest FM signal in the area. As the USGS ShakeAlert System begins issuing public alerts for the West Coast of the United States, ALERT FM receivers would be available for purchase by residents and businesses.

USGS has partnered with Global Security Systems because it is a systems integrator, service

Provider, and manufacturer of the ALERT FM, Alert Studio and GSSNet, a satellite data delivery system that has developed a commercially available end-to-end notification platform based on FM radio broadcasts fed by satellite for distributing mass notifications. GSS has a nationwide satellite delivery system to originate and uplink Common Alert Protocol (CAP) based emergency audio and text alerts. GSS Alert FM receivers, cell phones equipped with a radio chip and software, and other consumer devices receive the alert messages. The GSSNet satellite data delivery system for emergency alerts is currently in operation on over 500 radio stations in 17 states and Canada.

U.S. Fish and Wildlife Service: Aquatic Animal Drug Approval Program
The Aquatic Animal Drug Approval Program (AADAP) within the FAC Division currently has four CRADAs in place, including a relatively new CRADA with AquaTechnics, Inc. The three other existing agreements are with Merck Animal Health (Summit, NJ), Aquatic Life Sciences (Ferndale, WA), and Frontier Scientific (Logan, UT). These agreements permit the parties to identify research opportunities that support development of new aquatic animal drugs, broaden the U.S. technology base, and support accomplishment of FWS scientific mission objectives. For example, in 2015, AADAP developed research study protocols to define the objectives, design, procedures, and methods used to conduct clinical efficacy studies on a new sedative for use in aquaculture for the purpose of sedating fish prior to transporting, grading, and sorting them. The protocols have been accepted by FDA. Data generated under these protocols help inform New Animal Drug Approvals, which will provide new advances and tools for Federal, State, tribal, and private fish
culture facilities.

Office of Surface Mining Reclamation and Enforcement: Technical Innovation and Professional Services (TIPS) Training Program
This is a collaborative effort among the Office of Surface Mining Reclamation and Enforcement (OSMRE), States, and Tribes that provides specialized training to use specialized hardware and software tools related to mining and reclamation. Course developers and instructors are reclamation experts who use TIPS software to solve a wide-range of complex permitting, enforcement, and abandoned mine land problems. TIPS training is unique in that OSMRE tailors the training exclusively to mining and reclamation uses. Importantly, most of the tools it uses and provides training for are off-the shelf applications. The OSMRE delivers TIPS courses on-site at the customers' requests, and in dedicated training centers in OSMRE Regional Offices. TIPS conducted twenty-four instructor-led classes in FY 2015 with 314 students completing class sessions and another four online training courses for 41 students. The OSMRE conducted four of the training classes at on-site locations to meet the specific training needs of particular offices or groups of students, and enable broader participation throughout the SMCRA community. In FY 2015, the TIPS training program received a customer satisfaction rating of 98 percent, exceeding the annual Government Performance and Results Act goal by 5 percent.

Bureau of Reclamation: Next Generation Desalination Membranes
An ongoing CRADA with a U.S. manufacturer of desalination membranes produced two related subject inventions. Reclamation was also issued a patent for a new, promising chlorine resistant chemical monomer that could be a key ingredient for developing the next generation membrane that is the focus of this CRADA. The primary CRADA objective is to develop new membranes

that meet or exceed the current industry standard for water purification performance characteristics, while not deteriorating from chlorine exposure. This is also a long-sought goal of the global desalination community of practice. Chlorine dosing and management is a necessary and costly process to prevent membrane biofouling. Chlorine is also a residual component in many water sources that are treated by desalination membranes. The membrane damage caused by chlorine exposure not only compromises membrane performance but also increases desalination operations, maintenance, and replacement costs. The CRADA combines the research expertise, know-how, facilities, and relevant background intellectual property of both parties to accelerate achieving the CRADA objectives The CRADA research is making progress toward full scale testing and demonstration of new membranes.

Bureau of Reclamation: Improving Water Operation Decision Support Software
Under a CRADA with Colorado State University, Reclamation made improvements to water operation decision support software owned by Colorado State University. The software is used by many Reclamation water operation offices and others in the federal and nonfederal water management community. Under the terms of the CRADA, Reclamation received a no-cost perpetual license to use the software. Colorado State University will also make the improvements available to their other users.

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, State of Good Repair, Economic Competitiveness, Quality of Life in Communities, and Environmental Sustainability. In 2004, the Research and Innovative Technology Administration (RITA) was charged by its enabling legislation[34] with coordination of DOT-wide RD&T and technology transfer activities. In the Consolidated Appropriations Act, 2014 (P.L. 113-76), 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. Agency specific technology transfer plans may be found here.

Technology Transfer activities are executed by DOT agencies and their laboratories:

- Federal Aviation Administration (FAA): The FAA's Federal laboratory is the William J. Hughes Technical Center located at the 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); and
- National Highway Traffic Safety Administration (NHTSA): Vehicle Research and Test Center (VRTC, East Liberty, OH).

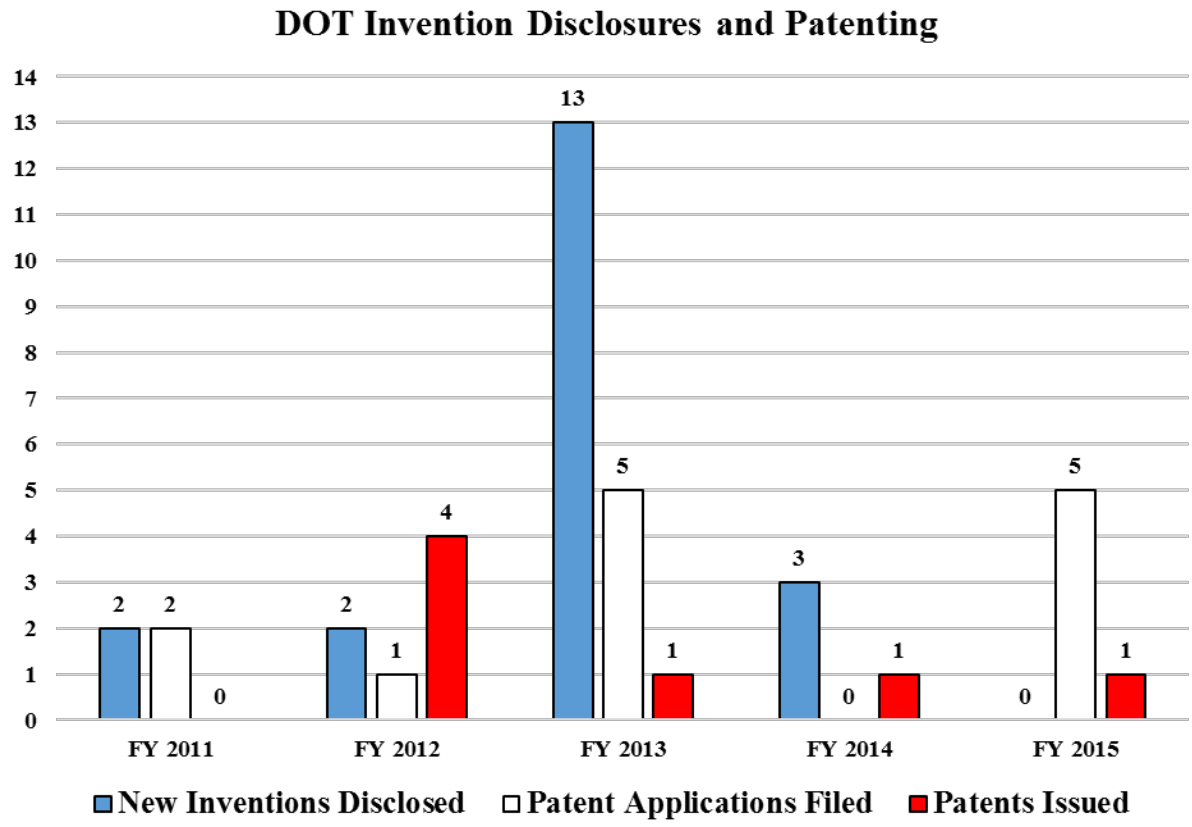
DOT's annual technology transfer report is available online at:
http://www.transportation.gov/open/research-facilities

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/
OST-R: https://www.rita.dot.gov/

[34] P.L 108-426, November 30, 2004 (118 Stat. 2423).

DOT Invention Disclosures and Patenting

There were no new invention disclosures in FY 2015. The number of patent applications filed went from two in FY 2011 to five in FY 2015. The number of patents issued during this five-year period went from zero in FY 2011 to one in FY 2015.

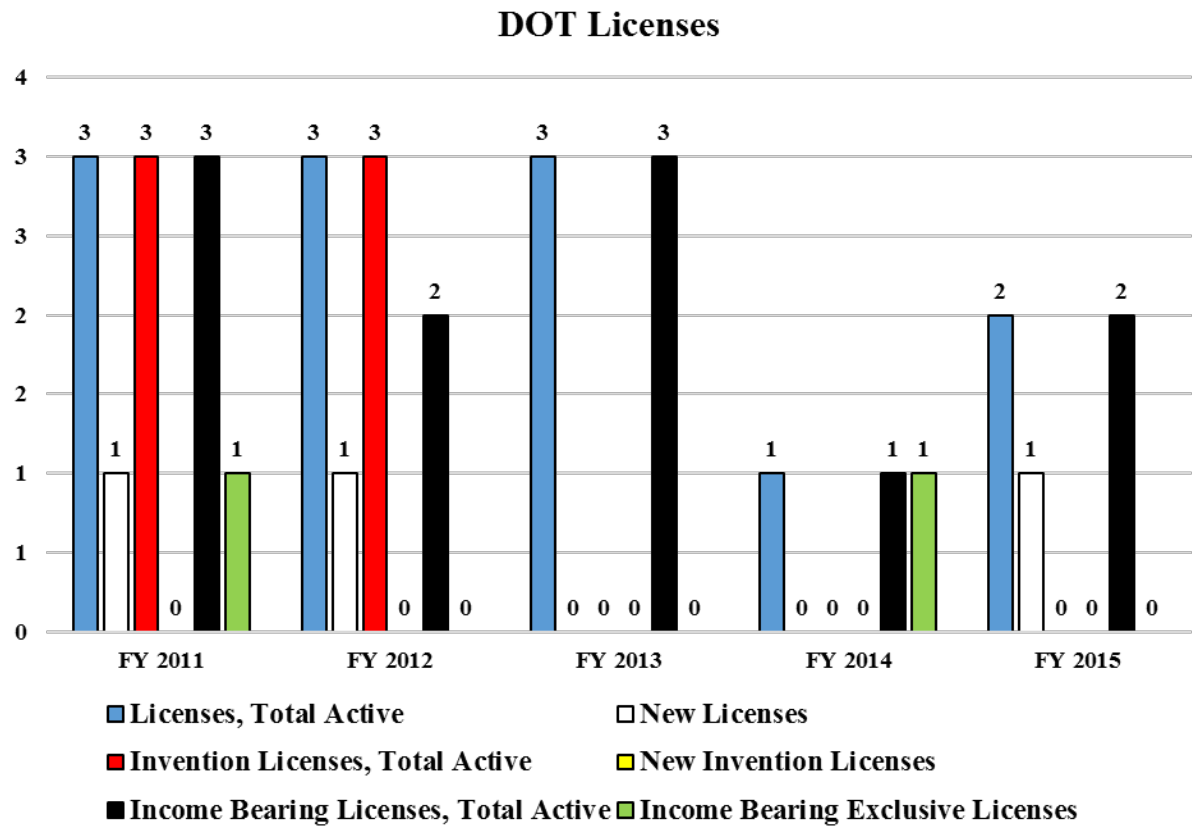


	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	2	2	13	3	0
Patent Applications Filed	2	1	5	0	5
Patents Issued	0	4	1	1	1

In FY 2015, the one patent issued to DOT involved a device to measure erosion potential of soils supporting structural foundations located in moving water. The technical area for this patent is Measurement.

DOT Licenses

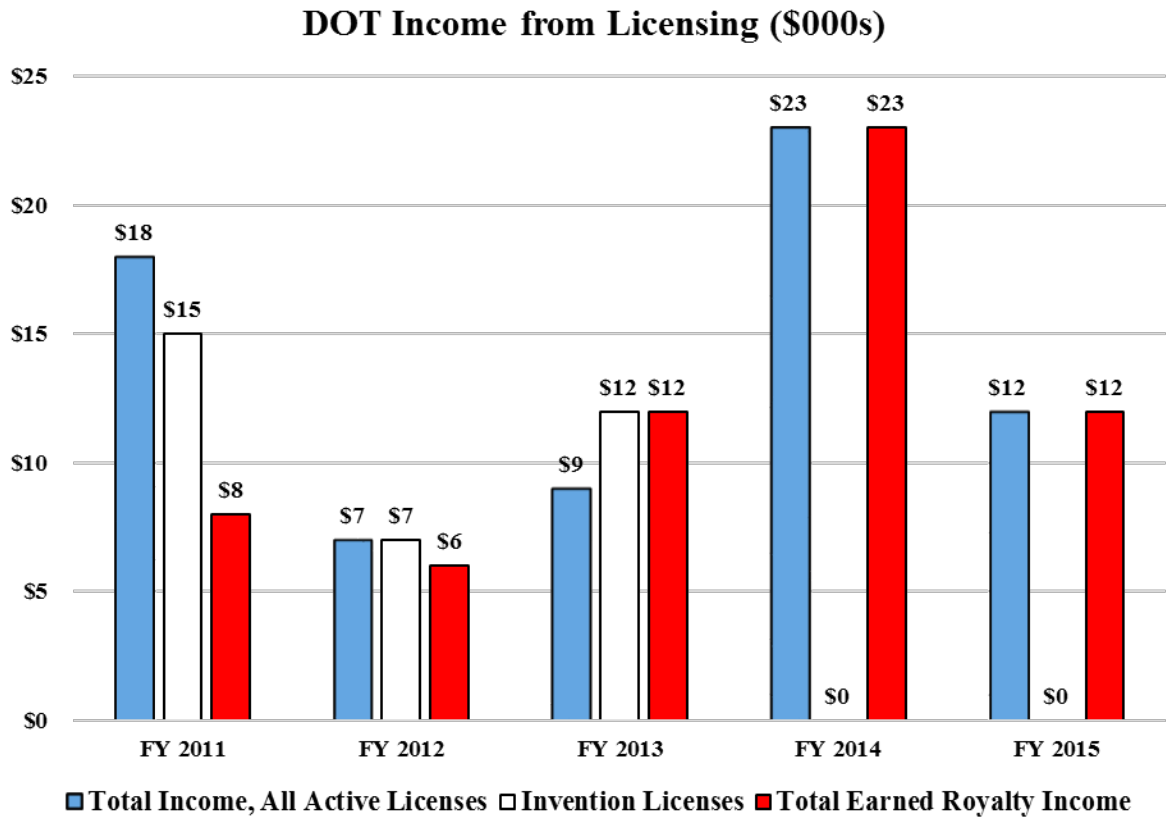
Between FY 2011 and FY 2015, the number of total active licenses decreased from three in FY 2011 to two licenses in FY 2015. There were no new invention licenses reported in FY 2015. The total active invention licenses decreased from three licenses in FY 2011 to zero in FY 2014 and FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	3	3	3	1	2
New Licenses	1	1	0	0	1
Invention Licenses, Total Active	3	3	0	0	0
New Invention Licenses	0	0	0	0	0
Income Bearing Licenses, Total Active	3	2	3	1	2
Income Bearing Exclusive Licenses	1	0	0	1	0

DOT Income from Licensing

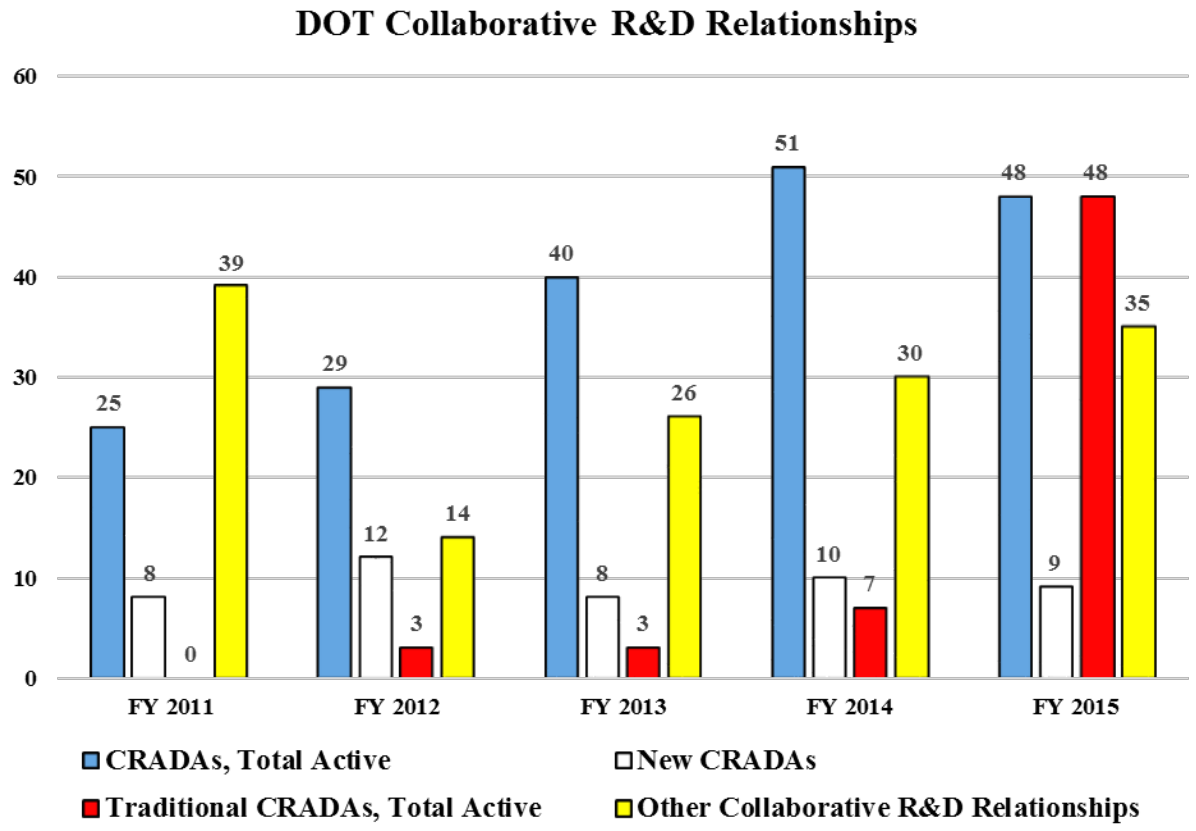
Between FY 2011 and FY 2015, total income from all active licenses decreased by 33% to $12 thousand in FY 2015. In FY 2015, there was no income from invention licenses. Total earned royalty income increased from $8 thousand in FY 2011 to $12 thousand in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$18	$7	$9	$23	$12
Invention Licenses	$15	$7	$12	$0	$0
Total Earned Royalty Income	$8	$6	$12	$23	$12

DOT Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased by 92% from 25 to 48 agreements. In FY 2015, there were a total of 48 active traditional CRADAs.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	25	29	40	51	48
New CRADAs	8	12	8	10	9
Traditional CRADAs, Total Active	0	3	3	7	48
Other Collaborative R&D Relationships	39	14	26	30	35

DOT Efforts to Streamline Technology Transfer Operations

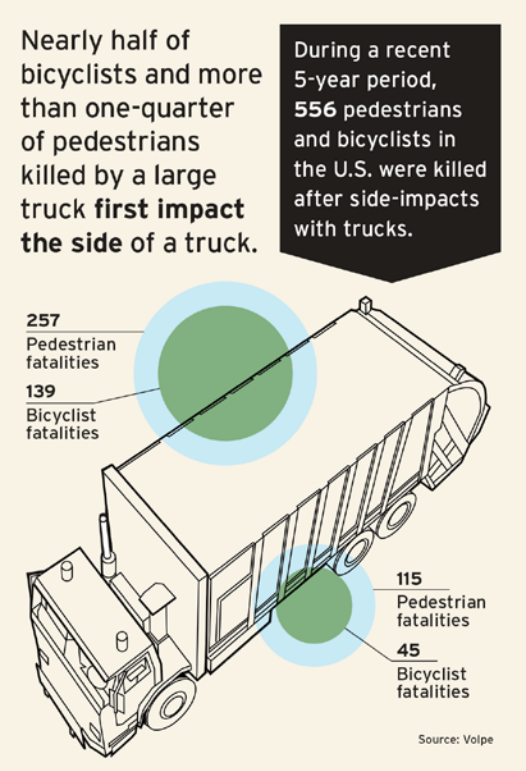
DOT is increasing coordination between Operating Administrations (OA) through the designation of identified technology transfer points of contact from each OA R&D program. These efforts are already providing enhanced efficiencies in the collection of intellectual property and technology transfer information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

- developing a website that will improve public awareness and access to information on DOT'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 DOT 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 DOT'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 DOT's research facilities and equipment, its research capabilities, and the technologies available for licensing.

DOT Downstream Success Stories

From Research to Reality, Volpe Brings Side Guards to Large Trucks

When trucks with high ground clearances strike vulnerable road users, such as bicyclists and pedestrians, those users can fall into exposed space between the front and rear wheels and suffer fatal crushing injuries. Side guards physically cover that exposed space.



Volpe's National Transportation Systems Center (Volpe) research coalesced years of international analysis on side guards. The United Kingdom, for instance, enacted a side guard requirement in the 1980s. After the requirement was implemented, bicyclist fatalities decreased 61 percent, and pedestrian fatalities decreased 20 percent for side impacts with large trucks. Through presentations at conferences and consultations with elected officials and transportation agencies, Volpe is helping bring side guards to the United States.

In 2014, the City of Boston asked Volpe to help expand on its truck side guard pilot—which was informed by Volpe research—and to craft the nation's first side guard ordinance for private truck fleets. The ordinance took effect in May 2015. At the same time, the neighboring City of Cambridge asked Volpe to recommend side guard specifications for its municipal trucks.

New York City also asked Volpe to study and develop a pilot truck side guard program for its largest-in-the-nation municipal truck fleet. In June 2015, New York unanimously passed a Volpe-advised law requiring side guards on 10,000 city-owned and regulated trucks by 2024.

The City has further leveraged the technology transfer by successfully soliciting the first vehicle procurement bids from major truck OEMs in North America to include integrated side guards. This demonstrates a milestone for Volpe's T2 effort by influencing the multinational automotive sector. With New York's truck fleet fully equipped with side guards, the city can expect to see several lives saved and dozens of serious injuries avoided per year.

In fall 2015, Volpe started to support the City of San Francisco's Vision Zero safety program to eliminate traffic deaths within one decade. Volpe and the City are working to identify regulatory or voluntary partnerships with local and state agencies, as well as with the manufacturing sector, to promote a robust side guard market and to accelerate this technology transfer in California. Additional Volpe consultations with the cities of Chicago, Seattle, Albany, and Washington, D.C., are expected to catalyze further nationwide adoption.

Volpe's Truck Side Guards Resource Page is available at: https://www.volpe.dot.gov/our-work/truck-side-guards-resource-page.

A Quantitative Non-Destructive Residual Stress Assessment Tool for Pipelines

DOT's Pipeline and Hazardous Materials Safety Administration's (PHMSA) SBIR Phase 1 and 2 funding led to the development of the eStress™ system, which measures the pipe wall internal stresses within a damaged area, allowing operators to thoroughly inspect and analyze at-risk areas before failures occur. A key advantage of the eStress™ system is that through-wall stress measurements can be taken while a pipeline is in service, which allows direct measurement of the complex stress state of the dented materials under operating conditions.

Through PHMSA's participation in the SBIR Program, Generation 2 Materials Technology, LLC, demonstrated this powerful new nondestructive evaluation system for analyzing through-thickness residual stresses in mechanical damaged areas of steel pipelines. The system is designed to help pipeline operators find problem areas before serious damage occurs. High levels of tensile stress are the fundamental driver for dangerous corrosion and cracking in pipelines, which can be identified and mitigated proactively.

The current 64-sensor array design can evaluate approximately one square foot in less than two minutes. It is also envisioned that the eStress™ system could be installed permanently along high consequence areas or other areas of concern for monitoring the dynamic stresses that come from transportation, operation, pigging, nearby industry/citizens, extend so forth. Visit PHMSA project site for more information: https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=441

UL Adopts Microscale Combustion Calorimeter (MCC)[35]

Underwriters Laboratories (UL) recently adopted the FAA-patented Microscale Combustion Calorimeter (MCC), which was developed by Rich Lyon and Rich Walters of the Fire Safety Branch, to verify that manufactured materials are compliant with the UL 94 flammability test standard. Many components in building materials and consumer products are required to meet the UL 94 flammability standard, and the material manufacturers are required to demonstrate each lot is compliant with the standard. Rather than conducting a UL 94 flammability test, which requires a large sample bar, a MCC test requiring a very small sample – as small as several milligrams – may be used to demonstrate continued compliance of the manufactured material.

The benefits of using the MCC are reduced cost, time and waste associated with molding plastic sample bars, and discarding the unused or unburned samples. The MCC also provides a more quantitative output – heat release rate signature – and significantly reduces the quantity of combustion products released during UL 94 testing. The MCC has become a common test method used by fire researchers since its development and application in many FAA fire research papers, and adoption as ASTM standard D7309. In recent years, it has become a quality control tool, as evidenced by the recent UL application, and previous use by the Boeing Company.

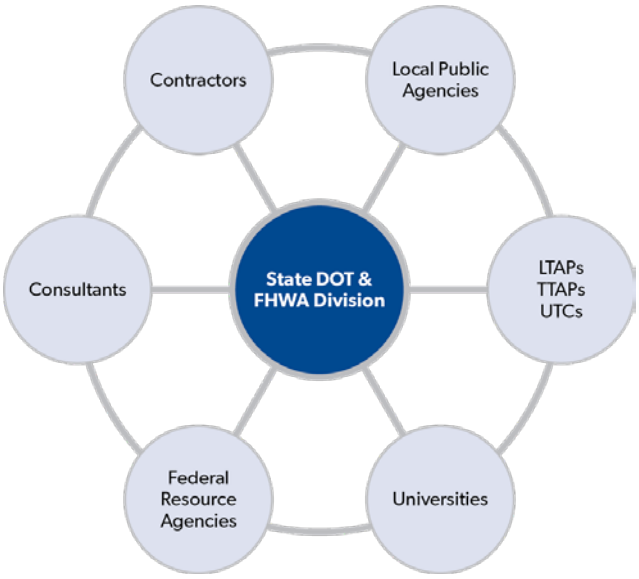
FHWA Provides Incentives to States to Field Test Research Results

The FHWA State Transportation Innovation Council (STIC) Incentive program provides resources to help States and local highway agencies make innovations standard practice in their States.

A STIC is an established group of representatives from various levels of the highway community in each State tasked with comprehensively and strategically considering sources of innovation. The STIC puts the State in the driver's seat to select the innovations that best fit unique program needs and quickly put those innovations into practice.

Launched in September 2013, the STIC Incentive Program offers technical assistance and up to $100,000 per STIC per year to support the costs of standardizing innovative practices in a State transportation agency or other public sector STIC stakeholder.

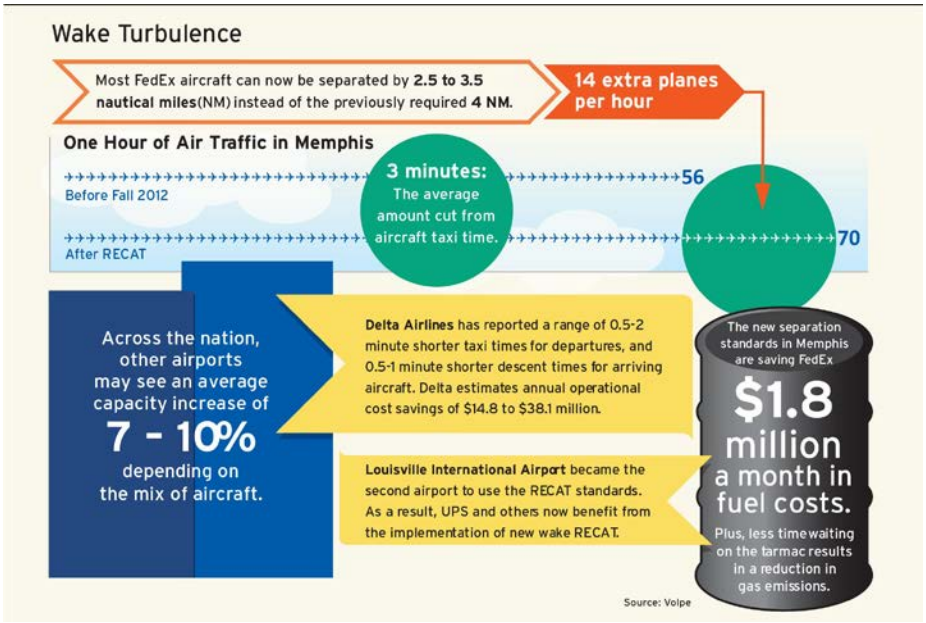
[35] "The Center News", Vol 51, No. 17, Wed. April 29, 2015, Page 2



The Colorado STIC, for example, plans to utilize STIC Incentive program funds to conduct training to accelerate construction site revegetation to reduce life cycle costs and environmental reliability. The New Mexico STIC is utilizing incentive funds to create a digital experience and other educational materials on the use of Diverging Diamond Interchanges, an alternative intersection design proven to save lives, reduce delays, and lower costs when compared to traditional intersection designs.

In federal fiscal year 2014, 36 States received a total of $3.5 million in STIC Incentive funds to advance the use of innovations such as 3D modeling, high friction surface treatments, design-build contracting, and diverging diamond interchange design into standard practice across the State. Several of the innovations are part of the FHWA's Every Day Counts initiative, which selects proven, market-ready innovations and provides technical assistance to accelerate their deployment. The STIC Incentives program had established 49 STICs by end of FY 2015 and is expected to continue in FY 2016 and beyond. For more information, visit: http://www.fhwa.dot.gov/stic/ and https://www.fhwa.dot.gov/innovation/everydaycounts/.

Wake Turbulence Analysis Leads to Increased Airport Efficiency



For 40 years, Volpe has collected and analyzed aircraft wake turbulence data at airports, providing the FAA with recommended changes to improve terminal air traffic safety and increase efficiency. Volpe engineers provide critical analyses to help the FAA achieve operational changes, among them enabling aircraft to land on closely spaced parallel runways (CSPRs) under instrument approaches, as well as revision of the single runway wake turbulence separation minima.

The FAA has achieved several significant milestones through Volpe's support, including approval of the Safety Risk Management Document for Wake Turbulence Mitigation for Arrivals–Procedural (WTMA–P) for Philadelphia International and Detroit Metropolitan Wayne County airports. This procedure enables airports to use dependent dual-arrival traffic streams on CSPRs with reduced diagonal separation under instrument conditions, where previously the two runways had to be treated as a single runway in less than good visual weather conditions.

Additionally, the FAA developed Wake Turbulence Recategorization, or RECAT, which revises aircraft single runway spacing defined in the early implementation of RECAT I. This new wake turbulence separation minimum integrates RECAT with earlier CSPR solutions developed under the framework of wake separation specified in 7110.65, and others; further reducing separations for certain aircraft pairs since the first RECAT implementation.

RECAT was implemented at Hartsfield-Jackson Atlanta International Airport, where it had a very positive impact. The new standards allow tighter arrival and departure sequences, resulting in improved flight efficiency as well as surface movements—especially during peak operation periods. As a result, Delta Airlines has reported a range of 0.5–2-minute shorter taxi times for departures, and 0.5–1-minute shorter descent times for arriving aircraft. Delta estimates annual operational cost savings of $14.8 to $38.1 million.

Volpe has collected, processed, and analyzed wake turbulence data to support various FAA and NextGen objectives, as exemplified by RECAT and WTMA–P.

FHWA Provides Incentives to States to Deploy Innovations

The FHWA launched the Accelerated Innovation Deployment (AID) Demonstration program in February 2014 to offset the risks associated with deployment of an innovation on a project. Approximately $30 million in incentive funding is available through the program to implement an innovation in any aspect of highway transportation including planning, financing, operation, structures, materials, pavements, environment, and construction on any project eligible for Federal assistance.

Applications are accepted on a rolling basis from State DOTs, federal land management agencies, and tribal governments. Metropolitan planning organizations and local governments may also apply as sub-recipients through their State DOT. The full cost of the innovation in a project may be awarded up to the maximum amount of $1,000,000. As of the start of FY 2015, 29 projects had received AID Demonstration awards totaling over $20 million.

For example, the Minnesota DOT and the City of St. James received an AID Accelerated Demonstration Program grant to construct two mini-roundabouts that will be the first on the state highway system, the first for the City of St. James, and the first in a constrained urban setting. The mini-roundabouts are part of an urban reconstruction project on State Highway 4 and will replace signals at both intersections.

The primary benefit to innovative intersection designs such as mini-roundabouts are enhanced safety performance through fewer or less severe crashes, but operational improvements have also been found, through overall reduced delay and less time spent stopped at red lights. Improved

safety and reduced congestion can also provide direct and indirect economic benefits to businesses and communities located near the intersections.

FHWA encourages the use of AID Demonstration funds to promote the deployment of the EDC innovations, including but not limited to innovative intersection designs, which provide ways of improving the work of highway planning, design, construction, and operation.

For more examples of AID Demonstration grants stories, visit: http://www.fhwa.dot.gov/accelerating/grants.

Researching and Delivering New Methods to Save Lives

Saving lives is the USDOT's primary mission, and the FHWA and its partners conduct scientific research and deploy innovative safety measures with the potential for reducing crashes and improving the safety of the Nation's roads.

One of FHWA's research and technology efforts to save lives involves crash modification factors (CMFs). A CMF is an estimate of the change in crashes expected after the implementation of a safety countermeasure. When used properly, CMFs can help transportation engineers identify and apply the most appropriate countermeasures for increasing roadway safety. Combined with crash cost data and project cost information, CMFs can help transportation engineers compare the benefit-to-cost ratio of multiple countermeasures and then choose the most appropriate CMF for a given situation.

The FHWA has developed information on CMFs and made it available to State and local agencies to assist with highway safety planning. The CMF Clearinghouse, a free online database introduced in 2009 and accessible at www.cmfclearinghouse.org, details the varying quality and reliability of CMFs available to transportation professionals.

The Clearinghouse houses a Web-based database of over 5,000 CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Many of the CMFs were developed through FHWA-led transportation pooled fund studies and research projects conducted at the FHWA's Turner-Fairbank Highway Research Center, a federally-owned research facility in McLean, VA, but knowledge gaps and opportunities still exist to continue developing new CMFs.

The FHWA also conducts webinars and web-based courses on using and developing CMFs. The Clearinghouse team is developing a new feature that enables users to compare CMFs. They can select up to 4 CMFs and compare them to identify the one best suited to their needs.

FAA Dedicates Runway Pavement Testing Facility[36]

The Federal Aviation Administration (FAA) today dedicated its new National Airport Pavement & Materials Research Center at the William J. Hughes Technical Center at Egg Harbor Township, N.J. The research center is a unique facility that allows FAA engineers to use a custom-designed vehicle simulator to test asphalt and other pavement materials at very high tire pressures and temperatures. Airport pavement temperatures can reach 140 to 150 degrees Fahrenheit as far north as New York City. Tire pressure ranges from 220 to 250 pounds per square inch on new generation aircraft like the Boeing 787 and Airbus 350. The vehicle simulator has an automated heating system that allows engineers to replicate and analyze the damage that heavy commercial jets can cause to the top asphalt layer when runways are hot. The vehicle was designed to simulate the behavior and weight of aircraft tires, and can show how repetitive aircraft operations affect pavement.

FAA engineers will move the Heavy Vehicle Simulator-Airfields (HVS-A) by remote control between four outdoor pavement test strips and two strips inside a new building, to allow for testing in a controlled environment. The new center will enable the FAA to research environmentally-friendly airport pavement materials such as warm-mix and recycled asphalt pavements. The FAA's goal is to expand the use of "greener" materials, and pavement materials that can be modified to enhance pavement durability, workability, and strength. This will reduce the costs of initial construction, maintenance, and provide a longer pavement life. The FAA has not recommended the use of environmentally-friendly airport pavement materials yet because research on the effects of aircraft tire pressure and heavy gear loads on green airport pavement materials has been limited. Construction of the test facility was completed in May 2015.

Officials dedicate new $8 million National Airport Pavement and Materials Research Center and Safety Building at the William J. Hughes Technical Center[37]

Heavy Vehicle Simulator - Airfields[38]

[36] http://www.faa.gov/news/updates/?newsid=83606

[37] Photo Credit - http://www.pressofatlanticcity.com/communities/eht/faa-tech-center-opens-new-research-center/article_ebde04fa-4d02-11e5-ace8-b7a91883ce1c.html

[38] FAA Federal Laboratory Consortium Planner Submission, 2015

UAS integration into the National Airspace System (NAS)
The safe integration of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS) is critical to the FAA. Processing and analysis to provide actionable information to clients across a wide range of civilian industries are critical to the nation. 16 of the FAA's 38 active CRADAs in FY 2015 relate to UAS/NAS integration. These agreement's bodies of work include, for example, research to allow operations within a structured volume of airspace and aerial data gathering.

On May 6, 2015, the FAA announced the UAS Focus Area Pathfinders initiative[39], a partnership with industry to explore the next steps in unmanned aircraft operations beyond the type of operations the agency proposed in the draft small unmanned aircraft systems (UAS) rule it published in February. To date, four companies (CACI, Inc., Burlington Northern Santa Fe (BNSF) Railway, PrecisionHawk USA, Inc., and Cable News Network, Inc.) work with FAA federal laboratories under CRDAs to further Pathfinder initiatives. Railway monitoring is a recent highlight of the FAA's work with BNSF under 16-CRDA-0309.[40]

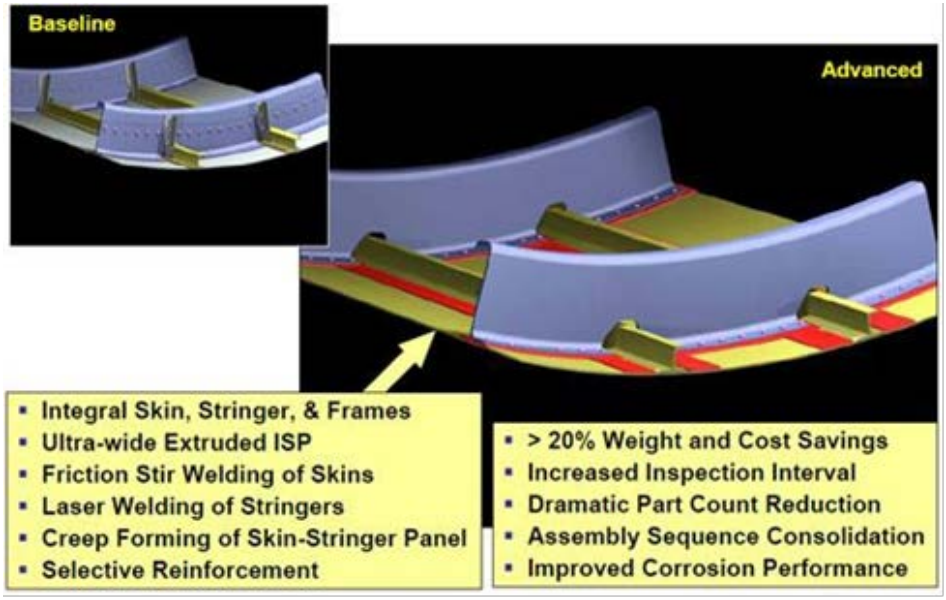
Insitu Inc., an unmanned aircraft systems (UAS) manufacturer, successfully conducted the first civil commercial beyond visual line of sight (BVLOS) operation in the continental United States on October 25, 2015, near Vaughn, NM.

The event was part of a week-long series of flights with BNSF Railway designed to show how UAS technology can be a powerful addition in the effort to further enhance railway safety and infrastructure inspection. The flight was part of the agency's Pathfinder program, an initiative to develop UAS regulations in collaboration with industry that was announced in May.

[39] http://www.faa.gov/uas/legislative_programs/pathfinders/
[40] https://my.faa.gov/focus/articles/2015/11/AVS_Flyer__UAS_Pathf.html

Advanced Metallic Fuselage Structure[41]

The aircraft industry is striving to reduce fabrication, operational, and maintenance costs by introducing advanced materials, construction methods, and production technologies. In light of the B787 and A350 advanced construction and increased competition from composite materials industry, the metallic material industry has made significant strides at unprecedented rates in developing new metallic alloys and material manufacturing processes that are competitive with composites in terms of cost and performance. With the introduction of new technologies, however, data and information are often lacking to allow for a comprehensive assessment of long-term safety concerns. Regulators and industry need to work together in preparation for their application and certification. Data is necessary to assess continued relevance of existing regulations and to develop additional safety standards and regulatory guidance if needed to maintain the current level of safety afforded by the existing airworthiness standards. For this new effort, the FAA will be collaborating with industry to assess durability and damage tolerance of EMST including unitized welded structure, new metallic alloys (Aluminum Lithium), and hybrid construction.

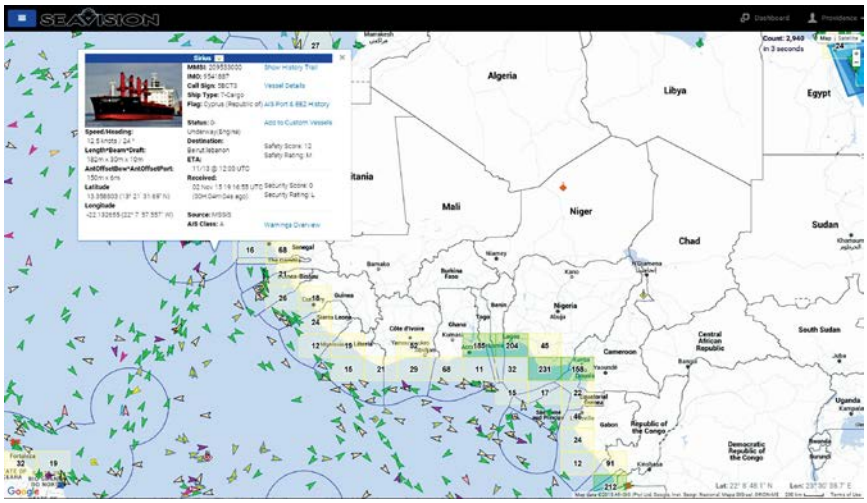


A five-year Cooperative Research and Development Agreement (CRDA; 15-CRDA-0310) between the FAA's William J. Hughes Technical Center federal laboratory and ALCOA was signed in August 2015. The purpose of this collaborative effort is to obtain full-scale fuselage panel test data to demonstrate how fuselage concepts utilizing EMST improve the durability and damage tolerance, compared to the current baseline aluminum fuselage structures, using the unique capabilities of the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility.

[41] FY15 R&D Annual Review V2

SeaVision Shines Light on the Global Seas

SeaVision is an evolving maritime domain awareness (MDA) tool originally developed by Volpe for the U.S. Naval Forces Africa (NAVAF). SeaVision was created to help countries on the western coast of Africa improve vessel traffic management and navigation safety; increase maritime situational awareness and security; reduce illegal fishing, illicit trading, human smuggling, and piracy; provide improved data for search-and-rescue operations; facilitate commerce; and enable disaster recovery efforts.



SeaVision displays Automatic Identification System (AIS) data from the Volpe-developed Maritime Safety and Security Information System (MSSIS) network on a Google map. AIS allows the automatic exchange of real-time ship-to-ship, ship-to-shore, and shore-to-ship vessel information, which includes information pertaining to vessel identity, characteristics, position, course, speed, and heading. It provides an historical and current view of MSSIS data that can be used to analyze vessel movements.

In 2015, SeaVision was used in three naval exercises including participation from 23 African countries and their respective Maritime Operation Centers (MOCs). On behalf of the U.S. Africa Command, Volpe recently hosted its second annual on-site and multi-week MDA Administrator and Technician Training Workshop. This workshop was purposed with training African government officials on SeaVision and additional MDA tools with the goal of "training-the-trainer" for in-country system sustainment.

As such, SeaVision is making a difference: Cabo Verde recently noted a significant improvement in the fight against illegal maritime activities after joining the system. The Cabo Verdean maritime police—in collaboration with the Senegalese MOC—were able to identify and interdict a foreign-flagged vessel illegally fishing both on and near the respective borders of each country, within their territorial waters.

Because SeaVision provides unclassified data, it is readily available to other countries, and its use has now spread well beyond Africa. Many countries use SeaVision to track vessel movements within their exclusive economic zones and waterways, and the system has enabled maritime safety and security professionals around the world to better track, analyze, and monitor vessel movements.

Department of Veteran Affairs (VA)

Every year, the Department of Veterans Affairs (VA) researchers develop hundreds of new health care-related technologies and other inventions. The Department of Veterans Affairs Technology Transfer Program's (TTP) mission is to facilitate the commercialization of VA inventions to benefit veterans and the American public. TTP achieves this mission by educating inventors concerning their rights and obligations, evaluating invention disclosures, applying for IP protection, and assisting in the commercialization of new products.

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.

In addition, 124 VAMCs have formal affiliations with academic institutions and many VA researchers also 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. To facilitate efficient technology transfer, TTP has executed interinstitutional agreements with many of VA's academic affiliates. These agreements have taken the form of Cooperative Technology Administration Agreements (CTAA) in the past. The CTAAs allow the affiliate to take the lead in the management of all co-owned inventions unless they decline to do so. Moving forward, TTP is now negotiating Invention Management Agreements (IMA). The IMAs are more balanced than the CTAAs in that they do not automatically give up control of invention management to the affiliate. With IMAs, the parties make a mutual decision with regard to who is to lead for each newly disclosed jointly owned invention. For all inventions solely owned by VA, or those jointly owned where VA is in the lead, TTP manages all aspects of invention management, including: commercialization assessment; patent prosecution; marketing; and, license negotiation.

Critical components of any successful intellectual property program include invention assessment, patenting, marketing, and licensing new inventions or technologies to ensure timely production and introduction into the marketplace. CTAAs allow affiliates to take the lead in these activities for most jointly owned IP. Where VA is the sole owner of an invention or lead partner in a jointly owned invention, VA undertakes these activities. VA assesses inventions for commercialization potential using a contractor which is engaged for this purpose. If VA decides to pursue patent protection of an invention, an appropriate contracted law firm is engaged to do so. Marketing includes both passive and active approaches. For passive marketing, all technologies available for licensing are listed on the TTP website. For those inventions selected for active marketing, TTP enlists the use of professional services from an IP marketing contractor.

TTP and VA Office of General Counsel (OGC) coordinate the negotiation of Cooperative Research and Development Agreements (CRADAs) and/or licenses with commercial entities. VA's OGC reviews and approves CRADAs and licenses prior to execution by the appropriate signing authority.

Successful patents licensed to manufacturers provide a royalty stream. 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.

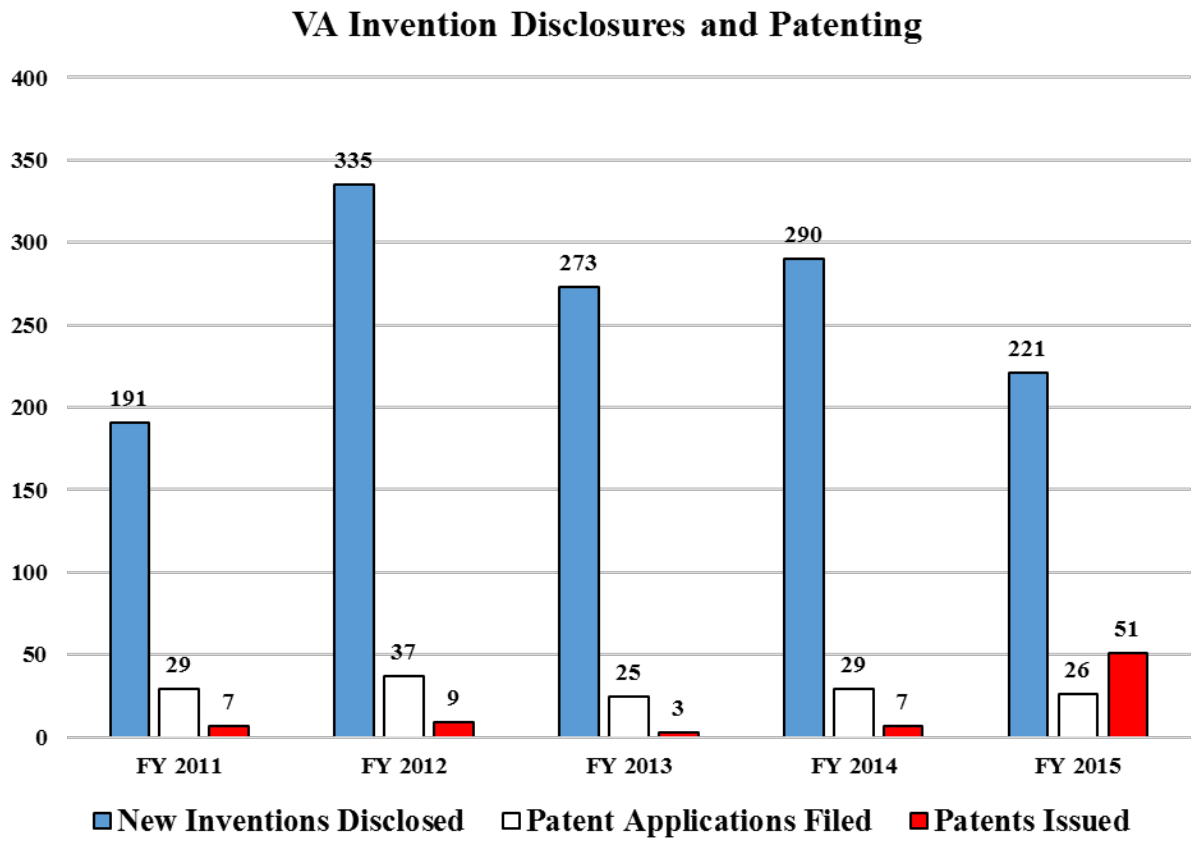
Explanation of the Agency's Plans for Conducting its Tech Transfer Function Mission
VA TTP has a variety of initiatives to fulfill its mission. Among these initiatives are: increasing the number and quality of Invention Disclosures (ID) VA receives; streamlining the process of determining whether the Federal Government is the owner of any invention; improving VA's current mechanisms for working with its affiliates; establishing a more systematic internal patent policy for VA; and improving VA's commercial licensing processes.

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 to ensure that VA receives their fair share of royalties from patents and joint ventures with nongovernmental agencies and private companies.

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

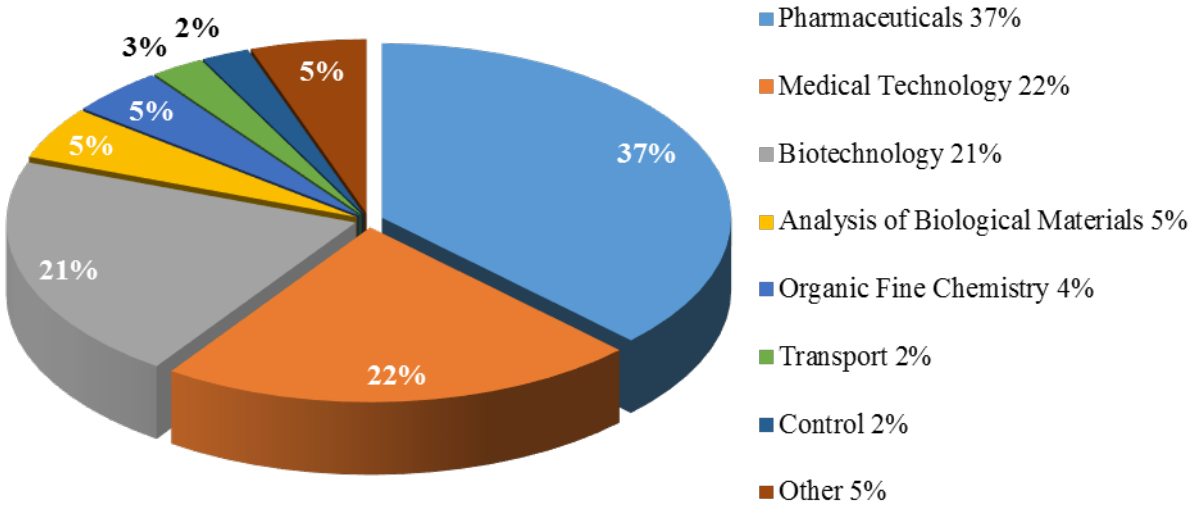
Between FY 2011 and FY 2015, the number of new inventions disclosed increased by 16% from 191 to 221 disclosures in FY 2015. The number of patent applications filed experienced a 10% decrease. The number of patents issued during this five-year period increased by 629% from 7 to 51 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	191	335	273	290	221
Patent Applications Filed	29	37	25	29	26
Patents Issued	7	9	3	7	51

Patents issued to VA in FY 2015 covered many technology areas, including pharmaceuticals (37%), medical technology (22%), biotechnology (21%), analysis of biological materials (5%), and organic fine chemistry (4%).[42]

USPTO Patents Assigned to VA by Technology Area: FY 2015[43]



[42] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.
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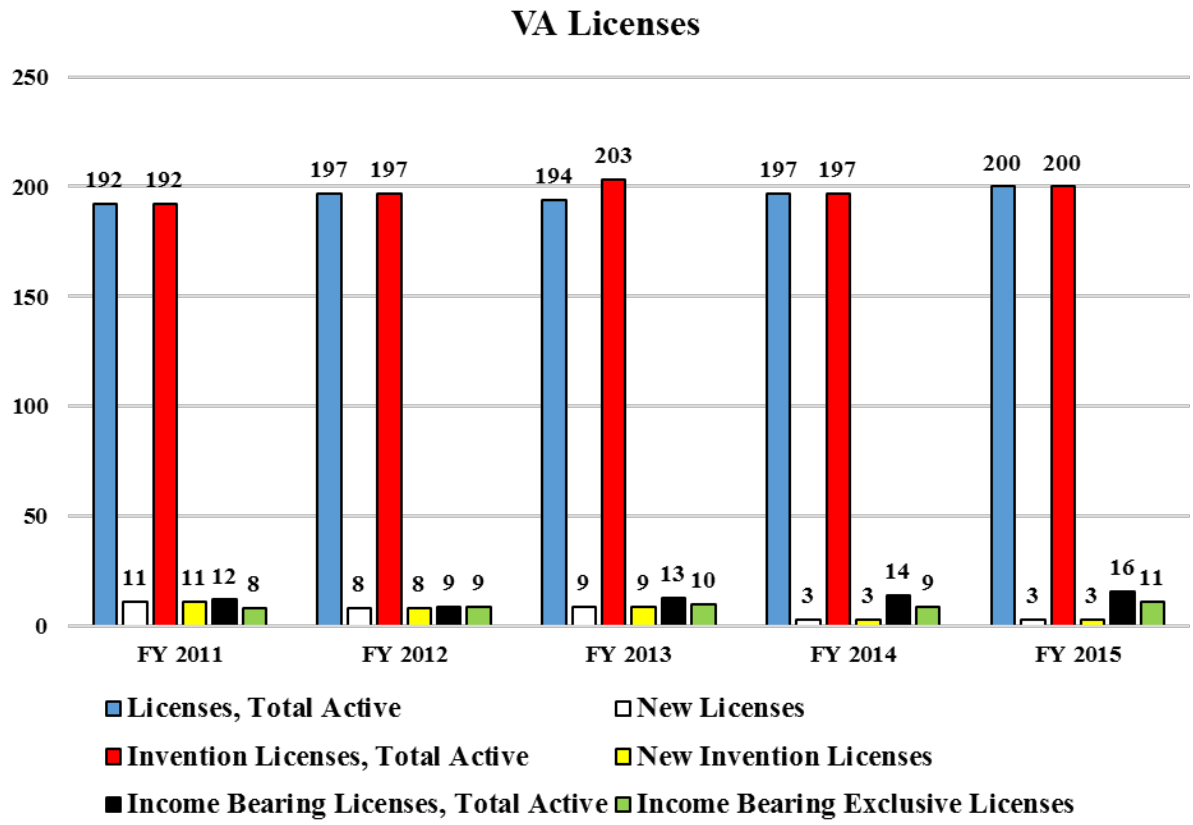
VA Licenses

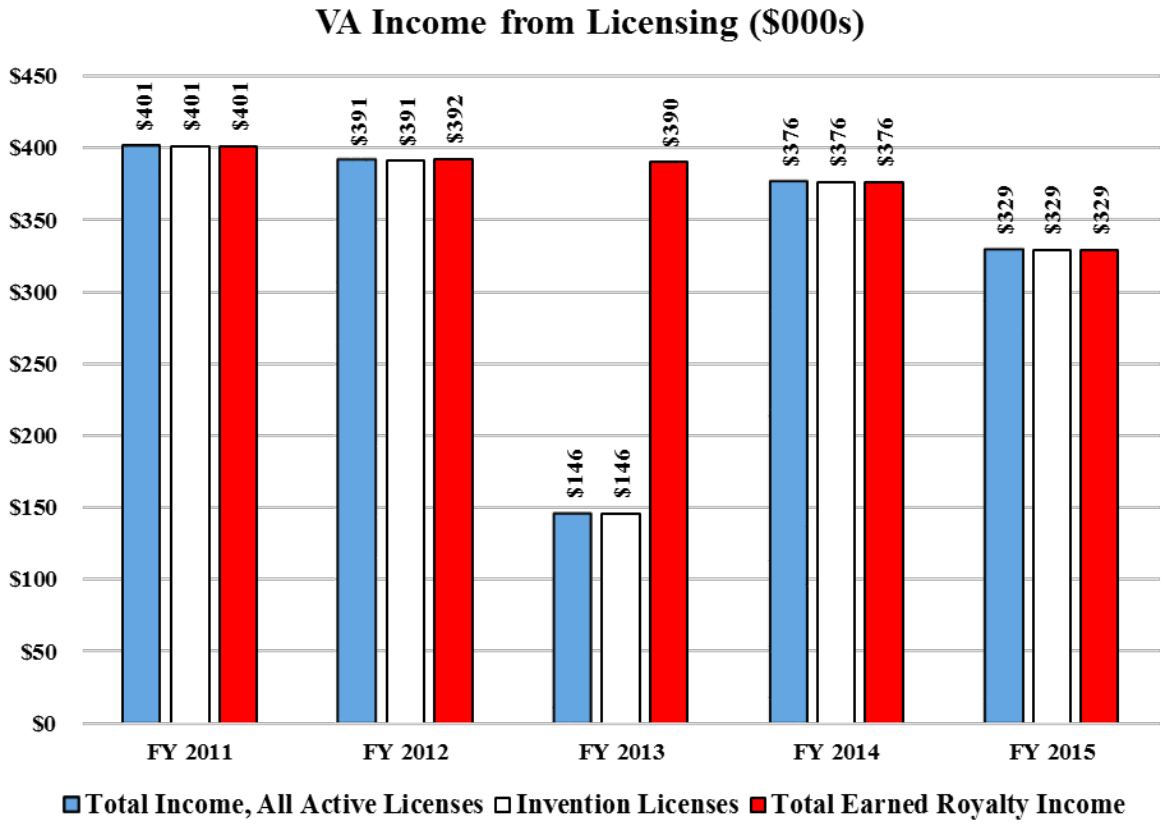
Between FY 2011 and FY 2015, the number of total active licenses increased by 4% from 192 to 200 licenses in FY 2015. New licenses decreased by 73% to 3 licenses from a previous 11 in FY 2011.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	192	197	194	197	200
New Licenses	11	8	9	3	3
Invention Licenses, Total Active	192	197	203	197	200
New Invention Licenses	11	8	9	3	3
Income Bearing Licenses, Total Active	12	9	13	14	16
Income Bearing Exclusive Licenses	8	9	10	9	11

VA Income from Licensing

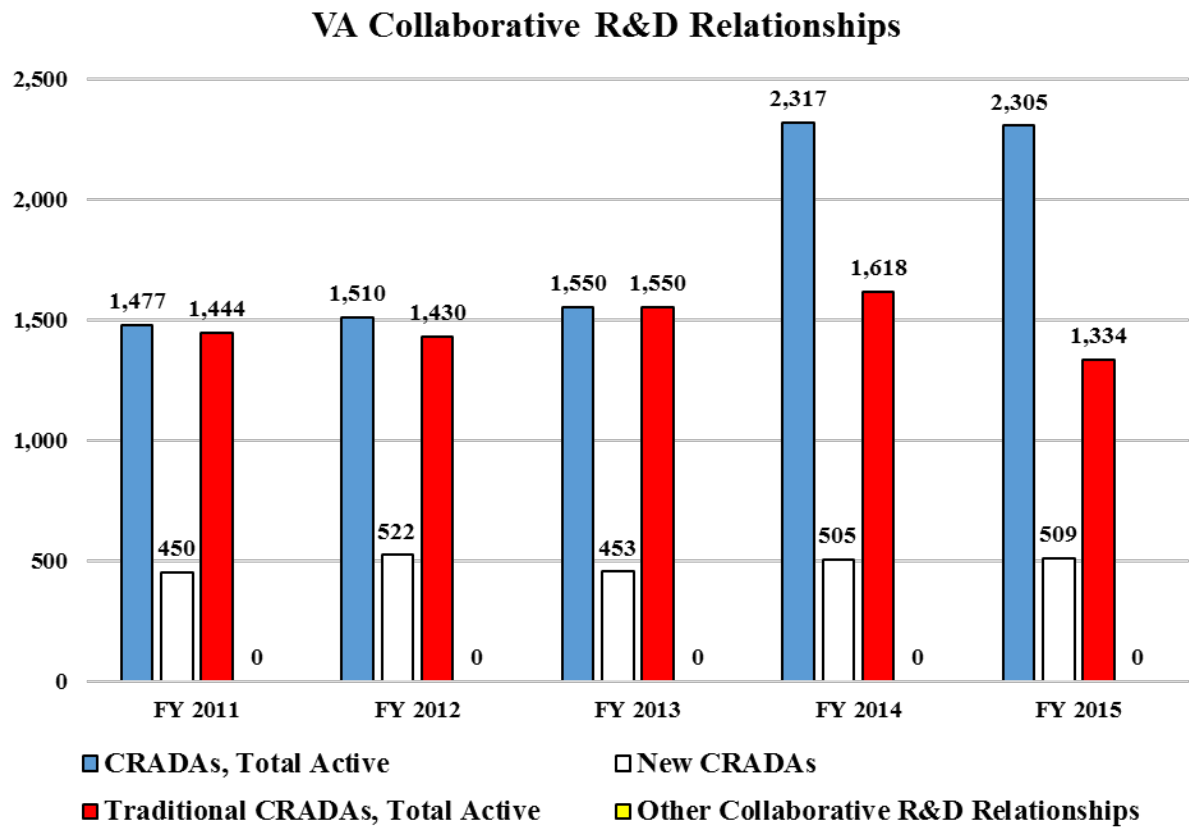
Between FY 2011 and FY 2015, total income from all active licenses decreased by 18% from $401 thousand to $329 thousand in FY 2015. Income from invention licenses and earned royalty income were the same as income from all active licenses.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$401	$391	$146	$376	$329
Invention Licenses	$401	$391	$146	$376	$329
Total Earned Royalty Income	$401	$392	$390	$376	$329

VA Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased 56% from 1,477 to 2,305 agreements. The number of new CRADAs per fiscal year increased by 13% to 509 new agreements in FY 2015. Total active traditional CRADAs decreased by 8% during the five-year period, totaling 1,334 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	1,477	1,510	1,550	2,317	2,305
New CRADAs	450	522	453	505	509
Traditional CRADAs, Total Active	1,444	1,430	1,550	1,618	1,334
Other Collaborative R&D Relationships	0	0	0	0	0

VA 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 VA's 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 intellectual property 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 intellectual property 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 were continued and expanded in FY 2014.

- **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, and 2) the academic affiliate is not taking the lead on intellectual property 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 Intellectual Property 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 receives 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 intellectual property estate and worse, a loss of control over intellectual property 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 VA's 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 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 VA's ability to track metrics and provide deliverables to academic affiliates and increase accountability and the ability to manage data.

  In FY 2012, 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 that 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 nongovernmental 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.

VA Downstream Success Stories

Universal Drape for Patient Lifting Systems

A nurse associated with VA's Safe Patient Handling Program has invented a set of disposable drapes that maintain sterility during patient prepping and clinical procedures. The drapes are configured to cover patient lifting systems used in hospitals and other healthcare facilities and are designed to reduce the rate of infection that patients acquire from patient lift systems as well as the injury rate of operating room nurses when lifting and maneuvering patients in the operating room. The patented invention was exclusively licensed in April of 2015 and is now being marketed and used in hospital operating rooms.

Antibody-Mediated Transduction of HSP70 into Living Cells

This protein therapy technology, developed by the VA, delivers a heat shock protein (HSP) that saves injured cells that suffer hypoxic and oxidative stresses that occur following common tissue injuries, such as heart attack, stroke, and traumatic brain injury. The protein is a targeted cytoprotectant that penetrates cells in regions of tissue damage and inhibits cell death. The protein has the potential to be developed as a protectant against toxic inhalants, nerve damage, and radiation, and as a treatment for myocardial infarction, traumatic brain injury, and stroke. The patented invention was exclusively licensed in May of 2015.

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.

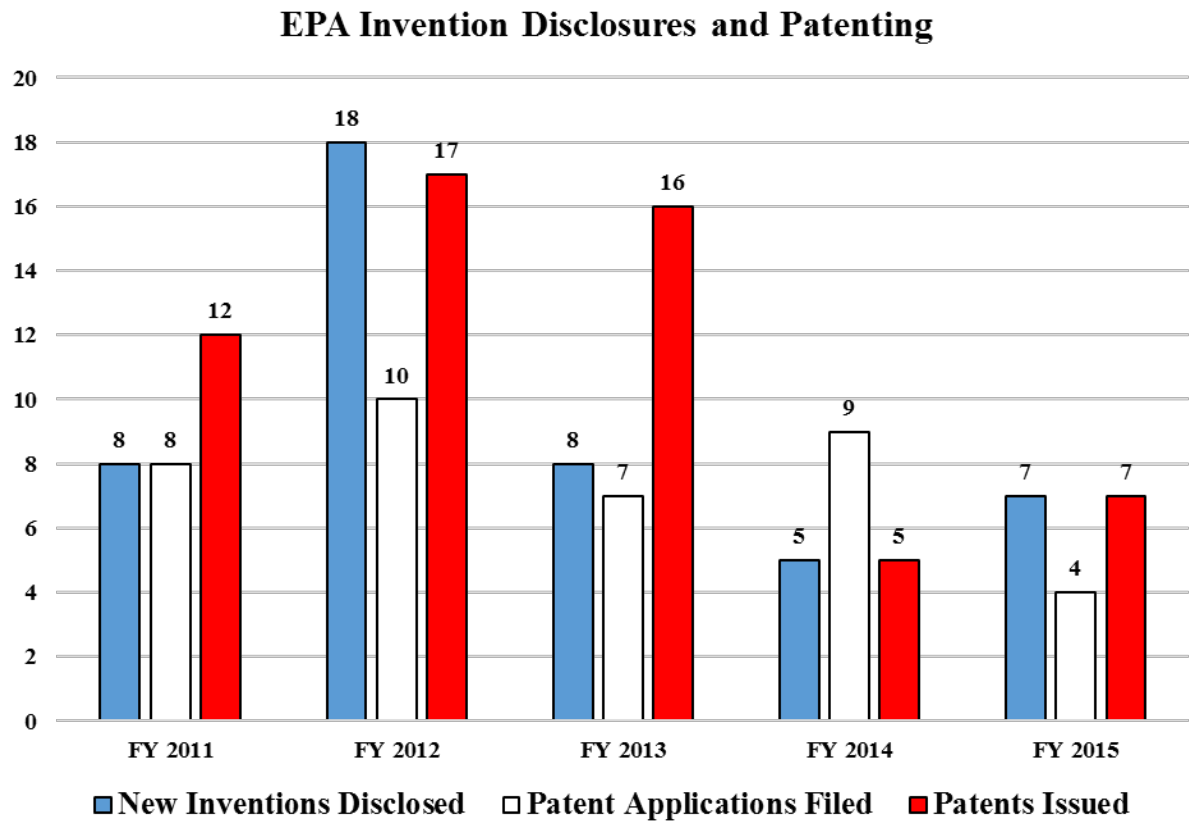
Partners in the FTTA Program have the benefit of collaborating with world-class EPA scientists involved in leading-edge research. Collaboration enhances the quality of research projects and helps move environmental technologies into the marketplace, resulting in better protection of human health and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

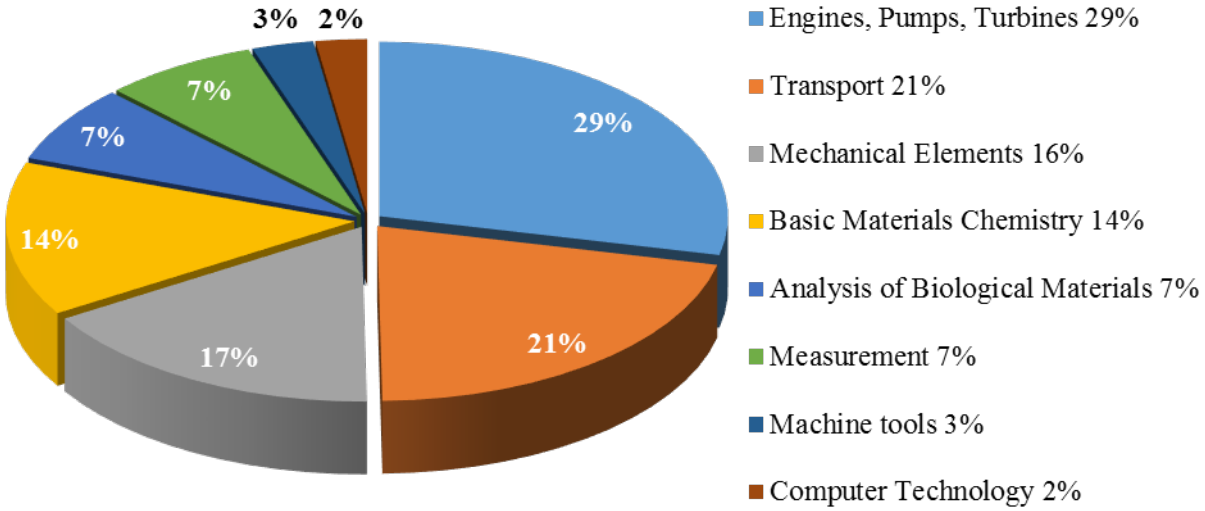
Between FY 2011 and FY 2015, the number of new inventions disclosed hovered between 5 and 8, with an outlier of 18 in FY 2012. The number of patent applications filed experienced a 50% decrease. The number of patents issued during this five-year period decreased by 42% from 12 in FY 2011 to 7 patents in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	8	18	8	5	7
Patent Applications Filed	8	10	7	9	4
Patents Issued	12	17	16	5	7

Patents issued to EPA in FY 2015 covered many technology areas including engines, pumps, turbines (29%), transport (21%), mechanical elements (16%), basic materials chemistry (14%), and analysis of biological materials (7%).[44]

USPTO Patents Assigned to EPA by Technology Area: FY 2015[45]



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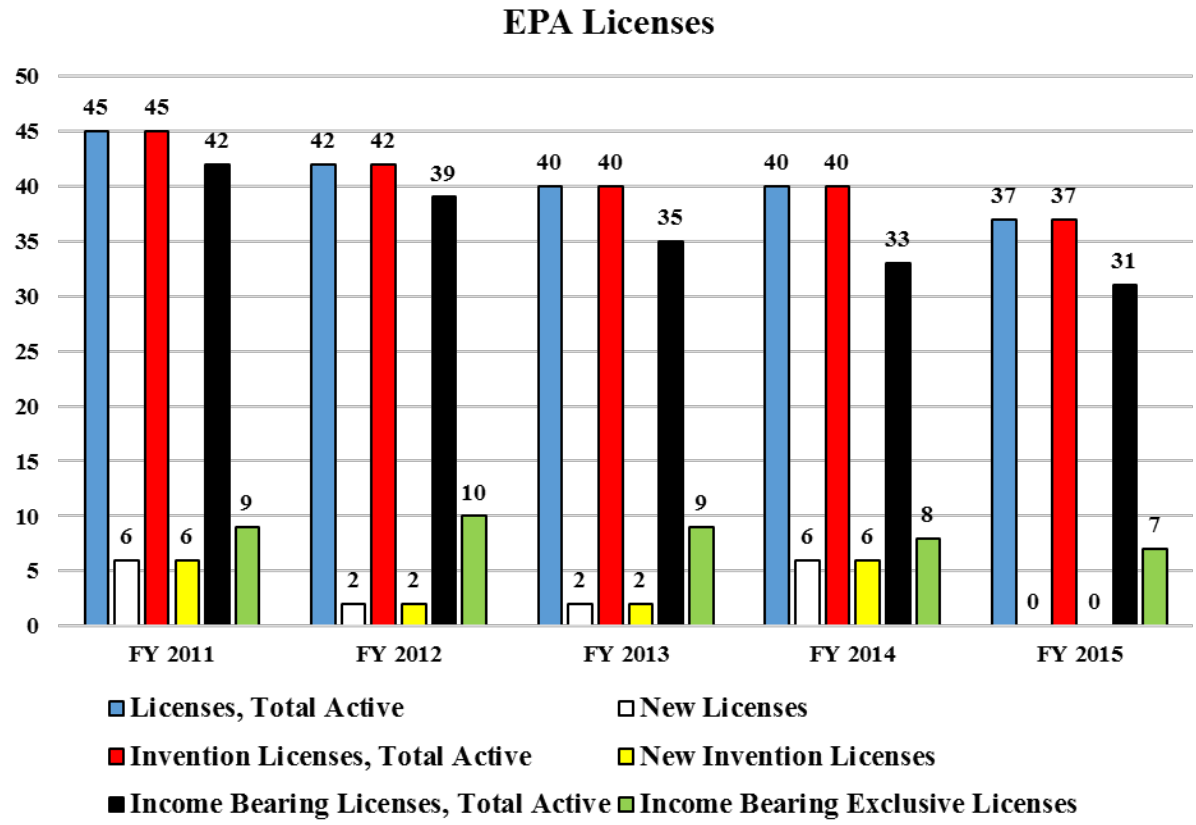
EPA Licenses

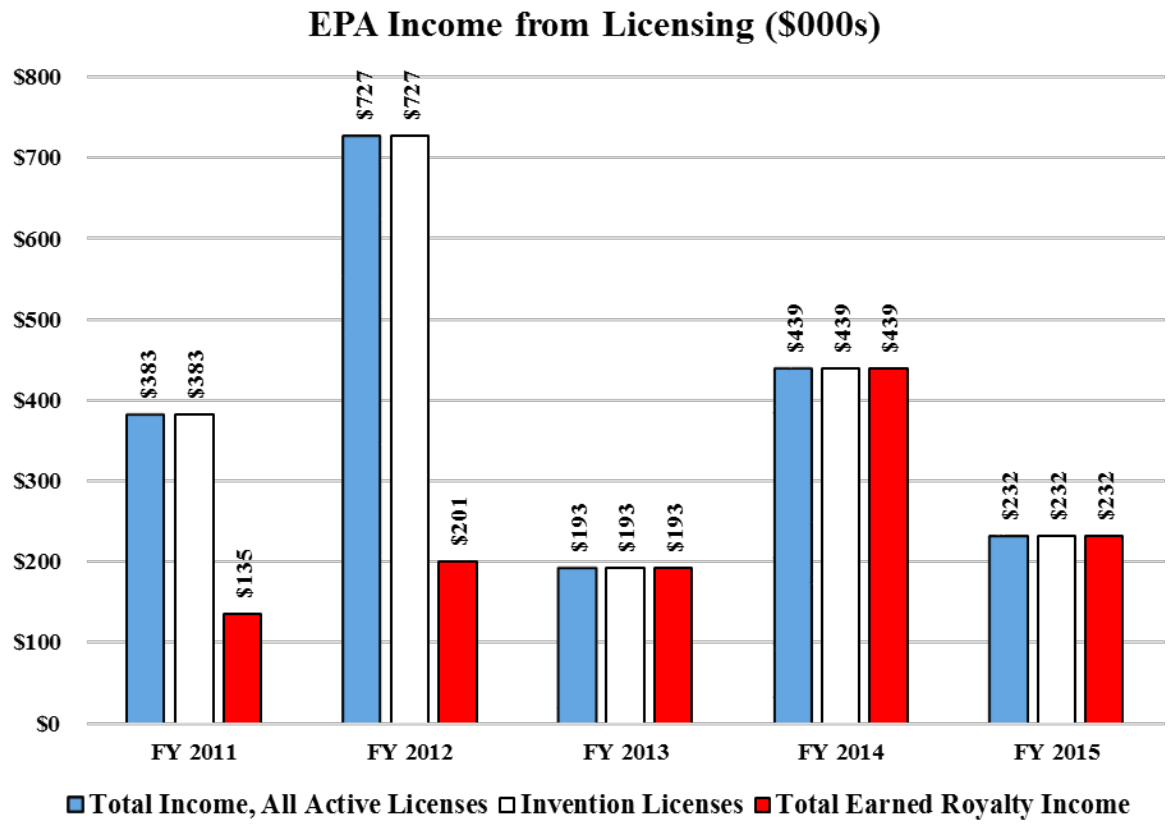
Between FY 2011 and FY 2015, the number of total active licenses decreased by 18% from 45 to 37 licenses in FY 2015. New licenses went from a high of 6, to a low of zero in FY 2015. Total active income bearing licenses has fallen every year since FY 2011.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	45	42	40	40	37
New Licenses	6	2	2	6	0
Invention Licenses, Total Active	45	42	40	40	37
New Invention Licenses	6	2	2	6	0
Income Bearing Licenses, Total Active	42	39	35	33	31
Income Bearing Exclusive Licenses	9	10	9	8	7

EPA Income from Licensing

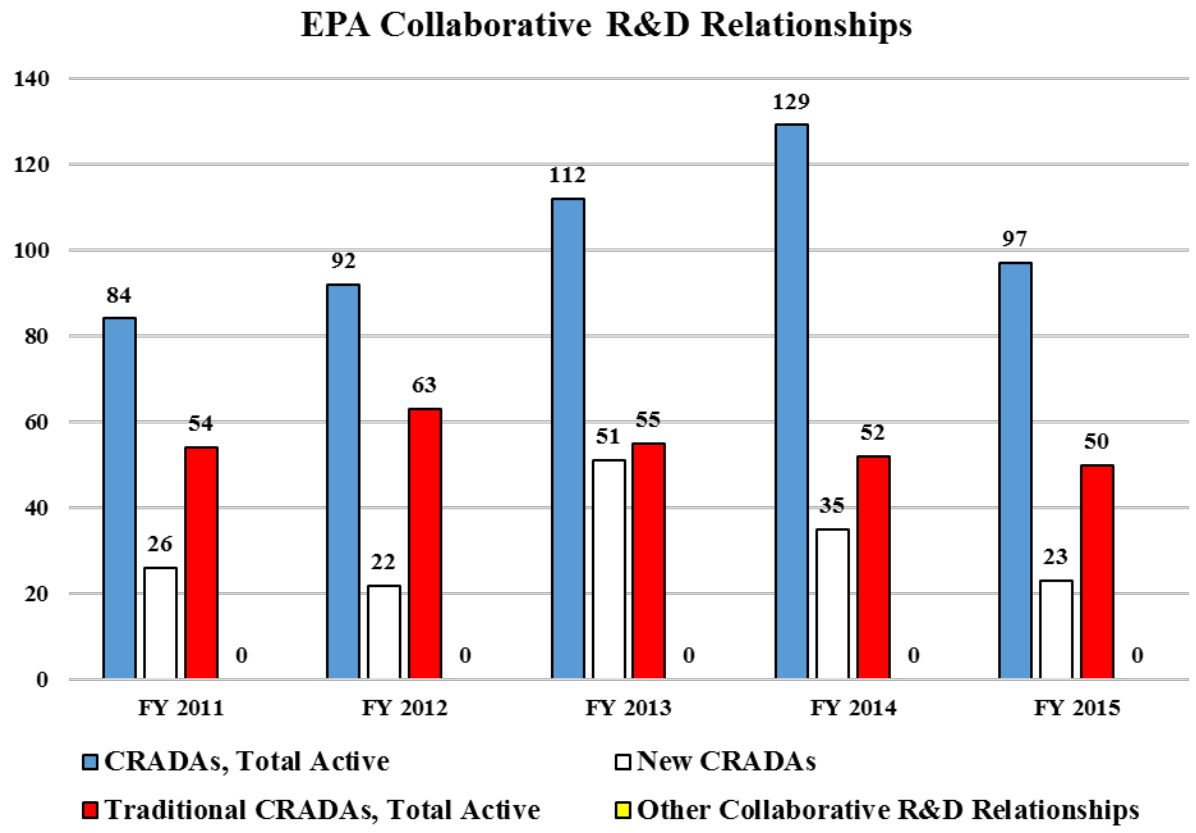
Between FY 2011 and FY 2015, total income from all active licenses decreased by 39% from $383 thousand to $232 thousand in FY 2015. The income from invention licenses decreased by the same amount, as all income from licenses came from invention licenses. Total earned royalty income increased 72% from $135 thousand in FY 2011 to $232 thousand in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses	$383	$727	$193	$439	$232
Invention Licenses	$383	$727	$193	$439	$232
Total Earned Royalty Income	$135	$201	$193	$439	$232

EPA Collaborative R&D Relationships

Between FY 2011 and FY 2015, the number of total active CRADAs increased 15% to 97 agreements from a previous 84 in FY 2011. The number of new CRADAs per fiscal year decreased by 12% to 23 new agreements in FY 2015. Total active traditional CRADAs decreased by 7% during the five-year period, totaling 50 agreements in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	84	92	112	129	97
New CRADAs	26	22	51	35	23
Traditional CRADAs, Total Active	54	63	55	52	50
Other Collaborative R&D Relationships	0	0	0	0	0

EPA Efforts to Streamline Technology Transfer Operations

EPA is 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

Advancing Air Quality Sensing Technology

EPA has a five-year Cooperative Research and Development Agreement (CRADA) with Aclima, Inc., an emerging California-based technology company, to advance next generation air quality sensing technology and provide more mobile and less expensive air sensing capabilities for citizens, communities, air quality managers, businesses, and others interested in air quality issues. The agreement was signed in April 2013.

EPA has an active research program in developing and evaluating sensor technology to measure air quality. The Agency's scientists are experts in developing and evaluating air quality methods and the application of those methods to understanding the relationships between air pollution and exposures and health. Aclima's expertise is developing and manufacturing indoor, outdoor, and mobile air sensor networks and deploying sensors to better understand indoor and outdoor air quality. They specialize in managing, analyzing, visualizing, and communicating the data they generate to inform decision making.

The CRADA's research efforts are focused in three broad areas:

- Developing and evaluating a low-cost, highly portable sensor for directly measuring fine and coarse particulate matter (PM) in indoor and outdoor settings in real-time;
- Measuring multiple indoor and outdoor air pollutants using stationary and mobile sensor platforms, including air sensors mounted on vehicles;
- Developing and evaluating sensors to detect chemical components of air pollutants, including black carbon, and non- and semi-volatile PM.

The goal of this research is to address the substantial technical challenges of developing high quality and verifiable data collection by air sensor technologies to protect public health. Study results will be made available by publication in peer-reviewed scientific journals.

This research will improve the ability to collect data on air pollutants needed by decision makers at EPA and states to support National Ambient Air Quality Standards. It will also help determine what types of sensors work best, and how they can be used in indoor and outdoor environments and on vehicles. Study results will provide information about how these new mobile sensors perform in comparison to reference instruments on mobile platforms and at stationary sites. Sensors will also enable individuals and communities to increase their awareness of air quality issues.

With inexpensive and reliable mobile and stationary measurement capabilities, EPA aims to obtain reliable data at a lower cost that can be used to:

- Evaluate and apply air quality modeling techniques to better understand air quality and the relationship between air quality and climate change;
- Support research to understand more about how we are exposed to air pollutants and the distribution of these exposures as they relate to health effects;
- Provide key information to support the development of cost effective and efficient emissions management control practices.

For more information about EPA's Air Research Program, visit http://epa.gov/airscience/next-generation-air-measuring.htm

Revamping EPA's FTTA Website to Better Reach Potential Partners

To better reach out to potential research partners and licensees, as well as to enhance the information available to EPA scientists and partners, the FTTA program conducted a major overhaul of its external website in FY14 and FY15.

The website, which can be found at www.epa.gov/ftta, was redesigned and expanded to include information on how EPA conducts collaborative research with nonfederal partners, protects intellectual property, licenses EPA's technologies, and generally advances the Federal Technology Transfer Act. This enhanced website focuses on providing resources to parties interested in collaborating with EPA on research and development projects. Specifically, the site provides background on the Program and legislation that spurs technology transfer efforts, provides detailed information on the processes for collaborating or licensing with EPA, and includes information on EPA's research facilities.

Additionally, the patent section was revamped, allowing businesses interested in licensing EPA technologies to view patented technologies by topic area, sort them by the more recently-issued patents, and to link to the actual patent on the U.S. Patent and Trademark Office website. Additionally, visitors to the site will be able to view more information on recently highlighted patents, which will be refreshed on an ongoing basis.

New and updated "success stories" are included on the website to provide real-world examples of the benefits of the collaborations between EPA and external parties. Additional links are provided to other resources, such as the annual reports to Congress on technology transfer, online training available on the Federal Laboratory Consortium (FLC) website, and other related EPA programs.

The FTTA Program hopes that the additional information included on the new website, written with the needs of external collaborators and licensees in mind, will better address the questions that potential partners may have. Through these collaborative efforts, we hope to expand the impact of the technology transfer program at EPA as well as enable beneficial outcomes for the protection of human health and the environment.

National Aeronautics and Space Administration (NASA)

Written into the founding legislation that created NASA in 1958 is a directive from Congress to ensure that the technologies created for space exploration and aeronautics benefit the whole of humanity. The agency's Technology Transfer Program is one of the many examples of how it meets that challenge.

NASA's Technology Transfer Program is a national asset. It brings together the agency's most capable problem-solvers with America's brightest commercial and entrepreneurial leaders in partnerships that transfer groundbreaking NASA technologies to the public. The program provides solutions for challenges in virtually every industry. It has two primary objectives: the identification, protection, and transfer of agency intellectual assets, and communication of the societal benefits resulting from NASA technology transfer. The program supports an office at each of NASA's ten field centers as well as an intellectual property management tool, the NASA Technology Transfer System (NTTS) and the Spinoff Program Office.

NASA's Technology Transfer Program proved extremely successful this year, with many significant advances in key areas. Multiple new initiatives were launched to coordinate the work of the NASA field centers under an agency-directed strategy that enables more efficient operations and ensures that more NASA technologies make their way into America's private sector. It has created tools that give the outside world a seamless and integrated interface with NASA. It has leveraged its technology portfolio's marketing collateral through numerous promising partnerships that will create new businesses that attract millions of dollars in seed funding for startup companies.

NASA has developed and executed a five-year plan designed to increase the rate, quality, and quantity of technology transfers to the private sector. The plan centers on seven core objectives:

1. Revise agency policies and strategies to ensure alignment with NASA's commitment to technology transfer best practices;
2. Increase new technology reporting;
3. Strategically acquire and manage intellectual property;
4. Market agency technology assets;
5. Develop and implement innovative methods for technology licensing;
6. Increase the release of NASA-developed software to new users; and
7. Build partnerships for technology development, transfer, and mutual benefit.

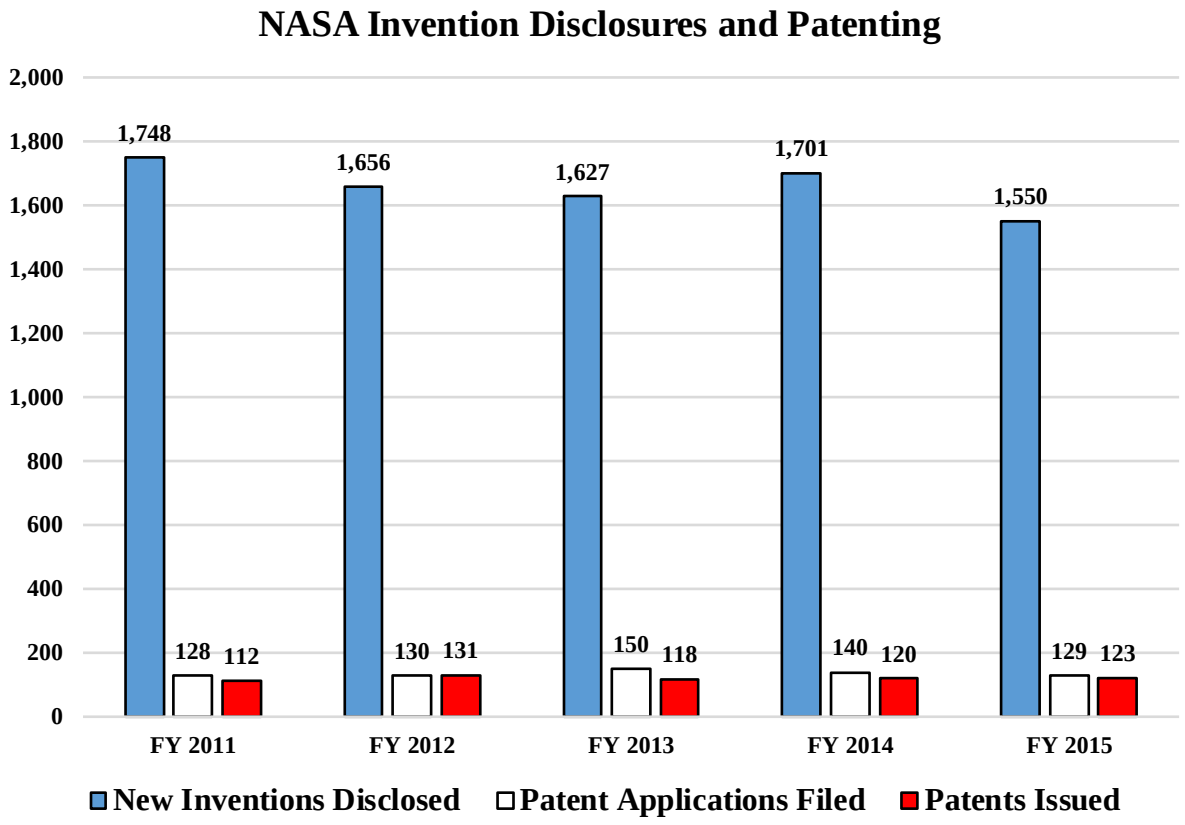
During fiscal year 2015, the fourth year of its plan, NASA has observed a "rising tide" across almost all data that track technology transfer successes: licenses of NASA inventions, software usage agreements, new technologies published, lowered barriers for those interested in finding and acquiring agency technology, and more. Its improving metrics across the board are the direct result of the agency's strategic approach to consolidating and managing its intellectual property portfolio, streamlining and simplifying processes and innovating in the field of technology transfer practices.

NASA’s annual technology transfer reports are 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[46]

Between FY 2011 and FY 2015, the number of new inventions disclosed decreased by 11% from 1,748 in FY 2011 to 1,550 disclosures in FY 2015. The number of patent applications filed increased by 1% to 129. The number of patents issued during this five-year period increased by 10% from 112 in FY 2011 to 123 patents in FY 2015.

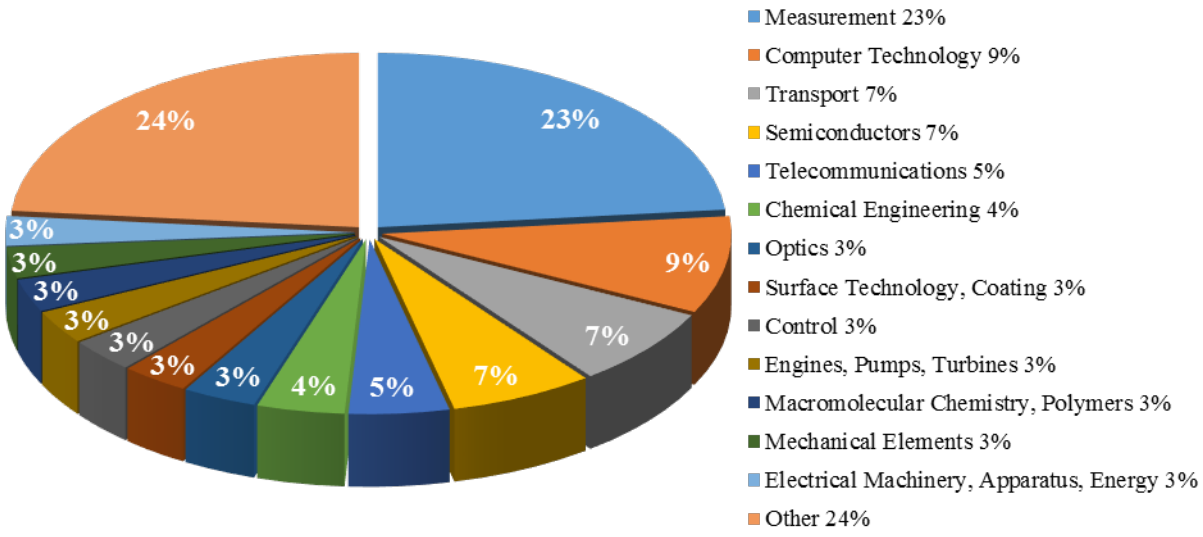


	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Inventions Disclosed	1,748	1,656	1,627	1,701	1,550
Patent Applications Filed	128	130	150	140	129
Patents Issued	112	131	118	120	123

[46] NASA has updated its data for improved accuracy. The changes allow for more accurate comparison with the other federal agencies and better reflect NASA's technology transfer activities, some of which are unique to the agency, such as NASA's use of Space Act Agreements for cooperative research and NASA's robust software release program.

Patents issued to NASA in FY 2015 covered many technology areas including measurement (23%), computer technology (9%), transport (7%), semiconductors (7%), telecommunications (5%) and chemical engineering (4%).[47]

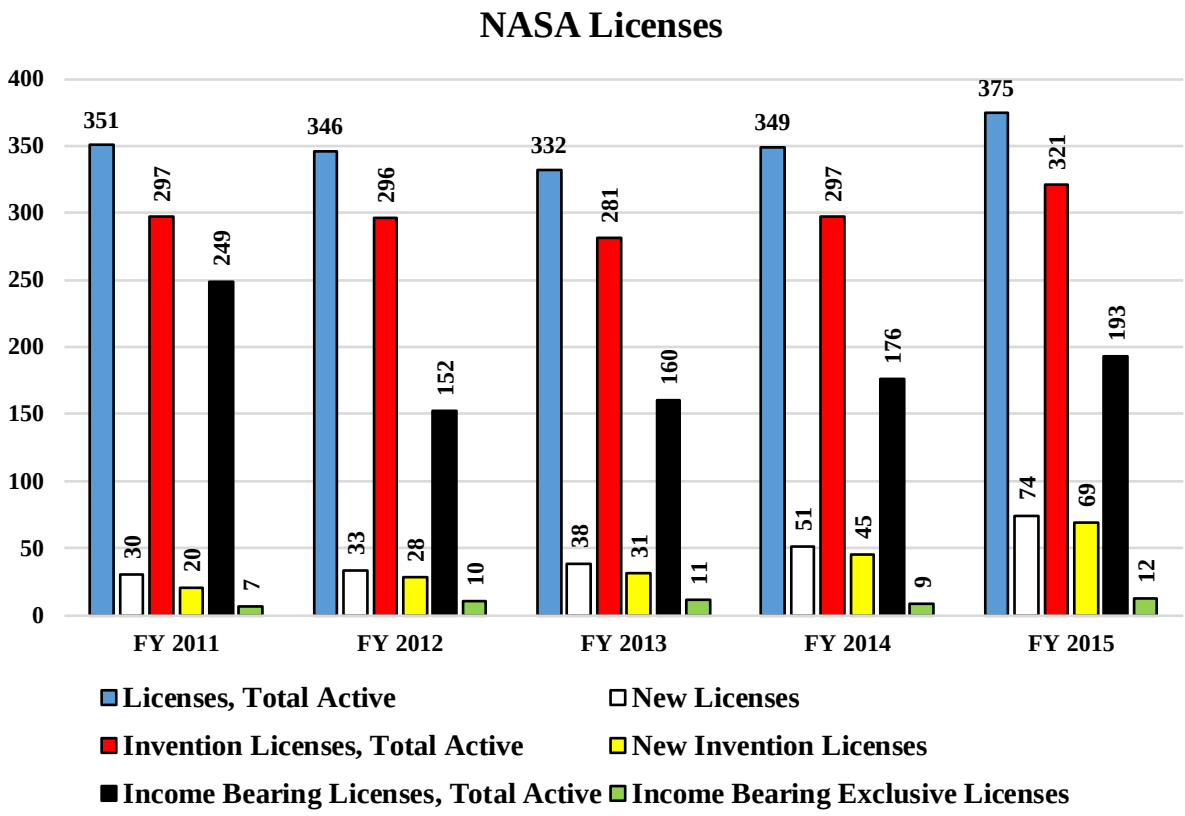
USPTO Patents Assigned to NASA by Technology Area: FY 2015



[47] Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT Spring 2016 edition (European Patent Office). Used with permission.

NASA Licenses

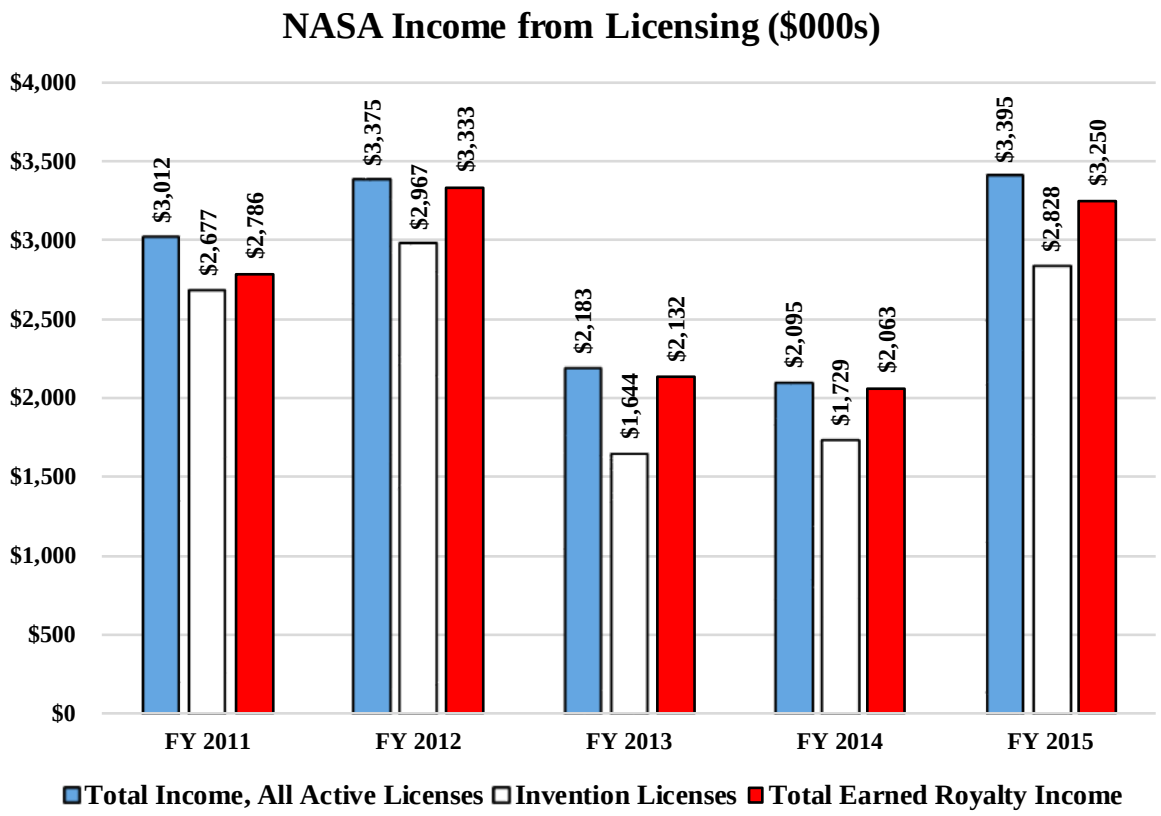
Between FY 2011 and FY 2015, the number of total active licenses increased by 7% from 351 in FY 2011 to 375 licenses in FY 2015. New licenses increased by 147% to 74 licenses from 30. The number of total active invention licenses increased by 8% from 297 to 321. New invention licenses increased 245%, from 20 to 69. Total active income bearing licenses decreased by 22%, from 249 to 193. The number of exclusive licenses increased by 71%, from 7to 12.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Licenses, Total Active	351	346	332	349	375
New Licenses	30	33	38	51	74
Invention Licenses, Total Active	297	296	281	297	321
New Invention Licenses	20	28	31	45	69
Income Bearing Licenses, Total Active	249	152	160	176	193
Income Bearing Exclusive Licenses	7	10	11	9	12

NASA Income from Licensing

Between FY 2011 and FY 2015, the total income from all active licenses increased by 13% from $3.012 million in FY 2011 to $3.395 million in FY 2015. The income from invention licenses increased by 6% to $2.828 million. Total earned royalty income increased 17% from $2.786 million in FY 2011 to $3.250 million in FY 2015.

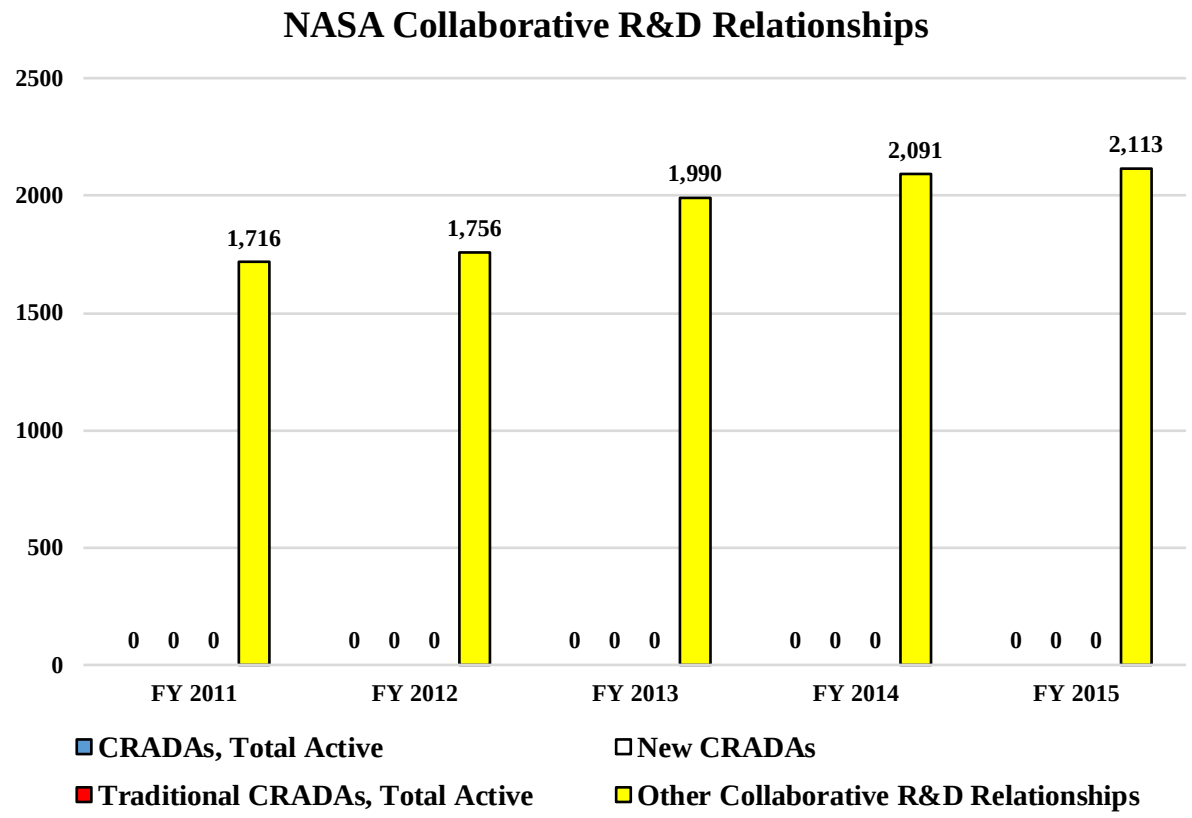


	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active	$3,012	$3,375	$2,183	$2,095	$3,395
Invention Licenses	$2,677	$2,967	$1,644	$1,729	$2,828
Total Earned Royalty Income	$2,786	$3,333	$2,132	$2,063	$3,250

NASA Collaborative R&D Relationships

The National Aeronautics and Space Act of 1958 provides NASA with the unique authority to enter into a wide range of "other transactions," commonly referred to as Space Act Agreements. NASA uses Space Act Agreements to engage in collaborative research projects with various partners to advance NASA's mission and program objectives, including international cooperative space activities. Space Act Agreements differ from traditional CRADA agreements and therefore in this report, Space Act Agreements are included under the category "Other Collaborative Agreements."

Between FY 2011 and FY 2015, the number of Space Act Agreements increased 23% from 1,716 agreements in FY 2011 to 2,113 in FY 2015.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs, Total Active	0	0	0	0	0
New CRADAs	0	0	0	0	0
Traditional CRADAs, Total Active	0	0	0	0	0
Other Collaborative R&D Relationships (Space Act Agreements)	1,716	1,756	1,990	2,091	2,113

Space Act Agreements	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Active Space Act Agreements	1,716	1,756	1,990	2,091	2,113
New Space Act Agreements Awarded	898	984	1,200	1,170	1,080
Cooperative Agreement	0	5	5	2	3
Funded Space Act Agreement	7		5	8	2
Interagency Agreement	223	263	330	380	330
Interagency Amendment	25	40	57	44	59
Interagency Umbrella Agreement/Annexes	44	76	70	58	65
International Agreement	4	7	5	1	1
Joint Sponsored Research Agreement	0	1			1
MOA/MOU	11	4	16	4	7
Space Act Agreement Amendment	59	102	146	163	140
Space Act Agreement	288	244	222	193	205
Technology Transfer Agreement	10	25	54	49	22
Umbrella Agreement/Annexes	227	217	289	268	245

Other Performance Measures Deemed Important by the Agency

Software Release

NASA reports the following software release data.

Software Release	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Software Usage Agreements					
New Software Usage Agreements Executed	1,068	1,316	1,368	1,685	2,107
Public Domain Release	38	29	56	218	303
US Release Only	521	787	665	699	930
Project Release	218	247	289	286	399
Interagency Release	79	99	110	146	167
NASA Release	81	104	166	181	174

NASA Downstream Success Stories

Now in its 40th year of publication, NASA's *Spinoff* annually highlights the best examples of technology transfer successes that making a positive impact in the world today. *Spinoff* 2016 featured 52 commercialized NASA technologies in the areas of health and medicine, transportation, public safety, consumer goods, energy and environment, information technology, and industrial productivity. These products and services came from a diverse group of companies—many of them small businesses—located in 24 states.

The technologies featured in *Spinoff* are creating jobs, developing new products/markets, increasing the industrial base of the country, producing billions of dollars in revenue, saving billions of dollars in costs and reducing the environmental impact of modern life. Spinoffs even save lives while improving the quality of life here on Earth, right now, in countless other ways. The 2,000 technologies featured in *Spinoff* since 1976 also illustrate to the American taxpayer that an investment in NASA yields numerous positive returns in secondary, tangible benefits.

The following *Spinoff* summaries highlight this year's accomplishments. The full text version of these stories, and more, can be found on the NASA Spinoff website: http://spinoff/nasa/gov.

Satellite Data Used to Stabilize Rice Markets, Enable Alternative Irrigation Practices
Applied Geosolutions, a small business, created web-based software under NASA funding. The software uses data from NASA satellites and others to generate real-time information about rice crops, including expected yields, throughout the growing season. Despite being one of the world's most important staple crops, rice has been a volatile commodity due to lack of reliable yield predictions, leading to price spikes, shortages, hunger, and unrest. The information gained from this NASA spinoff can be used by markets and public officials to stabilize markets and anticipate shortages. The system also helps farmers use alternative irrigation practices to save water and cut back on the amount of methane produced by rice farms – methane being one of the most powerful greenhouse gases.

Drug Tested on Space Station Treats Osteoporosis
Amgen, a biotechnology company, flew mice on three space shuttle-era missions to the International Space Station in partnership with NASA and BioServe Space Technologies. The mice were treated with antibodies designed to block a protein secreted by the body in microgravity that stops the strengthening of bones. One of the three antibodies tested became a key ingredient in Prolia, now a major pharmaceutical used to treat bone-density conditions, particularly osteoporosis. The results of the space-station testing helped validate the research Amgen did to gain federal approval for its drug.

Nanosatellites Provide Daily Picture of Earth for Mapping, Monitoring
Planet Labs, Inc., a small business, has garnered nearly $200 million in investment in order to release "flocks" of its nanosatellites into low Earth orbit, with the goal of providing full coverage of the Earth every 24 hours. Three former NASA employees started the Earth-imaging company using their experience developing and launching affordably built nanosatellites for the agency's PhoneSat project. Mobile-phone companies may use the fresh satellite data to improve maps in near-real time, insurance companies could verify homeowner damage claims following natural

disasters such as hurricanes, and environmental monitoring information could be used for mitigation planning and resource sustainability.

Software Predicts, Extends Life of Wind Turbines, Aircraft, and More
A NASA helicopter gear database was used to validate DigitalClone software, a product of the small business, Sentient Science, which predicts system performance and warns of upcoming failure aboard aircraft. Following validation, the company went commercial. Instead of years of physical testing to gather data, the program can accurately generate thousands of test points in just days. It's now used in the Hubble Space Telescope, several military aircraft programs, medical devices such as hip replacements, and more than 5,000 wind turbines belonging to eight operators. DigitalClone has helped reduce cost of wind energy and won the 2014 Tibbetts award, the government's highest recognition of outstanding achievements under the Small Business Innovation Research and Small Business Technology Transfer programs.

Mars Methane Detector Identifies Harmful Gas Leaks
To help determine whether Mars is, or ever was host to life, the Jet Propulsion Laboratory (JPL) invented the Tunable Laser Spectrometer (TLS) for measuring methane, which can be secreted by certain microbes. The TLS was found to be helpful for utility companies checking for gas leaks, which contribute to global warming and can cause explosions. Through a Space Act Agreement with Pipeline Research Council International, JPL created a methane detector that's easy to use and more sensitive and ergonomic than other technologies of its kind.

System-Health Monitor Predicts Failures Before They Happen
Inductive Monitoring System software developed by NASA is now part of a program that can monitor any system that has a normal baseline of behavior from which data can be collected, including mechanical, weather, and possibly biological systems. CEMSol, LLC, a small disadvantaged and economically disadvantaged women-owned small business, licensed the program, along with a software extension and the graphical user interface, to create its Integrated System Health Management (ISHM) software. The software spots anomalies in system behavior and predicts failures. In 2012 CEMSol, NASA's Ames Research Center and Lockheed Martin tried ISHM on the Hercules C-130 airplane. Lockheed Martin invested $70,000 in the test and quickly recouped 10 times as much in reduced maintenance costs and mission delays.

Chapter 3 Conclusion

Technology transfer is an active and essential mission of Federal R&D 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 R&D investments.

This report provides a summary of the technology transfer activities of all 11 Federal agencies that are actively involved in R&D. 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 an increase in invention disclosures and patenting activities over the five-year span from FY 2011 through FY 2015. During this period, Federal invention disclosures decreased by 8%, patent applications increased by 4%, and patents issued increased by 50%. In FY 2015, the largest number of Federal patents issued involved measurements (12%) followed by biotechnology (7%), pharmaceuticals (7%), computer technology (6%), other special machines (6%), electrical machinery (6%), and semiconductors (6%)

Between FY 2011 and FY 2015, total active licenses increased by 14%, new licenses decreased by 14%, invention licenses increased by 29%, new invention licenses increased by 38%, income-bearing licenses increased by 20%, and exclusive licenses decreased by 18%.[48] Income from all licensing increased by 21%, income from invention licenses increased by 32%, and total earned royalty income increased by 16%.

Federal collaborative R&D relationships increased by 19%, new CRADA agreements increased by 20%, traditional CRADA agreements increased by 3%, and nontraditional CRADA agreements increased by 17%.

In FY 2015, Federal researchers published 44,483 papers. More than half of these papers were in the fields of biological sciences (23%), medical sciences (20%), and physics (14%). In FY 2015, 14,470 papers cited in U.S. patents were authored or coauthored by Federal researchers. Of these papers, 78% involved research in the fields of biological sciences (43%), medical sciences (22%), and physics (12%).

Initial effort to determine the number of small businesses involved in Federal CRADA agreements reveals that out of the 4,710 traditional, Federal CRADA agreements from agencies that tracked small business participation, 16% involve small businesses as participants. Federal agencies also support small businesses through the licensing of technologies. Initial data reveal that of the 30,685 active, Federal licenses from agencies **that could identify company size**, 2% were issued to small businesses.

[48] DoD did not report "Income Bearing Exclusive Licenses for the FY 2013 to FY 2015 period.

Federally developed technologies are also transferred through the actions of 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. Review of preliminary data from four agencies identifies 93 companies that started between the years of 2010 and 2015, and have received critical technical support from Federal laboratories.

In summary, this report shows that agencies have made steady progress in their efforts to improve the transfer of technologies from Federal laboratories. By projecting trend lines for patents, invention licenses and CRADAs there is clear evidence that efforts to streamline and improve processes have been successful. Agencies are now engaged in efforts to assess the impact of these efforts to show how Federal technology transfer promotes economic growth, the creation of new products, and increased employment opportunities.

Appendix A

Federal Invention Disclosure and Patenting

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
USDA	New Inventions Disclosed	158	160	191	117	222
	Patent Applications Filed	124	122	157	119	125
	Patents Issued	49	69	65	83	94
DOC	New Inventions Disclosed	26	52	41	47	61
	Patent Applications Filed	17	25	26	25	30
	Patents Issued	16	14	21	19	20
DOD	New Inventions Disclosed	929	1,078	1,032	963	781
	Patent Applications Filed	844	1,013	942	916	884
	Patents Issued	523	1,048	648	670	623
DOE	New Inventions Disclosed	1,820	1,661	1,796	1,588	1,645
	Patent Applications Filed	868	780	944	1,144	949
	Patents Issued	460	483	554	693	755
HHS	New Inventions Disclosed	351	352	320	351	321
	Patent Applications Filed	272	233	230	216	222
	Patents Issued	270	453	428	335	501
DHS	New Inventions Disclosed	38	40	20	36	15
	Patent Applications Filed	12	10	4	5	7
	Patents Issued	0	0	4	3	4
DOI	New Inventions Disclosed	5	10	9	6	7
	Patent Applications Filed	2	3	8	4	8
	Patents Issued	1	3	4	2	3
DOT	New Inventions Disclosed	2	2	13	3	0
	Patent Applications Filed	2	1	5	0	5
	Patents Issued	0	4	1	1	1
VA	New Inventions Disclosed	191	335	273	290	221
	Patent Applications Filed	29	37	25	29	26
	Patents Issued	7	9	3	7	51

Federal Invention Disclosure and Patenting (continued)

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
EPA	New Inventions Disclosed	8	18	8	5	7
	Patent Applications Filed	8	10	7	9	4
	Patents Issued	12	17	16	5	7
NASA	New Inventions Disclosed	1,748	1,656	1,627	1,701	1,550
	Patent Applications Filed	128	130	150	140	129
	Patents Issued	112	131	118	120	123

Total	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
	New Inventions Disclosed	5,276	5,364	5,330	5,107	4,830
	Patent Applications Filed	2,306	2,364	2,498	2,607	2,389
	Patents Issued	1,450	2,231	1,862	1,938	2,182

Federal Licenses

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
USDA	Licenses, Total Active	358	384	400	414	424
	New Licenses	35	34	25	30	35
	Invention Licenses, Total Active	322	341	351	363	359
	New Invention Licenses	29	28	19	28	20
	Income Bearing Licenses, Total Active	354	379	397	412	421
	Income Bearing Exclusive Licenses	257	277	291	299	292
DOC	Licenses, Total Active	40	41	40	40	44
	New Licenses	5	6	5	7	13
	Invention Licenses, Total Active	40	41	40	40	44
	New Invention Licenses	5	6	5	7	13
	Income Bearing Licenses, Total Active	26	25	28	26	31
	Income Bearing Exclusive Licenses	12	12	15	15	17
DOD	Licenses, Total Active	633	520	527	430	560
	New Licenses	63	44	59	24	11
	Invention Licenses, Total Active	431	432	425	297	446
	New Invention Licenses	63	44	59	6	69
	Income Bearing Licenses, Total Active	214	356	264	223	213
	Income Bearing Exclusive Licenses	51	120	n/r	n/r	n/r
DOE	Licenses, Total Active	5,310	5,328	5,217	5,861	6,310
	New Licenses	822	757	567	573	648
	Invention Licenses, Total Active	1,432	1,428	1,353	1,560	1,336
	New Invention Licenses	169	192	153	171	155
	Income Bearing Licenses, Total Active	3,510	3,340	3,709	4,215	4,577
	Income Bearing Exclusive Licenses	315	344	199	141	98
HHS	Licenses, Total Active	1,613	1,465	1,426	1,555	1,767
	New Licenses	264	231	184	212	279
	Invention Licenses, Total Active	414	1,090	1,069	1,186	1,354
	New Invention Licenses	106	192	152	117	232
	Income Bearing Licenses, Total Active	849	809	809	845	843
	Income Bearing Exclusive Licenses	27	24	125	34	119
DHS	Licenses, Total Active	0	0	0	2	4
	New Licenses	0	0	0	0	3
	Invention Licenses, Total Active	0	0	0	2	4
	New Invention Licenses	0	0	0	0	3
	Income Bearing Licenses, Total Active	0	0	0	1	4
	Income Bearing Exclusive Licenses	0	0	0	0	0

Federal Licenses (continued)

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
DOI	Licenses, Total Active	25	26	20	18	20
	New Licenses	2	1	3	0	3
	Invention Licenses, Total Active	23	24	20	16	18
	New Invention Licenses	2	1	3	0	3
	Income Bearing Licenses, Total Active	22	22	16	15	18
	Income Bearing Exclusive Licenses	3	12	4	5	7
DOT	Licenses, Total Active	3	3	3	1	2
	New Licenses	1	1	0	0	1
	Invention Licenses, Total Active	3	3	0	0	0
	New Invention Licenses	0	0	0	0	0
	Income Bearing Licenses, Total Active	3	2	3	1	2
	Income Bearing Exclusive Licenses	1	0	0	1	0
VA	Licenses, Total Active	192	197	194	197	200
	New Licenses	11	8	9	3	3
	Invention Licenses, Total Active	192	197	203	197	200
	New Invention Licenses	11	8	9	3	3
	Income Bearing Licenses, Total Active	12	9	13	14	16
	Income Bearing Exclusive Licenses	8	9	10	9	11
EPA	Licenses, Total Active	45	42	40	40	37
	New Licenses	6	2	2	6	0
	Invention Licenses, Total Active	45	42	40	40	37
	New Invention Licenses	6	2	2	6	0
	Income Bearing Licenses, Total Active	42	39	35	33	31
	Income Bearing Exclusive Licenses	9	10	9	8	7
NASA	Licenses, Total Active	351	346	332	349	375
	New Licenses	30	33	38	51	74
	Invention Licenses, Total Active	297	296	281	297	321
	New Invention Licenses	20	28	31	45	69
	Income Bearing Licenses, Total Active	249	152	160	176	193
	Income Bearing Exclusive Licenses	7	10	11	9	12

Total	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
	Licenses, Total Active	8,570	8,352	8,199	8,907	9,743
	New Licenses	1,239	1,117	892	906	1,070
	Invention Licenses, Total Active	3,199	3,894	3,782	3,998	4,119
	New Invention Licenses	411	501	433	383	567
	Income Bearing Licenses, Total Active	5,281	5,133	5,434	5,961	6,349
	Income Bearing Exclusive Licenses	690	818	664	521	563

Federal Income from Licensing ($000s)

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
USDA	Total Income, All Active Licenses	$3,989	$3,806	$4,386	$4,928	$5,070
	Invention Licenses	$3,855	$3,671	$4,054	$4,733	$4,845
	Total Earned Royalty Income, (ERI)	$3,137	$3,060	$3,354	$3,611	$3,510
DOC	Total Income, All Active Licenses	$277	$248	$151	$220	$164
	Invention Licenses	$277	$248	$151	$220	$164
	Total Earned Royalty Income, (ERI)	$277	$248	$151	$220	$164
DOD	Total Income, All Active Licenses	$15,682	$7,055	$21,575	$10,890	$8,482
	Invention Licenses	$15,364	$6,552	$20,859	$10,890	$8,482
	Total Earned Royalty Income, (ERI)	$7,702	$6,335	$20,438	$10,890	$8,482
DOE	Total Income, All Active Licenses	$44,728	$40,849	$39,573	$37,885	$33,137
	Invention Licenses	$40,600	$36,103	$36,068	$32,869	$28,966
	Total Earned Royalty Income, (ERI)	$27,107	$28,735	$27,669	$23,321	$21,245
HHS	Total Income, All Active Licenses	$98,453	$110,576	$116,448	$137,249	$151,727
	Invention Licenses	$82,842	$108,308	$103,664	$133,814	$147,512
	Total Earned Royalty Income, (ERI)	$96,605	$110,930	$116,601	$116,765	$114,102
DHS	Total Income, All Active Licenses	$0	$0	$0	$3	$6
	Invention Licenses	$0	$0	$0	$0	$0
	Total Earned Royalty Income, (ERI)	$0	$0	$0	$3	$6
DOI	Total Income, All Active Licenses	$115	$76	$96	$58	$106
	Invention Licenses	$115	$76	$96	$58	$106
	Total Earned Royalty Income, (ERI)	$104	$65	$96	$58	$106
DOT	Total Income, All Active Licenses	$18	$7	$9	$23	$12
	Invention Licenses	$15	$7	$12	$0	$0
	Total Earned Royalty Income, (ERI)	$8	$6	$12	$23	$12
VA	Total Income, All Active Licenses	$401	$391	$146	$376	$329
	Invention Licenses	$401	$391	$146	$376	$329
	Total Earned Royalty Income, (ERI)	$401	$392	$390	$376	$329
EPA	Total Income, All Active Licenses	$383	$727	$193	$439	$232
	Invention Licenses	$383	$727	$193	$439	$232
	Total Earned Royalty Income, (ERI)	$135	$201	$193	$439	$232

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

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
NASA	Total Income, All Active Licenses	$3,012	$3,375	$2,183	$2,095	$3,395
	Invention Licenses	$2,677	$2,967	$1,644	$1,729	$2,828
	Total Earned Royalty Income, (ERI)	$2,786	$3,333	$2,132	$2,063	$3,250

Total	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
	Total Income, All Active Licenses	$167,058	$167,110	$184,760	$194,166	$202,660
	Invention Licenses	$146,529	$159,050	$166,887	$185,128	$193,464
	Total Earned Royalty Income, (ERI)	$130,456	$146,970	$161,488	$157,769	$151,438

Federal Collaborative R&D Relationships

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
USDA	CRADAs, Total Active	292	274	259	267	301
	New CRADAs	102	65	86	60	80
	Traditional CRADAs, Total Active	207	211	211	193	188
	Other Collaborative R&D Relationships	13,458	14,351	16,102	15,706	15,439
DOC	CRADAs, Total Active	2,245	2,410	2,428	2,359	2,751
	New CRADAs	2,192	2,844	2,289	2,111	2,548
	Traditional CRADAs, Total Active	99	153	196	206	315
	Other Collaborative R&D Relationships	2,899	2,782	2,977	3,031	3,172
DOD	CRADAs, Total Active	2,554	2,400	2,682	2,762	2,148
	New CRADAs	762	757	769	671	793
	Traditional CRADAs, Total Active	1,685	1,328	2,682	2,281	1,601
	Other Collaborative R&D Relationships	988	0	606	581	1,389
DOE	CRADAs, Total Active	720	742	742	745	734
	New CRADAs	178	184	142	180	184
	Traditional CRADAs, Total Active	720	742	742	745	734
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	430	377	427	532	400
	New CRADAs	81	93	104	98	112
	Traditional CRADAs, Total Active	284	245	313	378	202
	Other Collaborative R&D Relationships	0	0	114	154	150
DHS	CRADAs, Total Active	62	94	114	158	230
	New CRADAs	31	53	76	88	98
	Traditional CRADAs, Total Active	55	89	91	121	200
	Other Collaborative R&D Relationships	11	11	6	31	30
DOI	CRADAs, Total Active	351	379	476	601	826
	New CRADAs	295	284	376	423	586
	Traditional CRADAs, Total Active	22	28	21	35	38
	Other Collaborative R&D Relationships	209	283	322	292	318
DOT	CRADAs, Total Active	25	29	40	51	48
	New CRADAs	8	12	8	10	9
	Traditional CRADAs, Total Active	0	3	3	7	48
	Other Collaborative R&D Relationships	39	14	26	30	35

Federal Collaborative R&D Relationships (continued)

Agency	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
VA	CRADAs, Total Active	1,477	1,510	1,550	2,317	2,305
	New CRADAs	450	522	453	505	509
	Traditional CRADAs, Total Active	1,444	1,430	1,550	1,618	1,334
	Other Collaborative R&D Relationships	0	0	0	0	0
EPA	CRADAs, Total Active	84	92	112	129	97
	New CRADAs	26	22	51	35	23
	Traditional CRADAs, Total Active	54	63	55	52	50
	Other Collaborative R&D Relationships	0	0	0	0	0
NASA	CRADAs, Total Active	0	0	0	0	0
	New CRADAs	0	0	0	0	0
	Traditional CRADAs, Total Active	0	0	0	0	0
	Other Collaborative R&D Relationships	1,716	1,756	1,990	2,091	2,113

Total	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
	CRADAs, Total Active	8,240	8,307	8,830	9,921	9,840
	New CRADAs	4,125	4,836	4,354	4,181	4,942
	Traditional CRADAs, Total Active	4,570	4,292	5,864	5,636	4,710
	Other Collaborative R&D Relationships	19,320	19,197	22,143	21,916	22,646

Appendix B

Technology Area Classifications

Mapping of International Patent Classifications to Technology Area[49]

Analysis of Biological Materials – Includes the investigation or analysis of specific methods not covered by other groups. Materials analyzed include: food, water, metals, explosives, oils, paints, paper, textiles, concrete, resins, wood, and biological material.

Audio-Visual Technology – Includes but is not limited to: advertising, signs, labels or name-plates, seals, arrangements or circuits for control of indicating devices using static means to present variable information, scanning details of television systems, color television systems, still video cameras, loudspeakers, microphones, stereophonic systems, and printed circuits.

Basic Communication Processes – Includes but is not limited to: generation of oscillations, modulation, amplifiers, control of amplification, impedance networks, tuning resonant circuits, pulse technique, and general coding, decoding, or code conversion.

Basic Materials Chemistry – Includes but is not limited to: preservation of bodies of humans or animals or plants, nitrogenous fertilizers, explosive or thermic compositions, detonating or priming devices, means for generating smoke or mist, manufacture of matches, organic dyes, coating compositions, natural resins, preparation of glue, adhesives, drying or working-up or peat, cracking hydrocarbon oils, production of acetylene by wet methods, lubrication compositions, and detergent compositions.

Biotechnology – Includes but is not limited to: compounds of unknown constitution, peptides, apparatus for enzymology or microbiology, micro-organisms or enzymes, fermentation or enzyme-using processes to synthesize a desired chemical compound or composition or to separate optical isomers from a racemic mixture, and measuring or testing processes involving enzymes or micro-organisms.

Chemical Engineering – Includes but is not limited to: boiling, evaporating, sublimation, cold traps, crystallization, solvent extraction, displacing liquid, degasification of liquids, filters comprising of loose filtering material, cartridge filters of the throw-away type, processes of filtration, regeneration of the filtering material or filter elements outside the filter for liquid or gaseous fluids, separation of different isotopes of the same chemical element, chemical or physical laboratory apparatus for general use, separating solid materials using liquids or using pneumatic tables or jigs, centrifuges, flotation, spraying apparatus, treating textile materials by liquids, bleaching, drying solid materials or objects by removing liquid therefrom, and plasma technique.

[49] Derived from The World Intellectual Property Organization's International Patent Classification (IPC) Correspondence Table (http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/xls/ipc_technology.xls) and IPC Searchable Classification Database, Version 2016.01 (http://web2.wipo.int/classifications/ipc/ipcpub/#refresh=page).

Civil Engineering – Includes but is not limited to: construction of roads, sports ground, platforms and refuge islands, landing stages for helicopters, machines for making railways, bridges, devices providing protection against weather, street cleaning, ship-lifting devices, foundations, excavations, embankments, dredging, water installation, sewers, water-closets or urinals with flushing devices, general building constructions, building materials, skylights, gutters, stairs, floors, locks, handcuffs, swimming pools, hinges for doors, windows, or wings, safes or strong-rooms for valuables, bank protection devices, ladders, earth or rock drilling, mining or quarrying, large underground chambers, and safety devices.

Computer Technology – Includes but is not limited to: digital computers in which all the computation is effected mechanically, digital fluid-pressure computing devices, optical computing devices, electric digital data processing, analog computers, recognition of data, counting mechanisms, image data processing or generation, speech analysis or synthesis, speech recognition, and static stores.

Control – Includes but is not limited to: systems for controlling or regulating non-electric variables, ticket-issuing apparatus, time or attendance registers, handling or coins or of paper currency or similar valuable papers, con-freed or like apparatus, signaling or calling systems, traffic control systems, educational or demonstration appliances, ciphering or deciphering apparatus for cryptographic or other purposes involving the need for secrecy, and railway or like time or fare tables.

Digital Communication – Includes but is not limited to: transmission of digital information, selective content distribution, and wireless communication networks.

Electrical Machinery, Apparatus, Energy – Includes but is not limited to: incandescent mantles, lighting devices or systems, nonportable lighting devices or systems, cables, conductors, insulators, magnets, inductances, transformers, capacitors, electric switches, electric discharge tubes or discharge lamps, electric incandescent lamps, spark gaps, emergency protective circuit arrangements, dynamo-electric machines, electric heating, static electricity, and generation of electric power by conversion of Ingra-red radiation, visible light, or ultraviolet light.

Engines, Pumps, Turbines – Includes but is not limited to: steam engines, rotary-piston or oscillating-piston machines or engines, steam engine plants, cyclically operating valves for machines or engines, lubricating of machines or engines in general, cooling of machines or engines in general, internal-combustion piston engines, gas-turbine plants, jet-propulsion plants, starting of combustion engines, machines or engines for liquids, wind motors, positive- and non-positive displacement pumps, generating combustion products of high pressure or high velocity, fusion reactors, nuclear reactors, nuclear power plant, conversion of chemical elements, obtaining energy from radioactive sources, and nuclear explosives.

Environmental Technology – Includes but is not limited to: fire-fighting, separating dispersed particles from gases, combinations of devices for separating particles from gases or vapors, disposal of solid waste, reclamation of contaminated soil, gathering or removal of domestic or like refuse, water treatment, cremation furnaces, and measurement of nuclear or x-radiation.

Food Chemistry – Includes but is not limited to: new plants or processes for obtaining them, treatment of flour or dough for baking, preserving by canning, dairy products, edible oils or pats, coffee, tea, cocoa, coca products, protein compositions for foodstuffs, feeding-stuffs specially adapted for animals, brewing of beer, recovery of by-products of fermented solutions, wine, preparation of vinegar, production of sugar juices, extraction of sucrose from molasses, and drying sugar.

Furniture, Games – Includes but is not limited to: tables, desks, office furniture, chairs, child furniture, special furniture, household or table equipment, furnishings for windows or doors, kitchen equipment, sanitary equipment, toilet accessories, domestic washing or cleaning, apparatus for physical training, design or layout of courts, bowling games, card games, indoor games, merry-go-rounds, swings, toys, devices for theaters and circuses, racing and riding sports equipment and accessories.

Handling – Includes but is not limited to: labeling or tagging machines, containers for storage or transport of articles of materials, transport or storage devices, handling thick or filamentary material, elevators, escalators, moving walkways, cranes, capstans, winches, tackles, pulley blocks, hoists, applying closure members to bottles, and filling or emptying of bottles, jars, cans, casks, barrels, or similar containers.

IT Methods for Management – Includes data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory, or forecasting purposes.

Machine Tools – Includes but is not limited to: chemical means for extinguishing fires, rolling of metal, working or processing of metal wire, making forged or pressed metal products, making metal chains, making gears or toothed racks, thread cutting, soldering, welding, abrasive or related blasting with particulate material, tools for grinding, hand-held nailing or stapling tools, handles for hand implements, workshop equipment, saws for wood or similar material, working veneer or plywood, dovetailed work, removing bark or vestiges of branches, and accessory machines or apparatus for working wood or similar materials.

Macromolecular Chemistry, Polymers – Includes but is not limited to: polysaccharides, treatment or chemical modification of rubbers, derivatives of natural macromolecular compounds, use of inorganic or non-macromolecular organic substances as compounding ingredients, and compositions of macromolecular compounds.

Materials, Metallurgy – Includes but is not limited to: foundry molding, casting of metals, working metallic powder, non-metallic elements, ammonia compounds, cyanogen compounds, compounds of alkali metals, chemical composition of glasses, manufacture of iron or steel, processing of pig-iron, production or refining of metals, alloys, and changing the physical structure of non-ferrous metals or non-ferrous alloys.

Me**asurement** – Includes but is not limited to: measuring linear dimensions, measuring distances, surveying, navigation, gyroscopic instruments, measuring volume, weighing, measurement of mechanical vibrations, measurement of intensity or velocity, measuring temperature or quantity of heat, measuring force, testing static or dynamic balance of machines

or structures, sampling, investigating strength properties of solid materials by application of mechanical stress, investigating density or specific gravity of materials; investigating flow properties of materials, investigating or analyzing materials by use of optical or thermal means, and investigating or analyzing materials by the use of nuclear magnetic resonance, electron paramagnetic resonance or other spin effects.

Mechanical Elements – Includes but is not limited to: fluid-pressure actuators, fluid dynamics, devices for fastening or securing constructional elements or machine parts, shafts, couplings for transmitting rotation, springs, means for damping vibration, belts, cables, ropes, chains, fittings, gearing, pistons, cylinders, pressure vessels, valves, devices for venting or aerating, pipes, frames, casing, lubricating, safety devices in general, steam traps, gas-holders of variable capacity, vessels for containing or storing compressed gases, pipe-line systems, and control devices or systems insofar as characterized by mechanical features.

Medical Technology – Includes but is not limited to: diagnosis, surgery, identification, dentistry, veterinary instruments, filters implantable into blood vessels, physical therapy apparatus, containers specially adapted for medical or pharmaceutical purposes, methods or apparatus for sterilizing materials, devices for introducing media into or onto the body, electrotherapy, radiation therapy, ultrasound therapy, and x-ray technique.

Micro-Structural and Nano-Technology –Includes but is not limited to: micro-structural devices or systems, processes or apparatus specially adapted for the manufacture or treatment of micro-structural devices or systems, specific uses or applications of nano-structures, and nano-structures formed by manipulation of individual atoms, molecules, or limited collections of atoms or molecules as discrete units.

Optics – Includes but is not limited to: optical elements, spectacles, apparatus or arrangements for taking photographs, photosensitive materials for photographic purposes, apparatus for processing exposed photographic materials, photomechanical production of textured or patterned surfaces, electrography, devices used to stimulate emission, and holographic processes or apparatus.

Organic Fine Chemistry – Includes but is not limited to: cosmetics or similar toilet preparations, general methods of organic chemistry, acyclic or carbocyclic compounds, heterocyclic compounds, steroids, derivatives or sugars, nucleosides, nucleic acids, and combinatorial chemistry.

Other Consumer Goods – Includes but is not limited to: machines for making cigars, smoke filters, match boxes, shirts, corsets, outerwear, suspenders, artificial flowers, wigs, masks, feathers, hats and head coverings, characteristic features of footwear, buttons, pins, buckles, jewelry, coins, walking sticks, umbrellas, purses, luggage, hairdressing or shaving equipment, apparatus or methods for life-saving, bookbinding, filing appliances, implements for writing or drawing, apparatus or tools for artistic work, saddles, stirrups, upholstering methods, ropes or cables in general, musical instruments with associated blowing apparatus, and methods or devices for protecting against, or for damping, noise or other acoustic waves in general.

Other Special Machines – Includes but is not limited to: soil working in agriculture or forestry, planting, sowing, fertilizing, harvesting, mowing, threshing, cultivation of vegetables, manufacture of dairy products, animal husbandry, shoeing of animals, machines or equipment for making, slaughtering, processing meat, machines or apparatus for treating harvested fruit, preparing grain for milling, shaping clay or other ceramic compositions, working stone or stone-like materials, shaping or joining of plastics, additive manufacturing, manufacturing or shaping of glass, sugar extraction, weapons for projecting missiles without the use of explosive or combustible propellant charge, small arms, apparatus for launching projectiles or missiles from barrels, weapon sights, targets, explosive charges, blasting, and ammunition fuses.

Pharmaceuticals – Includes but is not limited to: preparations for dentistry, medicinal preparations characterized by special physical form, medicinal preparations containing organic and inorganic active ingredients, medicinal preparations containing peptides, preparations for testing in vivo, electrically conductive preparations for use in therapy or testing in vivo, radioactive non-metals and metals, specific therapeutic activity of chemical compounds or medicinal preparations, and containing or obtained from roots, bulbs, leaves, bark, seeds, grains, flowers, stems, branches, or twigs.

Semiconductors – Includes semiconductor devices and electric solid-state devices not otherwise provided.

Surface Technology, Coating – Includes but is not limited to: apparatus and processes for applying liquids or other fluent materials to surfaces, layered products, coating metallic material, enameling of metals, nonmechanical removal of metallic material from surfaces, cleaning or de-greasing of metallic material by chemical methods other than electrolysis, and single-crystal growth.

Telecommunications – Includes but is not limited to: transmission systems for measured values, waveguides, resonators, aerials, transmission, broadcast communication, multiplex communication, secret communication, jamming of communication, telephonic communication, and scanning, transmitting, or reproducing documents.

Textile and Paper Machines – Includes but is not limited to: appliances or methods for making clothes, manufacture of brushes, making articles of paper or cardboard, processes for the manufacture or reproduction of printing surfaces, typewriters, stamps, printing plates or foils, mechanical treatment of processing of leather in general, preliminary treatment of fibers, spinning or twisting, crimping or curling fibers, shedding mechanisms, auxiliary weaving apparatus, knitting, braiding or manufacturing of lace, sewing, embroidering, mechanical or pressure cleaning of carpets, decorating textiles, and paper-making machines.

Thermal Processes and Apparatus – Includes but is not limited to: methods of steam generation, superheating of steam, methods or apparatus for combustion using fluid or solid fuel, burners, grates, feeding fuel to combustion apparatus, regulating or controlling combustion, ignition, domestic stoves or ranges, air-conditioning, fluid heaters, ice production, steam or vapor condensers, other heat exchange apparatus, and cleaning of internal or external surfaces of heat-exchange or heat-transfer conduits.

Transport – Includes but is not limited to: vehicle wheels, vehicle tires, vehicle suspension arrangements, windows, windscreens, arrangement or mounting of propulsion units or of transmissions in vehicles, propulsion of electrically-propelled vehicles, power supply lines or devices along rails for electrically-propelled vehicles, vehicles adapted for load transportation, arrangement of signaling or lighting devices, vehicle brake control systems, air-cushion vehicles, locomotives, body details or kinds of railway vehicles, rail vehicle suspensions, shifting or shunting of rail vehicles, guiding railway traffic, hand-propelled vehicles, vehicles drawn by animals, trailers, cycle stands, cycle saddles or seats, brakes specially adapted for cycles, rider propulsion of wheeled vehicles or sledges, ships or other waterborne vessels, offensive or defensive arrangements on vessels, marine propulsion or steering, auxiliaries on vessels, lighter-than-air aircraft, airplanes, helicopters, equipment for fitting in or to aircraft, flying suites, parachutes, and cosmonautics.

Appendix C

Fields and Subfields of S&E Publications Data[50]

Agricultural Sciences: dairy animal sciences, agricultural and food sciences

Astronomy

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

Computer Sciences

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

Mathematics: applied mathematics, probability and statistics, general mathematics, miscellaneous mathematics

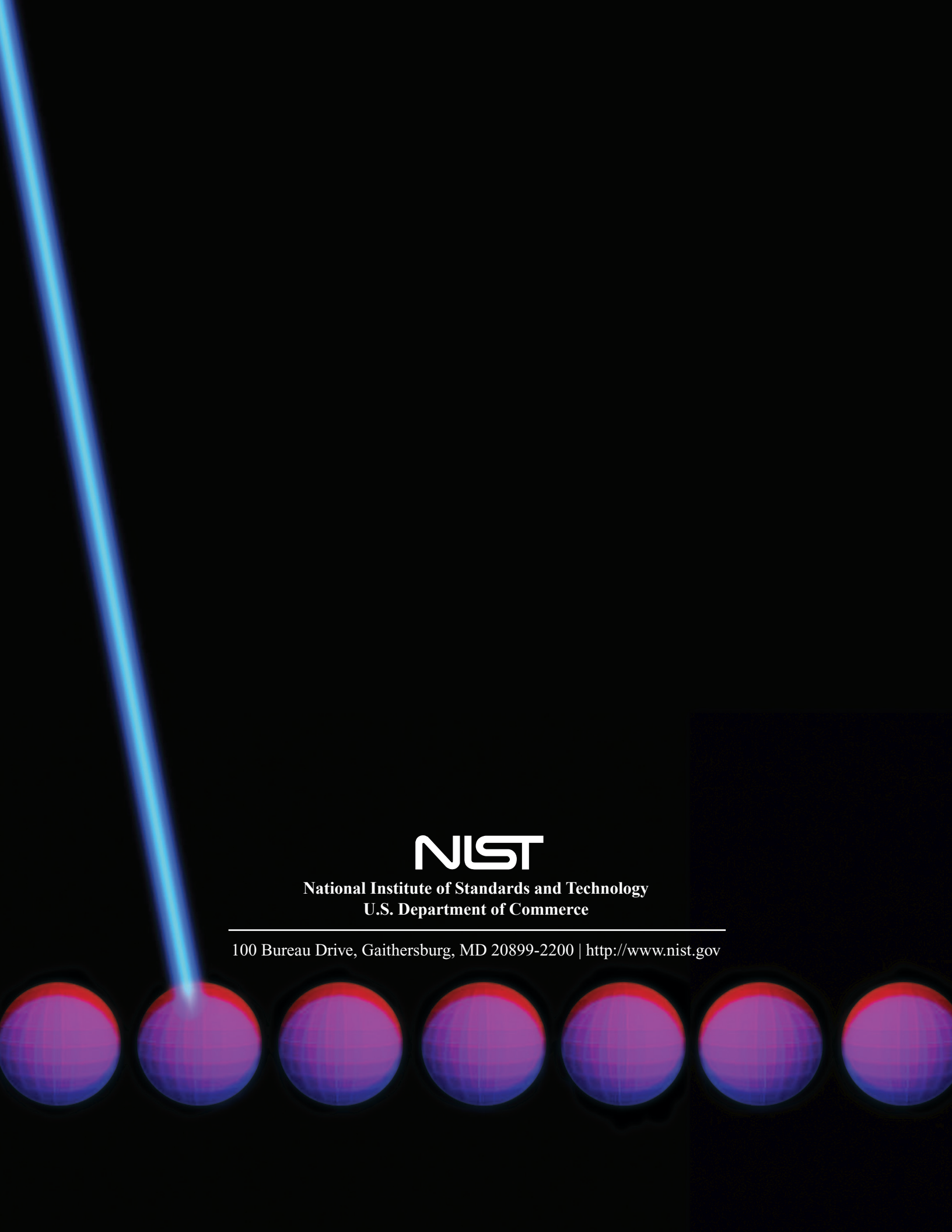
Medical Sciences: endocrinology, neurology and neurosurgery, dentistry, environmental and occupational health, public health, surgery, general and internal medicine, ophthalmology, pharmacy, veterinary medicine, miscellaneous clinical medicine, anesthesiology, cardiovascular system, cancer, gastroenterology, 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

Other Life Sciences: speech/language pathology and audiology, nursing, rehabilitation, health policy and services

[50] 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.

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

Social Sciences: economics, international relations, political science and public administration, demography, sociology, anthropology and archaeology, area studies, criminology, geography and regional sciences, planning and urban studies, general social sciences, science studies, gerontology and aging, social studies of medicine



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