Federal Laboratory Technology Transfer

Fiscal Year 2016

Summary Report to the President and the Congress

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

September 2019

This page intentionally left blank

FOREWORD

The Department of Commerce (DOC) is pleased to submit the Fiscal Year 2016 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 fundamental 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.

In 2018, the President's Management Agenda contained a Cross Agency Priority Goal to "Improve Transfers of Federally Funded Technologies from Lab-to-Market." As part of that effort, we have undertaken a program we call the Return on Investment Initiative. Under this initiative, the DOC National Institute of Standards and Technology is leading an effort to gather public input, examine our global competition, and examine how our underlying technology transfer structure and approach can be improved to maximize the return to the U.S. taxpayer for their investment in our Nation's research and development programs.

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 ongoing 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

This page intentionally left blank

Table of Contents

This page intentionally left blank

Chapter 1

Overview of Federal Technology Transfer

Many federal agencies conduct research and development (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 can 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 interagency coordination of efforts has led agencies to review their operations and propose new ways to improve the 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, 15 U.S.C. 3701 *et seq.*, the Patent and Trademark Act Amendments of 1980 (Bayh-Dole Act), 35 U.S.C. 200 *et seq.*, the Small Business Innovation Development Act of 1982, 15 U.S.C. 638, and the Federal Technology Transfer Act of 1986, 15 U.S.C. 3710a. 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 Administration (NASA)
Department of Homeland Security (DHS)	

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 https://www.nist.gov/tpo/federal-laboratory-interagency-technology-transfer-summary-reports.

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 2016, the total federal budget for R&D was $115,040 million. Of this, $71,616 million (62%) was used to support R&D activities that occurred outside of federal laboratories. This includes funding for grants, cooperative agreements, and similar instruments.[3] The remainder, $43,424 million (38%), supported R&D activities that occurred inside federal laboratories. This includes $32,020 million to support intramural activities and $11,404 million to support federally funded R&D centers (FFRDCs).[4] The technology transfer activities described in this report support new technologies that arise from these federal laboratory R&D investments. As shown in the table below, the percent of an agency's budget that was available for federal laboratory R&D 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 15 U.S.C. § 3705 or 15 U.S.C. § 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] A federal award is an instrument setting forth terms and conditions of an agreement between a federal agency and non-federal entity. Awards can include, among other things, grants and cooperative agreements. Grants and cooperative agreements are similar in that they transfer funds (or anything of value) to a non-federal entity but differ in that cooperative agreements involve substantial involvement by the federal awarding agency usually in terms of project oversight and management.

[4] For a list of FFRDCs see https://www.nsf.gov/statistics/ffrdclist/.

Federal Obligations for R&D
By Agency FY 2016 ($ million)[5]

	Total R&D	Intramural[(a)]	FFRDCs[(b)]	Intramural and FFRDCs	Percent of Total R&D Budget
All Agencies	$115,040	$32,020	$11,404	$43,424	38%
DoD	$44,749	$16,864	$1,703	$18,567	41%
DOE	$11,601	$939	$7,213	$8,152	70%
HHS	$32,216	$7,123	$520	$7,642	24%
NASA	$12,404	$1,785	$1,529	$3,314	27%
USDA	$2,358	$1,538	$0	$1,538	65%
DOC	$1,351	$1,055	$13	$1,069	79%
DOI	$857	$749	$1	$750	88%
VA	$695	$695	$0	$695	100%
DOT	$937	$253	$77	$331	35%
DHS	$532	$186	$89	$276	52%
EPA	$508	$255	$2	$258	51%
Other Agencies	$6,834	$576	$256	$832	12%

(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 2016, DoD spent the largest amount of funding for intramural activities and FFRDCs, $18,567 million (41% of its R&D budget). DOE was second with $8,152 million (70% of its R&D budget) and HHS was third with $7,642 million (24% of its R&D budget).

[5] 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 2016, Table 7. https://ncsesdata.nsf.gov/fedfunds/2016/html/ffs2016_dst_007.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 efforts to use technology transfer to advance the agency's mission and to promote U.S. competitiveness.[6] The following tables summarize federal technology transfer activities for the five-year period from FY 2012 through FY 2016.[7]

Federal Invention Disclosures and Patenting

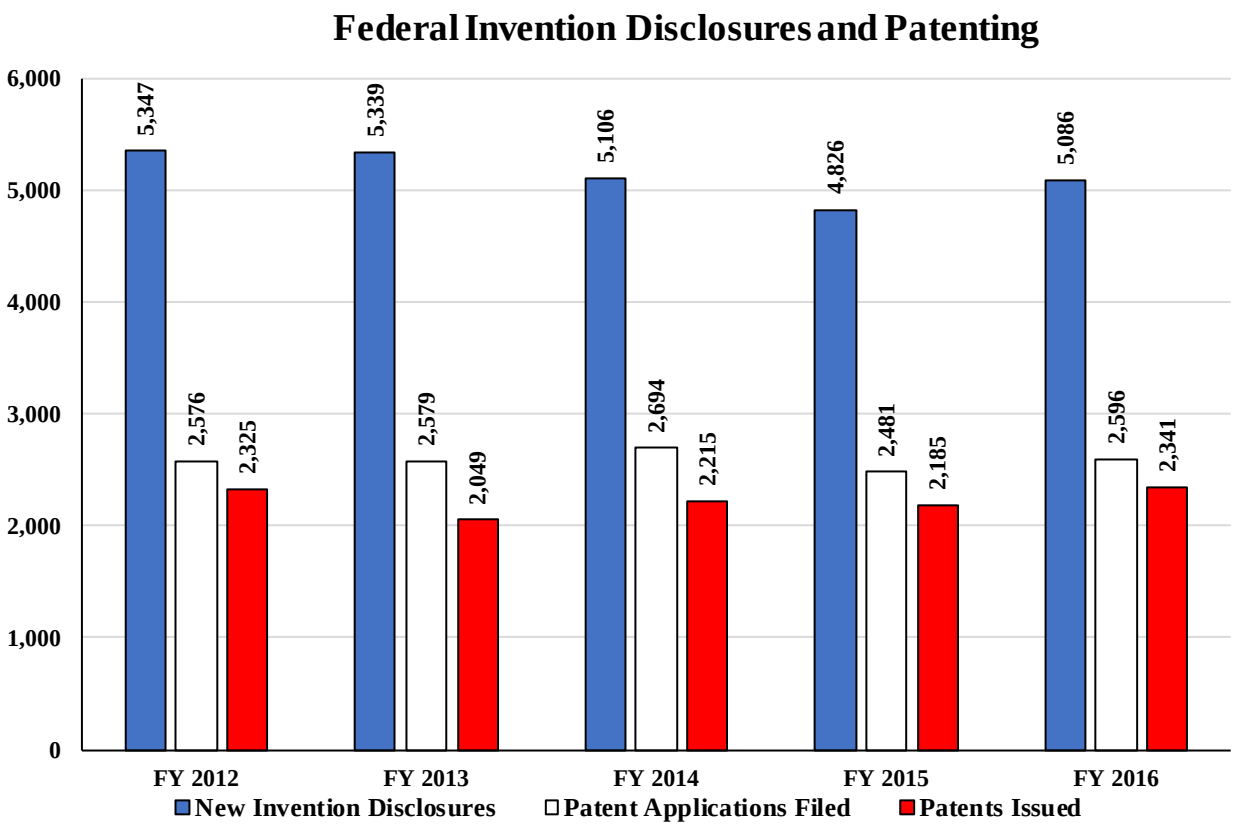
The protection of intellectual property can be vital to attracting the additional investment and product development resources necessary for early stage research products to be brought to their full commercial potential. Federal laboratory achievements in the areas of invention disclosures and patents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

Between FY 2012 and FY 2016, the number of invention disclosures reported by federal agencies decreased by 5% to 5,086. The number of patent applications filed increased by 1% to 2,596, and the number of patents issued increased by 1% to 2,341. DOE reported the largest number of invention disclosures with 1,760 in FY 2016, followed by NASA with 1,554 and DoD with 874. These three agencies accounted for 82% of all invention disclosures reported in this fiscal year.

In FY 2016, DOE reported the largest number of patent applications with 999 and patents issued with 856. DoD was second in both categories with 941 patent applications and 665 patents issued. HHS was third with 269 patent applications and 579 patents issued. These three agencies accounted for 85% of patent applications and 90% of patents issued.

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

[7] 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 2016 have been adjusted where necessary, to reflect the most accurate estimates for each year reported.

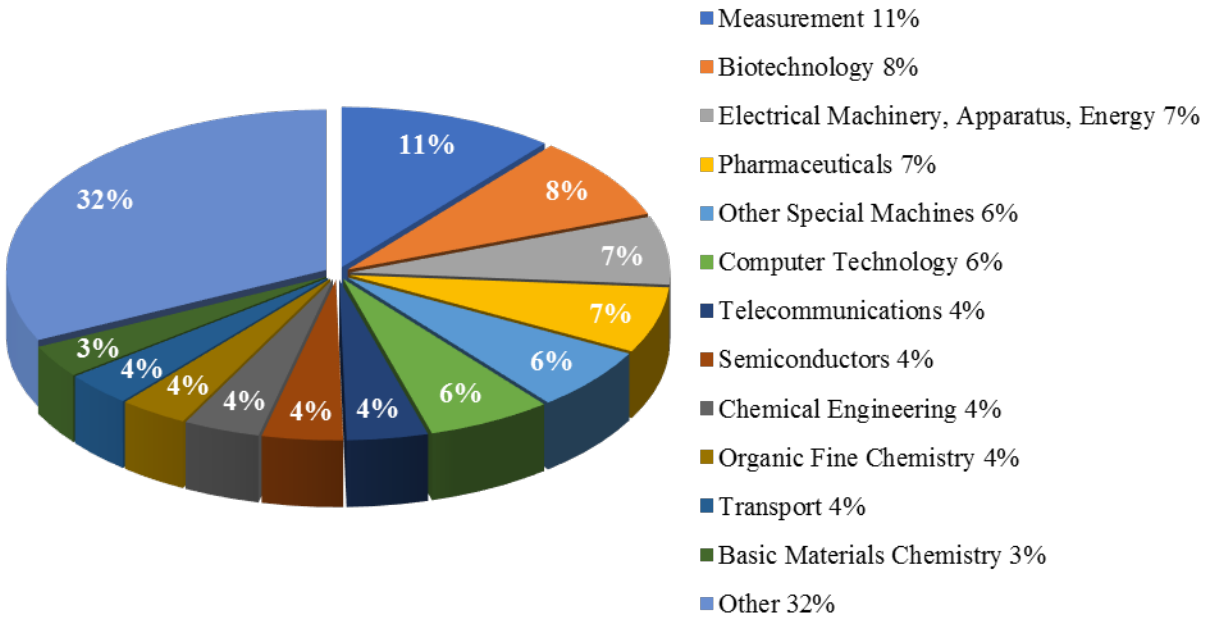


	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	5,347	5,339	5,106	4,826	5,086
Patent Applications Filed	2,576	2,579	2,694	2,481	2,596
Patents Issued	2,325	2,049	2,215	2,185	2,341

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 2016. The chart shows the percentage of patents issued to federal agencies by technology area based on a fractional count of patents.[8] In FY 2016, the largest number of federal patents issued to federal agencies involved Measurement (11%) followed by Biotechnology (8%), Electrical Machinery, Apparatus, Energy (7%), Pharmaceuticals (7%), Other Special Machines (6%), Computer Technology (6%), and Telecommunications (4%). Semiconductors (4%), Chemical Engineering (4%), Organic Fine Chemistry (4%), Transport 4% and Basic Materials Chemistry (3%). All other technology areas (32%).[9]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2016



Federal Licenses

Licensing of federally developed technologies is an important technology transfer mechanism that creates incentives for industry to invest the resources necessary to develop and commercialize nascent leading-edge technologies. Successful development and commercialization of federal technologies create benefits to the economy and contributes to competitiveness and domestic economic growth. The ability to grant licenses to the nonfederal sector helps protect utilize or further develop and utilize federally developed innovations, which

[8] 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 (WIPO technology classification) 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 PatentsView in April 2017. Used with permission.

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

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.

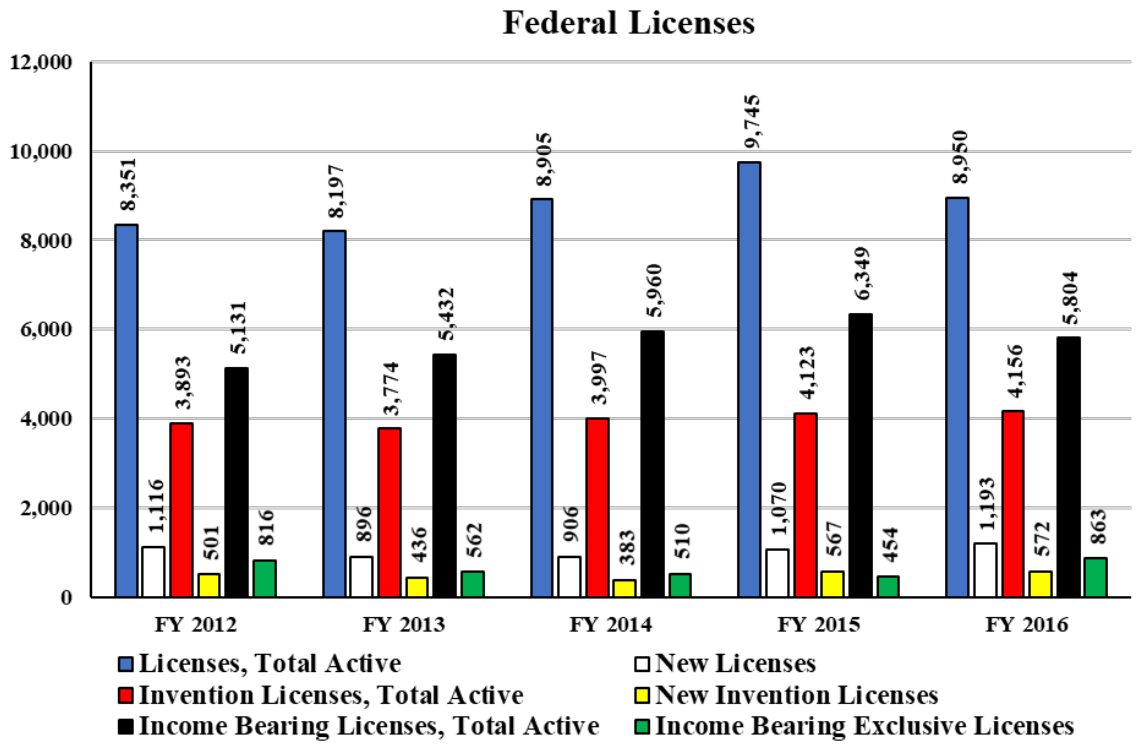
Between FY 2012 and FY 2016, the number of total active licenses reported by federal laboratories increased by 7% from 8,351 in FY 2012 to 8,950 in FY 2016. The number of new licenses increased by 7% from 1,116 in FY 2012 to 1,193 in FY 2016. The number of invention licenses increased by 7% to 4,156 while the number of new invention licenses increased by 14% to 572. Invention licenses refers to inventions that are patented or could be patented. The number of income-bearing licenses increased by 13% to 5,804, and the number of exclusive income-bearing licenses increased by 6% to 863.

DOE reported the largest number of total active licenses with 5,410 licenses. HHS was second with 1,750 licenses and DoD was third with 515 licenses. These three agencies accounted for 86% of all licenses reported in FY 2016.

HHS reported the largest number of invention licenses with 1,721, followed by DOE with 943 and NASA with 387. Together these three agencies accounted for 73% of invention licenses.

DOE reported the largest number of income-bearing licenses, 3,963, which was significantly higher than all other agencies combined. HHS was second with 837 followed by USDA with 439. Together these three agencies accounted for 90% of income-bearing licenses.

USDA reported the largest number of income-bearing exclusive licenses with 307, followed by DOE with 231, and DoD with 218. Together these three agencies accounted for 88% of income-bearing exclusive licenses.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	8,351	8,197	8,905	9,745	8,950
New Licenses	1,116	896	906	1,070	1,193
Invention Licenses, Total Active	3,893	3,774	3,997	4,123	4,156
New Invention Licenses	501	436	383	567	572
Income Bearing Licenses, Total Active	5,131	5,432	5,960	6,349	5,804
Income Bearing Exclusive Licenses	816	562	510	454	863

Federal Income from Licenses

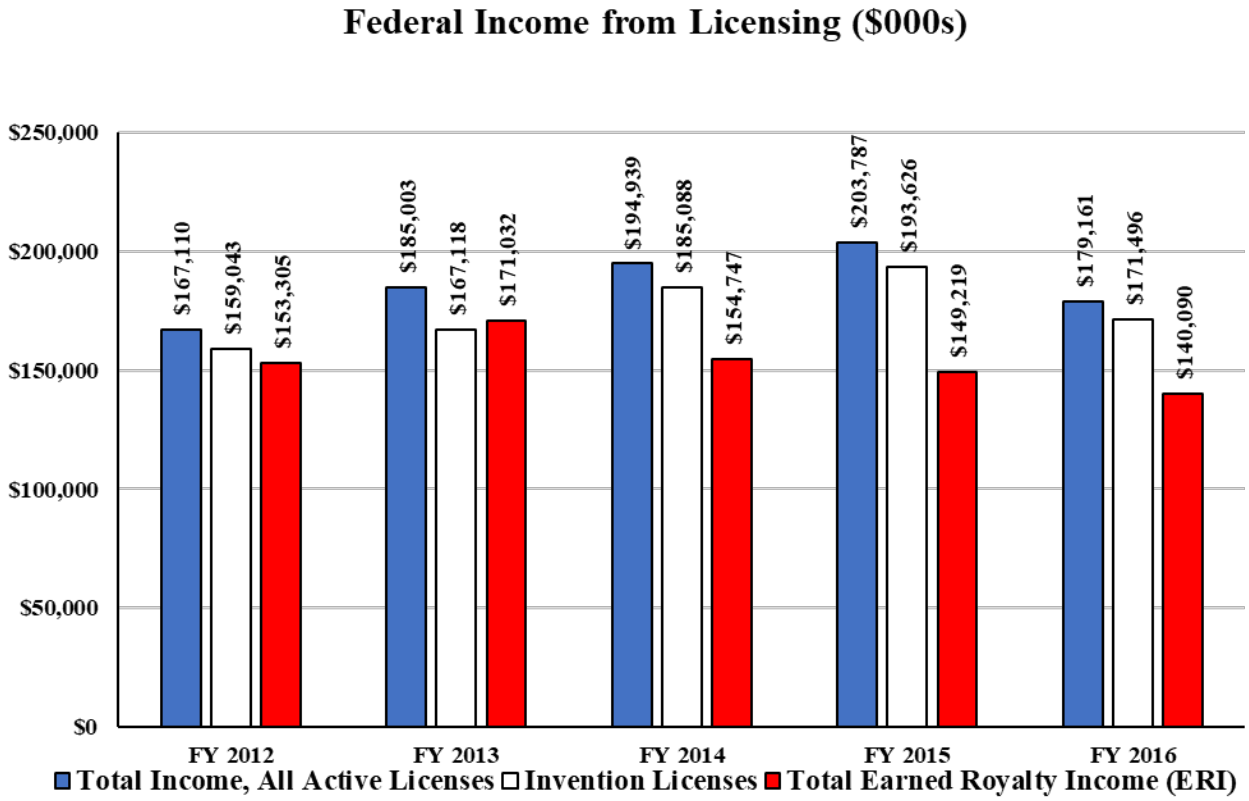
Licensing income includes income received for earned royalties from partners, license issue fees, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee, including patent costs. Between FY 2012 and FY 2016, income from all licensing increased by 7% to $179 million. Income from invention licenses increased by 8% to $171 million and total earned royalty income decreased by 9% to $140 million.

HHS accounted for the most licensing income in FY 2016 with $133 million, followed by DOE with $31 million, and DoD with $6 million. Together these three agencies accounted for 95% of reported licensing income.

HHS accounted for the most invention license income in FY 2016 with $131 million, followed by DOE with $27 million, and DoD with $5 million. Together these three agencies accounted

for 96% of Invention License Income.

HHS accounted for the most Earned Royalty Income in FY 2016 with $110 million, followed by DOE with $16 million, and DoD with $6 million. Together these three agencies accounted for 94% of Earned Royalty Income.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$167,110	$185,003	$194,939	$203,787	$179,161
Invention Licenses	$159,043	$167,118	$185,088	$193,626	$171,496
Total Earned Royalty Income, (ERI)	$153,305	$171,032	$154,747	$149,219	$140,090

Challenges in Federal Patent Licensing

On June 19, 2018, the Government Accountability Office (GAO) issued a report entitled *Federal Research: Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions* (GAO-18-327). This report recommends that "[t]he Secretary of Commerce should instruct NIST to fully report the range of challenges in federal patent licensing, such as those outlined in this report, by, for example, leveraging its survey of practices at federal technology transfer offices, past Federal Laboratory Consortium studies, and agency reports and including that information in its summary reports to Congress."

This recommendation aligns with the 2018 President's Management Agenda and is a continuation of long running efforts by the federal interagency technology transfer community.

As a part of the President's Management Agenda's Cross-Agency Priority (CAP) goal on improving the transfer of federally funded innovations from the laboratory to the market, NIST launched the Return on Investment (ROI) initiative to develop a report that identifies short-term and long-term findings to streamline and accelerate the transfer of the laboratory results from federal research and development funding efforts to the American marketplace. The ROI report will be a key input into the Lab to Market CAP goal, a cross-agency initiative co-led by NIST with the White House Office of Science and Technology Policy. The ROI initiative is an effort to work collaboratively with the public sector, private sector, and other federal R&D, intellectual property, and technology transfer stakeholders on a wide range of topics that impact the transfer of federally funded technologies.

In response to the GAO report and in support of the CAP goal effort, the Secretary of Commerce has instructed NIST to:

1. Fully report the range of challenges in federal patent licensing, such as those outlined in the GAO report, by, for example, leveraging its survey of practices at federal technology transfer offices, past studies conducted by the FLC, and agency reports, and including that information in its summary reports to Congress;
2. Clarify the link between the establishment of patent license financial terms and the goal of promoting commercial use, through appropriate means, such as the upcoming ROI rulemaking process and updating relevant guidance; and
3. Facilitate formal information sharing among the agencies to provide federal labs with information on financial terms in comparable patent licenses, as appropriate.

NIST is currently analyzing responses from the public on a wide-range of technology transfer topics submitted in response to a formal Request for Information as well as a series of public forums, meetings, and other engagements with stakeholders. A more complete report of the ROI findings will be included in the FY 2017 Federal Technology Transfer report.

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.

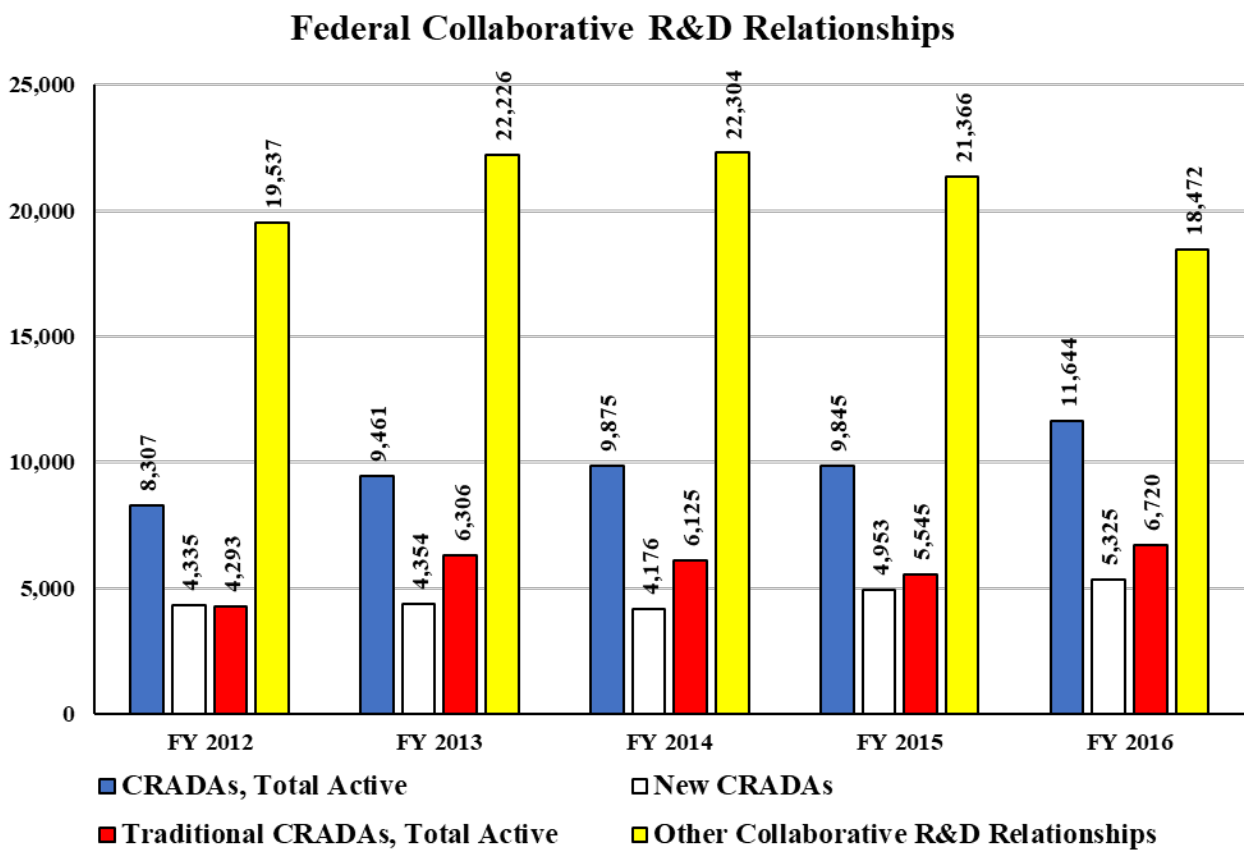
One frequently used mechanism for establishing joint research relationships is the cooperative research and development agreement (CRADA). The CRADA is a multifaceted mechanism that can be used to address several kinds of partnership needs. A "traditional CRADA" refers to formal collaborative R&D agreements 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 2012 and FY 2016, the number of active CRADAs increased by 40% to 11,644. The number of new CRADA agreements increased by 23% to 5,325. The number of traditional CRADAs increased by 57% to 6,720, while other collaborative R&D relationships decreased by 5% to 18,472.

In FY 2016, DoD reported the largest number of CRADAs with 3,125, followed by DOC with 2,940 and VA with 2,613. VA reported the largest number of traditional CRADAs with 2,359, followed by DoD with 2,297 and DOE with 739. USDA reported the largest number of other collaborative R&D relationships with 11,854, DOC was second with 3,273, and NASA was third with 2,204 (Space Act Agreements).



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	8,307	9,461	9,875	9,845	11,644
New CRADAs	4,335	4,354	4,176	4,953	5,325
Traditional CRADAs, Total Active	4,293	6,306	6,125	5,545	6,720
Other Collaborative R&D Relationships	19,537	22,226	22,304	21,366	18,472

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 two 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 each year (year "t"), by the value in the 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 2012. 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.

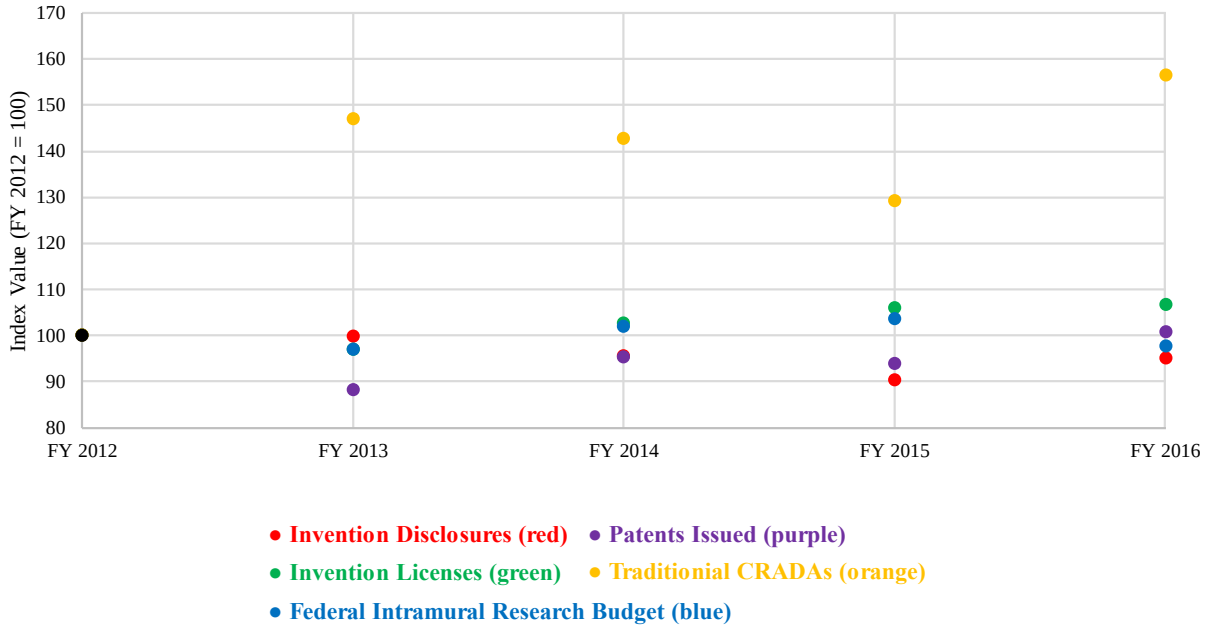
For example, to calculate the index value for patents issued in FY 2013, we divide the number of patents issued in FY 2013 by the number of patents issued in the base year (FY 2012) and then multiply by 100. Using data from the table on page five of this report, the index value for patents issued in FY 2013 is 88.

$$Index\ Value_{FY2013} = \frac{2{,}049}{2{,}325}\ x\ 100 = 88$$

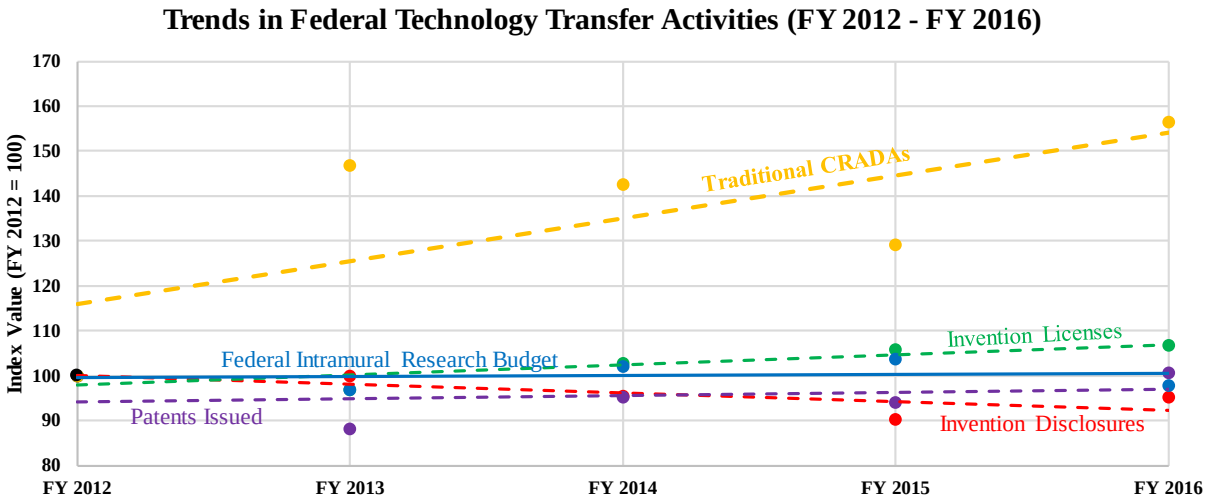
Because the index value of 88 is less than 100, we can interpret this as a 12% decrease in the number of patents issued between FY 2012 and FY 2013. In FY 2014, the index value for patents issued is 95 which we can interpret as a 5% decrease between FY 2012 and FY 2014.

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 three of this report. Note that all index values have a value of 100 in the base year, FY 2012.

Trends in Federal Technology Transfer Activities (FY 2012 - FY 2016)



To show the trend for a given metric, a straight line is positioned in the middle of the plotted values for that metric.[10] For example, in the chart below, index values for patents issued are shown 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.



The trend line plotted for traditional CRADAs has a significantly positive slope which means that CRADA activities have greatly increased during this period. The trend line for invention disclosures has a slightly negative slope indicating a decline in the number of invention disclosures while the trend line for invention licenses has a slightly positive slope indicating a slight increase. Trend lines for the number of patents issued and the Federal Intramural Research Budget, which includes the budget for intramural programs as well as the budget for FFRDCs, have been relatively consistent over these years with slight annual increases and decreases.

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 2016, Thomson Reuters reports that federal researchers authored or coauthored 55,971 articles using a whole-count basis (where each agency gets full credit for each article even if the article has co-authors from different agencies).[11] By using additional data

[10] Trend lines in this report are plotted using Microsoft Excel.
[11] Data prepared by Science-Metrix. Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) classified under Caspar fields using the CHI classification.

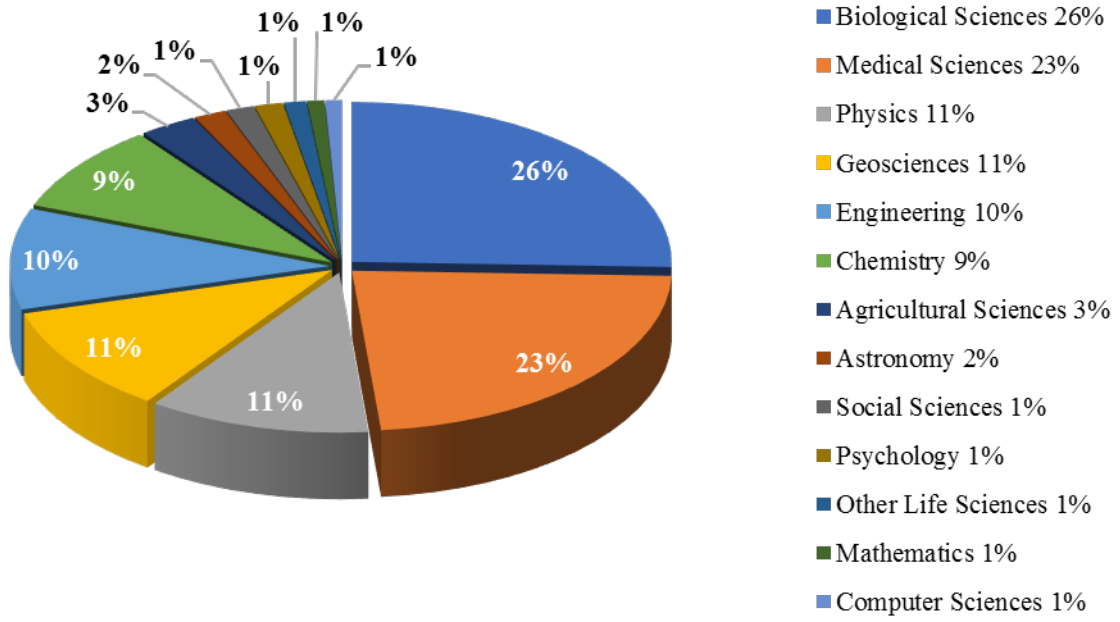
provided by agencies in their annual reports on technology transfer activities that considers publications not included in the Thomson Reuters' databases, the number of publications increases to 58,609.

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 (26%), Medical Sciences (23%), Physics (11%), Geosciences (11%), Engineering (10%), and Chemistry (9%).[12]

Articles are classified by the year they entered the database, rather than the year of publication, and are assigned to a federal agency based on the institutional addresses listed in the article. Because the CHI classification classifies journals accounting for only about 60% of all publications indexed in the Web of Science, the classification was expanded to fully cover the database using a two-step approach. The first step was to classify all journals under the same fields as those determined for the preparation of the NSF SEI 2018 indicators. The remaining journals were then assigned to a unique field using citations to and from journals to determine their most relevant field. Used with permission.

[12] Articles are credited on a fractional-count basis (i.e., each participating federal agency receives a share of the publication proportional to its share of addresses on the publication). Source: Prepared by Science-Metrix using the Web of Science database (Thomson Reuters) accessed in July 2017. All rights reserved. Used with permission.

S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: CY 2016[13]

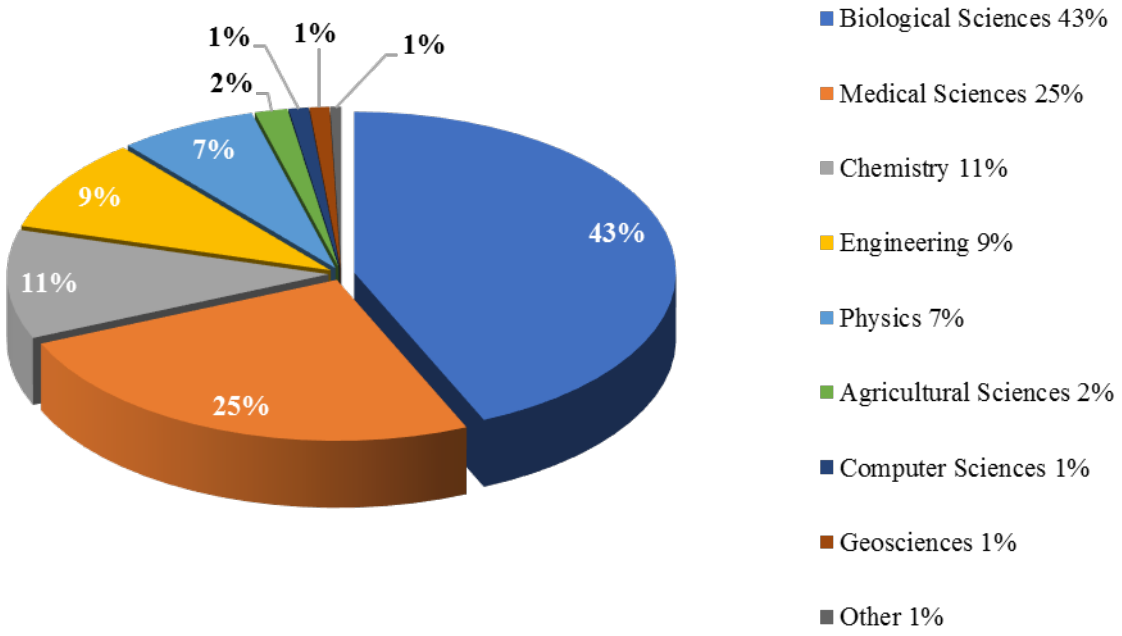


[13] Calendar Year

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 FY 2016, more than 15,644 articles authored or coauthored by federal researchers were cited in U.S. patents.[14] Of these, the greatest number of articles addressed research in Biological Sciences (43%), Medical Sciences (25%), Chemistry (11%), Engineering (9%), and Physics (7%).[15]

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2016



[14] Data prepared by Science Metrix. Cited articles are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) classified under Caspar fields using the CHI classification. Cited articles are classified by the year of publication and are assigned to a federal agency based on the institutional addresses listed in the article. Because the CHI classification classifies journals accounting for only about 60% of all publications indexed in the Web of Science, the classification was expanded to fully cover the database using a two-step approach. The first step was to classify all journals under the same fields as those determined for the preparation of the NSF SEI 2018 indicators. The remaining journals were then assigned to a unique field using citations to and from journals to determine their most relevant field. Used with permission.

[15] Citations are classified on a fractional-count basis (i.e., for cited articles with collaborating institutions from federal agencies, other U.S. institutions, or foreign institutions, each federal agency receives fractional credit based on the proportion of its participating institution(s)). Source: Prepared by Science-Metrix using the Web of Science (Thomson Reuters) accessed in July 2017 and PatentsView accessed in April 2017. All rights reserved. Used with permission.

Small Businesses Involved in Active Traditional CRADAs

Part of the Federal Technology Transfer Act (FTTA), codified at 15 U.S.C. § 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 10 agencies. This data reveals that out of 6,671 traditional CRADA agreements with these agencies, 1,281 (19%) involve small businesses as participants.

Agency	Number of Active CRADAs Involving Small Businesses FY 2016
DHS	75
DOC	93
DoD	351
DOE	282
DOT	12
EPA	23
HHS	252
NASA	0
USDA	76
VA	117
Total	1,281

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 8,381 active licenses granted by these agencies in FY 2016, 798 (10%) were issued to small businesses.

Agency	Number of Active Licenses Granted to Small Businesses FY 2016
DHS	0
DOC	14
DOE	255
EPA	17
HHS	112
NASA	243
USDA	152
VA	5
Total	798

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 6 agencies identifies 100 companies that started between the years of 2012 and 2016 and have received critical technical support from federal laboratories.

Agency	Number of Startups Supported FY 2016 (Preliminary Data)
DHS	0
DOC	51
DOT	0
EPA	14
HHS	16
NASA	19
Total	100

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™)[16] 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, other federal agencies have adopted the successful program to enhance the economic impact of their own technology transfer efforts.

At HHS, the National Institute of Health's (NIH) I-Corps™ Program accelerates the translation of biomedical research to the marketplace by providing training to Small Business Innovation

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

Research (SBIR) and Small Business Technology Transfer (STTR) grantees in the areas of innovation and entrepreneurship. Under this program, the NIH and the Centers for Disease Control and Prevention (CDC) foster the development of early-stage biomedical technologies, focus on teaching researchers how to gain a clearer understanding of the value of their inventions in the marketplace, and ultimately how to advance their technologies from the research lab into the commercial world. The program complements activities within the scope of the parent SBIR and STTR grant programs to help accelerate the commercialization of new products and services derived from NIH- and CDC-funded technical feasibility studies.

At DOE, the Energy I-Corps™ program, formerly known as Lab-Corps, pairs teams of researchers with industry mentors for an intensive two-month training where the researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Energy I-Corps is managed by DOE's National Renewable Energy Laboratory (NREL). NREL leads curriculum development and execution, recruits program instructors and industry mentors, and assembles teams from the following national labs:

Argonne National Laboratory	Los Alamos National Laboratory
Fermi National Accelerator Laboratory	National Renewable Energy Laboratory
Idaho National Laboratory	Oak Ridge National Laboratory
Lawrence Berkeley National Laboratory	Pacific Northwest National Laboratory
Lawrence Livermore National Laboratory	Sandia National Laboratories

Other agencies have incorporated I-Corps™ into their programs. DHS, DoD, and NASA partner with NSF to send their awardees through the NSF I-Corps™ programs. Other agencies develop their own programs that adapt the curriculum for their research communities: NSA's I-Corps™ for the Intelligence Community, I-Corps™ at ARPA-E, and the USDA I-Corps™ Agricultural Research Service pilot program.

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) 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 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.

Evaluating Impact

The Interagency Workgroup on Technology Transfer discussing ways to develop impact metrics. These discussions include:

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 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 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 2016

Each federal agency prepares and submits an annual report covering data on technology transfer as described in 15 U.S.C. § 3710(f). These reports include details on each agency's technology transfer program and efforts to use technology transfer to advance the agency's mission and promote U.S. competitiveness.[17]

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 2016) and several prior years (FY 2012-2016);
- 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.

[17] 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 cooperative research and development agreement (CRADAs) authorized by the Federal Technology Transfer Act, 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 (e.g., keeping costs low), and enhancing global competitiveness for the U.S. agriculture sector. Thus, technology transfer functions are critical to accelerating the utility of public research and development (R&D) investments, creating economic activity, 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.

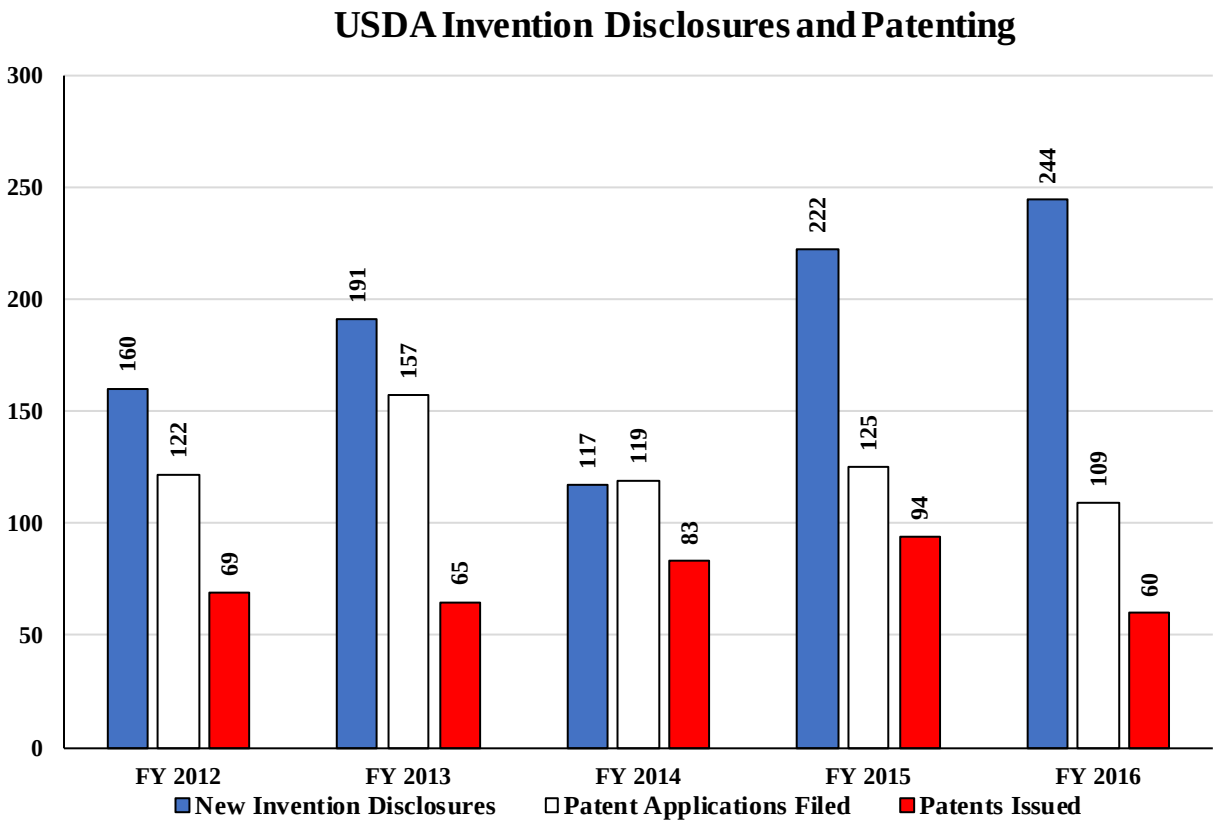
USDA's annual technology transfer report is available online at:
https://www.ars.usda.gov/business/Docs.htm?docid=24718.

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/
Forest Service: http://www.fs.fed.us

USDA Invention Disclosures and Patenting

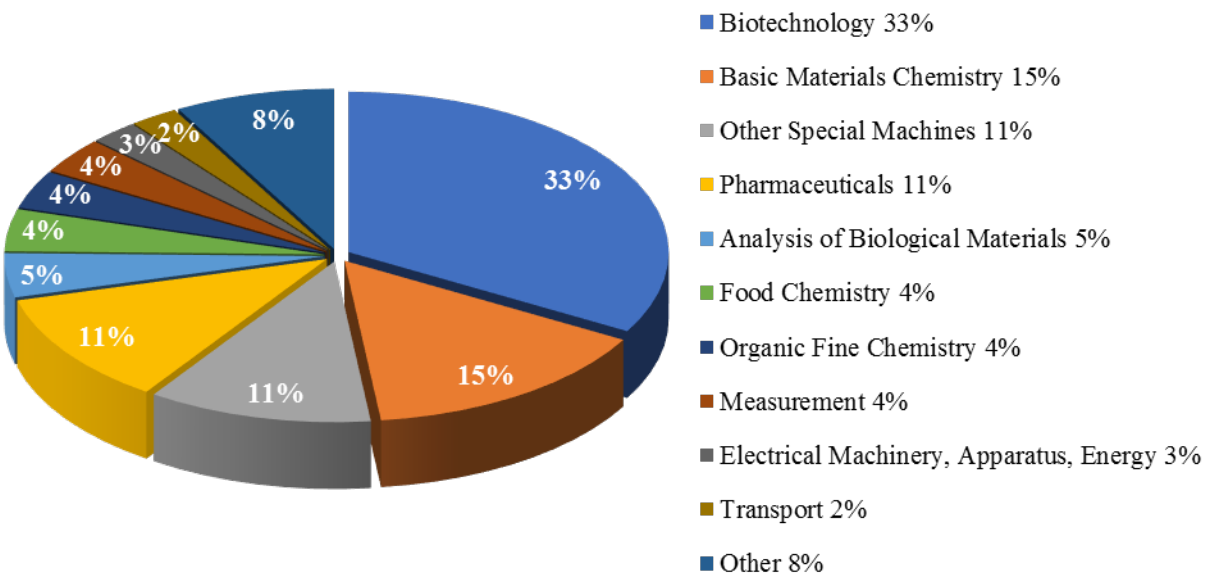
Between FY 2012 and FY 2016, the number of invention disclosures received increased by 53%, from 160 to 244. The number of patent applications filed decreased by 11%. The number of new patents issued decreased by 13% from 69 to 60 in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	160	191	117	222	244
Patent Applications Filed	122	157	119	125	109
Patents Issued	69	65	83	94	60

Patents issued to USDA in FY 2016 covered many technology areas including Biotechnology (33%), Basic Materials Chemistry (15%), Other Special Machines (11%), and Pharmaceuticals (11%).[18]

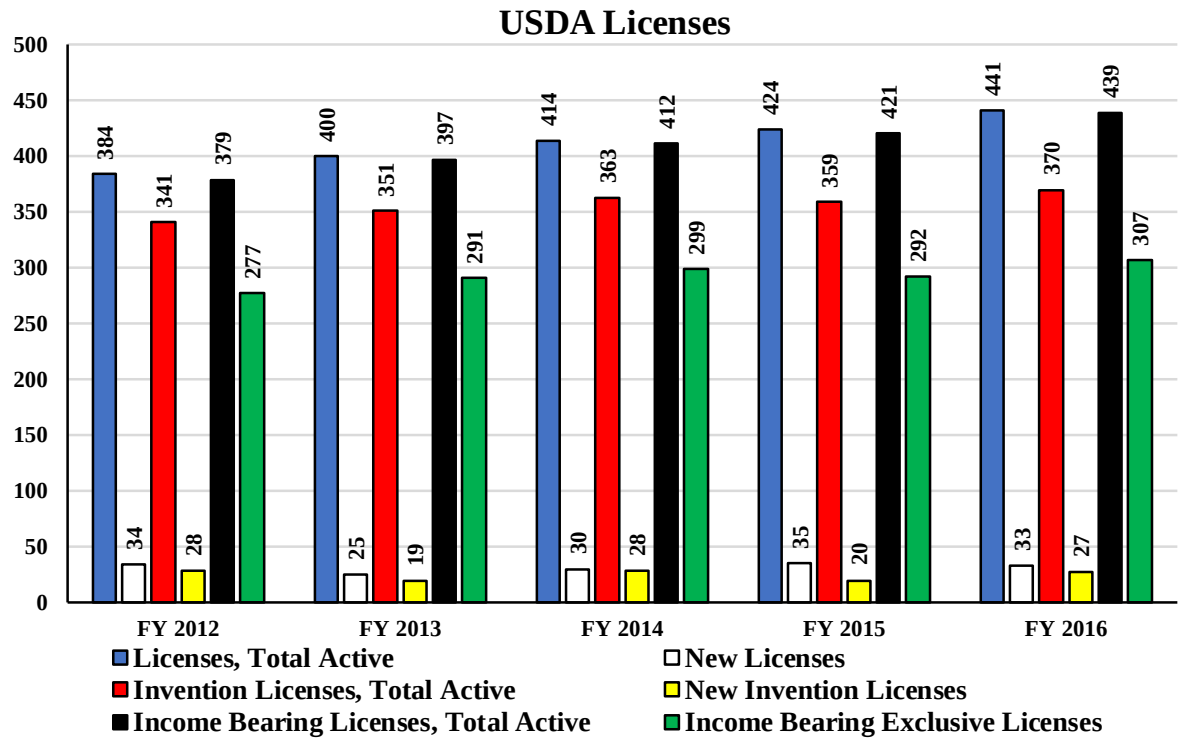
USPTO Patents Assigned to USDA by Technology Area: FY 2016



[18] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

USDA Licenses

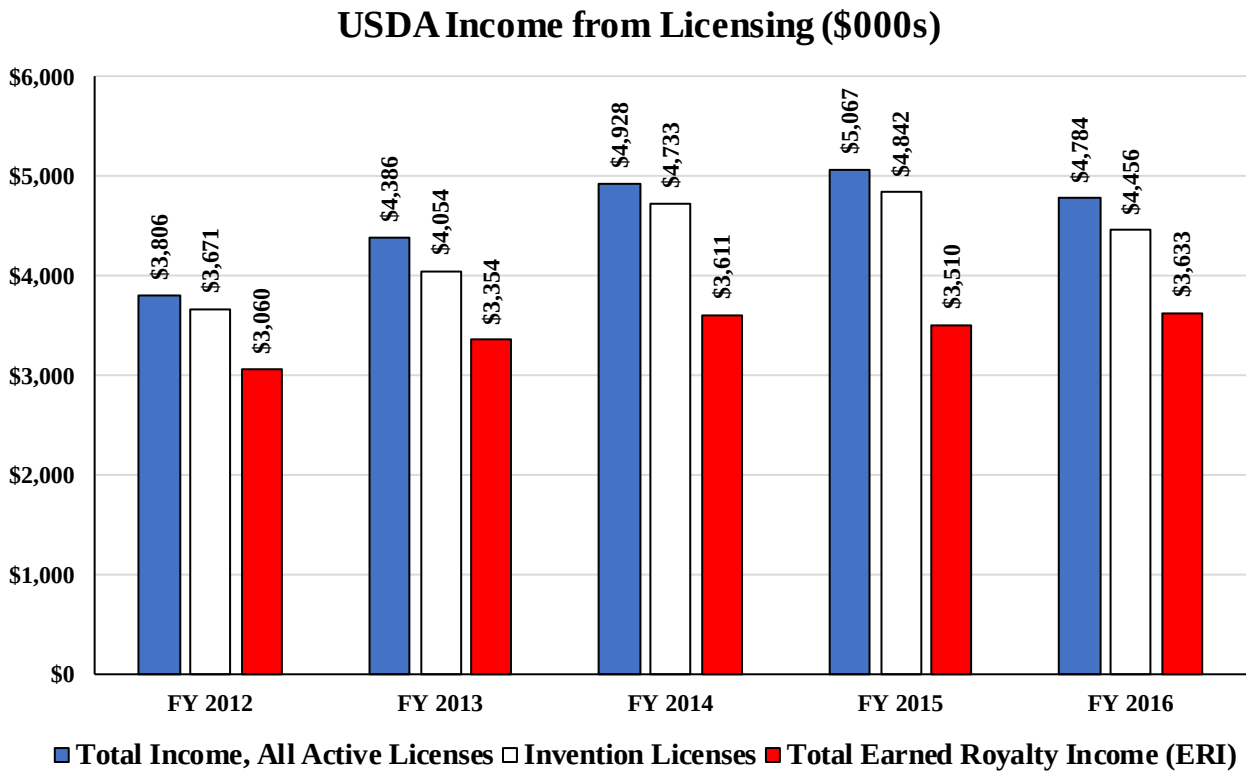
Between FY 2012 and FY 2016, the number of total active licenses increased by 15% to 441 licenses in FY 2016. The number of total active invention licenses increased by 9% to 370 licenses. Total active income-bearing licenses increased by 16%, from 379 in FY 2012 to 439 in FY 2016, while the total number of income-bearing exclusive licenses increased by 11% to 307.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	384	400	414	424	441
New Licenses	34	25	30	35	33
Invention Licenses, Total Active	341	351	363	359	370
New Invention Licenses	28	19	28	20	27
Income Bearing Licenses, Total Active	379	397	412	421	439
Income Bearing Exclusive Licenses	277	291	299	292	307

USDA Income from Licensing

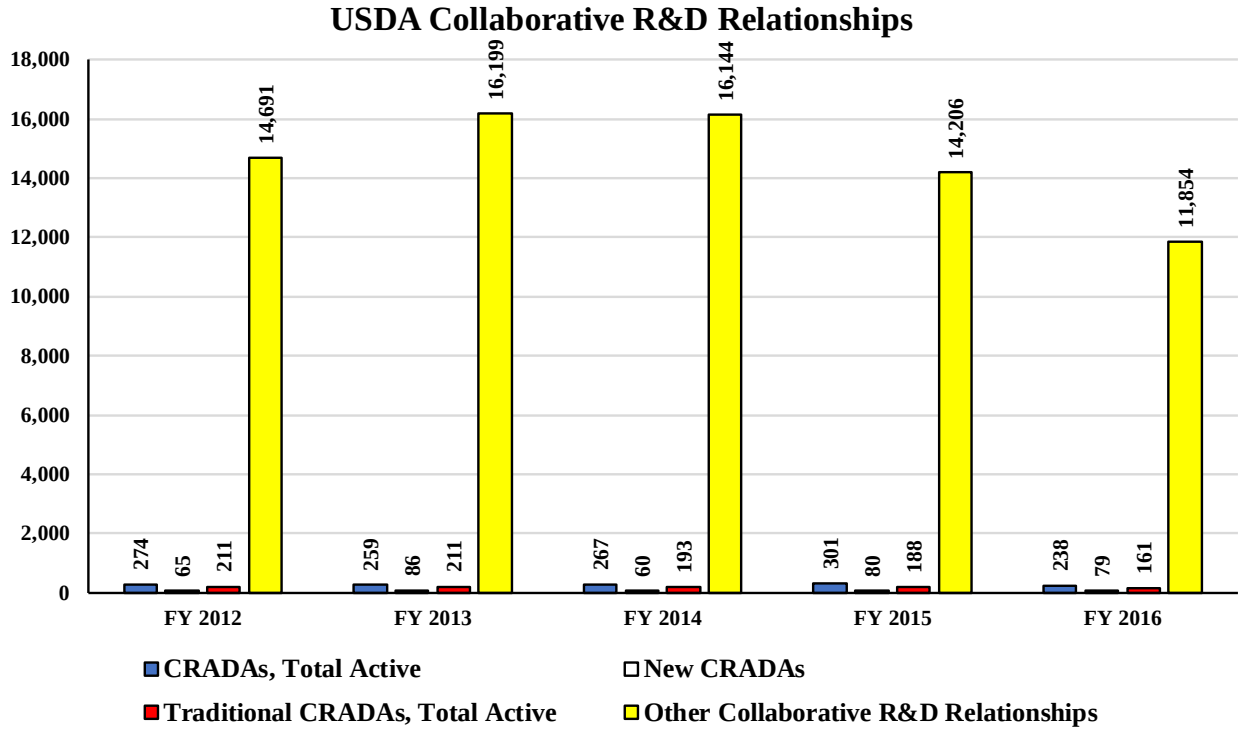
Between FY 2012 and FY 2016, total income from all active licenses increased by 26% to just over $4.7 million in FY 2016. The income from invention licenses increased by 21% to $4.5 million. Total earned royalty income increased by 19% from $3.1 million in FY 2012 to $3.6 million in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$3,806	$4,386	$4,928	$5,067	$4,784
Invention Licenses	$3,671	$4,054	$4,733	$4,842	$4,456
Total Earned Royalty Income, (ERI)	$3,060	$3,354	$3,611	$3,510	$3,633

USDA Collaborative R&D Relationships

Between FY 2012 and FY 2016, the number of total active CRADAs decreased by 13% to 238 agreements while the number of new CRADAs per fiscal year increased by 22% to 79. Total active traditional CRADAs decreased by 24% to 161 agreements. Other collaborative R&D relationships decreased by 19% to 11,854.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	274	259	267	301	238
New CRADAs	65	86	60	80	79
Traditional CRADAs, Total Active	211	211	193	188	161
Other Collaborative R&D Relationships	14,691	16,199	16,144	14,206	11,854

USDA Efforts to Streamline Technology Transfer Operations

- A template for a Commercial Evaluation License (CEL) was created. The CEL is a short-term, non-exclusive license to evaluate the commercial applications of the material and the licensed product and any inventions claimed in the licensed patent rights.
- To expedite and streamline the payment of license royalties, USDA's Office of Technology Transfer (OTT) established a pay.gov portal specific for royalty payments.

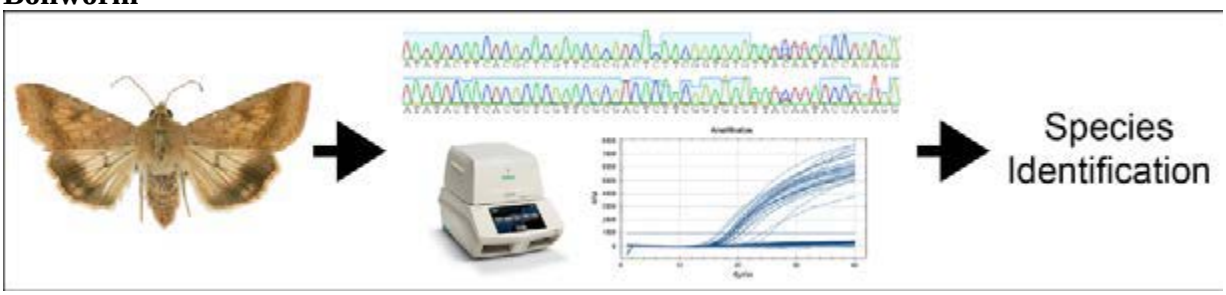
- In 2016, OTT established an Innovation Fund for ARS scientists to enable and expedite commercialization/adoption of their research outcomes. Projects are chosen based on their potential for advancement along the technology readiness continuum and moving closer to commercialization.

USDA Downstream Success Stories

Wildlife Services: Changes to Aircraft Lighting Increase Bird Awareness

Collisions between birds and aircraft (also known as bird strikes) are expensive, risk human lives, and increase bird mortality. Because birds see differently than people, changes to aircraft lighting have been proposed as a way to make birds avoid aircraft. USDA's National Wildlife Research Center (NWRC) researchers and partners from Purdue University investigated brown-headed cowbirds' responses to aircraft lighting systems tuned to match the birds' visual capabilities. Using a remote-controlled aircraft fitted with 470-nanometer lights that exhibit the "blue" portion of the human visual spectrum, scientists observed that cowbirds showed alert behaviors in less than half the time it took them to show alert behaviors with the lights off. However, for approaching aircraft with pulsing lights, the cowbirds' alert responses were delayed as aircraft speeds increased. This was not the case with approaching aircraft with nonplusing lights. Also, researchers observed that high ambient noise levels delayed the birds' avoidance of the aircraft, possibly by causing sensory overload and distracting the birds. Researchers believe that placing 470-nanometer lights on aircraft or at airports may improve some birds' abilities to detect and avoid aircraft. The approach may also make wind turbines, towers, and other large stationary structures involved in bird collisions more detectable.

Plant Protection and Quarantine: Advanced Molecular Diagnostics for the Old-World Bollworm



The Old-World bollworm is a moth that can attack and damage more than 180 plant species including cotton, corn, peanut, sorghum, and tomato. This moth was not thought to be present in the New World (i.e. the Americas) until 2012, when specimens were identified from an outbreak that started in Brazil. Since that outbreak, new records have been reported in North and South America and the Caribbean. This species is difficult to diagnose because it is nearly identical in appearance to a common native moth, the corn earworm. These two pests also attack similar crops, further complicating detection of the Old-World bollworm. Scientists from the Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine Program (PPQ) and the Center for Plant Health (CPHST) laboratories in Fort Collins, CO, and Mission, TX, and the ARS Southern Insect Management Unit have been developing new methods to identify these

moths. In FY 2016 APHIS verified molecular techniques to diagnose the moths based on slight differences in DNA. These published technologies have been developed into protocols for diagnosing a single moth and were presented to state and federal scientists at a strategic planning meeting for Old World bollworm held in Florida in 2016. The methods have been used by APHIS in 2016 to diagnose moth larvae collected during a survey of Puerto Rico in 2015 and to identify moth interceptions at U.S. borders to confirm safe trade practices. The APHIS scientists are currently testing new technologies to make it possible to diagnose hundreds of moths in a single reaction. These methods development and diagnostic activities are helping to exclude invasive exotic species from the United States in order to protect crops and natural resources.

Agricultural Research Service: Imaging Device for Meat Safety Inspection
Current meat inspection in slaughter plants for food safety and quality attributes, including potential fecal contamination, is conducted through visual examination by human inspectors working under conditions that are poorly suited to conventional fluorescence detection methods that require ambient darkness. ARS researchers in Beltsville, Maryland, developed a handheld fluorescence-based imaging device (HFID) to highlight contaminated food and equipment surfaces on a display monitor during use under ambient lighting. This study assessed the effectiveness of the HFID to enhance visual detection of fecal contamination on red meat, fat, and bone surfaces of beef under varying ambient luminous intensities. Overall, diluted feces were detectable on the beef surfaces for all but the brightest ambient light intensities tested in the fluorescence images. This technology is patented and under license and commercial development by an industry partner and will support and improve meat safety inspection programs implemented by U.S. processors and regulatory inspectors.

Foreign Agricultural Service: Global Partnership for Pesticide Standards
Residue data for establishing trade standards (i.e., Codex Alimentarius) pesticide maximum residue levels (MRLs) for fruit and vegetable crops are mostly generated in the United States and other industrialized nations. Therefore, many of the tropical crops grown in developing countries do not have MRLs and accordingly face international trade barriers due to residue violations in destination markets. The lack of MRLs for high-valued specialty crops from developing countries can have a significant economic impact, especially when exporters are excluded from potentially lucrative markets. To help address this problem, FAS is leading a Global Residue Project to establish an infrastructure and process whereby field trial residue data for crops most commonly grown in developing counties are generated and used to establish MRLs. The project is working with stakeholders in 20 partner countries in Africa, Asia, and the Western Hemisphere, where national research teams collaborate on joint residue trials, based on study protocols and technology models developed by the USDA-funded IR4 Project. In 2017 FAS and the IR-4 Project will host the third Global Minor Use Summit to review progress and identify additional joint projects, expand partnerships, and continue transfer of knowledge and information about safe crop protection. By transferring these policy concepts and technical skills to foreign partners, the Global Partnership for Pesticide Standards has continued complementing the IR-4 Project by supplementing U.S.-generated data and, in some cases, completely shifting the field trial responsibilities for generating pesticide data to partner countries. In addition to economizing U.S. resources for development and commercialization of pesticides, the Global Partnership continued to promote common standards among the U.S. and foreign agricultural trading partners and, overall, provide modern pest control tools that may be safely used by growers world-wide.

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 Institute for Telecommunication Sciences (ITS). Technology transfer, which is a key part of the programmatic activities in these laboratories, connects technological advances of DOC's science and engineering programs to the American economy.

In addition to the technology transfer efforts of DOC laboratories, DOC is responsible for coordinating technology transfer activities across federal agencies. DOC coordinates the Interagency Workgroup for Technology Transfer (IAWGTT) through the facilitation by NIST of interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency transfer programs.[19] NIST also serves as the host agency for the 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.

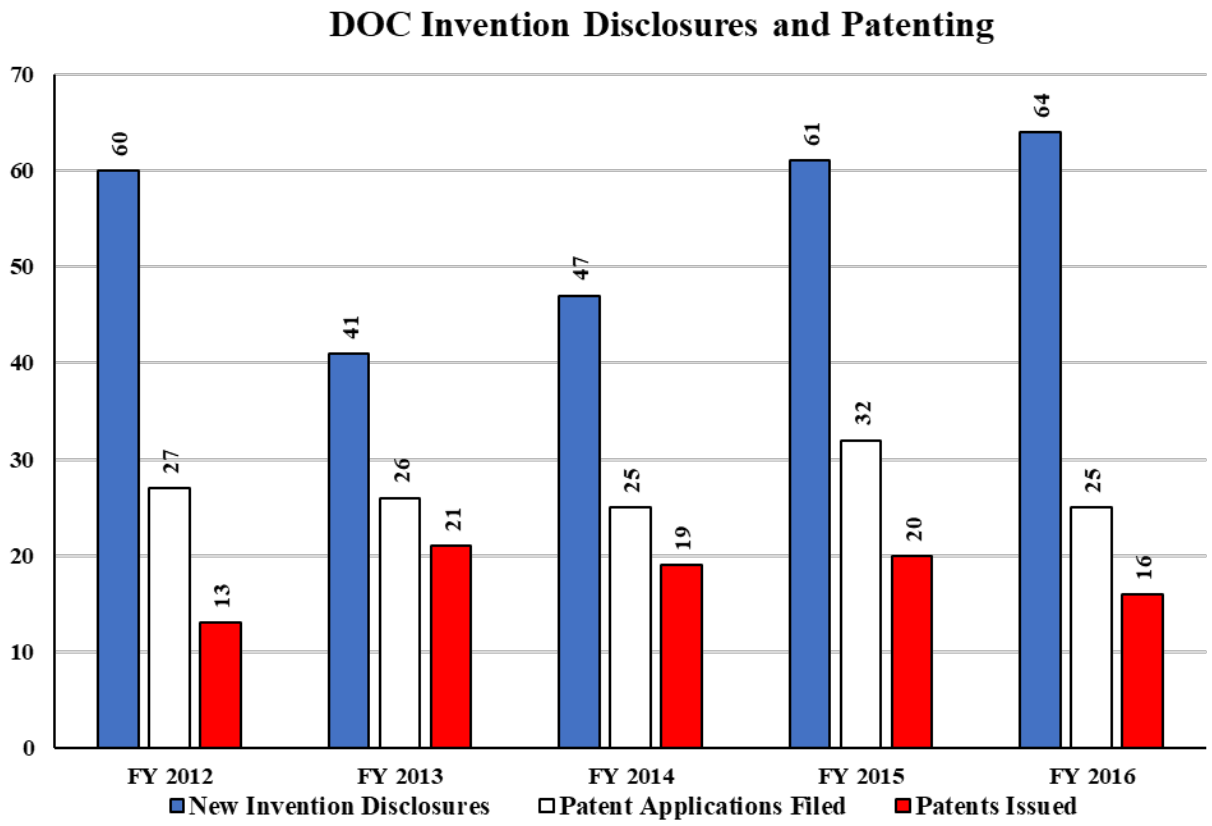
More information about DOC technology transfer is available on the following websites:

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

[19] 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

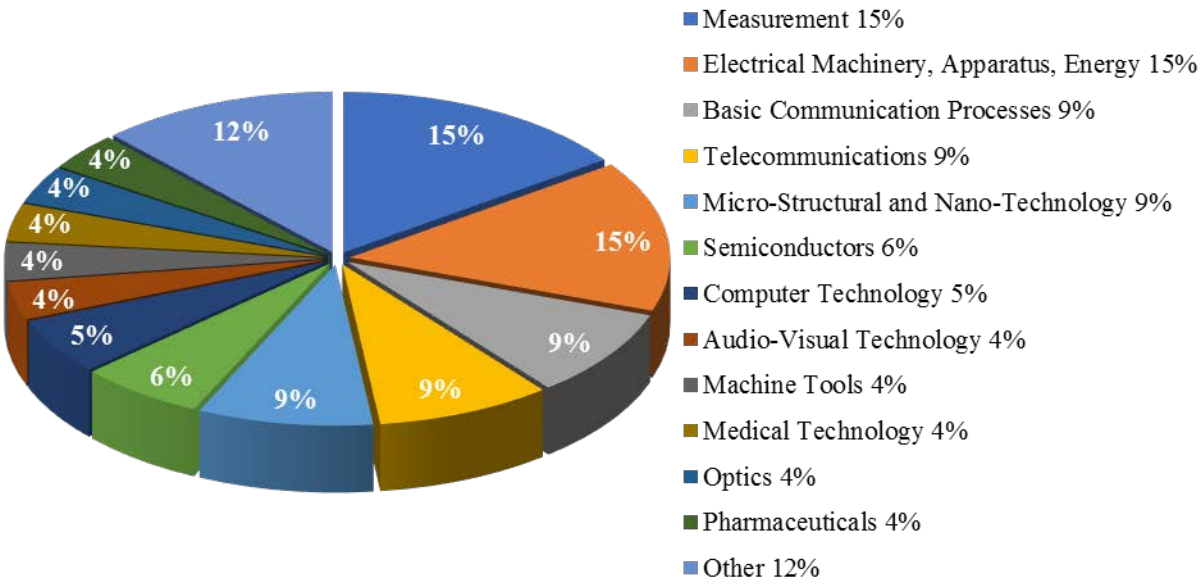
Between FY 2012 and FY 2016, the number of new inventions disclosed increased by 7% to 64 disclosures in FY 2016. The number of patent applications filed decreased by 7% to 25 and the number of patents issued increased by 23% to 16.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	60	41	47	61	64
Patent Applications Filed	27	26	25	32	25
Patents Issued	13	21	19	20	16

Patents issued to DOC in FY 2016 covered many technology areas including Measurement (15%), Electrical Machinery, Apparatus, Energy (15%), Basic Communication Processes (9%), Telecommunications (9%), and Micro-Structural and Nano-Technology (9%).[20]

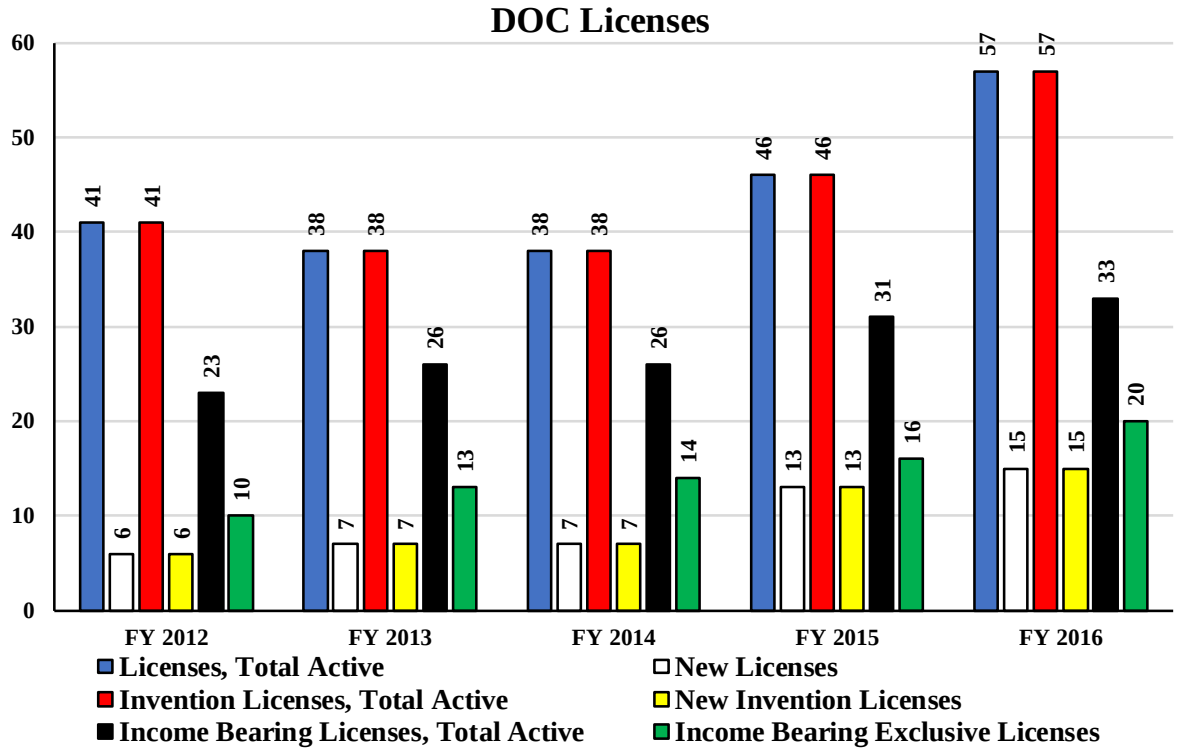
USPTO Patents Assigned to DOC by Technology Area: FY 2016



[20] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DOC Licenses

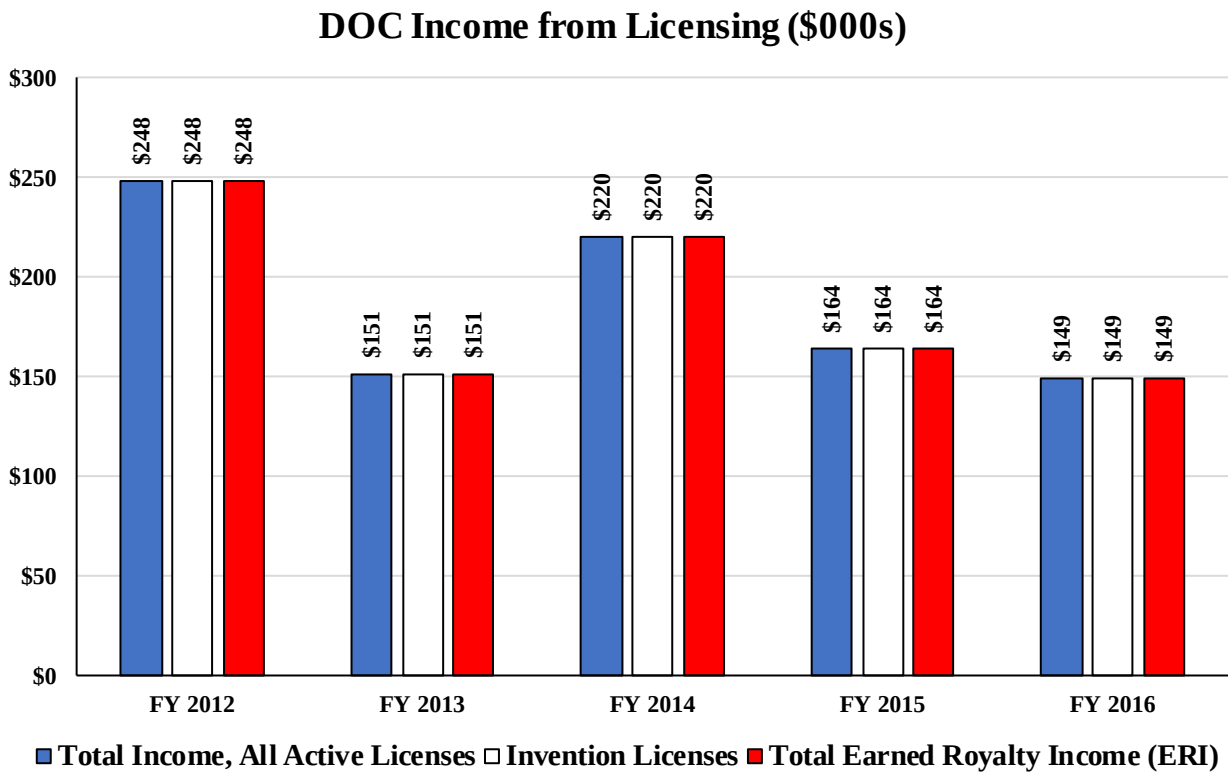
The number of total active licenses increased by 39% from 41 in FY 2012 to 57 in FY 2016. New licenses increased by 150% to 15. All licenses were invention licenses. Total active income-bearing licenses increased by 43% to 33, while income-bearing exclusive licenses increased by 100% to 20.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	41	38	38	46	57
New Licenses	6	7	7	13	15
Invention Licenses, Total Active	41	38	38	46	57
New Invention Licenses	6	7	7	13	15
Income Bearing Licenses, Total Active	23	26	26	31	33
Income Bearing Exclusive Licenses	10	13	14	16	20

DOC Income from Licensing

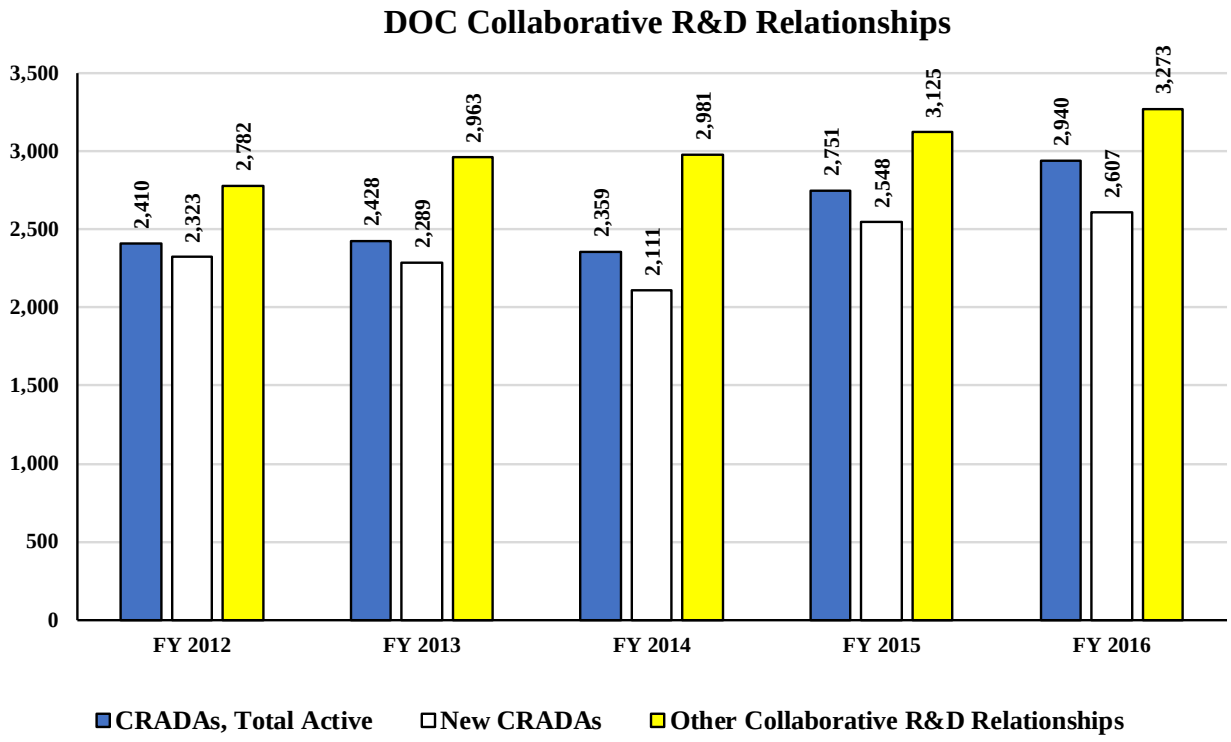
DOC reported that all income from licensing comes from invention licenses. During the five-year period, from FY 2012 to FY 2016, there was a 40% decrease in total income from all active licenses, from $248 thousand in FY 2012 to $149 thousand in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$248	$151	$220	$164	$149
Invention Licenses	$248	$151	$220	$164	$149
Total Earned Royalty Income, (ERI)	$248	$151	$220	$164	$149

DOC Collaborative R&D Relationships

Between FY 2012 and FY 2016, the number of total active cooperative research and development agreements (CRADAs) increased by 22% to 2,940 agreements while the number of new CRADAs per fiscal year increased by 12% to 2,607. Total active traditional CRADAs increased by 118% to 335 and other collaborative R&D relationships increased by 18% to 3,273.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	2,410	2,428	2,359	2,751	2,940
New CRADAs	2,323	2,289	2,111	2,548	2,607
Traditional CRADAs, Total Active	154	206	233	365	335
Other Collaborative R&D Relationships	2,782	2,963	2,981	3,125	3,273

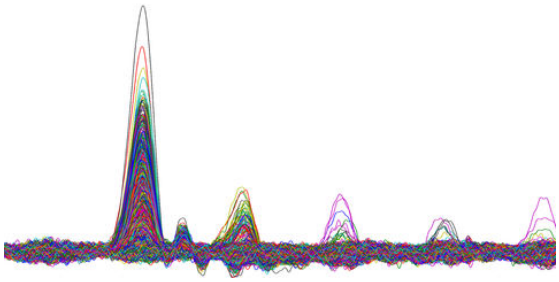
DOC Efforts to Streamline Technology Transfer Operations

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 participation by small businesses. These programs lay out financial 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 continuing efforts to identify and understand issues experienced

by partners, NIST expects to identify new ways to optimize technology transfer practices. In FY 2016, the transaction time taken for execution of a CRADA increased, and NIST is making efforts to address this negative outcome, including addressing administrative burdens, training for key staff members, and improving coordination with research staff. The average CRADA approval time was 104 days. Additionally, NIST is working to ensure timely protection of intellectual property. The average number of days between the receipt date of an invention disclosure and the filing date of the first non-provisional patent application was 442 days.

DOC Downstream Success Stories

NIST: Single-Photon Detector for Potential Encryption and Sensing Apps



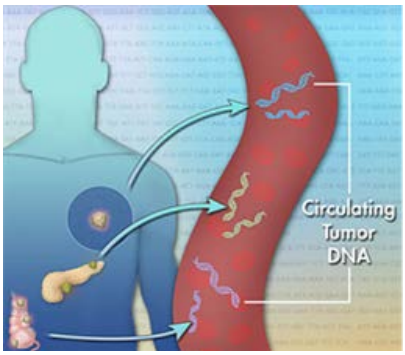
Individual photons of light now can be detected far more efficiently using a device patented by NIST scientists who have overcome longstanding limitations with one of the most commonly used type of single-photon detectors. Their invention could allow higher rates of transmission of encrypted electronic information and improved detection of greenhouse gases in the atmosphere.

The team, which also includes scientists working at the California Institute of Technology and the University of Maryland, has patented a method to detect the photons that arrive when the gates are either open or closed. The NIST team had developed a highly sensitive way to read tiny signals from the detector, a method that is based on electronic interferometry, or the combining of waves such that they cancel each other out.

The new detector can count individual photons at a very high maximum rate—several hundred million per second—and at higher than normal efficiency, while maintaining low noise. Its efficiency is at least 50% for photons in the near infrared, the standard wavelength range used in telecommunications. Commercial detectors operate with only 20 to 30% efficiency.

NIST: Precision Medicine Diagnostics

NIST efforts to support accurate diagnostic testing so that cancer treatments can be tailored to the tumor DNA and other characteristics particular to individual patients. The work in this field continues to gain momentum as the agency mounts a multi-laboratory studies to evaluate candidate reference materials for benchmarking measurements of circulating tumor DNA, so-called liquid biopsies.



Credit: National Human Genome Research Institute

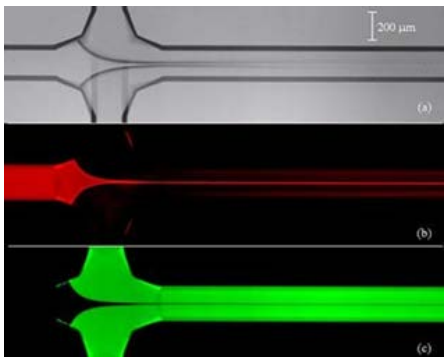
The comparative exercise, sometimes referred to as an inter-laboratory "round robin," benefits from a new three-year CRADA with SeraCare Life Sciences, located in Milford, Massachusetts. Under the agreement, SeraCare will supply its circulating DNA reference material technology to NIST to help further development and refinement of digital measurement methods. NIST will distribute

these materials for testing at laboratories in the National Cancer Institute's Early Detection Research Network and to other research and testing organizations.

Reliably accurate measurements are critical to the successful introduction and adoption of liquid biopsies for clinical applications, which include monitoring therapeutic progress and detecting drug resistance mutations.

NIST: Nanocontainers Useful for Drug Delivery

What if doctors could deliver anti-cancer drugs directly to tumors without making patients sick? Bringing this dream of targeted drug delivery closer to reality for pharmaceutical manufacturers, researchers at NIST have received a patent for a method to create precisely sized nanometer-scale capsules.



Credit: A. Jahn, W.N. Vreeland, M. Gaitan, L.E. Locascio/NIST

The NIST method employs microfluidics, the use of fluids at the microscopic level, to create precise nanoscale spherical capsules. Made of lipids, the kinds of biomolecules that also comprise fats, the spherical capsules are known as liposomes. The inside of a liposome could hold drugs, and the outside could be coated with receptors that bind to specific cancer cells. The method can produce liposomes with typical diameters of 100-400 nanometers, or billionths of a meter. This size range is useful for attaching to cells, whose size is typically one to 10 micrometers, or millionths of a meter.

Once this technique was developed, researchers were able to create a variety of liposomes of many useful sizes and the potential drug-delivery applications became clear. "This research and the resulting patent also have implications for the on-demand formulation of drugs in a way that's applicable to personalized or precision medicine," said Laurie Locascio, who was the director of NIST's Material Measurement Laboratory at that time.

NIST: Portable Test Solution for Laser Trackers

A collaboration between NIST researchers and a private-sector firm has led to development of a commercial device to fill a critical need in industry: field verification of laser tracking systems.

Laser trackers are state-of-the-art instruments capable of measuring the dimensions of objects as large as 120 meters in length to high accuracy and with uncertainties as low as 60 micrometers—about half the width of a human hair. Laser-tracker measurements are responsible for ensuring the functionality of millions of dollars in products each day, and are used, for example, in precision measurement of the size, shape, and alignment of aircraft wings during assembly. Performance testing of the tracker systems, which can cost about $200,000, is difficult because it requires long, high-accuracy, portable

reference artifacts that retain their exact dimensions and characteristics over multiple sites and uses.

Thanks to a successful CRADA between NIST's Engineering Physics Division and Brunson Incorporated, a U.S. manufacturer of metrology equipment, such an artifact—the first of its kind—is now a reality. Brunson Incorporated provided the funding, product design, and manufacturing, and PML provided state-of-the-art measurement expertise.

NIST invented the first laser tracker in 1987, and since then has continued research in measurement applications, standardization, uncertainties, and testing. This commercialized product is the latest of many significant achievements in improving the understanding, and therefore the functionality, of laser trackers.

NOAA: CRADA Chart New Territory for Ocean Science

NOAA Research and NOAA Fisheries have teamed up with academic and private sector partners to test innovative technologies that, if successful, will enable researchers to gather information in areas of the ocean virtually off limits to standard research vessels.

The Saildrone research platform is equipped with technologies to collect oceanographic data. Photo credit: Saildrone Inc.

Scientists will be using a novel research platform that resembles a windsurfer, called a Saildrone, developed by Saildrone, Inc. Scientists and engineers equipped two of these autonomous, wind- and solar-powered vessels with other newly designed technologies. Their goal is to collect needed oceanographic data and information for endangered and commercially important species living in remote areas of the Bering Sea. "As pioneers in this new research frontier we're seeking to discover more cost-effective ways to augment our existing research efforts and gather additional biological information in places that are difficult to navigate with a full-sized research vessel," said Douglas DeMaster, research and center director, NOAA Fisheries' Alaska Fisheries Science Center.

The mission unites scientists and engineers from NOAA, the University of Washington, the Joint Institute for the Study of the Atmosphere and the Ocean, Saildrone, Inc., Simrad AS/Kongsberg Maritime, and Greeneridge Sciences, Inc. The marine mammal related research is possible due to the generous support of the Marine Mammal Commission.

"This advance in technology and science is the result of a sustained partnership between the NOAA laboratories and the University of Washington and reflects the talent and quality of the engineers and scientists involved in the project. Understanding climate change in the Arctic requires new tools and innovative measurements and we are all pleased to be part of that effort. We look forward to the results of this summer's campaign, as well as future measurement

campaigns in the Arctic," said Thomas Ackerman, director, Joint Institute for the Study of the Atmosphere and Ocean at the University of Washington.

NOAA: The NOAA Big Data Project

NOAA's Big Data Partnership (BDP) was established in April 2015 through CRADAs between NOAA and Amazon Web Services, Google, IBM, Microsoft and the Open Cloud Consortium. The BDP is investigating how the value inherent in NOAA's data may be leveraged to broaden their utilization and dissemination through the use of modern cloud platforms and associated technologies. The CRADA collaborators work with NOAA experts to identify and deliver those datasets of interest, around which they can build business cases to justify their investments

NOAA's Next Generation Weather Radar (NEXRAD) weather radar data were among the first data to be delivered. The National Centers for Environmental Information (NCEI) transferred the complete NEXRAD Level II historical archive to four interested BDP collaborators. Amazon Web Services (AWS) was the first to make freely available the complete archived Level II data through its AWS platform, with The Climate Corporation as a business partner and data consumer. AWS also collaborated with Unidata/University Corporation for Atmospheric Research (UCAR) to establish a real-time NEXRAD data feed, thereby providing on-demand dissemination of both archived and current data seamlessly through the same access mechanism by October 2015. Through this cloud platform alone, the utilization of the NEXRAD data by volume has increased by 130% over the past usage patterns observed at the National Centers for Environmental Information (NCEI), while the load on NCEI systems has decreased by 50%.

Additional NOAA datasets including fisheries catch data, numerical weather prediction model output, advanced weather radar products, and geostationary satellite data are at various stages of discussion and development. NOAA and its collaborators are beginning to realize the potential of this collective effort among federal government, private industry, and academia, including stimulating new business opportunities and novel applications.

NOAA: SAIC Introduces New Generation of Commercial Tsunami Buoy Systems

by Rob Lawson, SAIC Senior Director International Tsunami Buoy Program[21]

Following 10 years of supporting the evolving tsunami buoy network, Science Applications International Corp. (SAIC), in collaboration with NOAA, will soon be deploying commercially available fourth generation (4G) buoy systems worldwide. As a leader in commercial tsunami buoy systems manufacturing, SAIC is helping to provide the world's tsunami warning centers with access to affordable technology and critical data.

Working with NOAA, SAIC develops, tests, and implements commercial tsunami buoy systems under a NOAA-license agreement. Under this license, SAIC has produced more than 35 second-generation buoy systems based on the NOAA Deep-ocean Assessment and Reporting of Tsunamis II (DART® II) system, and two types of third-generation systems based on the Easy-to-Deploy (ETD) DART® technology.

SAIC's second- and third-generation buoy systems are currently operational in maritime countries worldwide, including Australia, Chile, China, India, Japan, Russia, and Thailand, and

[21] See: https://www.oceannews.com/featured-stories/september-feature-story-saic

are gathering actionable data for its users and NOAA. Recently, SAIC provided developmental 4G payloads and bottom pressure recorders to NOAA in support of a 4G research effort off the coast of Chile.

Now, as SAIC enters another decade of work with NOAA, the company is manufacturing more than 85% of the world's commercially deployed tsunami buoys, helping to make the concept of a globally interconnected, tsunami buoy network a reality.

NOAA: Successful Completion of NE Fisheries Science Center/Envera CRADA
In 2016 NOAA's Milford Laboratory and Envera LLC completed research under their CRADA agreement to explore large-scale production trials of Milford Laboratory probiotic strain OY15 for potential commercialization. Probiotic strain OY15 is a marine bacterium isolated from an oyster (*Crassostrea virginica*) digestive tract and shown to possess probiotic activity. The availability of this genome sequence will facilitate the study of the mechanisms of probiotic activity as well as virulence capacity.

Under the CRADA, Envera provided the Milford Laboratory with freeze-dried and spray-dried formulations of Milford Probiotic Strain OY15, which were analyzed in the lab to see if they stimulate immune functions as well as live OY15. In addition, larval bioassays comparing these two formulations to live OY15 have been run. Future adjustments to the concentrations of these formulations will aid in confirming their probiotic effects on survival of oyster larvae and ideally lead to the commercialization of the Milford Probiotic Strain OY15.

NTIA: Telecommunication Standards
Models used to predict wireless propagation are fundamental to enabling spectrum sharing. The International Telecommunication Union – Radio Communication Sector (ITU-R), and international treaty organization, has as its primary objective to ensure interference free operations of radiocommunications systems. The ITU-R publishes internationally standardized propagation prediction models that are used to harmonize spectrum assignments internationally and to manage space-related spectrum assignments. Increasing spectrum crowding demands increased accuracy and granularity of these models, which are developed through the participation of technical committees from all the treaty nations.

Of particular interest at present are improving our understanding of air-to-ground propagation, world refractivity mapping, and the effects of sunspot number recalculation, all of which are critical to satellite communication systems. The ITS chair of ITU-R Study Group 3 Working Party 3K led the examination of over 70 input documents into the final 25 technical documents that were considered by ITU-R Study Group 3 during 2016 meetings. ITS authored four of the 18 technical contributions submitted by the U.S.

Strong unbiased standards are fundamental for widespread competitive advancement of new technologies. This is particularly of interest to the public safety community, which is gaining access to the expanded capabilities of a dedicated LTE broadband network through the First Responder Network Authority (FirstNet). The 3rd Generation Partnership Project (3GPP) sets the standards for commercial cellular equipment, which have not previously included standards for many features critical to first responders. Intense participation by ITS staff in 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 requirements being included in 3GPP Release 13, which was frozen in mid FY 2016. These features are critical to ensuring that LTE can meet public safety's requirements and are a prerequisite to allowing 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 Table Mountain Field Site and Radio Quiet Zone 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 2016, several companies used the Table Mountain site under a CRADA to safely test and demonstrate LADAR technologies under development in atmospheric conditions and at distances relevant to potential applications, to fully test the functionality of new antenna designs during product development, and to safely and accurately test an Adaptive Tactical Laser System (ATLAS) compensated beacon adaptive optics (CBAO) system under development. Applications for these technologies include detection and tracking of wind shear and wake vortices, remote wind measurements for the offshore wind energy industry, mission-critical communications, electronic warfare, direction finding/geolocation, and sensing of hazardous liquids and gases.
- For the past ten 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 aircrafts used for atmospheric science applications such as the study of tornado genesis.

NTIA: Video Quality Research

NTIA hosts the Consumer Digital Video Library (CDVL) to provide material for research and development of new techniques and encoding methods (codecs) for video transmission and delivery. This library is made available to resolve the impediment to new product and standards development caused by a lack of royalty-free test material. The video clips, some developed by NTIA in house and some contributed by industry and academia, are used to test codecs, to evaluate new display technologies, or for validation testing of new standards. For example, THE Telecommunication Standardization Sector (ITU-T) Study Group 12 has used CDVL clips for research into the development of parametric models and tools for multimedia quality assessment. ITU-T Recommendations are international voluntary standards that aid US industry to compete internationally. The new ITU-T recommendations currently in development will propose methods of estimation of perceived quality of transmitted video under different conditions. Such recommendations are used by internet service providers and wireless carriers to optimize network parameters for video transmission and provide customers the best Quality of Experience. Similarly, the Motion Picture Experts Group (MPEG) has an interest in using the CDVL video clips for validation testing of new video coding standards, which will eventually succeed the MPEG video codecs in use today, By choosing specific videos and making them

available for MPEG testing, we encourage MPEG to develop high quality codecs that will enable greater compression with no loss of quality to mitigate increasing wireless bandwidth demands.

NTIA also develops and makes available Video Quality Measurement (VQM) tools for use by industry and academia for research into new techniques for transmitting video. The rapid evolution of digital video compression, storage, and transmission technology presents a difficult network performance measurement task. To avoid immediate obsolescence, new performance measurement technology developed for digital video systems must be technology independent and non-proprietary. The VQM tools meet this need. These software products are no longer patented or licensed, in accordance with the Government's increasing emphasis on Open Data. Making these software tools available as an open source benchmark supports rapid development of commercial digital video quality measurements based on perceived picture quality but able to operate in-service to adjust network conditions on-the-fly using the actual video being transmitted.

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 DoD 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.

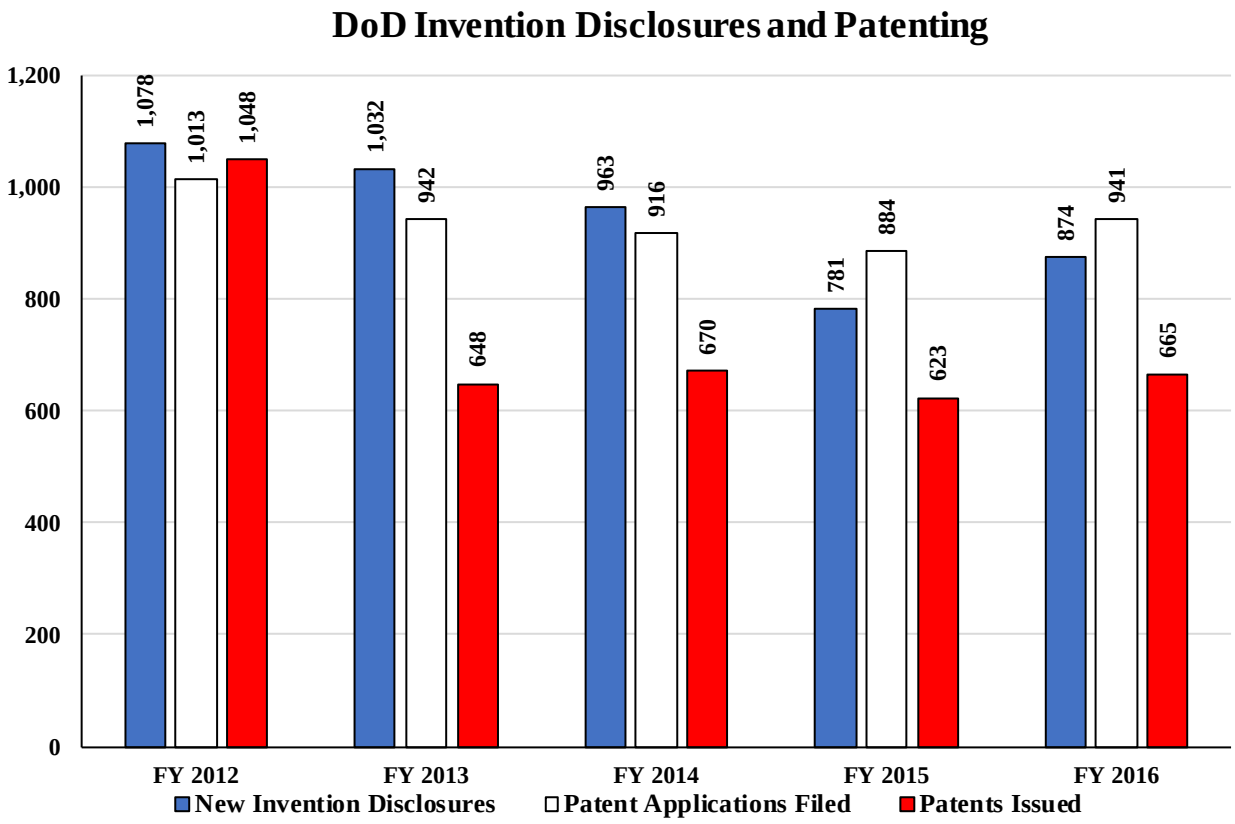
DoD is unique in applying the principles, practices, and tools of technology transfer in the execution of its mission. DoD funds and develops mission-focused technology, and technology transfer statutory authorities enable it to promote and facilitate the commercialization of that technology for both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

DoD research & Engineering enterprise: http://www.acq.osd.mil/chieftechnologist/index.html
U.S. Army Research Laboratory: http://www.arl.army.mil/main/Main/default.cfm?Action=6
Office of Naval Research: https://www.onr.navy.mil/

DoD Invention Disclosures and Patenting

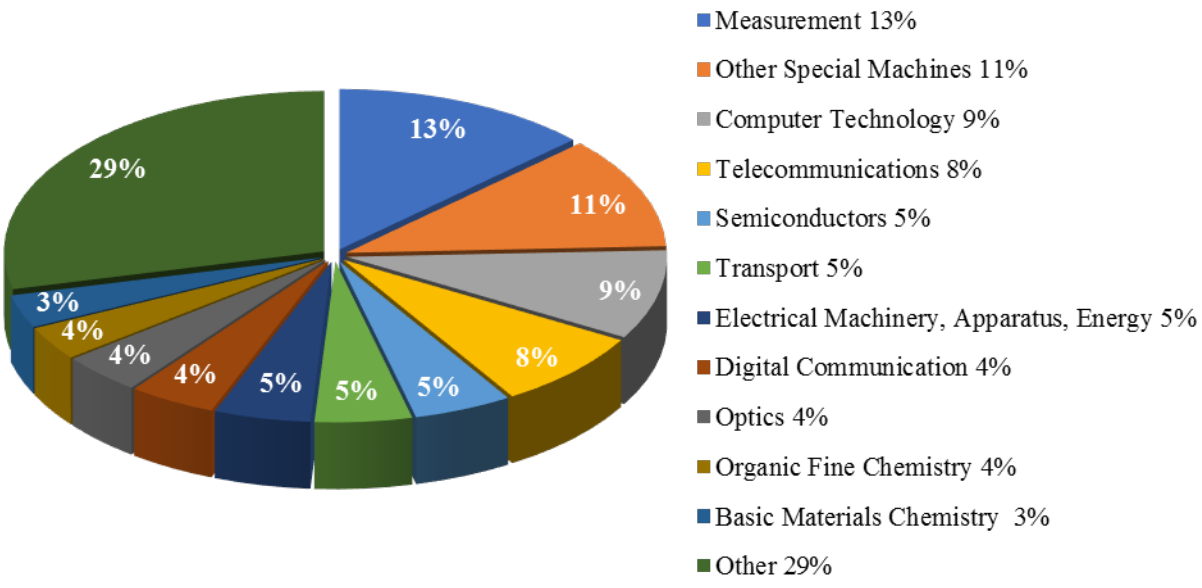
Between FY 2012 and FY 2016, the number of new inventions disclosed decreased by 19% to 874 disclosures in FY 2016. The number of patent applications filed decreased by 7% to 941. The number of patents issued during decreased by 37% to 665 patents.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	1,078	1,032	963	781	874
Patent Applications Filed	1,013	942	916	884	941
Patents Issued	1,048	648	670	623	665

Patents issued to DoD in FY 2016 covered many technology areas including Measurement (13%), Other Special Machines (11%), Computer Technology (9%), Telecommunications (8%), and Semiconductors (5%), Transport (5%), and Electrical Machinery, Apparatus, Energy (5%).[22]

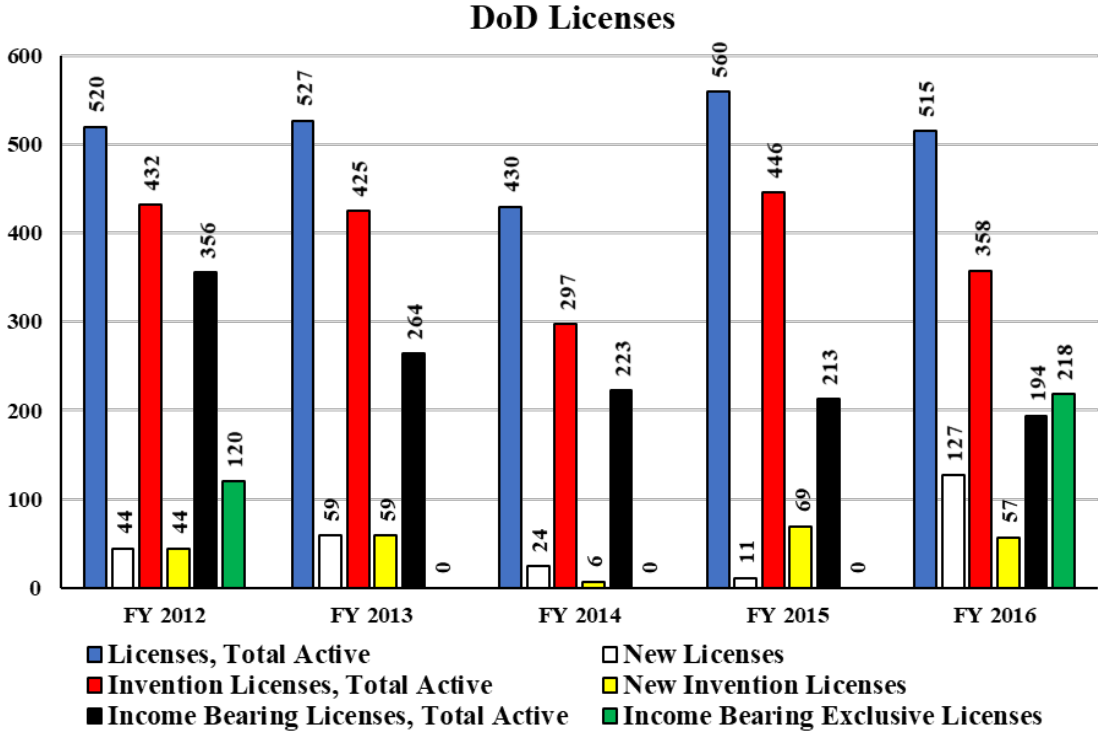
USPTO Patents Assigned to DoD by Technology Area: FY 2016



[22] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DoD Licenses

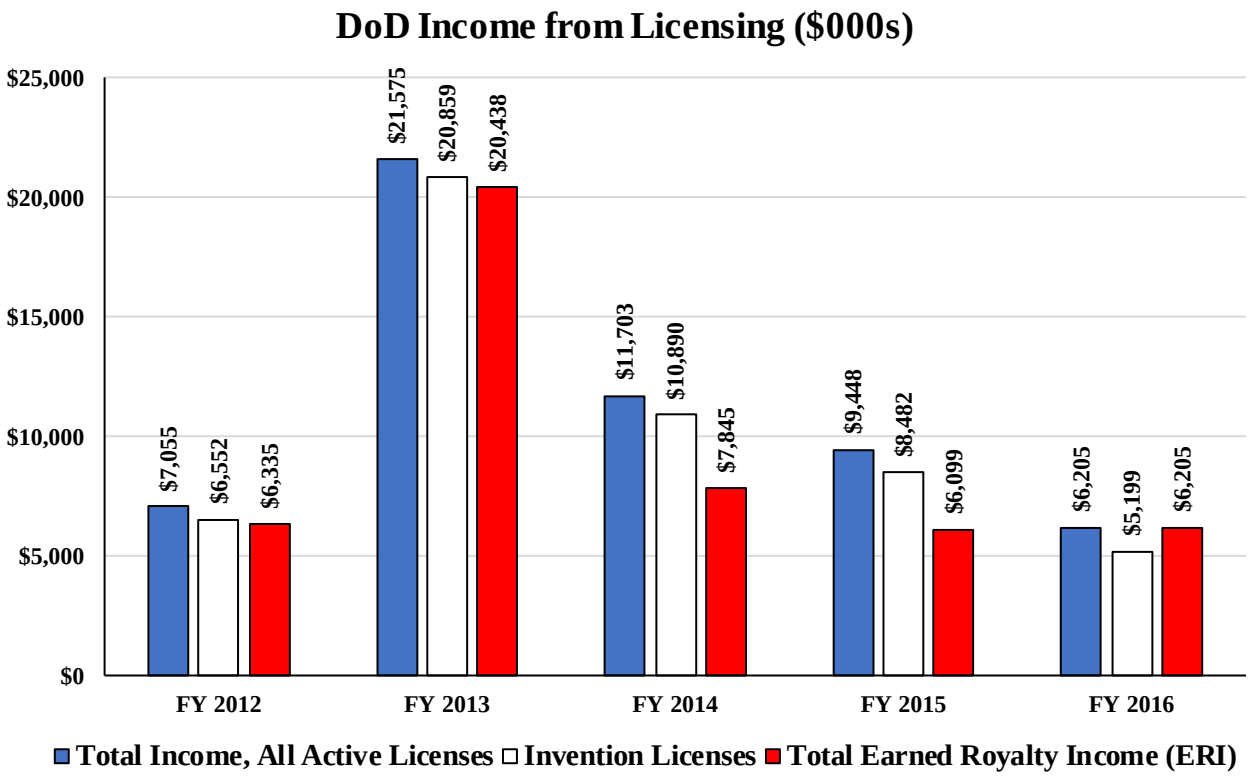
Total active licenses decreased by 1% from 520 licenses in FY 2012 to 515 licenses in FY 2016, while new licenses increased 189% to 127. Total active invention licenses declined by 17% to 358, while new invention licenses increased by 30% to 57. Total active income-bearing licenses declined by 46% to 194, and income-bearing exclusive licenses increased by 82% to 218. DoD was not able to report income-bearing licenses exclusive licenses for FY 2013 - FY 2015.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	520	527	430	560	515
New Licenses	44	59	24	11	127
Invention Licenses, Total Active	432	425	297	446	358
New Invention Licenses	44	59	6	69	57
Income Bearing Licenses, Total Active	356	264	223	213	194
Income Bearing Exclusive Licenses	120	n.a.	n.a.	n.a.	218

DoD Income from Licensing

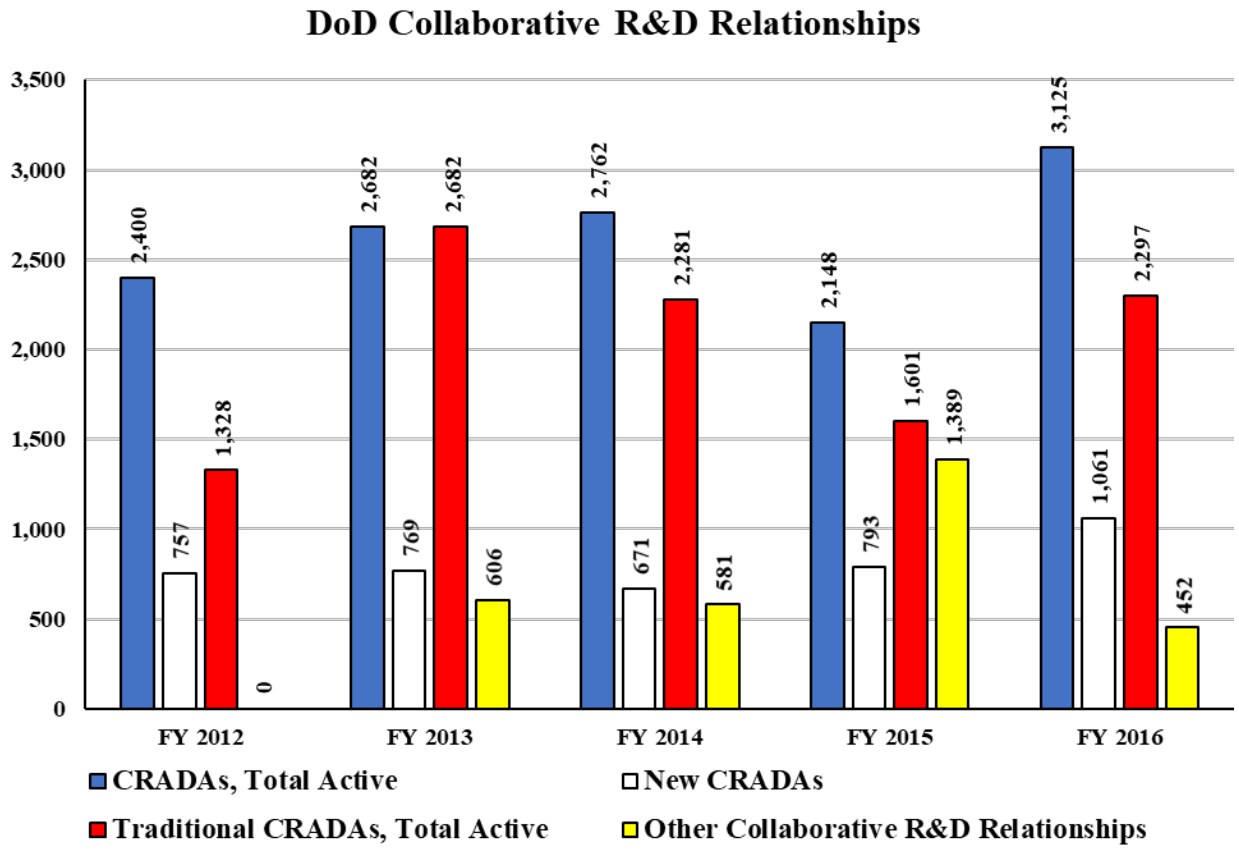
In FY 2016, total income from all active licenses decreased by 12% from $7 million in FY 2012 to $6.2 million in FY 2016. Income from invention licenses decreased by 21% to $5.2 million and total earned royalty income declined by 2% to $6.2 million.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$7,055	$21,575	$11,703	$9,448	$6,205
Invention Licenses	$6,552	$20,859	$10,890	$8,482	$5,199
Total Earned Royalty Income, (ERI)	$6,335	$20,438	$7,845	$6,099	$6,205

DoD Collaborative R&D Relationships

Between FY 2012 and FY 2016, DoD reported the number of total active cooperative research and development agreements (CRADAs) increased by 30% to 3,125 agreements, while the number of new CRADAs per fiscal year increased by 40% to 1,061. The number of total active traditional CRADAs increased by 73% to 2,297 agreements. There were 452 other collaborative relationships reported in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	2,400	2,682	2,762	2,148	3,125
New CRADAs	757	769	671	793	1,061
Traditional CRADAs, Total Active	1,328	2,682	2,281	1,601	2,297
Other Collaborative R&D Relationships	0	606	581	1,389	452

DoD Downstream Success Stories

Air Force: Roll-Out Solar Array

The primary source of power generation for spacecraft is solar power, and the solar panels used 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 of 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. Coupled to the tight launch confines is the exorbitant launch expense. 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 the overall system cost and increases the total power for the mission. To tackle these challenges, the Air Force Research Laboratory Space Vehicles Directorate (AFRL/RV)—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 provides six-time improvement in stowed power density, three times higher specific power, and four times higher stiffness, all while lowering the array cost by 25%. The outstanding improvement in performance enables ROSA to supersede spacecraft on-orbit power limits, which leads to substantially higher communication bandwidth for commercial applications and opens up new classes of DoD missions.

The technology transfer partnership was initiated using a Small Business Innovation Research (SBIR) contract with Deployable Space Systems, LLC, to improve the stowed volume and deployed on-orbit performance of solar arrays. LoadPath, LLC, a small business cooperative research and development partner with AFRL/RV, developed the boom fabrication methodology and provided the test data that was critical to demonstrating the capabilities of ROSA. NASA provided modeling support and transition to space exploration missions.

The multi-partner effort formed by the partnership led directly to the testing, demonstration, and commercialization of ROSA, with widespread adoption of the technology leading to broad economic impacts and transitioning to Space Systems Loral to replace its existing arrays for 37 geostationary orbit/low Earth orbit (GEO/LEO) communications satellites in production.

Army: Open Campus

The Army Research Laboratory's (ARL) Open Campus is a collaborative endeavor with the goal of building a science and technology ecosystem that encourages groundbreaking advances in basic and applied research areas of relevance to the Army. The initiative allows ARL to tap regional resources in order to gain knowledge and expertise from intellectual markets that have been underrepresented as a means to quicken the technology maturation process and allow the Army to maintain technology overmatch in critical areas. Through the Open Campus framework, ARL scientists and engineers work collaboratively with visiting scientists in ARL's facilities and as visiting researchers at collaborators' institutions. Ultimately, the Open Campus initiative hopes to create an enhanced defense research environment that fosters discovery and

innovation through collaboration on fundamental research. Advantages include:

- Reducing barriers to facilitate collaboration with academia, industry, and small businesses;
- Academia, industry, and small business access to ARL's specialized research staff and unique technical facilities;
- Staffing using novel approaches;
- Offering a career path for students and scientists; and
- Arranging on-site collaborator presence by leveraging Enhanced Use Lease agreements.

Thus far, two facilities have been established under the Open Campus model:

- ARL-West, opened in April 2016, is headquartered at the University of Southern California in Los Angeles and focuses on Human Information Interaction; and
- ARL-South, established in November 2016, is headquartered at the University of Texas at Austin and will initially focus primarily on materials and manufacturing including additive manufacturing, biosciences, energy, and power.

Army: HyperX Parallel Memory/Processor Network Chip for Communications Equipment

Evolving from hyperspectral image processing software created by Dr. Paul Wilson while employed by the U.S. Army Combat Capabilities Development Command Armaments Center (CCDC AC) in the 1990s, the commercialization of the HyperX processor chip spanned more than a decade. The HyperX processor chip is a low-power, scalable, and embedded processor platform that may become the world's processing standard for advanced communication and image/video devices. Capable of storing, processing and retrieving massive amounts of data, HyperX combines the high computational performance of application-specific integrated circuits, the reconfiguration performance of programmable technology, and the "ease of use" of general-purpose processors. These goals are achieved in a low-power processor less than a square centimeter in size.

From 2000 to 2012, a series of SBIR contracts between ARDEC and Coherent Logix (CLX) transformed Dr. Wilson's innovative software into a groundbreaking multicore parallel processing technology. Other technology transfer tools, such as a 2011 DoD Memorandum of Understanding, transitioned the technology to other locations. Throughout this time, Dr. Wilson, Michael Doerr (CLX Chief Executive Officer), and Dr. Robert Reuss (Defense Advanced Research Projects Agency, Program Manager for HyperX) worked diligently to advance the technology. Today the HyperX processor chip is the cornerstone of CLX's portfolio of commercial products, with 29 related patents. Among the multiple commercial products now with embedded Hyper technology are ixMax, the world's first carrier-class cognitive radio network, and small cell consumer and commercial wireless communications equipment from Public Wireless. As the power and popularity of mobile devices grows, HyperX has the promise to meet increasing commercial and military needs for faster data processing with lower power consumption.

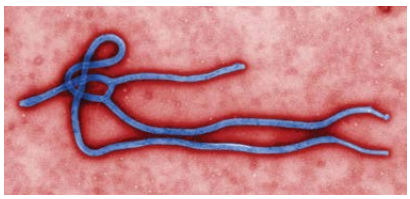
Army: Hardened Alternative Trailer System

The Hardened Alternative Trailer System (HATS) grew out of increasing numbers of forced entry, small-arms, and ballistic attacks impacting personnel in and around U.S. embassies. Existing containerized housing units offered little-to-no force protection and required up-armoring in the field, a costly and unreliable means of addressing federal forced entry and blast-resistant requirements. HATS modules were developed and tested to exceed threat-level requirements and to be fully compatible with conventional International Organization for Standardization (ISO) freight container dimensions. The HATS modularity enables standardized shipping and handling, and the ability to stack units at site destinations to create multi-level building complexes. This hardened turnkey approach permits rapid implementation of secure, cost-effective modules to serve as housing, offices, and safe havens for U.S. personnel abroad.

In just two short years (2011-2013), the HATS technology moved from concept to initial implementation. U.S. Army Engineer Research and Development Center Geotechnical and Structures Laboratory (ERDC-GSL) engineering capabilities were recruited to address the concept initiated by the Department of State, Bureau of Diplomatic Security (DoS-DS). In 2012, the ERDC-GSL team collaborated to design, prototype, and blast test HATS to meet DoS-DS standards. Advancing rapidly to address demands for HATS demonstration units, the team had security concerns about how to release the sensitive design specifications and future updates to achieve high-quality manufacturing. By devising a technology transfer solution, the team protected the HATS design and method of production in 2013 under a first patent application; developed a licensing process to prequalify applicant manufacturing capabilities; found licensees through the use of novel resources; and used the resulting license agreements as a means to assert quality control and transfer ongoing design changes to manufacturers. In 2013, a first license was executed, and the first contracting occurred for delivery of 38 HATS units.

By 2015, technology transfer efforts resulted in eight non-exclusive licenses with Charleston Marine Containers, ARMAG Corporation, HWH Protective Structures, MBI Global/CLS, Power Systems & Controls, Griffin Incorporated, Quality Manufacturing Group, and LoneStar Marine Shelters. To date, 211 HATS units have been contracted through the licensees, representing an estimated $53 million of HATS licensee sales revenue, with installation locations now including Peshawar, Pakistan; Juba, South Sudan; Damascus, Syria; and Adana, Turkey. HATS modules have successfully provided an affordable, commercially available, physical force protection system to enhance the survivability of U.S. embassy and industry personnel in hostile threat situations. Transfer of the HATS technology has yielded a new product and market for the licensees and has satisfied ERDC-GSL's mission to develop innovative technologies for survivability and protective structures on behalf of national interests.

Army: Zmapp Therapeutic Monoclonal Antibody Cocktail



In August 2014, within days of being stricken by the Ebola virus, two American medical workers received an experimental drug that had never been tested on humans. ZMapp saved their lives. The recovery of physician Kent Brantly and aid worker Nancy Writebol is a testament to the critical work done at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), where research scientists developed one of the

three monoclonal antibodies that comprise ZMapp. The antibody was licensed to Mapp Biopharmaceutical of San Diego in October 2009, five years before the unprecedented Ebola outbreak in 2014. Since then, MappBio received a $25.9 million contract from the HHS to support accelerated development of ZMapp; and Phase I, Class II clinical trials are now underway in West Africa.

The license agreement between the Army and MappBio was the first in the DoD, and perhaps the country, to leverage the U.S. Food and Drug Administration's (FDA) Tropical Disease Priority Review Voucher (PRV) program. As a technology transfer tool, the potential shared proceeds from a PRV represent one of the largest upsides in licensing ever negotiated.

Terms developed for the MappBio agreement regarding a potential PRV are now standard in all tropical disease licenses negotiated by the Army Medical Research and Development Command's (MRDC) Technology Transfer Office. Considerations include determining the value of the potential voucher and the relative contributions of the licensee and licensor, which are unique to each negotiation. This technology transfer has exceeded all partners' expectations. MappBio has transitioned from a company of nine employees to a world leader in biotechnology, while at USAMRIID and the MRMC Technology Transfer Office, interest in Army Ebola-related technology has soared, resulting in many licensing agreements and establishing the lab as a national and international resource. At the end of the day, it is about saving lives. Ebola patients and healthcare providers now have hope that there is an end to the 60% to 90% fatality rate of the deadliest virus on the planet.

Navy: METBENCH Calibration Management System

On April 16, 2014, the Naval Surface Warfare Center, Corona Division (NSWC Corona) signed a non-exclusive patent license agreement with American Technical Services, Inc. (ATS) of Norco, California. The agreement transferred the Navy's METBENCH Calibration Management System, a net-centric, browser-based information technology that automates standardized equipment calibration procedures and collects measurement data across the fleet. The historic cross-licensing agreement was the first of its kind for the U.S. Navy, creating a two-way exchange between ATS and the Navy of their respective calibration technologies. It also was the first PLA for NSWC Corona-designed technology.

The NSWC Corona team was principally responsible for the successful technology transfer activities that overcame fundamental challenges inherent to the lab's existing technology transfer culture. The team not only smoothly transferred METBENCH to the private sector, but also expanded the lab's emerging intellectual property (IP) and technology transfer culture.

For the Navy, the transferred technology promises major savings by reducing resources needed to regularly calibrate innumerable pressure gauges, contact switches, temperature indicators, infrared cameras, night vision goggles, radios, weapons systems and more. U.S. sailors perform

about 10,000 calibrations each year, and the Navy utilizes roughly 1.85 million pieces of calibration test equipment. The METBENCH technology increases collected data quality, eliminates technical errors, and decreases calibration times, with near real-time calibration guidance, asset tracking, and readiness reporting.

For ATS, the transfer instantly expanded company horizons from its Navy contractor focus to a vast commercial marketplace. Any sector, from pharmaceuticals to manufacturing, that uses electronic and physical measurement tools contains potential ATS customers. Ubiquitous in both private and public realms, equipment calibration is a multibillion-dollar industry.

Navy: Explosive Ordinance Disposal Robotics

Explosive Ordnance Disposal Robotics (EODR) is a system architecture for interoperability and operator control capability for unmanned ground vehicles (UGV) designated for explosive ordnance disposal duties. The Navy's Space and Naval Warfare Systems Center Pacific (SSC Pacific) has developed several robotics-related software systems, including a common operator interface software framework called the Multirobot Operator Control Unit (MOCU) and a software library for the Joint Architecture for Unmanned Systems interoperability standard.

SSC Pacific also maintained a Robotics Systems Pool that made the UGV platforms and technology available for transfer via Limited Purpose CRADA with industry, academia, and state and local governments for R&D purposes. In July 2009, SSC Pacific signed a CRADA with RE2 Robotics, Inc. of Pittsburgh, Pennsylvania. Results quickly supported a full CRADA between the two partners, which was executed in August 2009 and effective through August 2012. The SSC Pacific-RE2 exchange excelled in its seamless integration of the two partners' robotics expertise, based on mutual respect and willingness to achieve "interoperability" not only in robotics, but in the steps taken to transition the valuable technologies to industry and back to the military.

Both RE2 Robotics and SSC Pacific significantly contributed to the broader validation of open architecture for EODR UGV technologies. Their back-and-forth effort was critical to what ultimately became a paradigm shift in Navy and DOD robotics acquisition processes, from a process focused on unique solutions from a single company to one more focused on cost-effective open architecture and interoperability.

Navy: Multi-Robot Operator Control Unit (MOCU)

The Navy has developed an unmanned vehicle and sensor operator control interface capable of controlling and monitoring multiple sets of heterogeneous systems simultaneously. The modularity, scalability, and flexible user interface of the Multi-Robot Operator Control Unit (MOCU) enables control of a wide range of vehicles and sensors in varying mission scenarios. MOCU currently controls all SSC- Pacific developmental vehicles including land, air, sea, and undersea vehicles, the Spartan Advanced Concept Technology Demonstration (ACTD) unmanned surface vehicle (USV), the iRobot PackBot, and the Family of Integrated Rapid Response Equipment vehicle and sensors. Recently, a team consisting of both Department of Navy personnel and industry professionals collaborated to validate the integration of the MOCU with explosive ordnance disposal (EOD) robotic systems. The collaborative effort targeted multiple problems that decrease the field performance of EOD robots, and ultimately the safety

of the U.S. warfighter. The effort resulted in an agile robotic system that employs an open architecture, enables multi-manufacturer innovation, allows for forward and backward compatibility, and reduces the cost of EOD robots. The effort represents a shift in Navy and DoD acquisition processes from focusing a unique solution from one company, to focusing on a cost-effective open architecture that is interoperable with multiple solutions. MOCU validation under the CRADA was a key factor in MOCU becoming the required OCU for the Navy's Advanced EOD Robotic System program of record.

Department of Energy (DOE)

DOE is one of the largest supporters of technology transfers within the federal government. The Department plays a key role in moving new 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 DOE's mission to enhance the United States security and economic growth through transformative science and market solutions. By creating globally competitive industries in the U.S., the DOE enables significant cost-savings for industries and consumers and creates jobs for Americans.

The DOE's National Laboratories addresses 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 to innovation. Among the many things that the National Laboratories do, some include the following:

- 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 2016, these facilities were used by over 33,000 researchers from universities, national laboratories, private industry, and other federal science agencies.[23]

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

DOE laboratories and facilities that are actively engaged in technology transfer include:

Office of Science:

- Ames Laboratory (Ames),
- Argonne National Laboratory (ANL),
- Brookhaven National Laboratory (BNL),
- Fermi National Accelerator Laboratory (FERMI),
- Lawrence Berkeley National Laboratory (LBNL),
- Oak Ridge National Laboratory (ORNL),
- Pacific Northwest National Laboratory (PNNL),
- Princeton Plasma Physics Laboratory (PPPL),
- SLAC National Accelerator Laboratory (SLAC),
- Thomas Jefferson National Accelerator Facility (JLAB)

National Nuclear Security Administration:

- Lawrence Livermore National Laboratory (LLNL),
- Los Alamos National Laboratory (LANL),
- Sandia National Laboratories (SNL),
- Savannah River Site,
- National Security Campus (formerly the Kansas City Plant),
- Y-12 National Security Complex, Pantex Plant, Nevada National Security Site (formerly the Nevada Test Site)

Office of Energy Efficiency and Renewable Energy:

- National Renewable Energy Laboratory (NREL)

Office of Nuclear Energy:

- Idaho National Laboratory (INL)

Office of Fossil Energy:

- National Energy Technology Laboratory (NETL)

Office of Environmental Management:

- Savannah River National Laboratory (SRNL)

Science and engineering are not linear. 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, academia, and other federal and state agencies is essential to develop, demonstrate, deploy and commercialize the output from DOE's broad R&D investments.

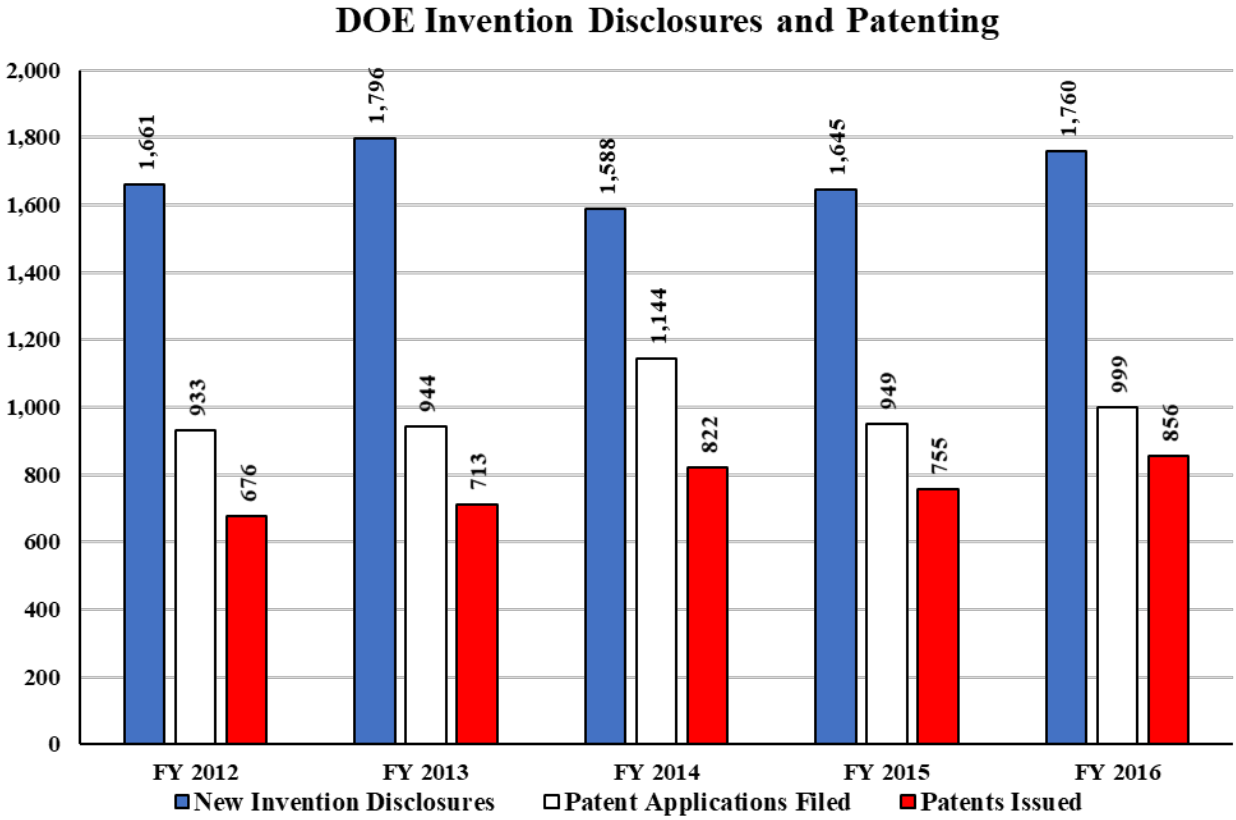
The Office of Technology Transitions (OTT) mission is to expand the commercial impact of the DOE's research and development portfolio to advance the economic, energy, and national security interests of the Nation. OTT develops DOE's policy and vision for expanding the commercial impact of its research investments and streamlines information and access to DOE's

national labs and sites to foster partnerships that will bring innovations from the labs into the marketplace.

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

DOE Invention Disclosures and Patenting

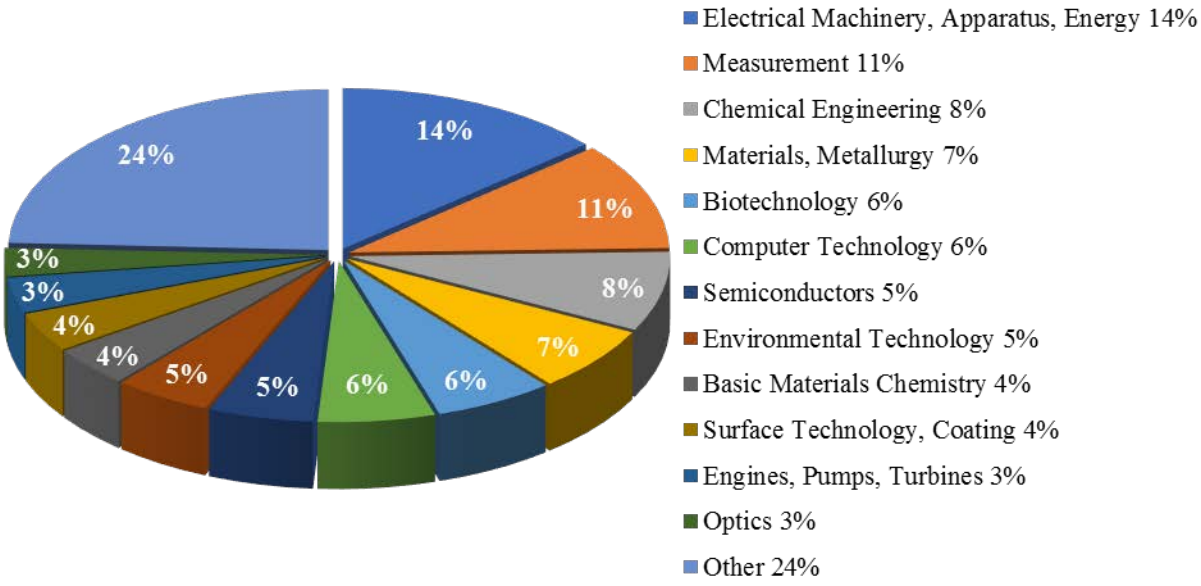
Between FY 2012 and FY 2016, the number of new inventions disclosed increased by 6% to 1,760 disclosures in FY 2016. The number of patent applications filed increased by 7% to 999. The number of patents issued increased by 27% to 856 patents in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	1,661	1,796	1,588	1,645	1,760
Patent Applications Filed	933	944	1,144	949	999
Patents Issued	676	713	822	755	856

Patents issued to DOE in FY 2016 covered many technology areas including Electrical Machinery, Apparatus, Energy (14%), Measurement (11%), Chemical Engineering (8%), Materials, Metallurgy (7%), Biotechnology (6%), and Computer Technology (6%).[24]

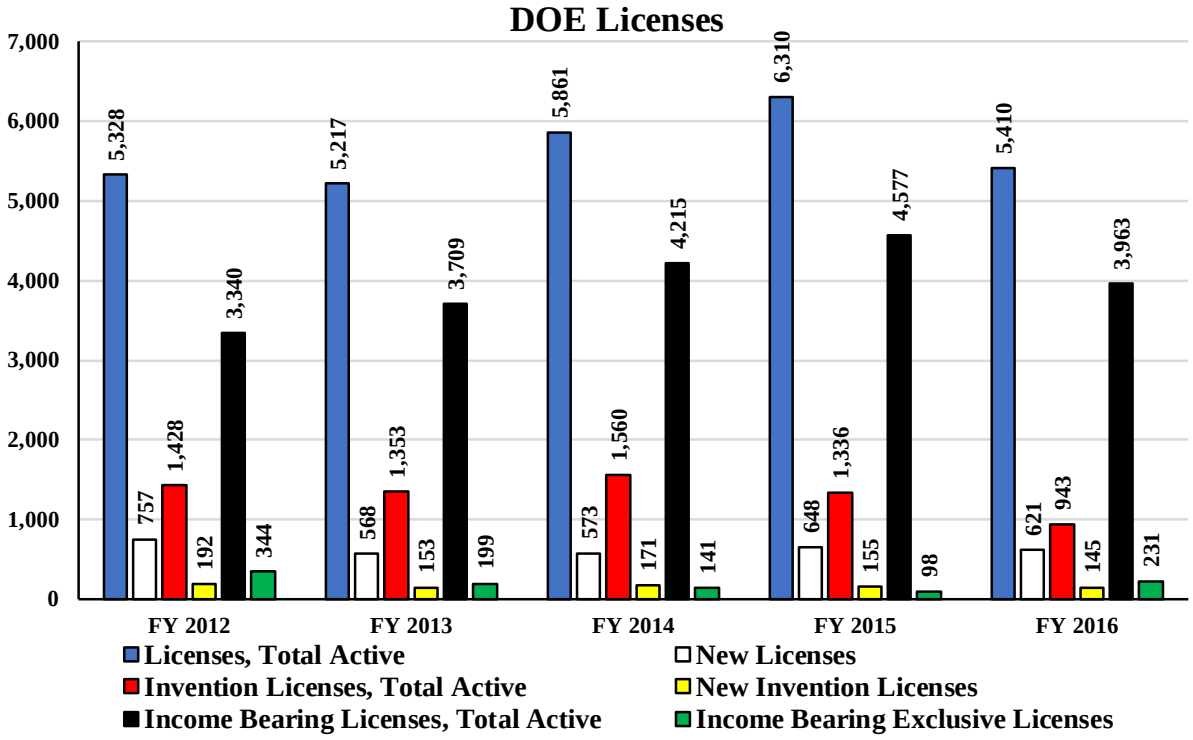
USPTO Patents Assigned to DOE by Technology Area: FY 2016



[24] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DOE Licenses

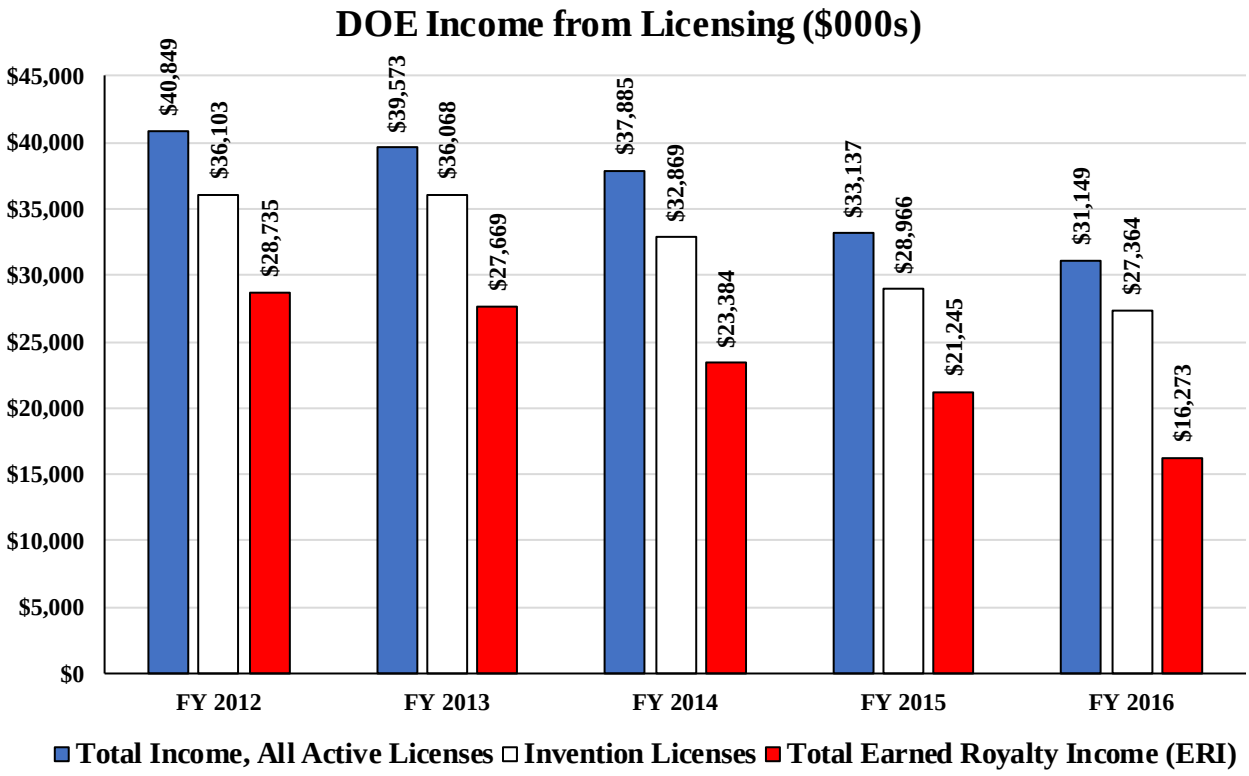
Between FY 2012 and FY 2016, the number of total active licenses increased by 2% to 5,410 licenses in FY 2016 while new licenses decreased by 18% to 621 licenses. The number of total active invention licenses decreased by 34% to 943 licenses while the number of new invention licenses decreased by 24% to 145. Income-bearing licenses increased by 19% to 3,963 while the number of exclusive income-bearing licenses decreased by 33% to 231.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	5,328	5,217	5,861	6,310	5,410
New Licenses	757	568	573	648	621
Invention Licenses, Total Active	1,428	1,353	1,560	1,336	943
New Invention Licenses	192	153	171	155	145
Income Bearing Licenses, Total Active	3,340	3,709	4,215	4,577	3,963
Income Bearing Exclusive Licenses	344	199	141	98	231

DOE Income from Licensing

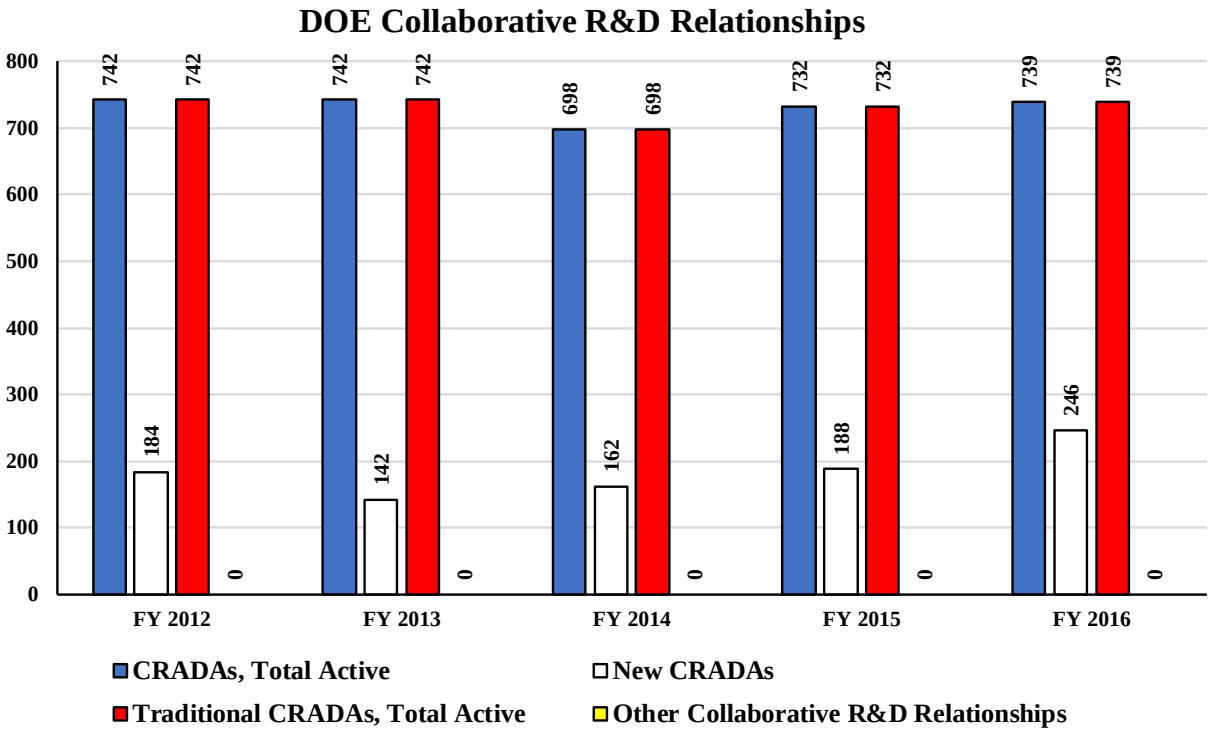
Between FY 2012 and FY 2016, DOE reported that total income from all active licenses decreased by 24% to $31.1 million in FY 2016. The income from invention licenses decreased by 24% to $27.4 million. Total earned royalty income decreased 43% to $16.3 million in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$40,849	$39,573	$37,885	$33,137	$31,149
Invention Licenses	$36,103	$36,068	$32,869	$28,966	$27,364
Total Earned Royalty Income, (ERI)	$28,735	$27,669	$23,384	$21,245	$16,273

DOE Collaborative R&D Relationships

Between FY 2012 and FY 2016, the number of total active cooperative research and development agreements (CRADAs) declined slightly from 742 in FY 2012 to 739 in FY 2016. The number of new CRADAs per fiscal year increased by 34% to 246. All of DOE's active CRADAs were reported to be traditional CRADAs.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	742	742	698	732	739
New CRADAs	184	142	162	188	246
Traditional CRADAs, Total Active	742	742	698	732	739
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

Ames Laboratory: Titanium Powder Processing Gains International Customer Base

Titanium powder created with DOE's Ames Laboratory-developed gas-atomization technology has hit the market. Praxair, Inc., headquartered in Danbury, CT, now offers fine, spherical titanium powder for additive manufacturing and metal injection molding of aerospace, medical and industrial parts. It marks the first-time large-scale amounts of titanium powder are available to industry with a potential for low-cost, high-volume manufacturing.

A titanium bolt and the corresponding amount of titanium powder necessary to create it.

Titanium's strength, light weight, biocompatibility and resistance to corrosion make it ideal for use in parts ranging from aircraft wing structures to replacement knee joints and medical instruments. Using ultra-fine, high-purity spherical titanium powder to 3-D print or mold these parts generates 10 times less metal waste than traditional casting of parts. However, ultra-fine titanium powder was nearly impossible to produce from the molten state because liquid titanium is readily contaminated by dissolved gases and cannot be contained by normal ceramic melting crucibles, which it can rapidly erode, to the point of spilling through.

The Ames Laboratory's invention of an in-stream melt heating guide tube was critical to boosting the melt temperature by at least 100˚C, allowing adaptation of water-cooled 'clean' melting technologies, normally used to melt and cast strong, reliable aerospace titanium parts. This new 'hot nozzle' made possible precise feeding of highly energetic close-coupled atomizers for efficient production of fine titanium powders. Development of the hot-shot pour tube was supported by DOE's Office of Science and Office of Fossil Energy. The specific work on titanium powder was supported by the Iowa State University Research Foundation, the State of Iowa Regents Grow Iowa Values Fund, the US Army through the Quad City Manufacturing Lab (QCML), and finally funding from Praxair. Strategic Partnership Projects were negotiated with both the QCML and Praxair.

Two members of the Laboratory's research team created a spinoff company, Iowa Powder Atomization Technologies (IPAT), and exclusively licensed Ames Laboratory's titanium atomization patents. IPAT worked to further optimize the titanium atomization process and along the way won several business and technology awards for their efforts, including DOE's Next Energy Innovator competition in 2012.

In 2014, IPAT was acquired by Praxair, a Fortune 250 company and one of the world's largest producers of gases and surface coatings. In 2016, Praxair announced they had begun to market titanium powder.

Brookhaven National Laboratory: Optically Active Nanostructures
Brookhaven National Laboratory (BNL) and Northrop Grumman (NG) launched a major initiative under a CRADA to discover, develop, and demonstrate techniques for the fabrication of arbitrarily designed 2D and 3D arrays from diverse optically functional nanoparticles (NP) using a macromolecular (DNA) assembly platform, a methodology that has been developed at the BNL Center for Functional Nanomaterials (CFN).

Don DiMarzio is an engineering fellow at NG and a senior scientist within the company's advanced research, development, design, and demonstration group NG Next, where he studies nanomaterials and radio-frequency metamaterials. He is also an adjunct professor at Stony Brook University, where he teaches a nanotechnology class. Since March 2016, he has been collaborating with CFN physicist Oleg Gang to investigate nanostructures whose self-assembly is directed through DNA scaffolds. Don DiMarzio utilized a broad range of advanced characterization labs at CFN.

Oleg Gang has been developing this DNA-based technique for a decade, and his group pioneered the fabrication of new nanoparticle-based 3D materials and the development of the by-design nano-assembly methods. Through incorporation of optically active nanoparticles into designed assembled architectures this collaboration seeks to establish novel methods for targeted fabrication of materials with desired light emitting and light modulating properties.

Recently, this BNL-NG collaboration resulted in a publication that describes a new approach for the assembly of precisely organized nanoparticle meso-clusters as it has been demonstrated through a comprehensive characterization at the CFN.[25] Brookhaven recently had the pleasure of hosting a visit from Tom Pieronek, Vice President, Basic Research at NG Aerospace Systems. We look forward to developing further collaborations in the future.

Fermi National Accelerator Laboratory: Electromagnetic boom and environmental cleanup technologies
Natural Science, LLC and Fermi National Accelerator Laboratory (Fermilab) announced an exclusive field-of-use license agreement that grants Natural Science rights to Fermilab's electromagnetic boom and environmental cleanup technologies for use in conjunction with magnetizable oil.

Through this agreement, Natural Science can utilize and develop electromagnetic oil recovery boom technologies across a broad range of applications, including on-and-off-shore oil remediation and control management systems as well as produced water hydrocarbon remediation. Through this exclusive field-of-use agreement, Natural Science customers will now have access to innovative technology that is environmentally safe and outstrips current solutions in terms of efficiency.

The electromagnetic mop system rests on the fact that micron sized magnetite particles will mix with oil more readily than water when these filings are spread on an oil-water mixture. The particles form a unique and preferential bond with the oil due to a combination of forces, forming a loose colloidal suspension. The filings are magnetic, so they can be

[25] See https://pubs.acs.org/doi/10.1021/acsnano.7b02671

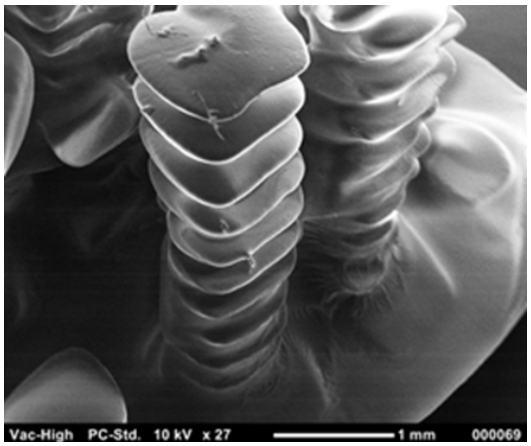
moved by a typical magnet. This allows one to use magnetic fields to manipulate, trap, and remove the oil in an environmentally safe manner with high efficiency. Natural Science is applying the licensed technology to an electromagnetic boom system that will replace the standard (and inefficient) passive boom and skimmer systems used today.

"Extracting crude oil from water has always been a difficult and inefficient process, despite the fact that the two liquids don't readily mix," said John Nelson of Natural Science. "Our system can extract over 90% of the oil from the surrounding water, which represents a substantial gain over traditional systems."

"This license agreement, with one of the most recognized laboratories in the world, represents our commitment to finding the best technologies and delivering the best solutions to our customers," said David Cathey of Natural Science. "Given the nature of our product, we feel our technology will quickly become an industry standard for oil spill remediation."

Kansas City National Security Campus: Polyphenylene Sulfide Powders

In an effort to maximize partnership activities with outside industry and academia, DOE's Kansas City National Security Campus (KCNSC) created a series of science and engineering-based Consortia aligned with technology roadmaps around targeted technical areas. The science-based manufacturing environment of the current and not too distant future requires increased early cooperation, interaction, and partnerships.



Scanning electron microscope (SEM) image of pillar microstructure of silicone elastomer printed using stereolithography, a polymer additive process.

KCNSC technical leaders identified technologies that will need to be developed or expanded over the next 10, 15, or 20 years. These technologies include next generation radar, metal and polymer based additive manufacturing, reverse engineering, and augmented reality, among others. Each university or industry partner is selected to create strategic partnerships that will develop technology to increase weapon safety, capability, and functionality, while reducing cycle time and cost.

One of the "game changing" technologies identified for expansion by the KCNSC is Polymer Additive Manufacturing (PAM). KCNSC strategically selected specific university, laboratory, and industry partners for its PAM consortium, because of the considerable amount of fundamental, basic, and applied research required. The PAM consortium provides rapid development from concept to the manufacturing floor with a less expensive alternative to metals in certain circumstances. The KCNSC works with a myriad of polymeric materials that are used in tooling, fixtures, and war reserve parts, and it has the ability to rapidly scan objects and use Polymer AM to reproduce these objects on-site and on-demand. Typically referred to as Rapid Prototyping, this technique can be used very effectively to provide quick answers to evolving technical questions about processes or products.

As one of the broader public-private consortia, KCNSC's PAM Consortium worked closely with university collaborators and a vendor to develop polyphenylene sulfide (PPS) powders with appropriate particle sizes for use in low-temperature Powder Bed Fusion, also known as Selective Laser Sintering processing. These materials have great potential for use in the electronics industry as encapsulating materials designed for component packaging and sealers.

Lawrence Livermore National Laboratory: Spray-on DNA Bar Codes

Foodborne illnesses kill roughly 3,000 Americans each year and about one in six is sickened, according to the Centers for Disease Control and Prevention. Yet most contaminated foods are never traced back to their source. That is because existing methods to track tainted food along its supply chain from table to farm are highly inefficient, jeopardizing the health of millions and costing the food industry billions. A typical process to trace food includes interviewing consumers and suppliers and examining every detail of the supply chain, a tedious method that takes weeks at best to complete.

DNATrax sprayed on food.

DOE's Lawrence Livermore National Laboratory (LLNL) researchers, in collaboration with the startup company DNATrek through an exclusive license, have developed a cost-effective and highly efficient method to accurately trace contaminated food back to its source. LLNL originally designed the technology, known as DNATrax, to safely track indoor and outdoor airflow patterns. One of the unexpected capabilities of DNATrax was being able to apply it to food products. The technology was first developed for biosecurity applications.

DNATrax are particles comprised of sugar and non-living and non-viable DNA that can serve as an invisible barcode. It is an odorless and tasteless substance that has been approved by the Food and Drug Administration as a food additive, safe for consumption. It can be thought of as a microscopic barcode that is sprayed on food at the farm or processing plant. If the food turns out to be contaminated when it reaches the store or dinner table, DNATrax can be lifted off the food and analyzed in the lab using polymerase chain reaction (PCR) to identify the source.

It is anticipated that DNATrax can be used to assist in training to determine if articles of personal protective equipment (PPE) such as hazmat suits used by emergency responders and health care workers to treat Ebola patients have been breached. DoD's Defense Threat Reduction Agency funded this Federal Work for Others research project.

Princeton Plasma Physics Laboratory: Edison Award for X-ray Imaging Invention

Three scientists at DOE's Princeton Plasma Physics Laboratory (PPPL) have invented a new extreme ultraviolet (EUV) imaging apparatus for EUV spectroscopy, EUV microscopy, EUV lithography and x-ray imaging. This new imaging apparatus will make significant contributions to EUV lithography at wavelengths in the range from 10 to 15 nm, which is presently being developed for the manufacturing of the next-generation of computer processors and other semi-conductor integrated circuits.

The optimization of EUV lithography for the manufacture of next-generation integrated circuits is a subject of intense research in industry and laboratories worldwide. The new EUV imaging apparatus is considered to be the next generation of computer chip manufacturing because the EUV light, called soft X-rays, allows designers of computer chips to place 100 times more components, like transistors, in the same area of tiny computer chips. The linear distance between components is also 10 times shorter, which means the speed of the chip could be 10 times faster.

The physicists who invented this device, Manfred Bitter, Kenneth Hill, and Philip Efthimion, won an Edison Patent Award in the imaging systems category for an imaging apparatus from the New Jersey Research Council for their work.

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.

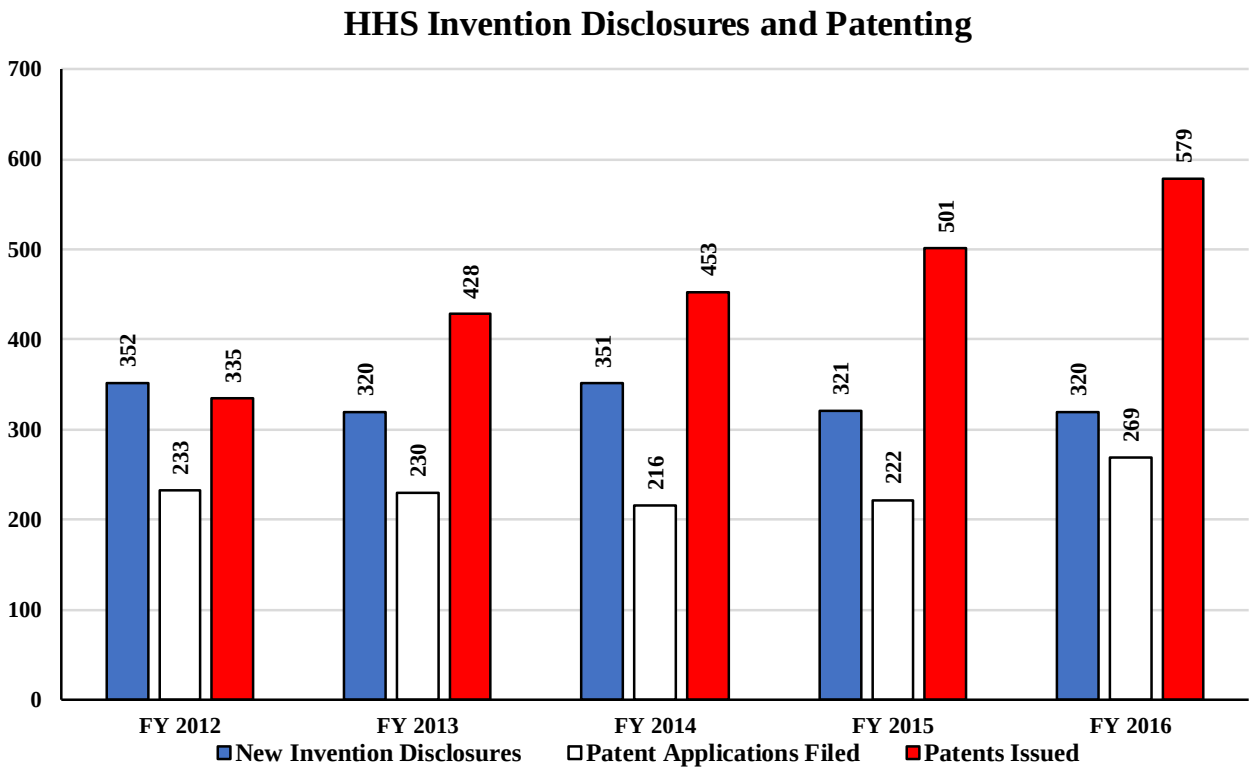
NIH's annual technology transfer report is available online at:
https://www.ott.nih.gov/reportsstats/annual-reports

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

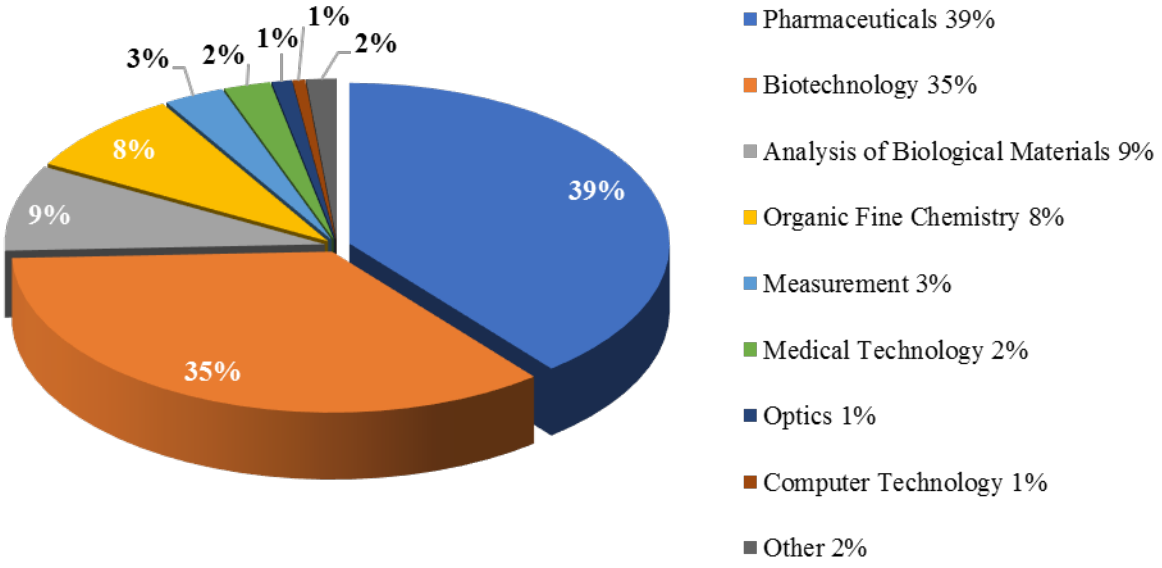
Between FY 2012 and FY 2016, HHS reported the number of new inventions disclosed decreased by 9% to 320 disclosures in FY 2016. The number of patent applications filed increased by 15% to 269. The number of patents issued increased by 73% to 579 patents.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	352	320	351	321	320
Patent Applications Filed	233	230	216	222	269
Patents Issued	335	428	453	501	579

Patents issued to HHS in FY 2016 covered many technology areas including Pharmaceuticals (39%), Biotechnology (35%), Analysis of Biological Materials (9%), and Organic Fine Chemistry (8%).[26]

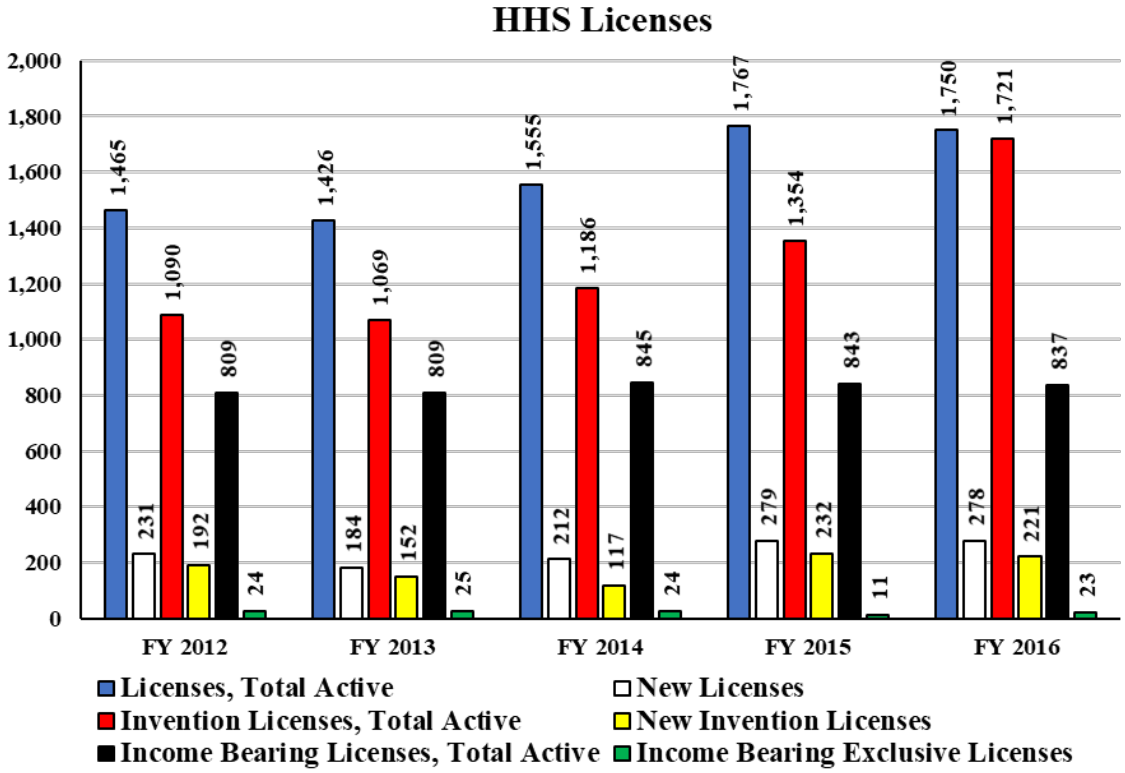
USPTO Patents Assigned to HHS by Technology Area: FY 2016



[26] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

HHS Licenses

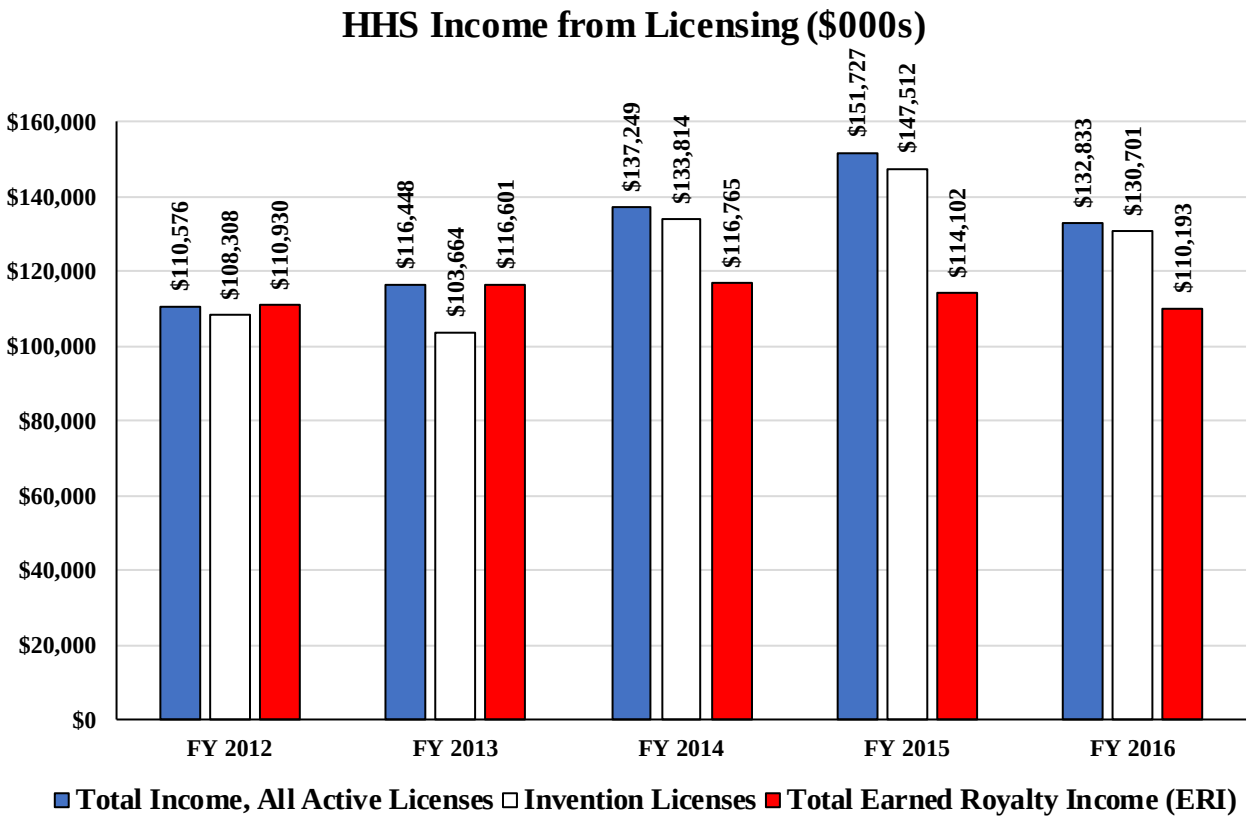
Between FY 2012 and FY 2016, the number of total active licenses increased by 19% to 1,750 licenses in FY 2016 while new licenses increased by 20% to 278. The number of total active invention licenses increased by 58% to 1,721 licenses while the number of new invention licenses increased by 15% to 221. Total active income-bearing licenses increased by 3% to 837 while income-bearing exclusive licenses decreased 4% to 23 licenses.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	1,465	1,426	1,555	1,767	1,750
New Licenses	231	184	212	279	278
Invention Licenses, Total Active	1,090	1,069	1,186	1,354	1,721
New Invention Licenses	192	152	117	232	221
Income Bearing Licenses, Total Active	809	809	845	843	837
Income Bearing Exclusive Licenses	24	25	24	11	23

HHS Income from Licensing

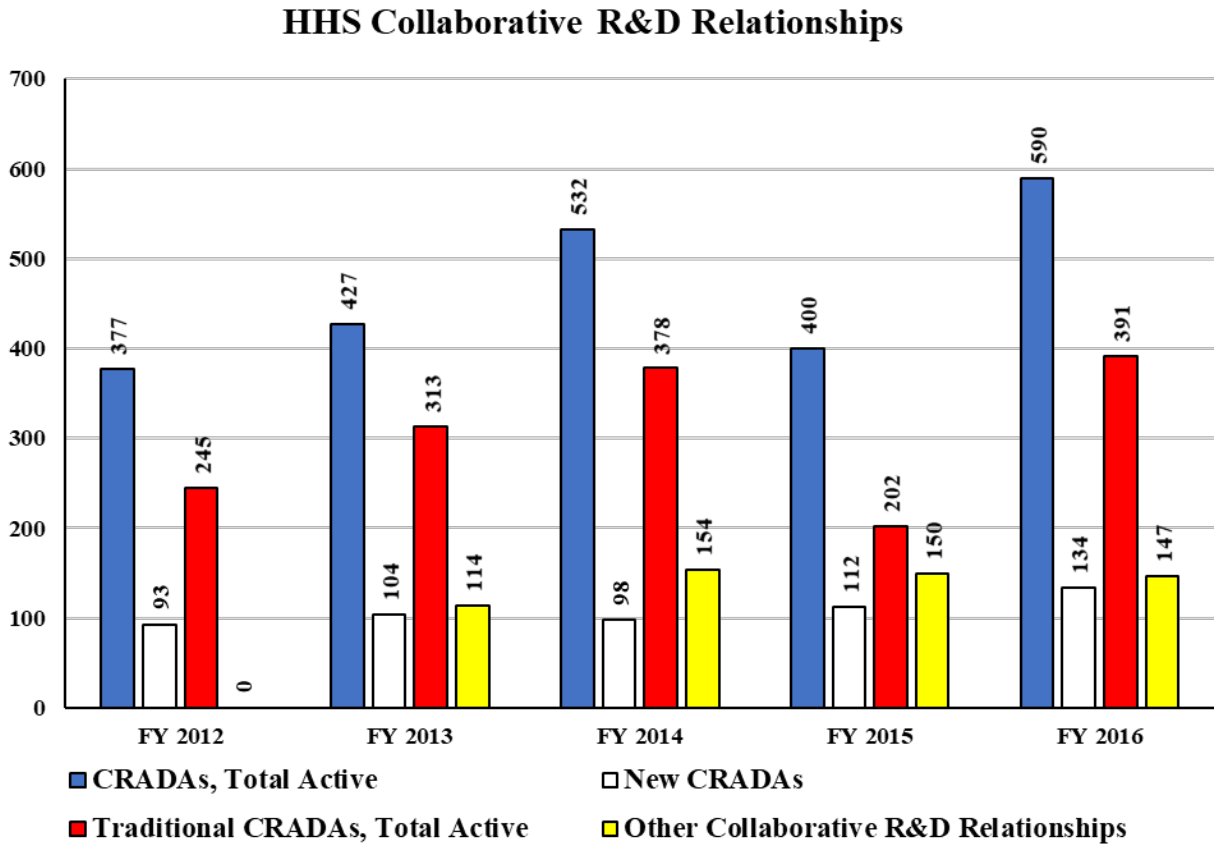
Between FY 2012 and FY 2016, total income from all active licenses increased by 20% to $132.8 million in FY 2016. The income from invention licenses increased by 21% to $130.7 million. Total earned royalty income decreased 1% to $110.2 million.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$110,576	$116,448	$137,249	$151,727	$132,833
Invention Licenses	$108,308	$103,664	$133,814	$147,512	$130,701
Total Earned Royalty Income, (ERI)	$110,930	$116,601	$116,765	$114,102	$110,193

HHS Collaborative R&D Relationships

Between FY 2012 and FY 2016, the number of total active cooperative research and development agreements (CRADAs) increased by 56% to 590 agreements while the number of new CRADAs per fiscal year increased by 44% to 134. Total active traditional CRADAs increased by 60% to 391. There were 147 other collaborative research and development (R&D) relationships reported in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	377	427	532	400	590
New CRADAs	93	104	98	112	134
Traditional CRADAs, Total Active	245	313	378	202	391
Other Collaborative R&D Relationships	0	114	154	150	147

HHS Efforts to Streamline Technology Transfer Operations

Launch of New Online Tool Streamlines NIH CRADA Process

In 2013, with seed money from the National Cancer Institute (NCI) and the Centers for Disease Control and Prevention (CDC), a project team comprised of staff from the NIH, CDC, and the Federal Drug Administration (FDA) worked with NCI's Center for Biomedical Informatics & Information Technology (CBIIT) to create an online, automated agreement builder, called CRADA Builder, that allows technology transfer staff to create custom draft agreements tailored to the specific needs of the collaboration. At the same time, a working group refreshed the Public Health Service template CRADA language with more clearly stated, concise language, which in turn was used to populate the CRADA Builder system. As a result of this enterprise effort, CRADA Builder was launched in September 2015.

The NIH CRADA Subcommittee has approved several CRADAs generated from CRADA Builder. The tech transfer specialists who have used the tool report it to be more efficient than beginning a CRADA with a model template and expressed that having a customized draft agreement streamlines negotiations. CRADA Builder saves the specialist's time, provides a standardized method of building a CRADA, and minimizes problems with version control.

CRADA Builder is currently available for use by specialists at the NIH, FDA and CDC. The NCI shared the code with NIST. NIST, via its contractor, is developing an improved version of the tool for use by the Federal Laboratory Consortium on a secure platform that will be made available to other federal agencies.

Human Brain Collection Core at NIMH

NIH's National Institute of Mental Health (NIMH) modified the existing Material Transfer Agreement (MTA) template for the Human Brain Collection Core to streamline programmatic operations. This new MTA template contains monitoring and annual reporting provisions to more effectively capture metrics and distribution language that minimizes the burden associated with recipients' transfer of materials to other research organizations.

Streamlining Availability of Plasmids at NINDS

NIH's National Institute of Neurological Disorders and Stroke (NINDS) Technology Transfer Office (TTO) has streamlined the process by which its researchers obtain materials from a major plasmid repository by pre-approving transfers associated with established terms and conditions known to be acceptable. Previously, the technology transfer office confirmed the accuracy of orders with researchers prior to approving the associated agreement, which was manually accomplished through the repository's website. These two steps introduced a variable delay into the overall process. After consulting with and receiving concurrence from NINDS researchers responsible for a majority of repository orders, these steps were eliminated. Utilizing the new process resulted in a time savings for technology transfer staff of nearly a week in a four-month trial, faster receipt of the reagents by the scientists, and zero incorrectly processed orders. NINDS TTO provides the researchers with bi-annual reminders of the terms and conditions of the pre-approved agreements.

HHS Downstream Success Stories

Centers for Disease Control and Prevention: Autocidal Gravid Ovitrap

CDC's Autocidal Gravid Ovitrap (AGO) mosquito trap has been successfully used by mosquito control programs for mosquito surveillance and control. The patented AGO attracts and catches female Aedes aegypti mosquitoes looking for a place to lay eggs. Field trials in which the AGO trap has been installed in most homes in a community have shown it reduces mosquito populations and rates of infection. Smaller scale field trials were so successful that CDC and the Puerto Rico Department of Health are implementing large-scale installation of AGO traps throughout several communities to help reduce mosquito populations and the viruses they spread.

The CDC Technology Transfer Office and CDC staff worked with a commercial partner, SpringStar, Inc., to mass produce the trap and expand its use in Puerto Rico. Phase I SBIR efforts were successful, and the partner secured Phase II SBIR funding to continue work on the AGO trap. The Technology Transfer and Intellectual Property Office at the National Institute of Allergy and Infectious Diseases, which manages patenting and licensing for the CDC, also negotiated a non-exclusive license with another commercial partner to expand public availability of the technology.

National Cancer Institute: Screening Methods for Cervical Pre-cancer

Multiple collaboration agreements negotiated in FY 2016 with external partners (for-profit and not-for-profit) will facilitate the development of low-cost human papillomavirus (HPV) screening and triage tools for the detection of cervical pre-cancer and human papillomavirus (HPV) management protocols for implementation in low-resource settings. Since persistent infections with HPV can lead to cervical carcinomas, the development of HPV vaccination and HPV testing is leading to major changes in cervical cancer prevention programs worldwide. These agreements involve NCI's Division of Cancer Epidemiology & Genetics and include the transfer of cervical specimens from large epidemiological studies.

National Cancer Institute: Nanotechnology Startup Challenge Winners

The NCI partnered with the Center for Advancing Innovation (CAI) to launch the Nanotechnology Startup Challenge in Cancer or NSC2. The Challenge was centered on commercially viable, nanotechnology cancer-related inventions conceived by the NCI. Once accepted into the Challenge, international teams competed by selecting one of these intramural inventions and creating a business plan to launch a startup. Alternatively, teams could elect to bring other commercially viable, nanotechnology cancer-related inventions into the challenge that are not from NCI. The primary goal was to stimulate the creation of start-up businesses to advance development and commercialization of these nanotechnology inventions. NSC2 launched in October 2015, and winners were announced in July 2016. The winners are now in various phases of launching their startups, including incorporation, negotiating a license for the technology and raising

funding. The NSC2 was the third NIH Startup Challenge and is based upon the award-winning model created by the Breast Cancer Startup Challenge, and the more recent Neuro Startup Challenge.

National Institute of Allergy and Infectious Diseases: Fighting Zika

Zika dominated the news in 2016. The Zika virus is a mosquito-borne flavivirus that was identified in humans in 1952 in Uganda and the United Republic of Tanzania. From the 1960s to 1980s, human infections were found across Africa and Asia, typically accompanied by mild illness. In October 2015, Brazil reported an association between Zika virus infection and microcephaly. By late spring 2016, it was confirmed that Zika virus infection during pregnancy is a cause of congenital brain abnormalities, including microcephaly; and that Zika virus is a trigger of Guillain-Barré syndrome.

The urgent need for diagnostics, vaccines, and treatments for Zika virus infection led to a surge in NIAID-related research and partnership activities, and NIAID's Technology Transfer and Intellectual Property Office (TTIPO) rose to the challenge. During FY 2016 TTIPO completed 36 agreements and filed two patent applications to help advance Zika research and medical countermeasures development projects at NIAID. TTIPO also worked with HHS and CDC to make scarce Zika samples rapidly available to the global research community using one of NIAID's biological materials repositories.

National Institute of Allergy and Infectious Diseases: Dengue Vaccine

Dengue virus 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 two million cases of severe dengue and 21,000 deaths. An effective vaccine is a public health priority. Dr. Stephen Whitehead and others at NIAID's Laboratory of Infectious Diseases (LID) have developed a tetravalent live attenuated dengue virus vaccine, TV003, which was shown to elicit a robust antibody and cellular immune response after just one dose.

In 2016, TV003 protected all 21 volunteers who received the vaccine from Dengue infection in a virus challenge study, while all 20 placebo recipients developed challenge infection. The Butantan Institute, a non-profit producer of immunobiologic products for Brazil, is sponsoring a placebo-controlled, multi-center Phase 3 trial in over 16,000 subjects. This technology was licensed to five licensees, including the Butantan Institute, covering worldwide development and commercialization. In FY 2016, TTIPO continued to market this technology and added two more non-exclusive licensees, enhancing the commercialization in Taiwan, India, South East Asia, Middle East, Australia and New Zealand.

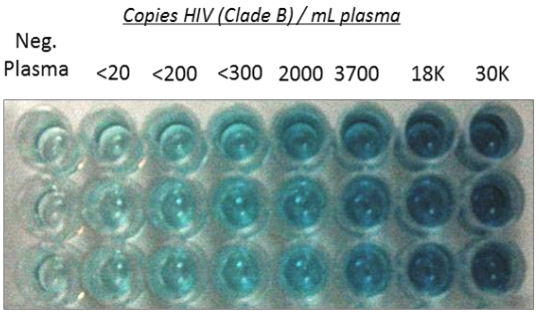
National Institutes of Health: Encochleated Drugs to Treat Infections
This Cooperative Research and Development Agreement (CRADA) was the first of what is anticipated to be several clinical trial CRADAs between NIH and Matinas BioPharma Holdings, Inc. The partnership led to the development of a unique CRADA model agreement to examine safety, efficacy and pharmacokinetics of a proprietary encochleated delivery platform for orally administered drugs. Encochleated drugs are resistant to premature enzyme degradation and, potentially, can be targeted to the site of infection, thereby reducing effective dosages and toxicity. Under this CRADA encochleated drugs are being studied to treat fungal, bacterial, or viral infections. Matinas is providing encochleated formulations of anti-infective medications and funding to NIH in support of this important research objective.

National Institute of Allergy and Infectious Diseases: Ebola Vaccine Development
Under a Research Collaboration Agreement initiated in 2008, NIAID's Vaccine Research Center (VRC) and Okairos Srl, a Switzerland-based biotechnology company, collaborated to develop vaccine candidates to combat Ebola virus infection. The Ebola vaccine candidate cAd3-EBOV is a chimpanzee adenovirus that expresses isolated, modified Ebola glycoproteins. As the 2014 Ebola Virus outbreak began to reach historic proportions, the VRC expedited its clinical development plans and joined efforts with GlaxoSmithKline (GSK), which acquired Okairos Srl in 2013. Other partners quickly joined the VRC to accelerate development of the sorely needed vaccine through trials in the United States, the United Kingdom, Switzerland, and Mali. The urgency of the situation in west Africa demanded that the technology transfer team generate creative and pragmatic solutions to enable the rapid start of clinical trials.

Within two months, all agreements enabling the start of Phase I clinical trials were completed. In many cases, unique agreements were drafted to avoid anticipated delays. For example, early on a Material Transfer Agreement (MTA) was utilized to jump-start preparations for the conduct of a clinical trial of cAd3-EBOV in the United Kingdom. This allowed the trial to begin immediately after negotiation of the clinical trial agreement. Further, as GSK agreed to have more cAd3-EBOV clinical product manufactured through a contract research organization, a specialized MTA was created for VRC to transfer the necessary materials for cGMP manufacturing. The vaccine has great promise in meeting public health needs, including the ongoing crisis in east Africa.

National Institute of Diabetes and Digestive and Kidney Diseases: Point of Care Diagnostic Platform

A diagnostic platform that uses peptide nucleic acids to bind the target RNA or single strand DNA has been developed at NIH's National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The proof of concept test was targeted to HIV viral load measurement. License applications were received from four companies, each planning to incorporate the NIDDK technology with its own proprietary operating system. The technology may be deployable in minimally resourced areas as well as developed countries.



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 the Science and Technology Directorate (S&T) and DHS more generally. These policies are applicable throughout DHS and its laboratories. The ORTA's responsibilities include the following:

- Standardizes, reviews, negotiates, and approves DHS's cooperative research and development agreements (CRADAs), licensing, and other technology transfer agreements;
- Prepares application assessments for selected research and development (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 S&T 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.[27] TTP is unique in that the program selects technologies from various federal laboratories, including DOE's National Laboratories, DoD's affiliated laboratories, FFRDCs, 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 their 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

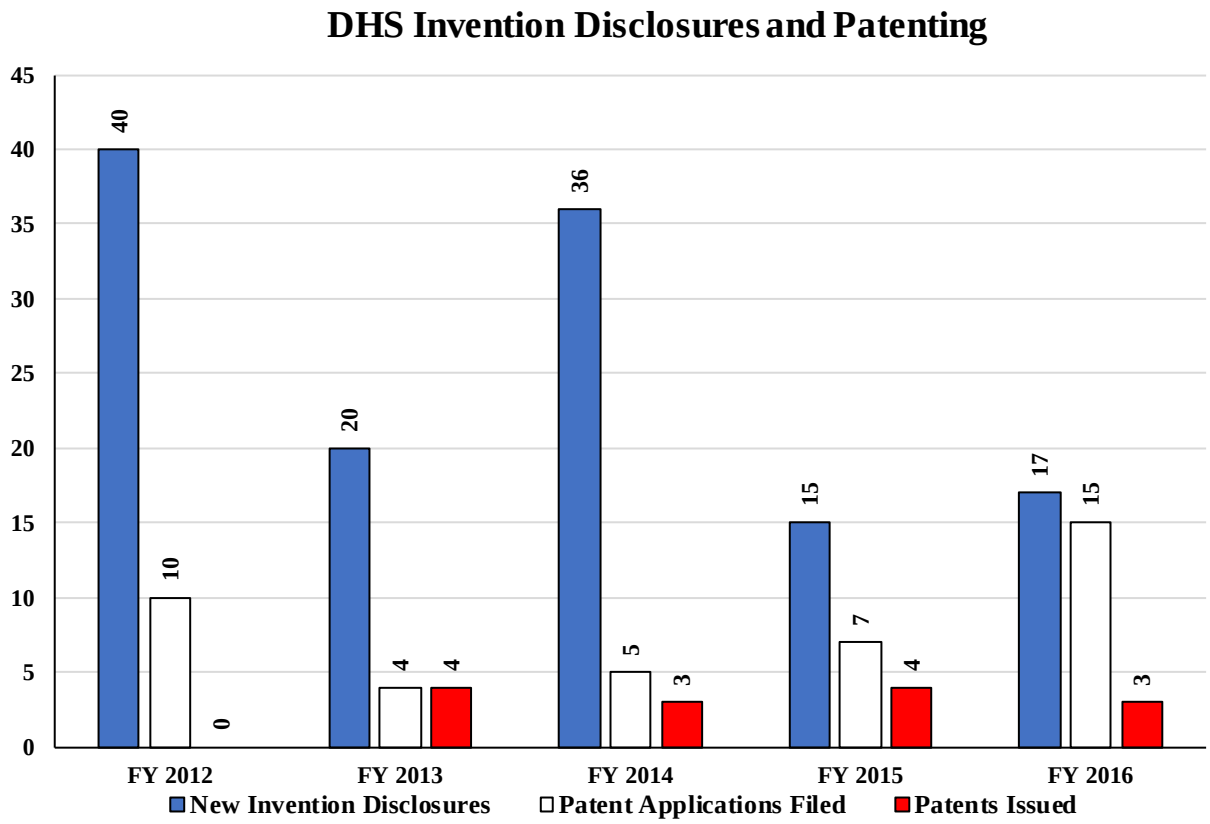
[27] The "Valley of Death" refers to the difficulties entrepreneurs and developers face when trying to fund new, high-risk, early stage technologies and products. Transfer recipients of federal technologies often face the Valley of Death because technologies from federal labs tend to have a low readiness level and require additional funding to support further development and integration costs. For a discussion of the "Valley of Death" see https://www.nist.gov/property-fieldsection/panel-culture-innovation

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

DHS Invention Disclosures and Patenting

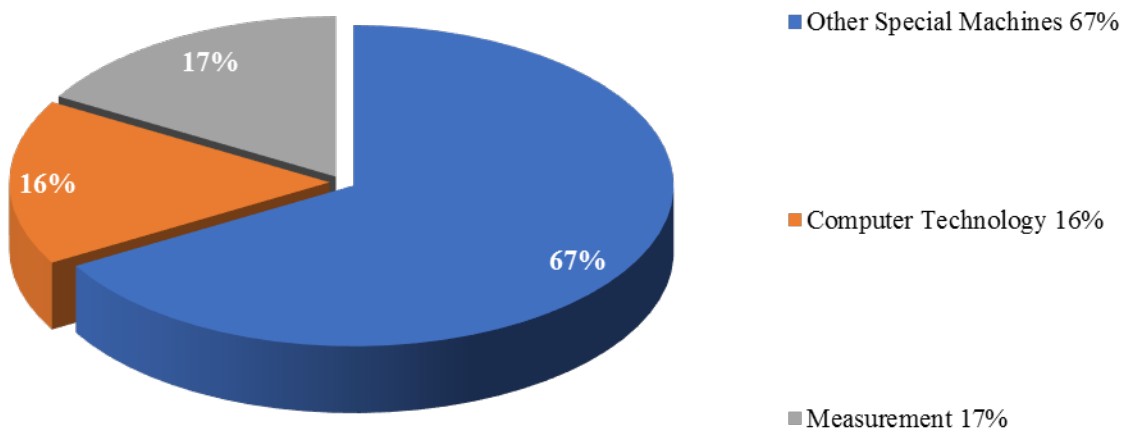
Between FY 2012 and FY 2016, DHS reported the number of new inventions disclosed decreased by 58% from 40 disclosures to 17 disclosures in FY 2016. The number of patent applications filed increased by 50% to 15 and there were three patents issued in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	40	20	36	15	17
Patent Applications Filed	10	4	5	7	15
Patents Issued	0	4	3	4	3

Patents issued to DHS in FY 2016 covered three technology areas: Other Special Machines (67%), Computer Technology (16%), and Measurement (17%).[28]

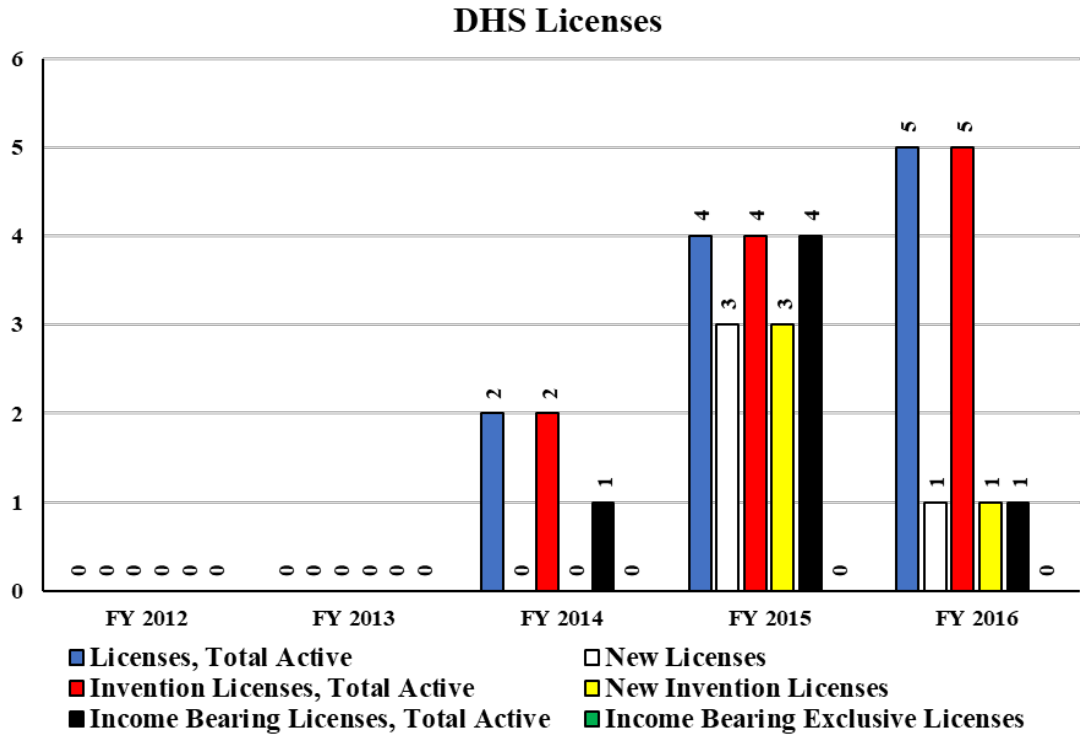
USPTO Patents Assigned to DHS by Technology Area: FY 2016



[28] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DHS Licenses

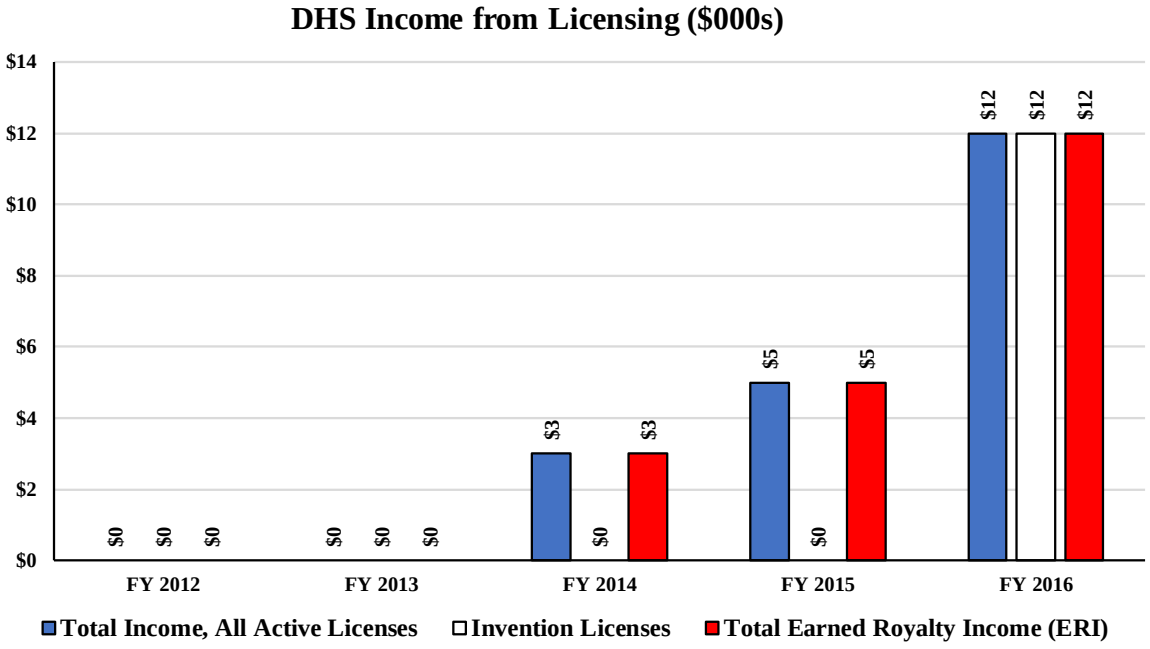
In FY 2016, DHS executed one new license agreement and managed five active license agreements. Out of the five active agreements, one was income-bearing.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	0	0	2	4	5
New Licenses	0	0	0	3	1
Invention Licenses, Total Active	0	0	2	4	5
New Invention Licenses	0	0	0	3	1
Income Bearing Licenses, Total Active	0	0	1	4	1
Income Bearing Exclusive Licenses	0	0	0	0	0

DHS Income from Licensing

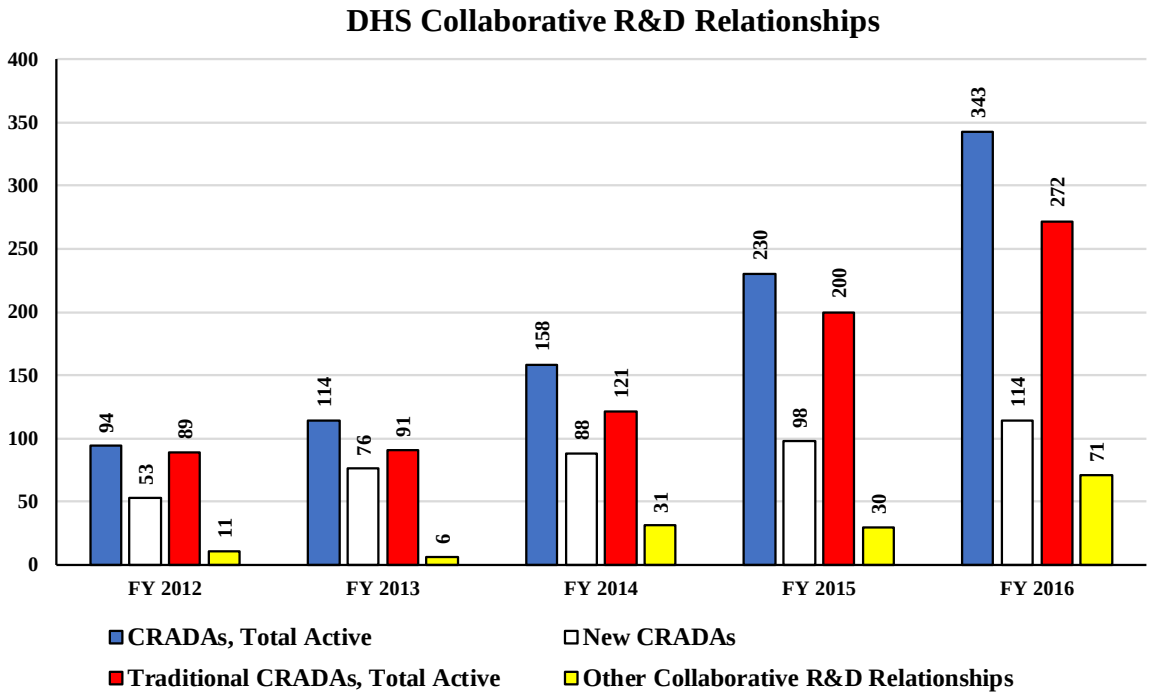
Licensing income increased from $3,000 in FY 2014 to $12,000 in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$0	$0	$3	$5	$12
Invention Licenses	$0	$0	$0	$0	$12
Total Earned Royalty Income, (ERI)	$0	$0	$3	$5	$12

DHS Collaborative R&D Relationships

Between FY 2012 and FY 2016, the number of total active CRADAs increased by 265% from 94 to 343 agreements. The number of new CRADAs per fiscal year increased by 115% to 114 new agreements in FY 2016. Total active traditional CRADAs increased by 206% to 272 agreements. Other collaborative R&D relationships increased by 545% to 71.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	94	114	158	230	343
New CRADAs	53	76	88	98	114
Traditional CRADAs, Total Active	89	91	121	200	272
Other Collaborative R&D Relationships	11	6	31	30	71

DHS Downstream Success Stories

Countering Weapons of Mass Destruction Office: Algorithm Improvement Program
DHS's Algorithm Improvement Program has created a tool that the Countering Weapons of Mass Destruction Office (CWMD), industry, and academia can to use to improve isotope identification algorithms for radiation detection and identification systems as well as to compare the results between a government algorithm and industry using well-known scoring criteria. This tool, the Algorithm Development Kit (ADK), provides a method that allows one to measure the performance of one detector and then predict the performance in another with a lower energy resolution. The ADK provides radionuclide data (i.e., source strength and shielding variations) that is normally unavailable or too expensive to be collected by industry or academia. The kit sets up an environment where the performance of any detector can be run against, and then compared against, a set of high-quality benchmark radiation spectrum that scores the vendor's algorithm on an absolute scale.

CWMD has established thirteen CRADAs with Radiation Detection Equipment vendors and another with one academic institution. Since this is a pre-release of the ADK package to industry, all feedback received from CRADA participants has helped CWMD make improvements and provide a better user interface for the ADK.

As an example of the ADK success, a participant was able to add 35 new radionuclides to their algorithm library as a result of participating in the CRADA. This will not only improve the CRADA participant's radionuclide identification capabilities in their products, but it also lifts the commercial sector so that when CWMD procures commercial off-the-shelf products, better performing systems are available.

Countering Weapons of Mass Destruction Office: Replay Tool Program
In February 2016, CWMD established a requirement for all new acquisitions of Radiation Detection Equipment to provide a Replay Tool to CWMD specification. A Replay Tool is a computer software tool that replicates the function of a detection device in the field. Given the same input as a device in the field, a Replay Tool will produce the same results on a computer in the laboratory. A Replay Tool allows the government to replay old data and to use synthetic data to analyze the performance of a radiation detector system over a far larger range than what is possible from testing as well as the ability to optimize the performance for the environment in a fielded system.

CWMD established CRADAs with seven different radiation detection equipment vendors in order to help the vendors apply the technical requirements to their specific Replay Tool and to ensure the government generated requirements were correct. The results of the CRADAs showed that there was little economic impact to Radiation Detection Equipment vendors and that all Replay Tool specifications requirements were well-developed.

Countering Weapons of Mass Destruction Office: Plastic Scintillator Program
The Plastic Scintillator CRADAs were established with the only two United States polyvinyl toluene (PVT) scintillator crystal manufacturers. PVT gamma sensors are used in radiation detection equipment that are used by Customs and Border Protection (CBP) at land, sea, Express

consignment courier facilities (ECCF), International mail facilities (IMF), and Preclearance airports points of entry to the United States to detect gamma radiation. The purpose of the PVT gamma detector screening of commerce is to detect and interdict nuclear and radiological threats entering the United States; however, their performance is degraded after cycles of cold weather common on the northern border. The purpose of the CRADAs was for government experts and PVT manufactures to work together to better understand the problem, improve the PVT longevity in the field and improve or revise the manufacturing process of the PVT.

The Plastic Scintillator CRADA's have provided an unprecedented level of collaboration between the government and industry. The early results are showing the possibility for new and improved PVT gamma detectors for radiation detection.

In addition, DHS is working with DOE's NSDD (Nuclear Smuggling Detection and Deterrence) Office to leverage the knowledge of both government agencies since NSDD supports similar detectors overseas. DHS and NSDD have established an Interagency Integrated Program Team (IPT) Charter. This interagency coordination will further benefit the industrial development of viable solutions.

National Protection and Programs Directorate: Cyber Information Sharing and Collaboration Program

DHS's Cyber Information Sharing and Collaboration Program (CISCP) enables information exchange and the establishment of a community of trust between the federal government and critical infrastructure owners and operators. CISCP aims to foster collaboration with owners and operators by leveraging all areas of DHS's National Cybersecurity and Communications Integration Center (NCCIC). This collaboration can assist stakeholders with assessing cyber-related threats, vulnerabilities, and consequences so that stakeholders can prevent, mitigate, or recover from cyber incidents.

NCCIC/CISCP Successes

- In FY 2016, a record 97 Indicator Bulletin products and CISCP Forum Posts were published. Of note, 76 of the 97 products were based on stakeholder submitted data.

- In March 2016, the CISCP coordinated a request for assistance from a CISCP member seeking support from another CISCP member regarding their abuse notification website. CISCP coordinated approvals for both CISCP members to initiate communications. This example highlights how the CISCP program was able to preserve anonymity and expedite a request for information on behalf of another CISCP member.

- In November 2016, CISCP received a non-stakeholder request for information regarding possible targeting of companies involved in the Dakota Access Pipeline. CISCP shared the information with an Information Sharing and Analysis Center (ISAC) and to a Distributed Denial of Service protection entity. This effort allowed organizations to evaluate their security posture and close potential vulnerabilities in their perimeters.

- In April 2016, CISCP coordinated a Locky Ransomware Indicator Bulletin (IB-16-10045E) that had inputs from multiple critical infrastructure stakeholders. Multiple

organizations detected and reported Locky activity while NCCIC analysts worked to share Indicators of Compromise with CISCP members. The collaborative product allowed CISCP to share indicator information within hours of discovery.

- In August 2016, approximately 45 CISCP stakeholders participated in the inaugural Legal Discussion Working Group (LDWG). The LDWG facilitated information sharing with the DHS Office of General Counsel and CISCP stakeholder legal teams focusing on the Cybersecurity Information Sharing Act of 2015, cybersecurity legal issues, policy, and CRADA inquiries.

Science and Technology Directorate: Open Source Tactical Geospatial Intelligence Plugfest

In September 2016, DHS's Science and Technology Directorate (S&T) conducted the first in a planned series of "Plugfests" to demonstrate the utility of commercial satellite systems to provide Open Source Tactical Geospatial Intelligence (OSTGI) for border security missions. This Plugfest was a live demonstration of integrated systems and data focused on the ability of commercial Satellite Automatic Identification Systems (S-AIS) to enhance maritime domain awareness (MDA). Nine companies from the United States, Canada, and Europe participated at the Multi-Agency Collaboration Environment (MACE) in Herndon, Virginia. This Plugfest used live data from 28 commercial AIS satellites and notional DHS operational scenarios to enable vendors and Government stakeholders to consider the potential tactical utility of S-AIS to enhance maritime surveillance operations. This event supported the following key end users: CBP, United States Coast Guard (USCG), Office of Intelligence and Analysis (I&A), and Office of Operations Coordination (OPS).

Science and Technology Directorate: Collaboration with Test Article Developers

The S&T's Transportation Security Laboratory (TSL) conducts formal tests of detection performance of explosives detection systems used for airline passenger checked luggage screening. The TSL as well as the private sector design explosive surrogates, non-hazardous "mimics" of explosives that are used for field testing and certain types of evaluation. Through CRADAs with two companies, the TSL provided independent physical and chemical measurements of surrogates developed by these private sector partners to the companies. This information is used to validate their own formulations. These collaborations are ongoing and expected to continue through FY 2017.

Science and Technology Directorate: Enabling Development of New Screening Technologies

Based on original research conducted at the TSL, a patent entitled "Method for identifying materials using dielectric properties through active millimeter wave illumination," was issued in February 2015. This patent describes a methodology of interrogating anomalies detected with millimeter wave imaging systems to determine if anomalies are benign or threat materials. In FY 2016, the TSL continued work towards implementation of this patent on commercially available millimeter wave imaging systems and presented information on the patent at meetings and workshops. Interest in licensing the technology has been received from multiple system developers working on screening equipment used in airports, security check points, etc.

U.S. Coast Guard: Diesel Outboard Development

Two Mercury Marine 175HP spark-ignited diesel outboard engines installed on Training Center Yorktown's 25' Response Boat-Small for test and evaluation. USCG photo.

By partnering with industry on diesel outboard engine technology development, the Coast Guard's Research, Development, Test and Evaluation Program's Research and Development Center (RDC) was able to save nearly $350 thousand in prototype procurements for technology demonstrations. Additionally, since this technology is emergent to the market, RDC was able to help industry put real end-user operational hours on the engines and track performance over time. This provided critical understanding to marine engine CRADA partners that helped them improve the technology. It provided the Coast Guard with an understanding of the technology's capabilities and limitations.

Overall, it has been a highly beneficial collaboration for both the private sector and government. Industry's innovative adaptation of diesel engine technology to outboard engines could help position the Coast Guard to becoming a single fuel surface fleet, resulting in many operational, maintenance, and logistical benefits, as well as significant long-term cost savings. This work supported the following end users: DoD, law enforcement (including CBP, USCG, and the Immigration and Customs Enforcement program (ICE)), and commercial market developers.

U.S. Coast Guard: Robotic Aircraft for Maritime Public Safety

The Coast Guard's RDC, through its continuing research into the application of unmanned aircraft system technology for Coast Guard missions, partnered with DHS S&T in the development of a Robotic Aircraft for Maritime Public Safety (RAMPS) project to test and evaluate small unmanned aircraft systems for potential use by first responders in the maritime community.

CRADA partners AeroVironment launch a Wasp All-Environment UAS from CGC Chock during their demonstration week. USCG photo.

The goal of this project was to better understand the risks, benefits and limitations of operating existing small unmanned aircraft in a marine environment. The RDC partnered with industry through CRADAs to conduct a series of technology demonstrations to evaluate realistic maritime security and first responder scenarios. These technology demonstrations were conducted at the Navy-operated Webster Field facility in Southern Maryland in partnership with the Navy Unmanned Aerial System Test Directorate (UASTD). This supported the following end users: federal, state, local and Tribal Public Safety and Law Enforcement (including CBP, USCG, & ICE).

This collaboration provided benefit to both government and industry. The RDC and DHS S&T were able to evaluate unmanned aircraft systems in a realistic maritime environment to better understand their potential utility in aiding Coast Guard, DHS component, and first responder missions. Additionally, it provided the industry partners with an opportunity to test their product in a maritime environment, which many had not had the opportunity to do, and to refine their designs.

Department of the Interior (DOI)

Technology transfer for DOI includes a range of activities designed to disseminate scientific and technical information and knowledge between the DOI 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 DOI manages. In general, technology transfer activities within DOI 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 describes the actions DOI took in FY 2016 to advance technology transfer. These range from helping develop new technologies such as nanofiltration membranes to reduce contaminants in potable water to testing and demonstrating the U.S. Geological Survey's (USGS) ShakeAlert System to broadcast early warning of temblors in earthquake-prone areas. These activities demonstrate the innovation, expertise and dedication of the DOI's employees, including its many scientists and engineers, to help reduce risks to public health, safety and the environment from natural and man-made hazards.

The FY 2016 enacted budget for DOI included $963.5 million for research and development. Much of the funding was for applied research ($764.5 million), while basic research and basic development received $53.8 million and $145.2 million, respectively. The programs supported through these funds generate large amounts of knowledge, information, and technology, which help DOI meet its mission objectives and are transferred to resource managers, stakeholders, and the general public.

DOI's bureaus have varying levels of involvement with scientific and technical research and innovation, and technology transfer. In FY 2016, as in previous years, the majority of technology transfer activities reported by DOI under the Federal Technology Transfer Act were undertaken by USGS because it is the largest research and development organization within DOI, both in terms of budget and personnel. Typically, USGS accounts for over 70% of DOI's (research and development (R&D) budget.

The DOI's scientists, engineers, and other technical personnel advance the state of knowledge related to the DOI's resources and ensure that this information is accessible to resource managers, private industry, and the general public. The vast majority of DOI'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 2016, USGS and U.S. Fish and Wildlife Service (FWS) personnel authored or co-authored over 9,500 reports, books, fact sheets, and other publications, including approximately 3,500 scientific publications. The other bureaus, while also active in publishing and distributing scientific, technical, and engineering results, 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, seven DOI bureaus are active participants in the network of seventeen Cooperative Ecosystem Studies Units (CESUs), a collaboration among more than 400 partner organizations, including 15 federal agencies and nearly 400 non-federal partners (including universities, Tribes and tribal organizations, state agencies, museums, aquariums, arboretums, and conservation organizations). Each CESU is hosted by a university.

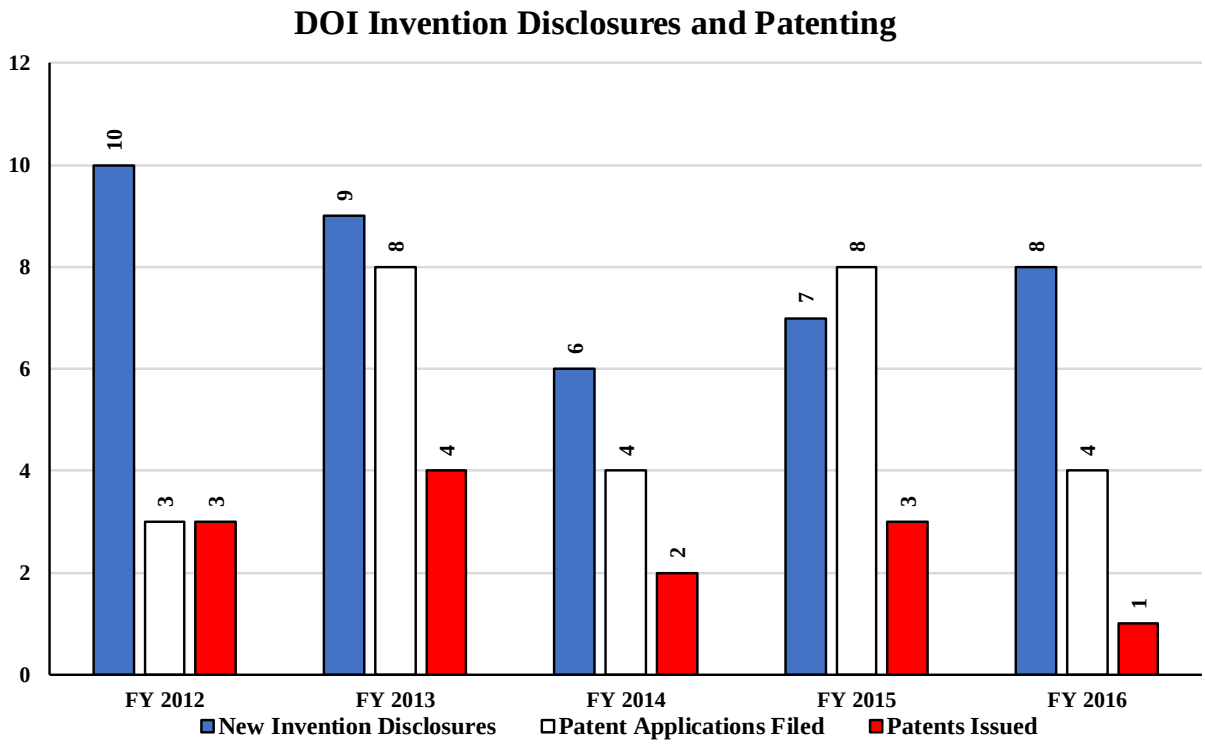
Bureaus that are active in research and development, or have research capabilities that complement U.S. commercial interests, may also utilize technology transfer agreements authorized by the Federal Technology Transfer Act to join forces with non-federal partners. Such agreements allow the Department's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

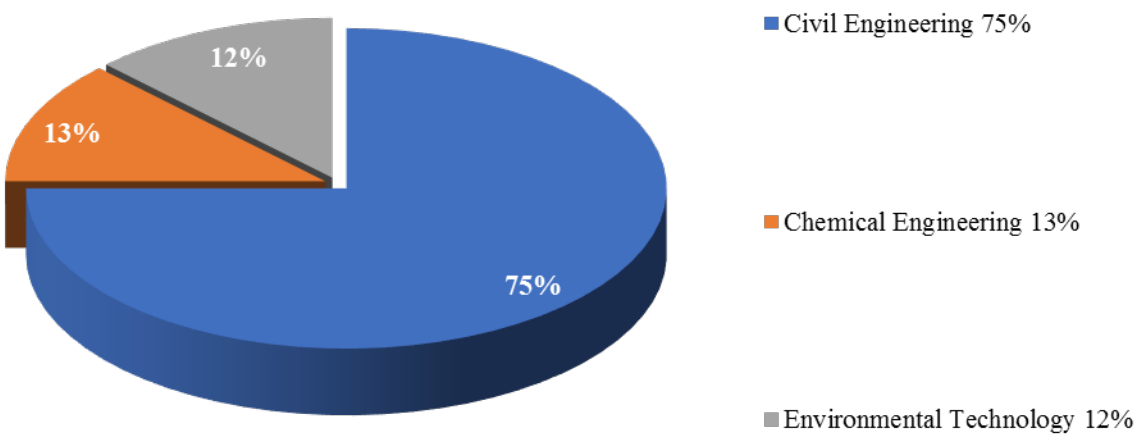
From FY 2012 to FY 2016, DOI reported the number of new inventions disclosed decreased by 20% to eight disclosures. The number of patent applications filed increased by 33% to four. One patent was issued in FY 2016, down from three in FY 2012.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	10	9	6	7	8
Patent Applications Filed	3	8	4	8	4
Patents Issued	3	4	2	3	1

The patent issued to DOI in FY 2016 covered three technology areas: Civil Engineering (75%), Chemical Engineering (13%), and Environmental Technology (12%).[29]

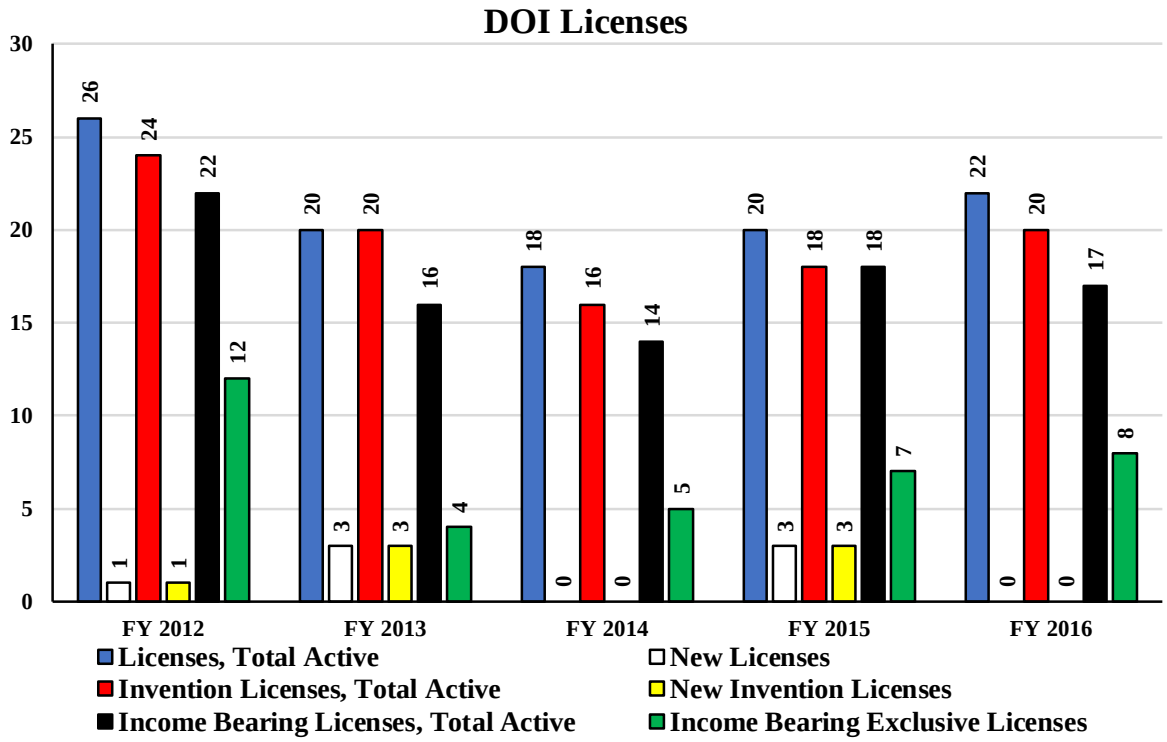
USPTO Patents Assigned to DOI by Technology Area: FY 2016



[29] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DOI Licenses

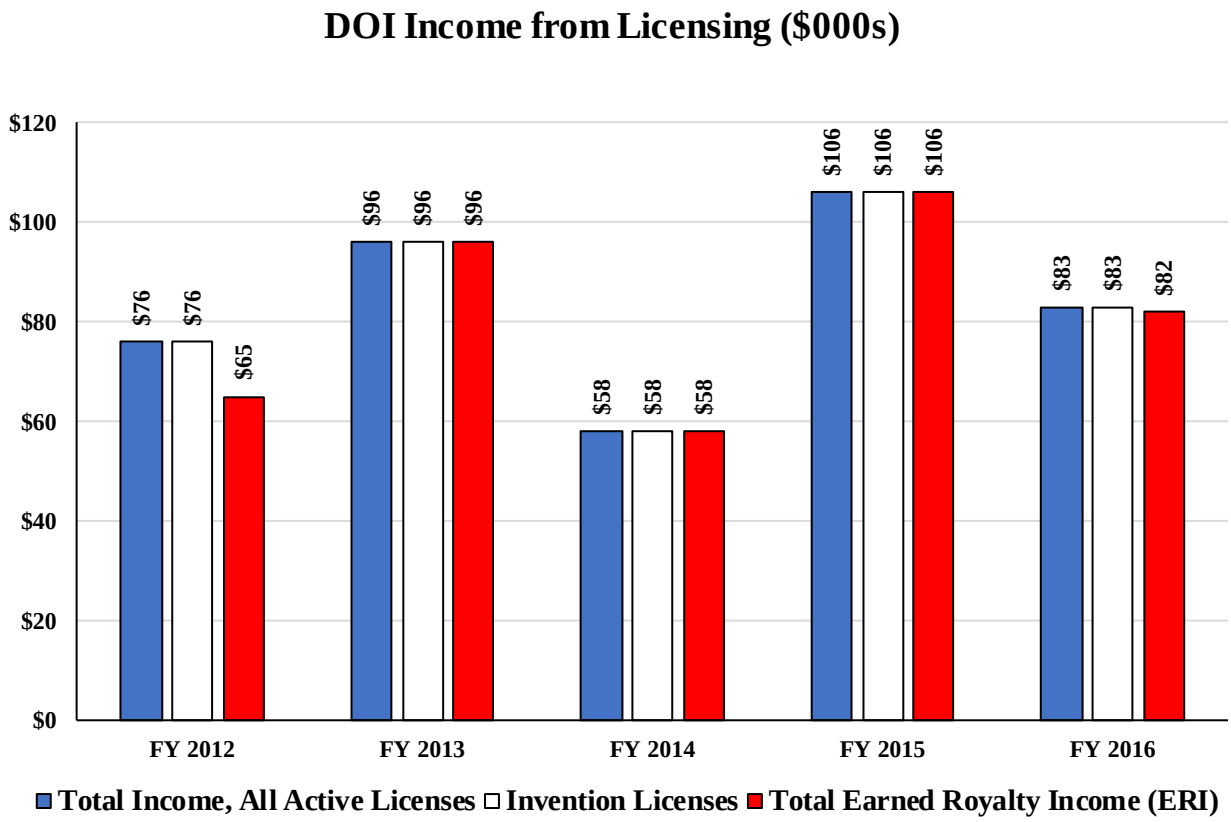
From FY 2012 to FY 2016, the number of total active licenses decreased by 15% to 22 licenses in FY 2016. There were zero new licenses in FY 2016. The number of total active invention licenses decreased by 17% to 20 licenses, and the number of income-bearing exclusive licenses decreased by 33% to eight licenses.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	26	20	18	20	22
New Licenses	1	3	0	3	0
Invention Licenses, Total Active	24	20	16	18	20
New Invention Licenses	1	3	0	3	0
Income Bearing Licenses, Total Active	22	16	14	18	17
Income Bearing Exclusive Licenses	12	4	5	7	8

DOI Income from Licensing

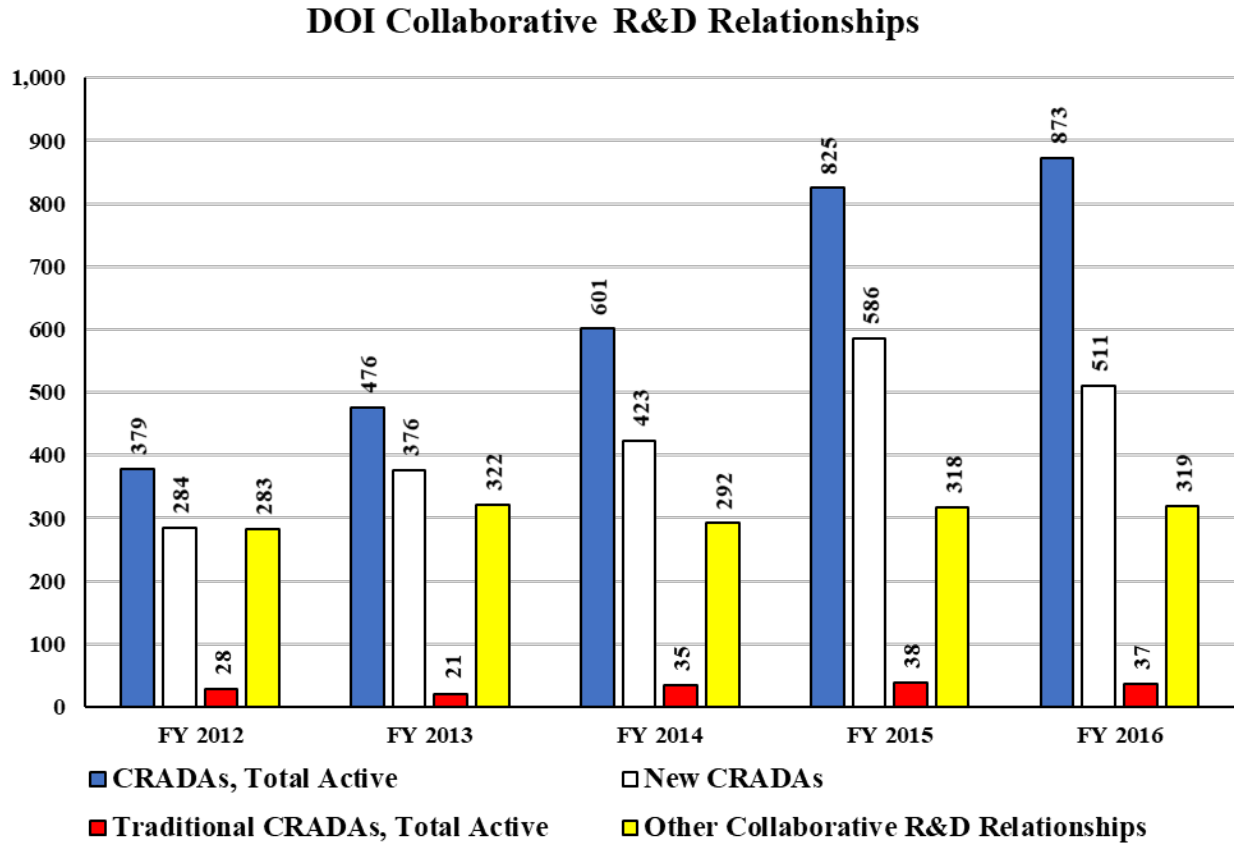
Between FY 2012 and FY 2016, total income from all active licenses increased by 9% to $83 thousand in FY 2016. The income from invention licenses increased by the same amount, as all income received came from invention licenses. Total earned royalty income increased by 26% to $82 thousand in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$76	$96	$58	$106	$83
Invention Licenses	$76	$96	$58	$106	$83
Total Earned Royalty Income, (ERI)	$65	$96	$58	$106	$82

DOI Collaborative R&D Relationships

From FY 2012 to FY 2016, DOI reported the number of total active cooperative research and development agreements (CRADAs) increased by 130% from 379 to 873 agreements. The number of new CRADAs per fiscal year increased by 80% to 511 new agreements in FY 2016. Traditional CRADAs increased by 32% to 37. Other collaborative R&D relationships increased by 13% to 319.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	379	476	601	825	873
New CRADAs	284	376	423	586	511
Traditional CRADAs, Total Active	28	21	35	38	37
Other Collaborative R&D Relationships	283	322	292	318	319

DOI Efforts to Streamline Technology Transfer Operations

In FY 2016, the DOI continued to build on actions initiated since FY 2011 to institutionalize technology transfer programs within DOI. 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 DOI's bureaus through presentations, where bureaus with greater experience with instruments made available through the FTTA shared their knowledge with bureaus with less experience. These sessions also illustrated the benefits of using these instruments to leverage the resources made available to bureaus to pursue their mission;

- Increased accessibility to resources to advance technology transfer through improvements to DOI'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 DOI'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 DOI 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

National Park Service: Device to Facilitate Water Quality Measurement in High Biofouling Environments

National Park Service (NPS)'s Gulf Coast Inventory and Monitoring Network has entered into a CRADA with In-Situ, Inc., to develop and test an NPS employee's invention and evaluate its potential for commercial manufacture and sale. The device enables currently available *datasondes*, which are devices used to measure water quality, to greatly increase the length of unmanned or continuous monitoring deployments in biofouling environments. It may also increase accuracy under turbulent flow conditions. The device modifies the calibration chamber of the sondes so that instrument/sensor drift, rather than water quality conditions, drives recalibration frequency requirements. By extending service intervals, this device may reduce operational costs by 50% or more.

Modified datasonde.
Credit: Joe Meiman, NPS

The NPS and the company are collaborating to produce beta test instruments and initiate their deployment to collect data and conduct analysis at sites with high biofouling or sediment issues in differing conditions, such as warm marine, cold marine, and fresh water lake and river environments.

Office of Surface Mining Reclamation and Enforcement: University Partnerships—Minority Higher Education Program

The Office of Surface Mining Reclamation and Enforcement (OSMRE) continues to work on building mutually beneficial partnerships with minority serving colleges and universities under its Minority Higher Education Program (MHEP). This includes collaborating with its MHEP partners on training and education programs and providing guidance and direction to ensure that the intended results are achieved. In addition to traditional training within the surface mining community, OSMRE's Technical Innovation and Professional Services program continued its collaborative partnership with Adams State University (ASU), a Hispanic Serving Institution in Alamosa, Colorado, through a cooperative agreement with ASU, recognizing that cooperation on resources and knowledge, as well as the advancement of the Clean Energy Economy, would benefit the government, ASU, its students, and the public. The agreement guides the parties in pursuit of common objectives to enhance education, job opportunities, and access to "real world" experience.

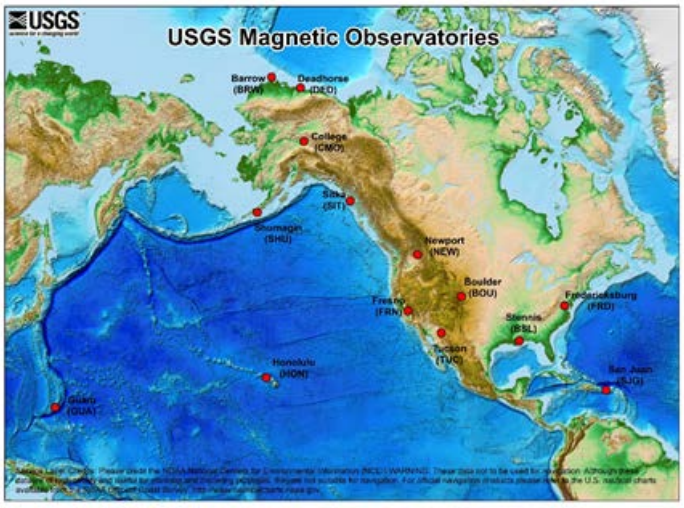
U.S. Fish and Wildlife Service: Aquatic Animal Drug Approval Program

The Aquatic Animal Drug Approval Program (AADAP) within the Fish and Aquatic Conservation (FAC) Division currently has four CRADAs in place. Individual CRADAs have been established with AquaTechnics, Inc. (Sequim, WA), 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 2016, AADAP developed a research study protocol to define the objectives, design, procedures, and methods used for an FDA-acceptable research study evaluating the target animal safety of 17α-methyltestosterone, a chemical used for gender manipulation in rainbow trout fry. The protocol was submitted and accepted by FDA and made available with funding support via one of the above-described CRADAs.

U.S. Fish and Wildlife Service: Crushed Ivory Design Challenge Prize

The Service announced winners of its Crushed Ivory Design Challenge in May 2016, which invited entrants to propose visual concepts for powerful public displays of crushed ivory from the U.S. ivory crushes in order to raise public awareness about the illegal ivory trade and its negative consequences for elephant conservation. The winners include Kelly Lance of Monterey, California, and Jacqueline Nott of Auburn, California.

U.S. Geological Survey: Geomagnetism



The Geomagnetism Program monitors and records the Earth's magnetic field by taking measurements at 14 Geomagnetic Observatories located throughout the United States and its territories (Guam and Puerto Rico). [See map on this page.] The Program's newest observatory in Deadhorse, Alaska, was built and is operated through a public-private partnership under a technical assistance agreement. This observatory allows the Geomagnetism Program to expand its coverage in the auroral zone and Alaska. The geomagnetic data produced by this observatory fills a critical geographic gap in the collection of magnetic data, and is now available to the general public and global scientific community in real-time. This additional observatory provides the USGS and the scientific community with an improved understanding of geomagnetic currents in the northern latitudes.

U.S. Geological Survey: Microbial inhibition of fungal pathogens of snakes

Snake fungal disease (SFD) is an emerging infection caused by the fungus *Ophidiomyces ophiodiicola* (*O.o.*). Fungal diseases, including SFD, have been linked to fatal infections and population declines in many types of wild animals. Since many species of wildlife provide important services, such population declines can have negative effects on the environment and human health. For example, snakes consume large numbers of rodents that can damage agricultural crops and transmit diseases to humans. They also serve as prey for many birds and thus are essential components of the food web.

The eastern massasauga (Sistrurus catenatus) is a federally threatened species of snake that is being affected by fungal skin infections in some areas. Credit: Rori Paloski, Wisconsin Department of Natural Resources

Currently, the major roadblock in mitigating the impacts of fungal infections is a lack of effective tools to manage the diseases. The USGS is a leader in investigating the reasons behind the recent emergence of fungal infections in wildlife and is helping wildlife managers develop strategies to protect vulnerable animals. This is accomplished through collaborations with outside agencies that have expertise in various methods for controlling fungi that can cause disease. For example, USGS is working with researchers at the University of Massachusetts to identify microorganisms, and substances produced by microorganisms, that can inhibit the growth of *O.o.* This work helps our understanding of how the beneficial bacteria that naturally live on snakes and in the environment, might be able to protect snakes from deadly fungal diseases, and may also help wildlife managers develop strategies for conserving rare snake species.

Department of Transportation (DOT)

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[30] 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 activities may be found at: https://www.transportation.gov/research-technology.

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

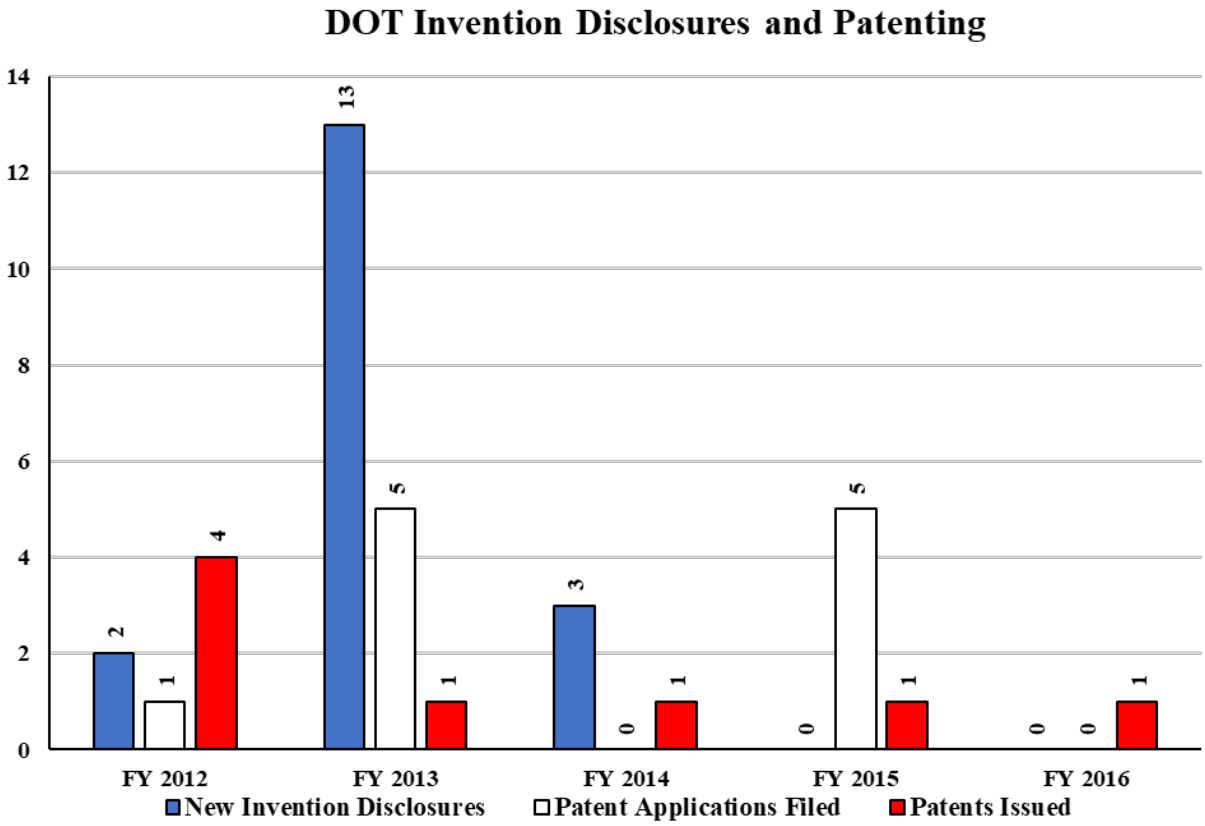
More information about DOT technology transfer activities is available on the following websites:

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/

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

DOT Invention Disclosures and Patenting

In FY 2016, DOT reported zero invention disclosures or patent applications. One new patent was awarded. In FY 2016, the one patent issued to DOT was within the category of Civil Engineering.[31]

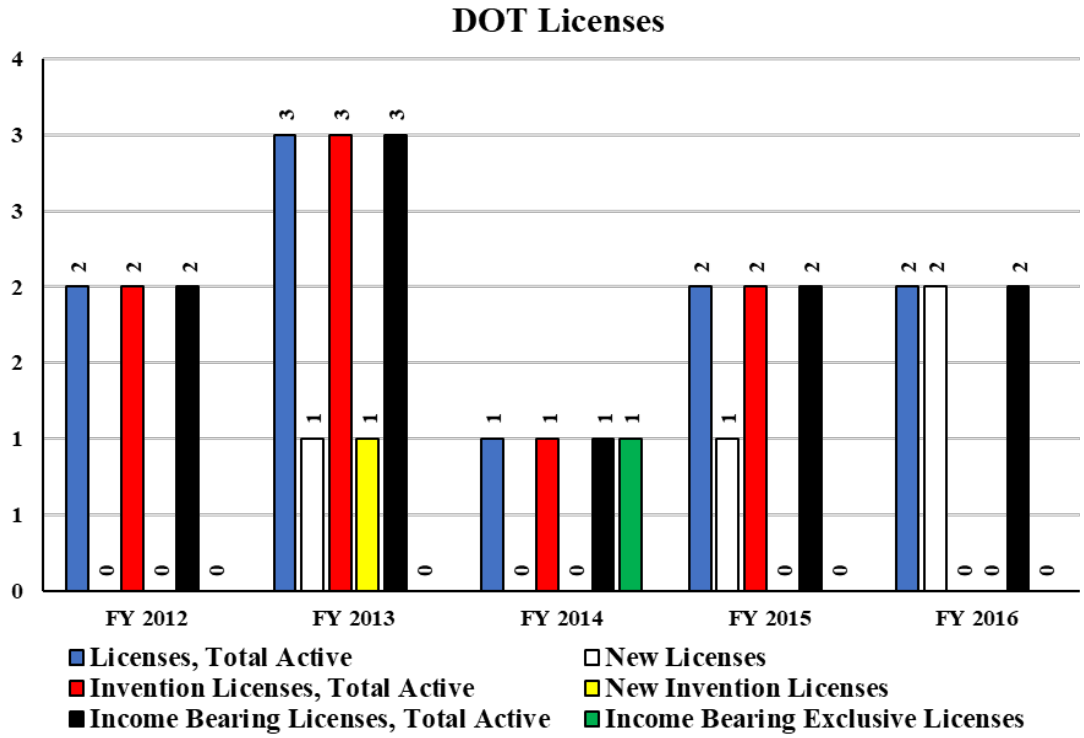


	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	2	13	3	0	0
Patent Applications Filed	1	5	0	5	0
Patents Issued	4	1	1	1	1

[31] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

DOT Licenses

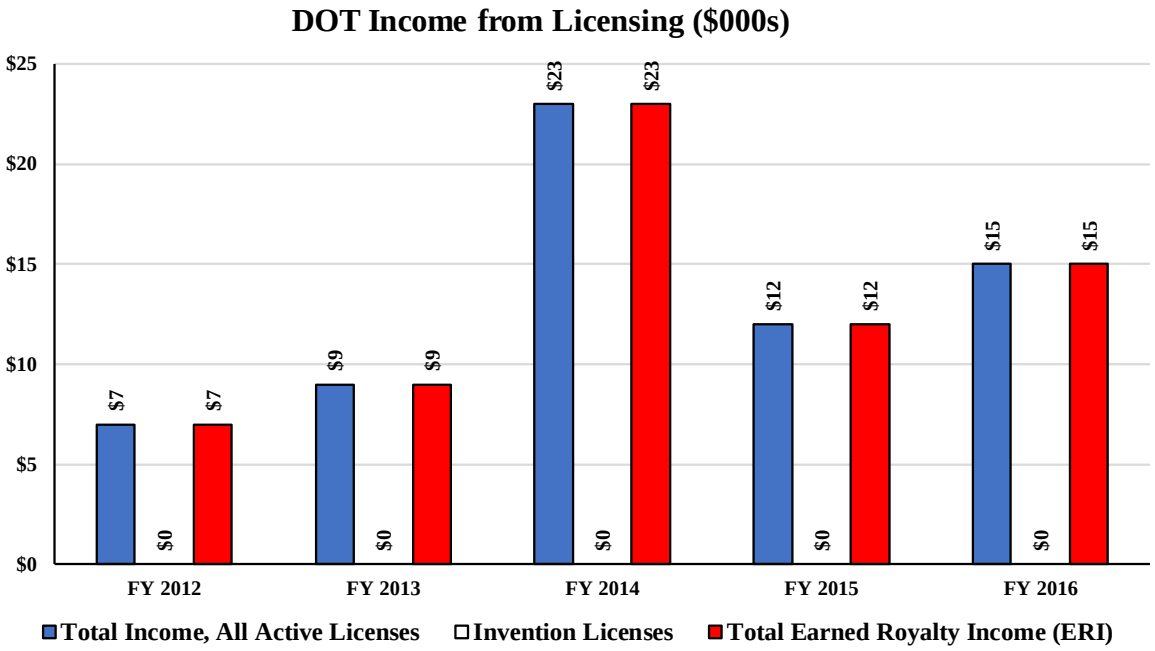
Between FY 2012 and FY 2016, DOT reported that there were two active licenses in FY 2016, the same number reported in FY 2012. All active licenses are reported to be income-bearing licenses. There were zero new invention licenses reported in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	2	3	1	2	2
New Licenses	0	1	0	1	2
Invention Licenses, Total Active	2	3	1	2	0
New Invention Licenses	0	1	0	0	0
Income Bearing Licenses, Total Active	2	3	1	2	2
Income Bearing Exclusive Licenses	0	0	1	0	0

DOT Income from Licensing

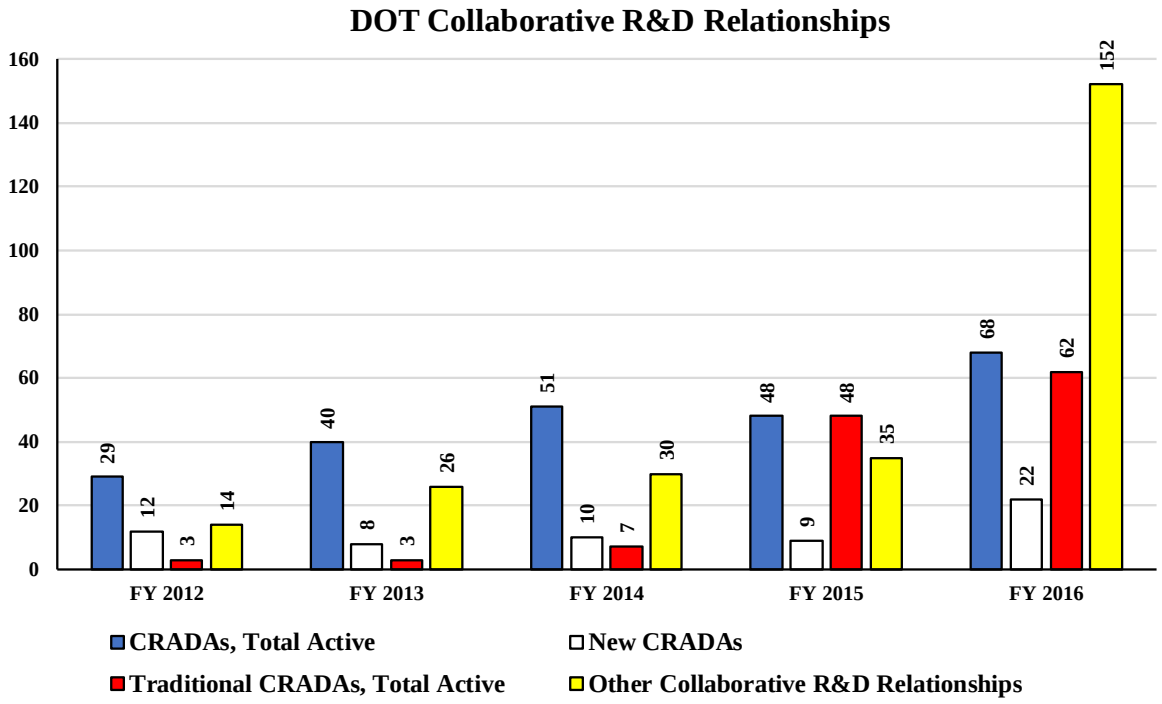
Between FY 2012 and FY 2016, DOT reported that total income from all active licenses increased by 114% from $7 thousand in FY 2012 to $15 thousand in FY 2016. All income reported is earned royalty income. DOT reported zero income from invention licenses in the past five years.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$7	$9	$23	$12	$15
Invention Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income, (ERI)	$7	$9	$23	$12	$15

DOT Collaborative R&D Relationships

Between FY 2012 and FY 2016, DOT reported the number of total active cooperative research and development agreements (CRADAs) increased by 134% from 29 to 68 agreements. New CRADAs increased by 83% to 22 new agreements in FY 2016. Total active traditional CRADAs increased significantly to 62 agreements in FY 2016, from just three agreements in FY 2012. Other collaborative research and development (R&D) relationships also increased significantly from 14 agreements in FY 2012 to 152 in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	29	40	51	48	68
New CRADAs	12	8	10	9	22
Traditional CRADAs, Total Active	3	3	7	48	62
Other Collaborative R&D Relationships	14	26	30	35	152

DOT Efforts to Streamline Technology Transfer Operations

DOT's technology transfer program, housed within the Office of the Assistant Secretary for Research and Technology (OST-R), is responsible for coordinating, documenting, and supporting technology transfer activities across the Department. Technology transfer activities focus on research collaboration, knowledge transfer, information dissemination and the practical application of research. Specific efforts include:

- Tracking the progress of technologies that have been adopted and implemented by internal and external stakeholders. Progress is often described through success stories;
- Developing training materials to help R&D personnel incorporate various technology transfer practices into their research programs. For example, a Transportation Tech Transfer Primer was created to help R&D personnel think about stakeholder maps and efforts that may foster adoption and implementation of research outputs[32];
- Aligning DOT's acquisition, research, and technology transfer processes through an interagency working group charged with developing cross-functional training materials for contracting officers and their technical representatives; and
- Incorporating technology transfer into DOT's Research, Development, and Technology Strategic Plan, FY 2017 - FY 2021.

DOT Downstream Success Stories

Federal Aviation Administration: Fire Testing Next Generation Engineering Material Arresting System

Federal Aviation Administration's (FAA) CRADA between Airport Safety Research & Development and Zodiac ESCO Inc., enabled fire testing of the next generation Engineered Material Arresting System (EMAS). This CRADA has developed ways to improve runway safety areas at commercial service airports. The project evaluates how two prototype EMAS blocks burned in the presence of a fuel fire, assessed fire propagation through the material, and examined what type of Airport Rescue Fire Fighting (ARFF) response will be needed to extinguish this type of fire.

FAA Airport Safety Firefighter extinguishing fire during evaluation per Advisory Circular requirements

Federal Highway Administration: Collaborative Partnership Supports Continued Advancement of Innovation

On May 25, 2016, FHWA's Center for Accelerating Innovation (CAI) and the American Association of State Highway Transportation Officials (AASHTO), through the AASHTO Innovation Initiative (AII), executed a Memorandum of Understanding to provide a framework for the advancement of innovation deployment activities and to foster a culture of innovation within the highway community. The Memorandum of Understanding relies on FHWA's Every Day Counts (EDC) program which evaluates and identifies market-ready technologies for potential deployment in future EDC cycles. FHWA entered into a Cooperative Agreement with AASHTO in September 2016 to further achieve these goals.

[32] See http://ntl.bts.gov/lib/57000/57400/57403/Transportation_TechTransfer_Primer.pdf

Federal Highway Administration: Incentivizes State-Based Innovation Deployment
U.S. DOT's Federal Highway Administration launched the State Transportation Innovation Council (STIC) in 2013. The STIC represents an established group of representatives from various levels of the highway community in each state tasked with comprehensively and strategically considering the implementation of innovations. The STIC places the states in the "driver's seat" to select innovations that best meet unique program needs and quickly implement them.

In 2016, STIC enabled the Department of Public Works & Transportation in Prince Georges County, MD, to complete, adopt, and institutionalize standard drawings for low-cost bridge structures. The drawings include beam details for bridges spanning from 40 to 80 feet. This led to benefits in saving construction time and enabling bridges to be traffic ready almost immediately after being erected.

The Pennsylvania STIC enhanced dialogue between State and local leaders and promoted state-of-the-art safety practices and resources. The STIC and local governments collaborated on a Salt and Snow Management Course that trained 600 participants on innovative winter maintenance techniques, demonstrated the effectiveness of high-friction surface treatment in high-crash locations, and reached out to 445 local public agencies to understand their top transportation issues.

Federal Highway Administration: ASCT Improves the Traffic Flow at Intersections
Conventional traffic signal systems use preprogrammed timing schedules that do not adjust to traffic conditions and can contribute to traffic congestion and delay. FHWA's adaptive signal control technology (ASCT) research program supported both development and deployment of this technology which improves signal timing to accommodate variability in traffic.

From conventional to adaptive traffic control.

Topeka, Kansas installed ASCT on its 21st Street corridor and the technology is estimated to save drivers 123,000 gallons of gasoline and 191,000 pounds of CO2 per year. Crashes also dropped nearly 30% along the corridor during the system's first year of operation. Since 2009, over 176 ASCT systems have been implemented, and many other agencies are considering the technology. Through FHWA's ASCT deployment efforts of providing the knowledge, training and support to the owner agencies, it influenced technology firms to continue the development of ASCT systems. There are eight ASCTs vendors and more are forming. Sixty-one agencies are in various stages of implementing ASCT at 63 locations.

Federal Highway Administration: Traffic Incident Management Training

The FHWA-sponsored Border Technology Exchange Program, coordinated by the Office of International Programs, collaborated with the Strategic Highway Research Program 2 (SHRP2) and stakeholders (AZ and TX DOTs) to train nearly one thousand fire, law-enforcement, emergency-management and transportation officials from local Mexican entities in Traffic Incident Management, which is critical to standardizing procedures of effective and safe cross-border transportation movements. Collaboratively, they have conducted nearly a dozen of the modified versions of the "National Traffic Incident Management Responder Training" in various cities in Mexico. SHRP 2's modified training sessions have featured a Spanish version of the popular video "Manage to Survive" developed by the International Association of Chiefs of Police in cooperation with FHWA.

National Traffic Incident Management Responder Training in Ciudad Juarez, Chihuahua, Mexico

Since it first launched in 2013, the training has been very well received and has gathered wide coverage from local media. A better trained emergency management force saves lives, money, and time, and given the volume of cross-border activity between the U.S. and Mexico, this standardized approach to Traffic Incident Management directly impacts the safety of U.S. citizens and businesses.

Maritime Administration: Building Energy Simulation Tools for Use in the Shipboard Environment

DOT's Maritime Administration (MARAD) is collaborating with the DOE's National Renewable Energy Laboratory (NREL) and the Naval Surface Warfare Center (Carderock and Philadelphia Divisions) on ongoing research. The Maritime Prescreening Assessment of Conservation Technologies (M-PACT) project utilized the U.S. Marine Corps' Expeditionary Energy Concepts (E2C) program to demonstrate the functionality of land-based energy efficiency technologies at-sea, and then paired the resulting field-demonstration test data with advanced modeling capabilities to assess the technology's energy savings potential across a range of shipboard operational scenarios. In the first technology demonstration, the M-PACT team evaluated the maritime suitability and energy savings potential of a variable refrigerant flow (VRF) system to enhance the U.S. Navy's ability to optimize ship operational reach and tactical performance.

DOT's Maritime Administration Training Ship - Kennedy

The research teams evaluated the accuracy of the modified version of E2C by comparing results to direct measurements taken over a six-week period onboard MARAD's Training Ship (TS)

Kennedy. E2C performed as intended while the ship was under way, which resulted in a joint-research and collaboration success. Data were collected during the TS Kennedy's annual six-week winter cruise, which took place from January 10 to February 17, 2016.

Department of Veteran Affairs (VA)

VA is the cabinet level agency whose mission statement strives to fulfill President Lincoln's promise:

> *"To care for him who shall have borne the battle and for his widow, and his orphan."*

The VA works to meet that promise through the service and honor of the men and women who are America's Veterans, by holding all employees to the core values of Integrity, Commitment, Advocacy, Respect and Excellence. VA has three administrative elements whose goals are to provide encompassing and integrated care for our Nation's veterans and their families.

- Veterans Health Administration (VHA), whose mission is to honor America's Veterans by providing excellent health care that improves their health and well-being.
- Veterans Benefits Administration, whose mission is to provide benefits and services to the Veterans and their families in a responsive, timely and compassionate manner in recognition of their service to the Nation.
- National Cemetery Administration, whose mission is to honor Veterans and their eligible family members with final resting places in national shrines and with lasting tributes that commemorate their service and sacrifice to our Nation.

As of September 30, 2016, VA employed 19.4% of the cabinet level agency federal workforce (373,152 of 1,923,064); these employees stayed with the agency an average of 10 years and are located throughout the continuous United States, Hawaii, Alaska, Puerto Rico, Guam, the Philippines and Virgin Islands. VHA has 330,988 full or part time paid employees, while the National Cemetery Administration has 1,849 and the Veterans Benefits Administration has 22,002 employees. This highly diverse workforce of professionals provides the intellectual engine for VA's Technology Transfer Program (TTP).

VHA is both the largest VA administration and the largest integrated health care system in the United States, providing care at 1,233 health care facilities, including 166 VA Medical Centers and 1,053 outpatient sites of care of varying complexity, serving more than 8.9 million veterans each year. Veteran patients using VHA programs come from conflicts ranging from World War II through Operation Iraqi Freedom and Operation Enduring Freedom and have highly diverse healthcare needs. To meet these needs, VHA has developed robust partnerships with academic affiliates and a national intramural research and development program. Both efforts are designed to promote the creation and use of cutting-edge treatments and technologies within the VA.

Technology Transfer in the VA

VA's Technology Transfer Program (TTP) started as an arm of the Rehabilitation Research R&D Service which specializes in providing wheelchair improvements. TTP currently operates within VA's Office of Research and Development but provides services throughout the agency. TTP has three main areas of focus: 1) protection and commercialization of intellectual property (IP); 2) facilitating technology transfer and cooperative research and development activities between academic partners, local VA Medical Centers (VAMC's), and industry; and 3)

educating investigators within VA about their rights and obligations regarding IP management and cooperative research activities.

A significant difference between VA Technology Transfer and other federal technology transfer programs are the number of stakeholders having partnership with VA TTP. VA TTP works in partnership with the VA Office of General Counsel, investigators and leadership within VAMC's, National Cemetery Administration, academic affiliates, non-profit corporations, contract attorneys and businesses.

The VA conducts basic and applied clinical research to discover new treatments and therapies for diseases which affect our Nation's Veterans at more than 100 VAMC's, each of which is a federal laboratory. The majority of investigators at these laboratories also have appointments with their local academic affiliate, usually a medical school. Consequently, the majority of VA inventions are jointly owned by VA and its academic affiliates.

Most jointly owned inventions are managed under cooperative agreements with these affiliates. The agreements allow the VA or the affiliates to take the lead in commercializing jointly owned inventions.

TTP cooperates with local academic affiliates in the patenting and licensing of jointly owned technologies.

- TTP works closely with the Office of General Counsel (OGC) Specialty Team Advising Research (STAR) attorneys on IP management issues and cooperative research agreement review.
- TTP receives invention disclosures and conducts a review and evaluation of the inventions. This evaluation is then provided to STAR attorneys who issue a determination of rights (DOR) decision to the inventors regarding the government's interest in such invention.
- After the DOR is issued, TTP seeks patent protection where appropriate, and may begin efforts to find commercialization partners for any VA owned invention.
- TTP also works closely with local VA-affiliated nonprofit research and education corporations (NPC). NPCs were authorized by Congress to provide flexible funding mechanisms for the conduct of research and education at VA facilities nationwide. Currently there are over 80 NPCs.

Research agreements, including CRADAs, are initiated by the local VAMC with the negotiation and administration of such agreements being handled by a local NPC. TTP and STAR collaboratively provide a review of such research agreements prior to signature.

In FY 2016, the VA TTP developed the mission motto "BRAVE—Bringing Research Advancements to Veterans and Everyone" and determined that there were two key programmatic improvements which had to be immediately addressed to meet our mission of becoming BRAVE:

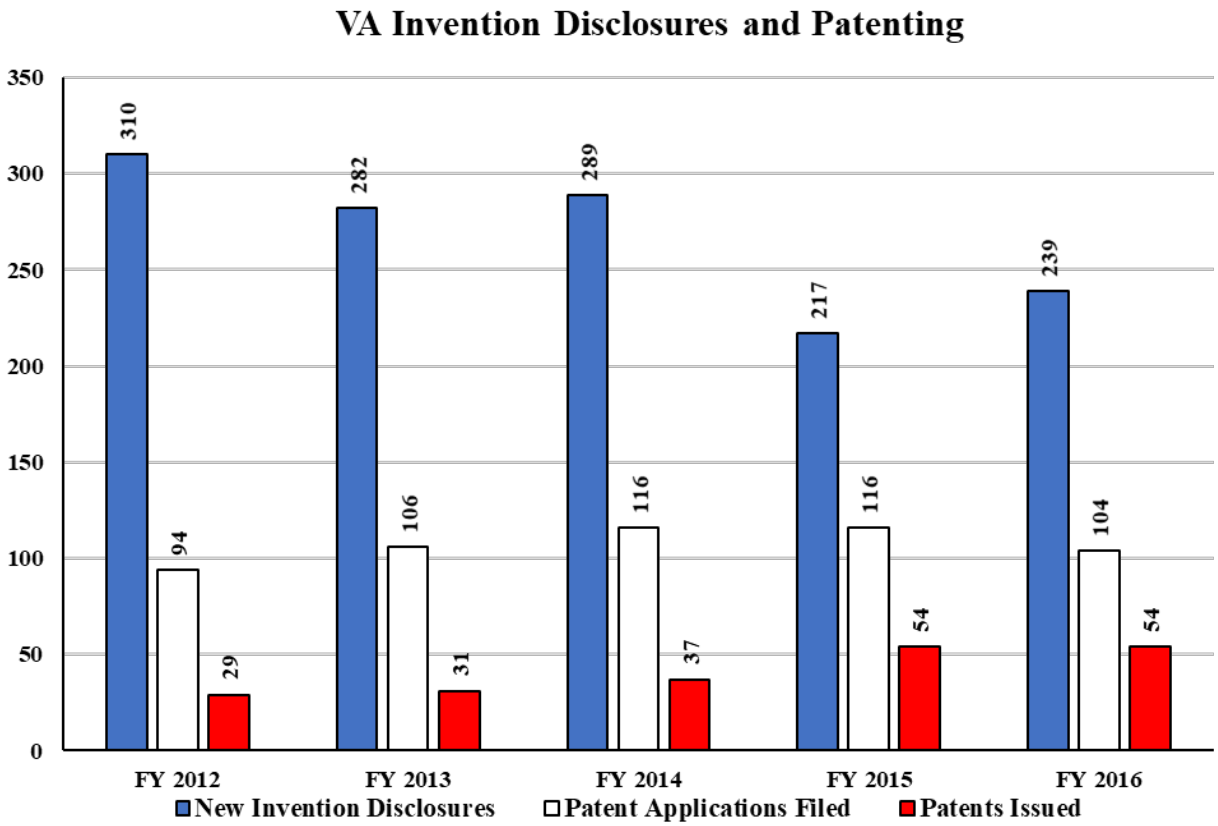
1. Developing and maintaining communications, managing the flow of documentation and providing timely information; and
2. Identifying those operations which have the greatest opportunities for improvement and developing improvement plans for implementation.

Improving communications and operations were the focus of continuous improvement in FY 2016.

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

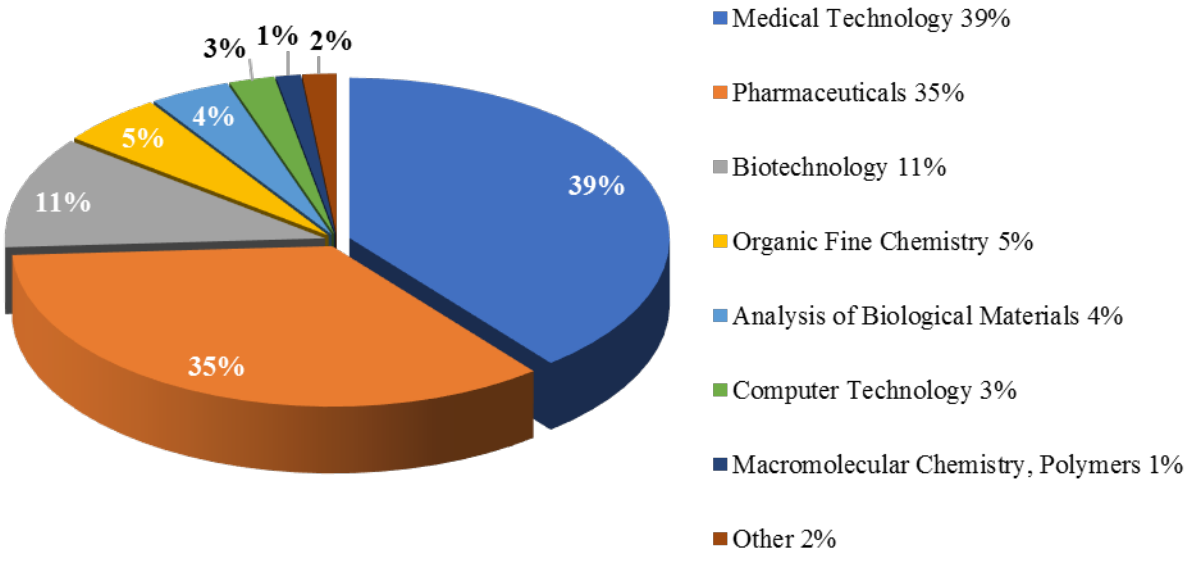
Between FY 2012 and FY 2016, the number of new inventions disclosed decreased by 23% from 310 to 239 disclosures in FY 2016. The number of patent applications filed increased by 11% to 104. The number of patents issued increased by 86% to 54 patents.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	310	282	289	217	239
Patent Applications Filed	94	106	116	116	104
Patents Issued	29	31	37	54	54

Patents issued to VA in FY 2016 covered many technology areas, including Medical Technology (39%), Pharmaceuticals (35%), Biotechnology (11%), Organic Fine Chemistry (5%), and Analysis of Biological Materials (4%).[33]

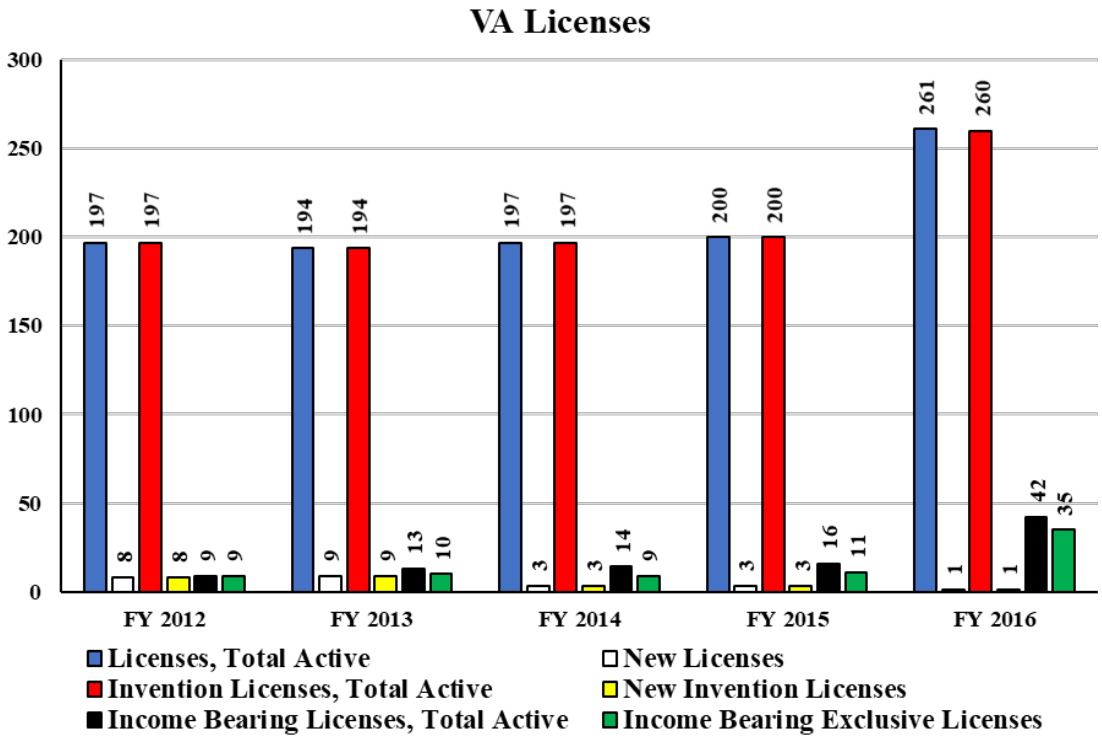
USPTO Patents Assigned to VA by Technology Area: FY 2016



[33] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

VA Licenses

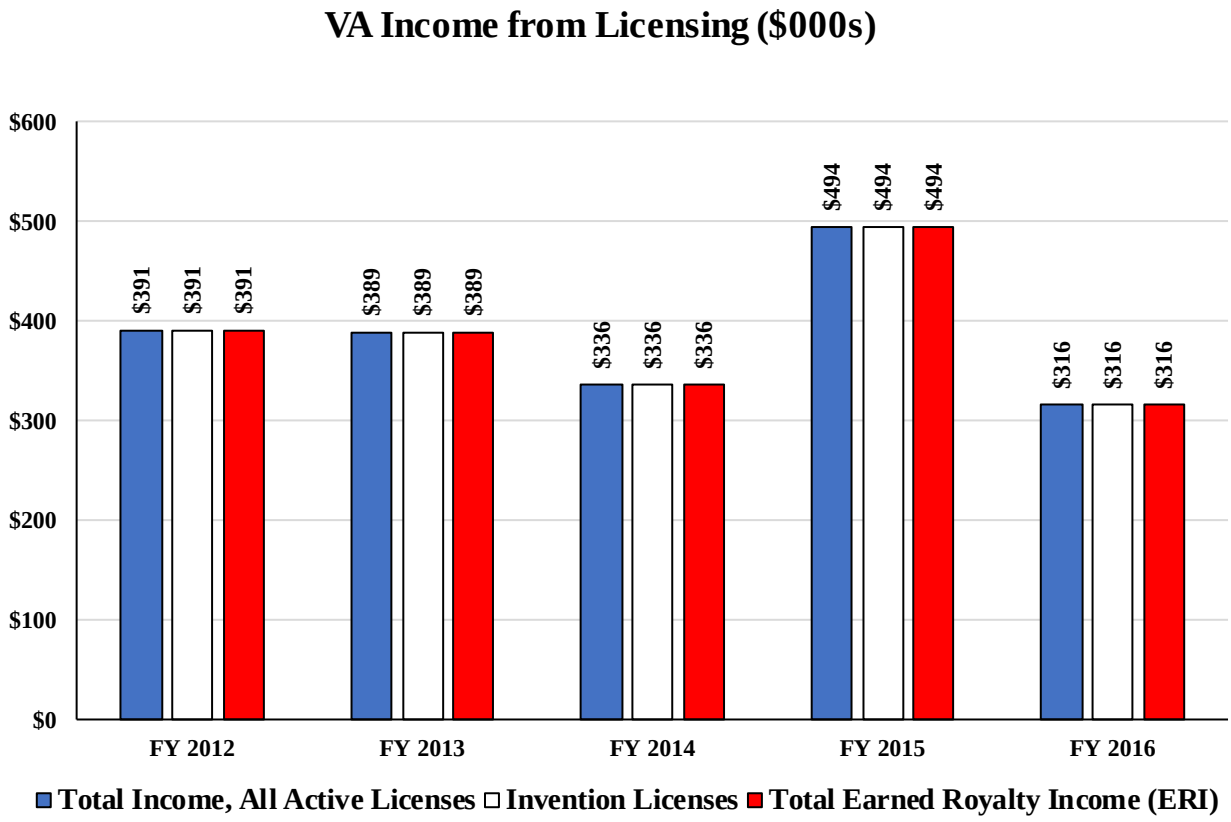
Between FY 2012 and FY 2016, VA reported the number of total active licenses increased by 32% from 197 to 261 licenses while new invention licenses declined by 88% to one. Income-bearing licenses increased by 367% to 42 while income-bearing exclusive licenses increased by 289% to 35.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	197	194	197	200	261
New Licenses	8	9	3	3	1
Invention Licenses, Total Active	197	194	197	200	260
New Invention Licenses	8	9	3	3	1
Income Bearing Licenses, Total Active	9	13	14	16	42
Income Bearing Exclusive Licenses	9	10	9	11	35

VA Income from Licensing

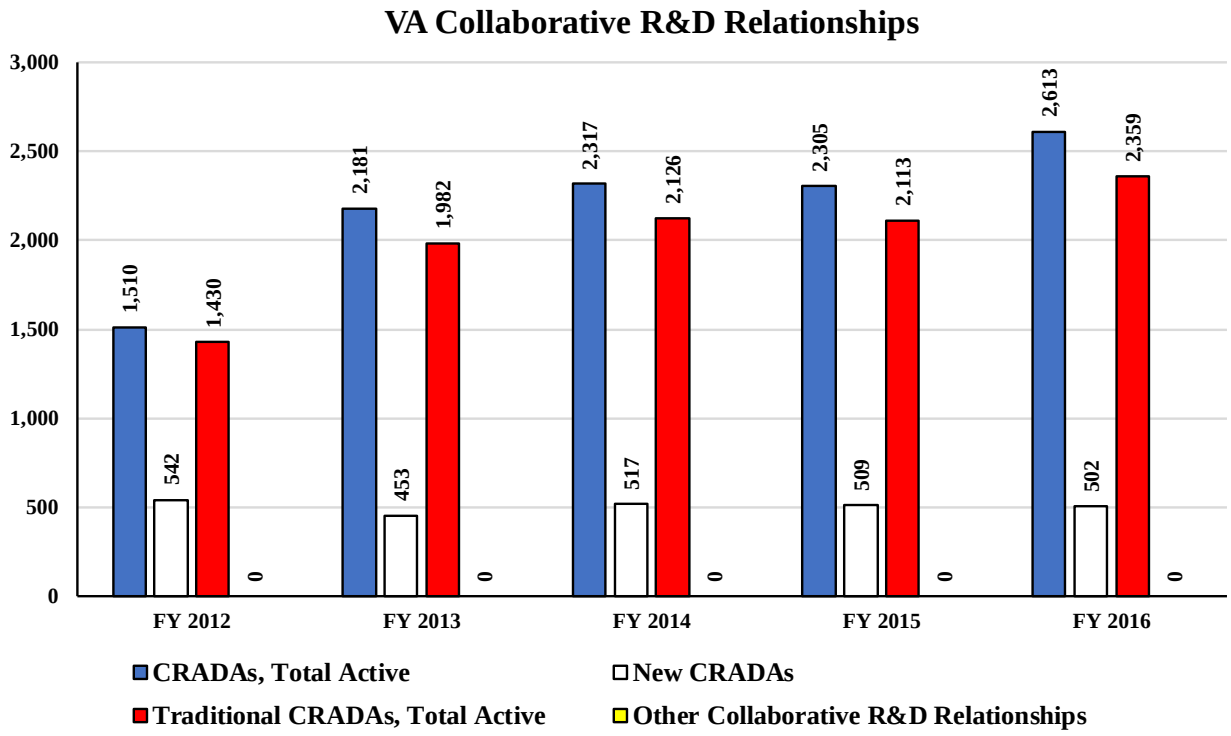
Between FY 2012 and FY 2016, VA reported that total income from all active licenses decreased by 19% from $391 thousand to $316 thousand in FY 2016. Income from invention licenses and earned royalty income were the same as income from all active licenses.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$391	$389	$336	$494	$316
Invention Licenses	$391	$389	$336	$494	$316
Total Earned Royalty Income, (ERI)	$391	$389	$336	$494	$316

VA Collaborative R&D Relationships

Between FY 2012 and FY 2016, VA reported that the number of total active cooperative research and development agreements (CRADAs) increased 73% from 1,510 to 2,613 agreements. The number of new CRADAs per fiscal year decreased by 4% to 502 new agreements in FY 2016. Total active traditional CRADAs increased by 65% to 2,359 agreements in FY 2016. No other collaborative research and development (R&D) relationships were reported.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	1,510	2,181	2,317	2,305	2,613
New CRADAs	542	453	517	509	502
Traditional CRADAs, Total Active	1,430	1,982	2,126	2,113	2,359
Other Collaborative R&D Relationships	0	0	0	0	0

VA Efforts to Streamline Technology Transfer Operations

Revision of "VA Directive 1200.18 Determination of Rights for Inventions and Disclosures"
One of the first lines of communication to partners and stakeholders are those documents defining VA Technology Transfer Policy (TTP). VA TTP's parent document entitled, "VA Directive 1200.18 Determination of Rights for Inventions and Disclosures" had been in effect since November 1, 2008, without edits or revisions. To provide clarity in the current process, a revised directive was placed into the concurrence process in FY 2016. This new directive

updated and clarified policy and defined scope. A major change in scope increased the reporting requirements to the following groups within the agency:

Employees or Government employee means any officer or employee, civilian or military, of VA. Part-time, without compensation (WOC) employees and part-time consultants are included." 38 CFR §1.651(b). Additionally, the term "employee" or "Government employee" includes any "special Government employee" as defined in 18 U.S.C. § 202; an individual working for VA pursuant to an IPA (5 U.S.C. §§ 3371-3375); a WOC (38 U.S.C. § 7405(a)(1)); or a consultant (5 U.S.C. § 3109).

Invention Disclosures

The start of the intellectual property process is the disclosure of the invention to VA TTP. This is done by the investigator submitting an invention disclosure form (ID) and the inventor certification form (IC).

The process improvement in FY 2016 was the reformatting of both the VA ID and VA IC forms and their placement onto the VA Technology Transfer Internet website www.research.va.gov. The VA TTP has an organizational email for electronic Inquires related to Invention Disclosures or Inventor Certification, vattid@va.gov, where all ID and IC submissions are to be sent. The management and monitoring of this tool has been a key business improvement in FY 2016.

Once these forms have been submitted to VA TTP, a Technology Transfer Specialist (TTS) evaluates the technology and forwards their recommendations to the legal counterparts at VA STAR. Another FY2016 process improvement involved placing dedicated legal staffers on the invention disclosure management process to aid in reducing backlogs and tracking down ID's which had languished in the system without a determination of rights. The combination of new forms, staff oversight and improved communication with partners virtually eliminated the 400 plus backlog of unaddressed IDs in the system. Plans for ongoing improvement include monitoring of determination times by Technology Transfer Specialists; a proposal to take the entire Determination of Rights (DOR) process into TTP and create an online ID and IC process which will reduce the number of partial and incomplete submissions received by TTP. These steps should both eliminate backlogs and reduce the time it takes to issue DORs.

Patent Management Improvements

In FY2016, VA TTP assigned a dedicated staffer to review both USPTO databases and academic affiliates annual reports to identify domestic patents which were not reported to VA. This information was used to update the Wellspring Sophia database used by VA TTP. To meet Federal Laboratory Consortium (FLC) standards, all identified patents were placed onto the VA TTP Internet site along with a synopsis. These steps were also applied to FY 2015, FY 2014 and FY 2013 U.S. Patent and Trademark Office and affiliate identified patents. Next steps for improving patent reporting will include foreign patents from VA inventors, and adding to the website patent reporting in FY 2012 and before. The other improvement planned for FY 2017 was to monitor and manage the academic affiliate reporting on patents to assure that VA is named on all patents which they have rights to.

Coordination of IP Management with Affiliates
While Intellectual Property at the VA is an agency-wide initiative, historically, biomedical and rehabilitative researchers have been the primary users of the TTP. Most of these individuals also have dual appointments with their academic affiliate. To assure that a consistent process for managing IP with academic affiliates was used, the VA began negotiating Cooperative Technology Administration Agreements (CTAAs) with the majority of its larger academic affiliates in FY2000. These CTAAs described mechanisms for handling jointly-owned inventions, including a formula for sharing revenue and expenses from patenting and licensing activities. 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.

TTP has developed a new Invention Management Agreement (IMA), which is designed to replace the CTAAs. The IMA is compliant with current federal regulations and will ensure VA's contribution to commercialization of new technologies is recognized. TTP is in active negotiations with all 79 current affiliates to transition from the existing CTAA to the new IMA agreement, with the goal of transitioning all affiliate agreements from CTAAs to IMAs by the end of FY 2018.

In Fiscal Year 2016 the VA's TTP requested annual reporting from its 66 academic affiliates who had active CTAAs. Forty of those programs responded (for a 60.6% response rate), and five of those respondents had a reply of no activity. Two of these affiliates CTAA's are consolidated, which impacts the numbers of unique institutions reporting to the VA. Historically, academic programs have used their unique internal processes to create responses for annual reporting information. A key business process improvement planned in FY2016 has been the creation and distribution of a standardized format for reporting. This will allow the academic affiliates to accurately and systematically report intellectual property activities (patents issued/applied for, licensing activities, invention disclosures, revenues and general workload) to VA TTP. This form should reduce reporting of IP which is not attributed to the VA by its partners and improve data management.

CRADA Streamlining
VA Medical Centers conduct hundreds of clinical trials each in collaboration with pharmaceutical companies, other federal entities including the National Institutes of Health, and universities. These trials seek to find new therapies that will improve Veteran's health. The VA has executed over 400 CRADAs per year over the past five years. Over 70% of these CRADAs are clinical trial CRADAs. VA has negotiated 19 Master CRADAs primarily with large pharmaceutical companies for clinical studies. These agreements can be signed at the local level with minimal review by central office staff. This year VA updated three of these Master CRADAs and finalized one new agreement. Currently an additional five new Master CRADAs are in negotiation. Master CRADAs are important in that they expedite and facilitate the negotiation process on these complicated agreements ultimately benefiting VA's ability to conduct research and participate in clinical studies. VA has also executed 26 Master Confidential Disclosure Agreements (CDA) which deal with the protection of information shared between entities at any level of Clinical or Biomedical discovery. Having Master CDAs in place helps to expedite the negotiation process between VA and other entities and shorten the timeline to start new research programs. Another streamlining improvement which was implemented in

2010 was the CRADA registry, which allows nonprofits to directly submit new CRADAs. Other questions related to CRADA activity are addressed electronically by sending an email to vhacottc@va.gov.

VA Downstream Success Stories

Suicide Soft Door

At the Sheridan VA Medical Center (VAMC), Lisa Garstad doesn't wear a lab coat and goggles. Performing research is not included in her official VA work duties. In fact, her Medical Center is so small that it does not have an established research program or affiliated research relationship.

Lisa Garstad, Co-Inventor of the Soft Suicide Door

However, Garstad saw a need and created a solution with the Soft Suicide Prevention Door (SSPD), a lightweight door formed of foam and covered in fireproof vinyl that has magnetic hinges. The SSPD is designed to pull off of its hinges after 20 pounds of pressure is applied to it, thereby eliminating door anchor points and significantly reducing the possibility that the door could be used in a suicide attempt.

Garstad is a rare "garage inventor" at the VA; most VA inventions are developed by employees with established research relationships within their VAMC and/or an academic affiliate. She joined the Sheridan VAMC in November 2006 as a Patient Safety Risk Manager. Shortly after she arrived, she was tasked with bringing the hospital's acute mental health facility into compliance with the "Environment of Care" checklist, a set of guidelines designed to reduce the number of suicides in acute mental health units.

When Garstad walked into Sheridan's mental health facility, one of the most urgent issues she encountered was in the bathroom. Bathroom interiors pose many serious hazards as there are multiple mounted fixtures that provide anchor points. Many suicide incidents occur in bathrooms each year.

Constantly monitoring patients in this room was not practical as it is important to respect patients' privacy while finding ways to ensure their safety. Regular doors were still too much of a risk, however; there were too many anchor points where someone could intentionally injure themselves. Garstad felt that it was necessary to provide some type of door covering in order for patients to feel more at ease. Thin curtains were suggested as an alternative to solid doors, but Garstad wanted to do better. She felt that a comfortable, livable environment was important for these patients' recovery.

Determined to find a better alternative when faced with a lack of commercial solutions, Garstad started working with the Sheridan Public Affairs Specialist, Jackie Van Mark, who suggested

that the doors be made with a foam core and suspended by using Velcro™ hinges. Thus, the idea for the Soft Suicide Prevention Door (SSPD) was born.

Their prototype performed very well; it provided a solid barrier so that patients would have privacy in their rooms but lacked anchor points and would not sustain weight. The Sheridan VAMC was thrilled with the SSPD and wanted to install them throughout its mental health unit, so Garstad and Van Mark began to look into how to mass produce and market their invention. Van Mark contacted the VA's TTP and submitted an invention disclosure. The SSPD design was quickly processed by TTP and was soon patent-pending.

In order to get the SSPD to the market as soon as possible, TTP looked for potential licensing opportunities and found Kennon Products, Inc. (Kennon). Kennon, a U.S. manufacturing company, was interested and worked closely with Garstad and Van Mark to finalize the design. New features, such as magnetic hinges, were added and the heavy duty, waterproof vinyl is now printed with large images that both beautify the environment and appeal to the patients of the acute mental health units.

The SSPD was awarded the 2009 Design Award from the National Center for Patient Safety. TTP and Kennon finalized an exclusive license agreement, royalties from which are still being paid today.

The SSPD is currently in use at the Sheridan VAMC. It was installed throughout the facility's acute mental health unit as both standard and shower doors. Despite regular use, they have only needed to be replaced once in the past decade. The SSPD is also a multi-use tool; it has been used by staff at the VAMC as a mat and by security teams as a shield.

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 FTTA, EPA facilitates the transfer of new technologies to the marketplace while protecting the intellectual property rights of all parties.

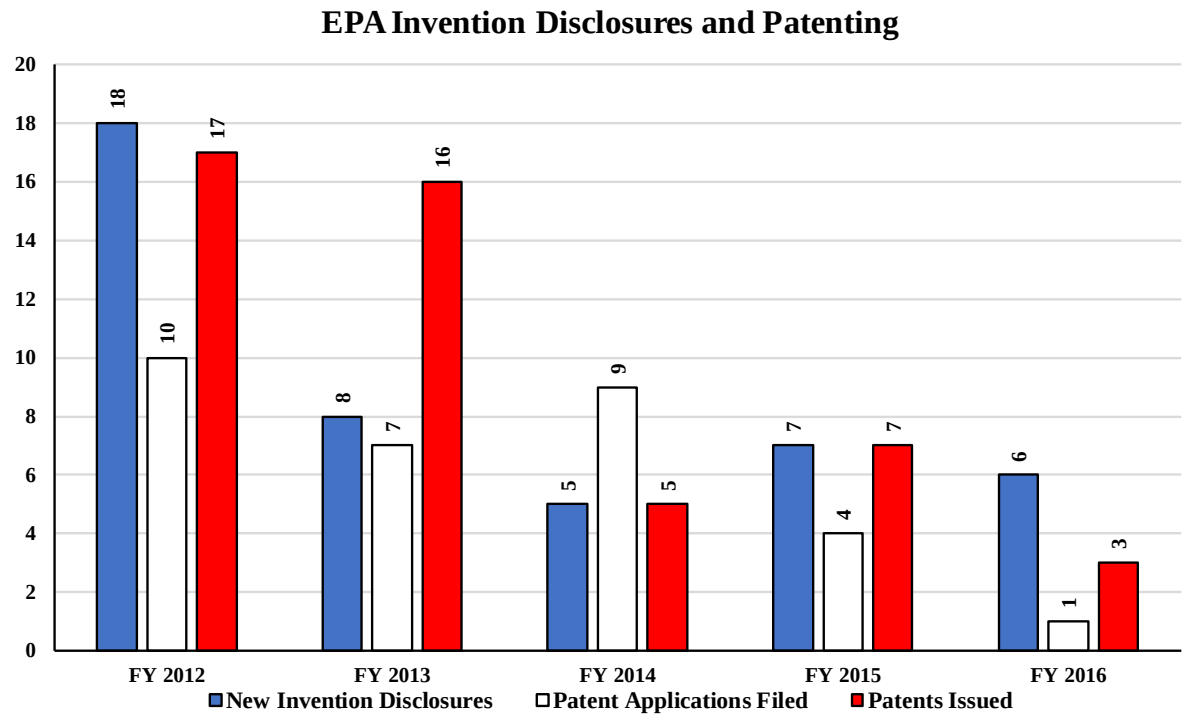
Partners in the FTTA Program have the benefit of collaborating with world-class EPA scientists involved in leading-edge research. Collaboration enhances the quality of research projects and helps move environmental technologies into the marketplace, resulting in better protection of human health and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

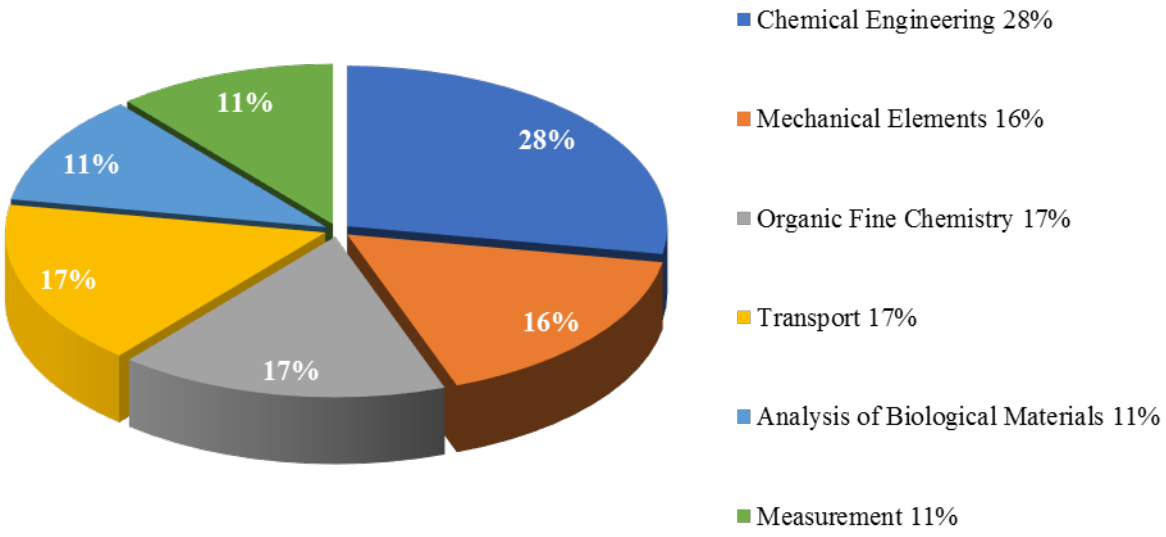
Between FY 2012 and FY 2016, EPA reported the number of new inventions disclosed decreased by 67%, from 18 disclosures in FY 2012 to 6 in FY 2016. The number of patent applications filed decreased by 90% to one. The number of patents issued decreased by 82% to three patents.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	18	8	5	7	6
Patent Applications Filed	10	7	9	4	1
Patents Issued	17	16	5	7	3

Patents issued to EPA in FY 2016 covered many technology areas including Chemical Engineering (28%), Mechanical Elements (16%), Organic Fine Chemistry (17%), Transport (17%), Analysis of Biological Materials (11%), and Measurement (11%).[34]

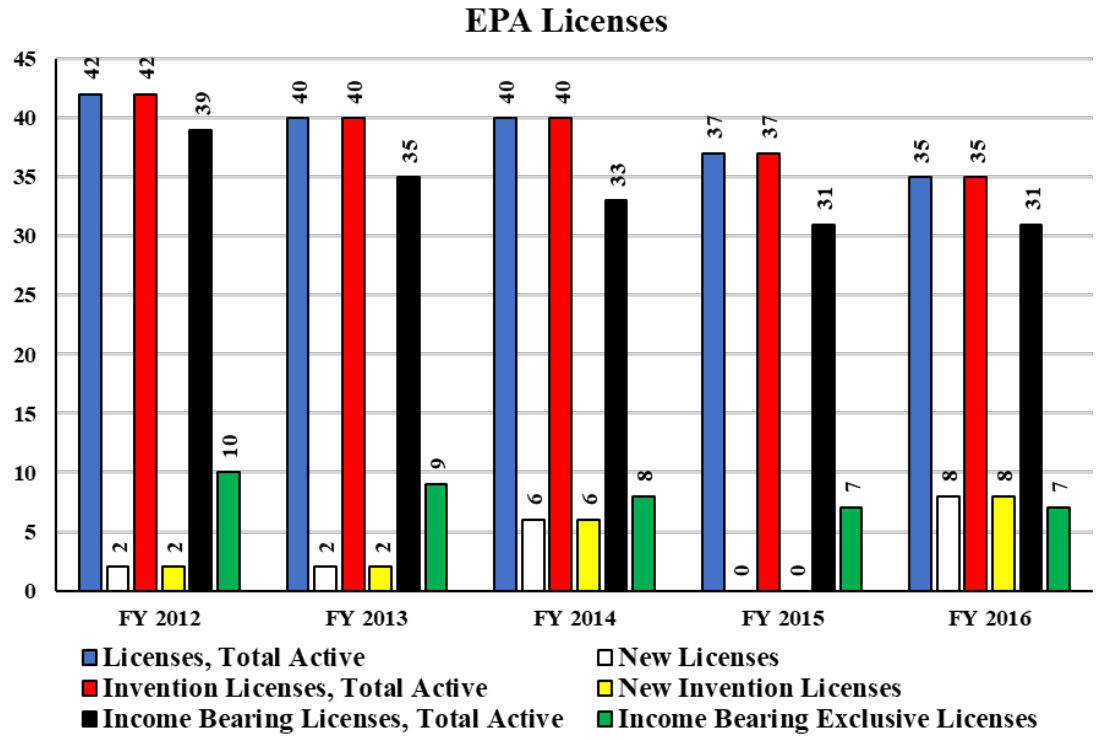
USPTO Patents Assigned to EPA by Technology Area: FY 2016



[34] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

EPA Licenses

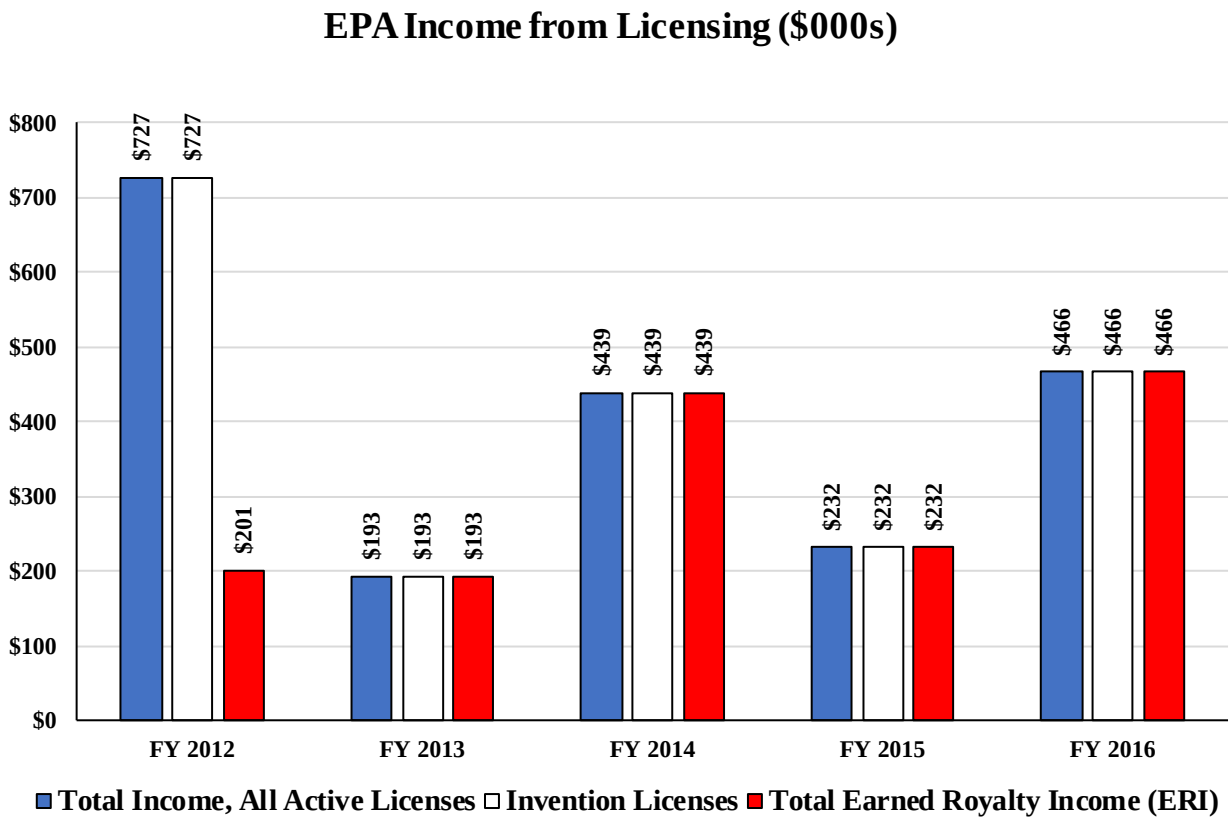
Between FY 2012 and FY 2016, EPA reported that the number of total active licenses decreased by 17% from 42 to 35 licenses in FY 2016 while the number of new licenses increased by 300% to eight. All active licenses were invention licenses. The number of exclusive income-bearing licenses declined by 21% to 31 while the number of exclusive income-bearing licenses declined by 30% to seven.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	42	40	40	37	35
New Licenses	2	2	6	0	8
Invention Licenses, Total Active	42	40	40	37	35
New Invention Licenses	2	2	6	0	8
Income Bearing Licenses, Total Active	39	35	33	31	31
Income Bearing Exclusive Licenses	10	9	8	7	7

EPA Income from Licensing

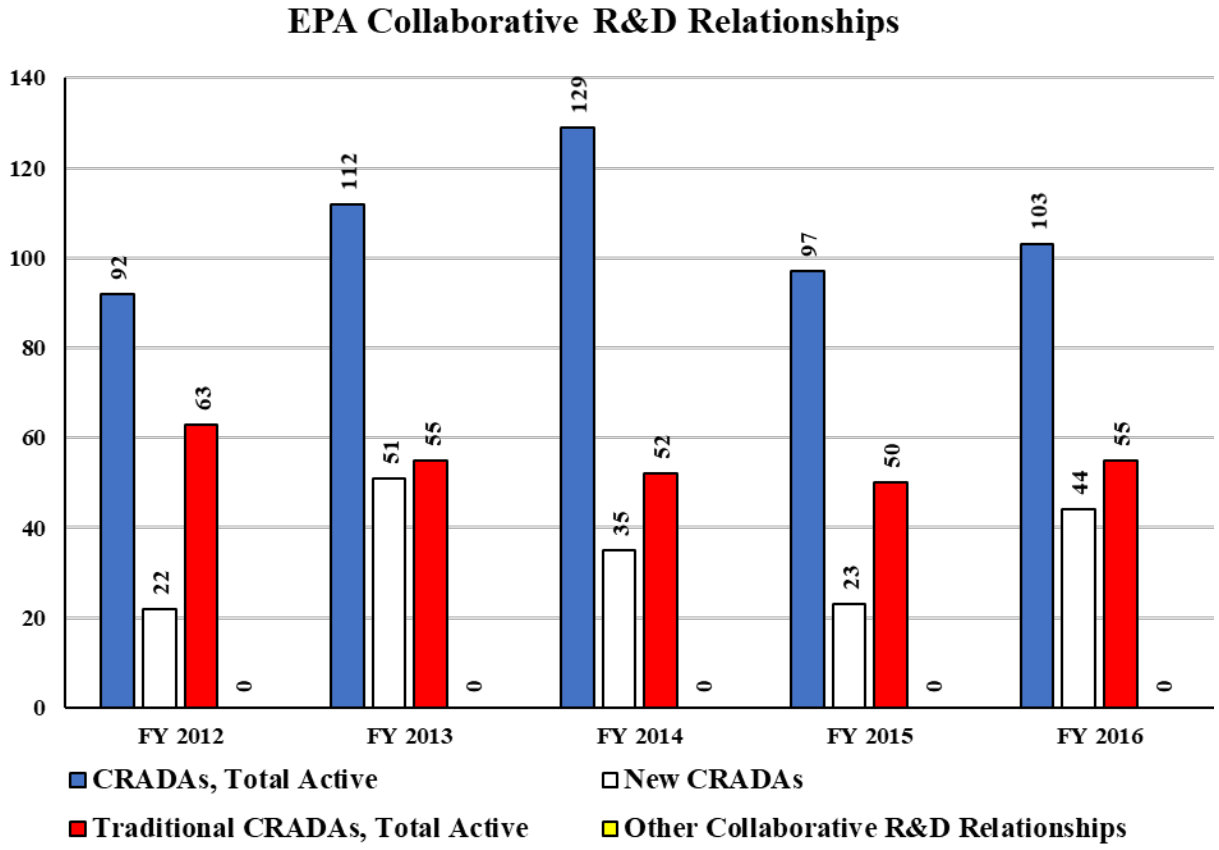
Between FY 2012 and FY 2016, EPA reported that total income from all active licenses decreased by 36% from $727 thousand to $466 thousand in FY 2016. All income from licenses came from invention licenses. Total earned royalty income increased 132% from $201 thousand in FY 2012 to $466 thousand in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$727	$193	$439	$232	$466
Invention Licenses	$727	$193	$439	$232	$466
Total Earned Royalty Income, (ERI)	$201	$193	$439	$232	$466

EPA Collaborative R&D Relationships

Between FY 2012 and FY 2016, EPA reported that the number of total active cooperative research and development agreements (CRADAs) increased by 12% to 103 agreements from a previous 92 in FY 2012. The number of new CRADAs per fiscal year increased by 100% to 44 new agreements in FY 2016. Total active traditional CRADAs decreased by 13% to 55 agreements in FY 2016. No other collaborative research and development (R&D) relationships were reported.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	92	112	129	97	103
New CRADAs	22	51	35	23	44
Traditional CRADAs, Total Active	63	55	52	50	55
Other Collaborative R&D Relationships	0	0	0	0	0

EPA Downstream Success Stories

EPA: Tracking Microbial Sources of Water Contamination

According to the EPA's National Water Quality Inventory Report to Congress, fecal bacteria are one of the leading causes of U.S. surface water impairment. The presence of fecal bacteria at elevated levels originating from human and other animal wastes in community water systems, at recreational beaches, and shellfish harvesting areas is correlated to negative public health outcomes ranging from the more common mild gastrointestinal illness to the rare and more severe illness or even death.

To protect human health, in 1972 Congress passed the Clean Water Act, mandating the EPA to provide the public with technologies to monitor for fecal pollution. The scientific community responded with the development of technologies ranging from chemical indicators to canine monitoring. EPA scientists recently sought an innovative approach through the study of fecal bacterial communities at a molecular level. The result was the development of novel genetic based technologies that can measure human and cattle fecal pollution levels in surface water samples. The Microbial Source Tracking (MST) methods are technologies aimed at identifying and, in some instances, quantifying fecal animal sources of contamination in environmental waters.

The EPA's U.S. Patents 7,572,584, 8,058,000, and 8,574,839 describe genetic technologies that can estimate the concentration of human, cattle, pig and dog fecal pollution in environmental water samples. Due to nationwide fecal pollution concerns and more than 290 peer-reviewed scientific citations, there is a growing demand by academic, state, and municipal government laboratories to implement EPA MST technologies. To accommodate interest from nonprofit entities, the EPA developed a new strategy whereby technology can be simultaneously transferred to commercial partners while making it available to noncommercial entities. This was accomplished through two new license formats in addition to the commercial license.

To date, 13 licenses have been awarded to university research laboratories, leading to important scientific advancements in the MST field and a better understanding of EPA technology performance. Three private companies have applied for and been granted commercial licenses.

EPA: Reducing Energy Consumption of Commercial Buildings

In 2016, EPA completed work on a CRADA with Natural Resources Canada (NRCan) aimed at helping to reduce the energy use of commercial buildings in Canada. In 2008, as part of an investigation into various methods used globally for assessing energy use in commercial buildings, the Canadian government approached EPA with a proposal to base its new energy benchmarking initiative on the ENERGY STAR® methodology and EPA's ENERGY STAR Portfolio Manager® benchmarking tool.

Portfolio Manager is a free, interactive online energy, water, waste, and greenhouse gas (GHG) benchmarking tool in which more than 50,000 account holders have assessed the performance of nearly 500,000 buildings. It allows building owners and operators to efficiently track and assess the energy, water, waste, and GHG performance of their buildings, and to compare their energy

performance with those of their peers based on data from reference buildings in the United States.

In 2011, NRCan signed a CRADA with the U.S. EPA to facilitate the necessary updates to the Portfolio Manager tool to add value and accuracy for Canadian users. In the new tool that was built, Canada-specific enhancements included, but were not limited to:

- Energy performance scales for Canadian buildings (including offices and K-12 schools initially, followed by hospitals, retail stores, and others);
- Canadian weather data;
- Canadian conversion factors to convert site energy entered by users into source energy used in metrics calculations;
- Canadian greenhouse gas emission factors;
- Capabilities to enter data or retrieve results in metric units; and
- French language capabilities.

The new tool was launched in July 2013 and subsequent work focused on continuing to develop additional new functionality. In the time after the launch of the new Portfolio Manager tool, CRADA researchers performed enhancements in a number of areas. The first enhancement was metrics development. When the new tool was launched, it included 1-100 ENERGY STAR Scores for only Canadian office buildings and K-12 schools. In the time after the initial launch of the tool, significant effort was spent to develop, program, and release additional scores for hospitals, warehouses, medical office buildings, food retail stores, and senior care facilities. A second area of focus was Portfolio Manager security. Specifically, several enhancements were made to accommodate the needs of NRCan's users, including adding reminders to reset passwords, and warnings associated with document uploads. Finally, new functionality was developed to facilitate training of users within the tool by allowing them to select from five different types of sample buildings to populate their account. In addition to these highlights, researchers made other mutually beneficial enhancements to the database, user interface, and web services employed by both U.S. and Canadian users.

EPA: Managing Municipal Solid Waste

More sustainable approaches to solid waste management can be accomplished using a life-cycle analysis that considers cost and energy flows through a system analysis. This type of analysis helps communities to understand the environmental tradeoffs of different management options. A tool developed by EPA's Office of Research and Development calculates the material and energy flows from the collection, transport, processing, composting, combustion and landfilling of commercial and residential waste. The tool also calculates the economics using full cost accounting of managing materials. It has received international and national recognition as the leading tool for use in helping communities identify more sustainable and resilient management options considering both economics and environmental tradeoffs.

Through a CRADA with Covanta Energy, the interface of the tool was upgraded to enable users to calculate the life cycle environmental tradeoffs, material and energy flows, and the full costs associated with how to manage materials in municipal solid waste. The user interface of the tool was completed in 2016, which was the culmination of several years of effort to develop a beta

version of a second-generation tool. The data from testing landfills is included in the dataset for the tool along with changes in process design and operation for municipal solid waste management.

Covanta's interest in the tool is that if a scientific and peer-reviewed tool is available, then communities, as well as industrial and commercial generators of waste, will better understand the tradeoffs and potential benefits of waste to energy in addition to providing more accurate information on all management options for more efficient and effective environmental management.

The CRADA also supported direct measurement of methane, mercury, and other landfill gas emissions from landfills. A source of criteria and hazardous air pollutants, landfills are considered the most challenging source to measure because of their size and ever-changing nature, due to changes in waste composition, design, and operations. Comparatively few direct measurements have been completed and the CRADA added substantially to the body of publicly available data. This data is crucial to support development of tools like that described above.

National Aeronautics and Space Administration (NASA)

Even revolutionary technology can face a long road on its way to commercial success. The camera in every cell phone, for example, runs on a sensor originally developed at NASA, but it took nearly two decades for the technology to achieve its dominance in the field of digital imaging. Innovations often require multiple generations of inventors, engineers, and entrepreneurs to go from lab to store shelf—a process that NASA's Technology Transfer Program (T2) specializes in facilitating.

Since its founding by the National Aeronautics and Space Act of 1958 , NASA has worked to ensure that the results of its space and aeronautics activities benefit the whole of humanity. To that end, the T2 program serves as the Nation's curator of aerospace technology assets, identifying and protecting inventions and ensuring they are distributed to individuals, academia, and industry as widely as practicable. The program processes more than 1,500 new technologies created by NASA innovators each year, assessing each for its commercial potential and patenting those that are particularly promising. It manages the agency's technology portfolio, negotiates license agreements, and handles requests for NASA software.

T2 also communicates the societal benefits of NASA's work to the public through its annual *Spinoff* publication, which has featured more than 2,000 successfully commercialized space technologies since its first issue in 1976.

NASA's increased marketing and promotion of its various technology portfolios has led to a dramatic spike in public and government interest in NASA technology for secondary applications. Managing this increased interest requires constant and continuous process improvements across all areas of the technology transfer pipeline—from new internal tools to help NASA innovators publish their discoveries and inventions to websites and mobile applications the public can use to discover and acquire NASA technology. T2 develops and maintains these tools while also conducting public outreach through media, conferences, and other interactions with government, university, and commercial organizations.

Program Achievements in 2016

Thanks in large part to recent T2 initiatives, NASA technology has never been more easily accessible or more easily transferred from government to private use. Fiscal Year 2016 saw improvements to: tools to help NASA innovators disclose and track their new technologies, agency patent strategy and licensing practices, software release processes, and public outreach.

Invention Disclosure

NASA employees are required to disclose their inventions , though for various reasons it is a perennial challenge to ensure they are aware of this requirement and follow through with action. This year, in order to increase the number of agency invention disclosures, T2 launched a highly successful inventor's notebook initiative to help promote awareness of the disclosure process and requirements. The initiative put sought-after, high-quality, hard-back notebooks in the hands of NASA innovators, which through design and branding now remind them daily to report new

technologies. Additionally, the program coordinated training for nearly 2,500 civil servants on their requirements to report.

NASA also continued regular improvements to the newly-launched Innovator Dashboard, a web-based tool for tracking what happens to technologies after their disclosure. The dashboard gives innovators a one-stop shop for tracking information that before now was spread out in many places: for example, whether a technology was patented by the agency, resulted in licenses or commercial spinoffs, or was published.

Finally, in 2017, T2 was undertaking an overhaul of the disclosure process that will enable inventors to pursue different pathways depending on whether they are civil servants or contractors—with different paths for small businesses, large entities, and grantees—and the end goal of the disclosure (e.g. software release, technology transfer, intellectual property protection, contract requirement, etc.).

Patent Strategy and Licensing

NASA's consolidated, coordinated marketing approach has matured over the course of several years, during which time (since 2011) patent licensing has increased by 293%. Fiscal year 2016 saw an increase in patent licensing of 29% over the previous year. Currently, there are about 450 active licenses for NASA-patented technologies, with roughly 100 new licenses being executed each year.

T2 continues to manage the patent filing process through policy statements, direction to individual centers, and routine budget and strategy meetings with agency patent counsel. Through this management, the centers are coordinated and strategic in their intellectual property management, filing only patents with known commercial potential and actively managing the portfolio to keep it relevant to industry.

NASA is still the only federal agency with a consolidated intellectual property portfolio marketing approach. Centered around a web portal, each center uses matching collateral and a routine publication schedule to promote technologies developed at that site. The entire portfolio is managed through a single, public-facing, fully searchable repository (http://technology.nasa.gov/patents) that is always up to date. Every one of the thousand-plus technologies in this database has a corresponding fact sheet in HTML and PDF formats containing a plain-language description of the technology, lists of its advantages and applications, and NASA contacts for further information.

T2's outreach strategy also includes a coordinated approach to industry conferences. In 2016 the program created a new exhibit and sent it to nine agency-level showcases.

There are also thousands of formerly patented technologies that NASA has gifted into the public domain—again, with a central, searchable database developed by T2 within the last few years (https://technology.nasa.gov/publicdomain). Anyone can pursue product development using these technologies for free, with no requirement to contact NASA. Of notable value among these patents are many space-based technologies (e.g., propulsion) that will help foster America's growing commercial space sector.

Software Release
Today more than ever people are using NASA software to solve their technical challenges. In 2016 software release—that is, acquisitions of software following a request and NASA approval—increased by 25%, part of an overall 145% increase since 2011.

A key element of NASA's software release success is the software catalog, which is updated annually. The release this year was amplified with a comprehensive media campaign and resulted in web traffic of over 7.5 million visitors to the T2 website in a 48-hour period and 167 news stories within the first week. As with the patent portfolio, the public can browse a central repository for NASA software (http://software.nasa.gov) that contains the agency's publicly released codes—all of which are available free of charge and can be downloaded from the site via an automated request system. This catalog, first released in 2014, was the first of its kind among all agencies of the federal government, which is the world's largest creator of custom code.

One new initiative in 2016 was the release of the internal-facing Software Release System, which provides the agency's software developers a dashboard to track their code as it moves through the approval process. This system streamlines and standardizes the review process for software across all ten field centers and increases efficiency by allowing for parallel processing of approvals, replacing a manual, serial process. The new system also improves our ability to track metrics, enabling program specialists to identify and correct problems in the release process to be identified and corrected in a timely manner.

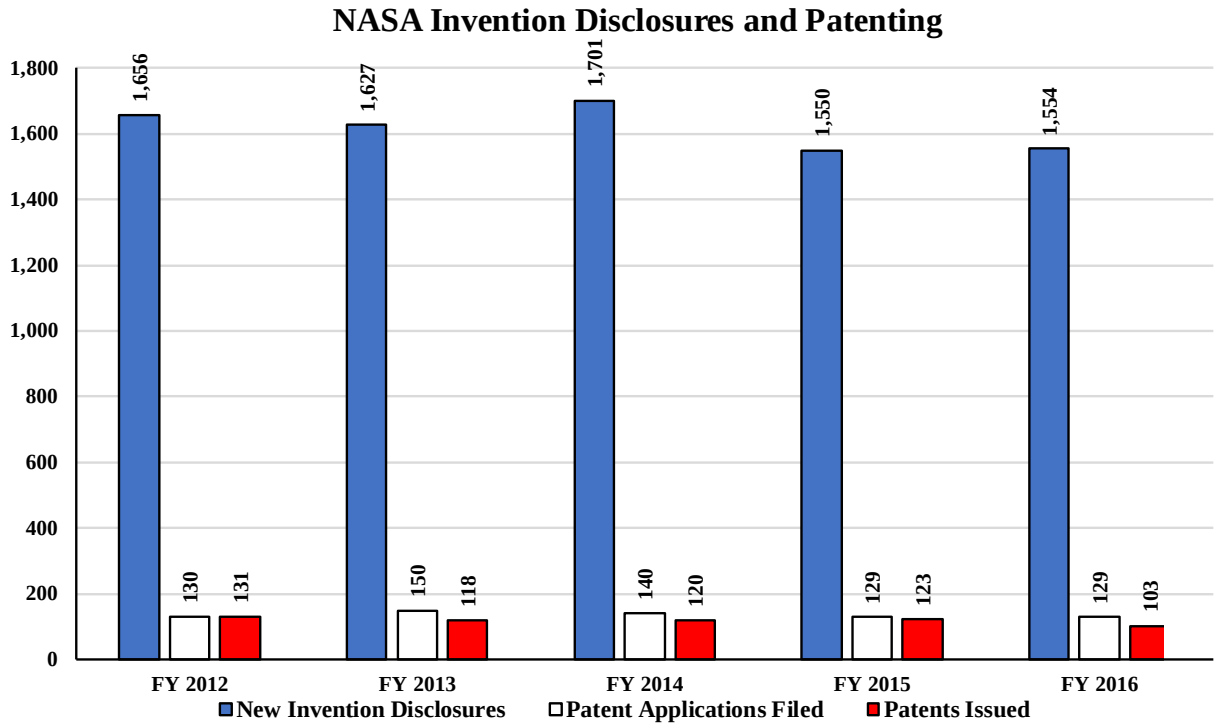
NASA's software release practices have become a model for other federal agencies, showing them how to capture, track, review, and release code to the public.

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

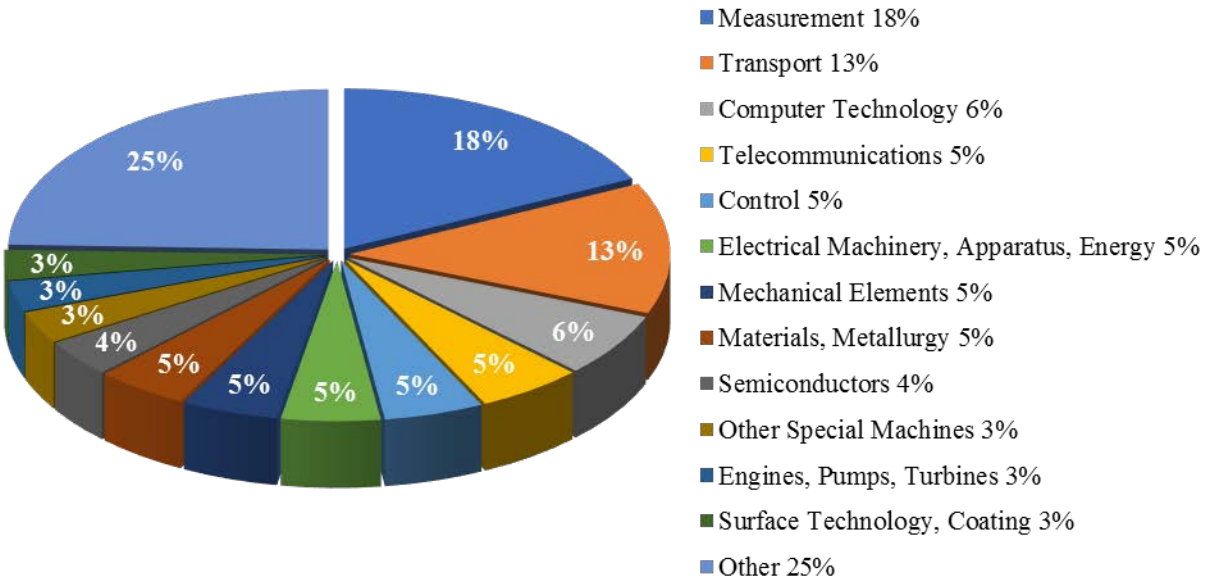
Between FY 2012 and FY 2016, the number of new inventions disclosed decreased by 6% from 1,656 in FY 2012 to 1,554 disclosures in FY 2016. The number of patent applications filed decreased by 1% to 129. The number of patents issued decreased by 21% to 103 patents in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Invention Disclosures	1,656	1,627	1,701	1,550	1,554
Patent Applications Filed	130	150	140	129	129
Patents Issued	131	118	120	123	103

Patents issued to NASA in FY 2016 covered many technology areas including Measurement (18%), Transport (13%), Computer Technology (6%), Telecommunications (5%), and Control (5%) Electrical Machinery, Apparatus, Energy (5%), Mechanical Elements (5%), and Materials, Metallurgy (5%).[35]

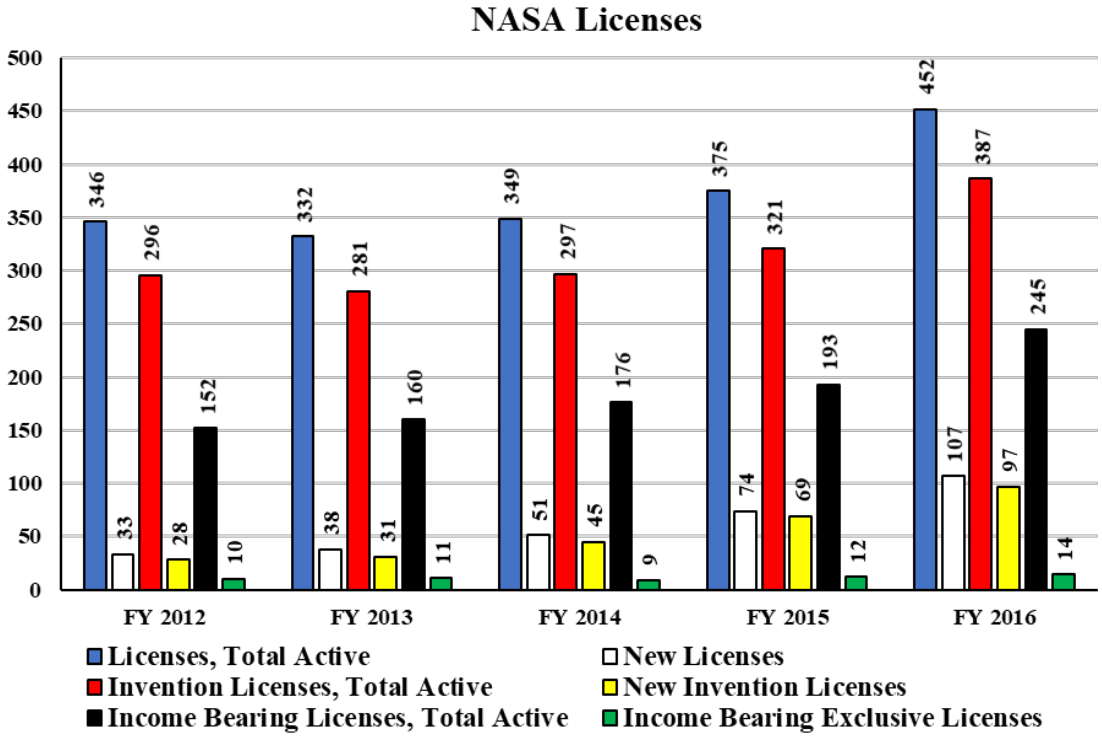
USPTO Patents Assigned to NASA by Technology Area: FY 2016



[35] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in April 2017. Used with permission.

NASA Licenses

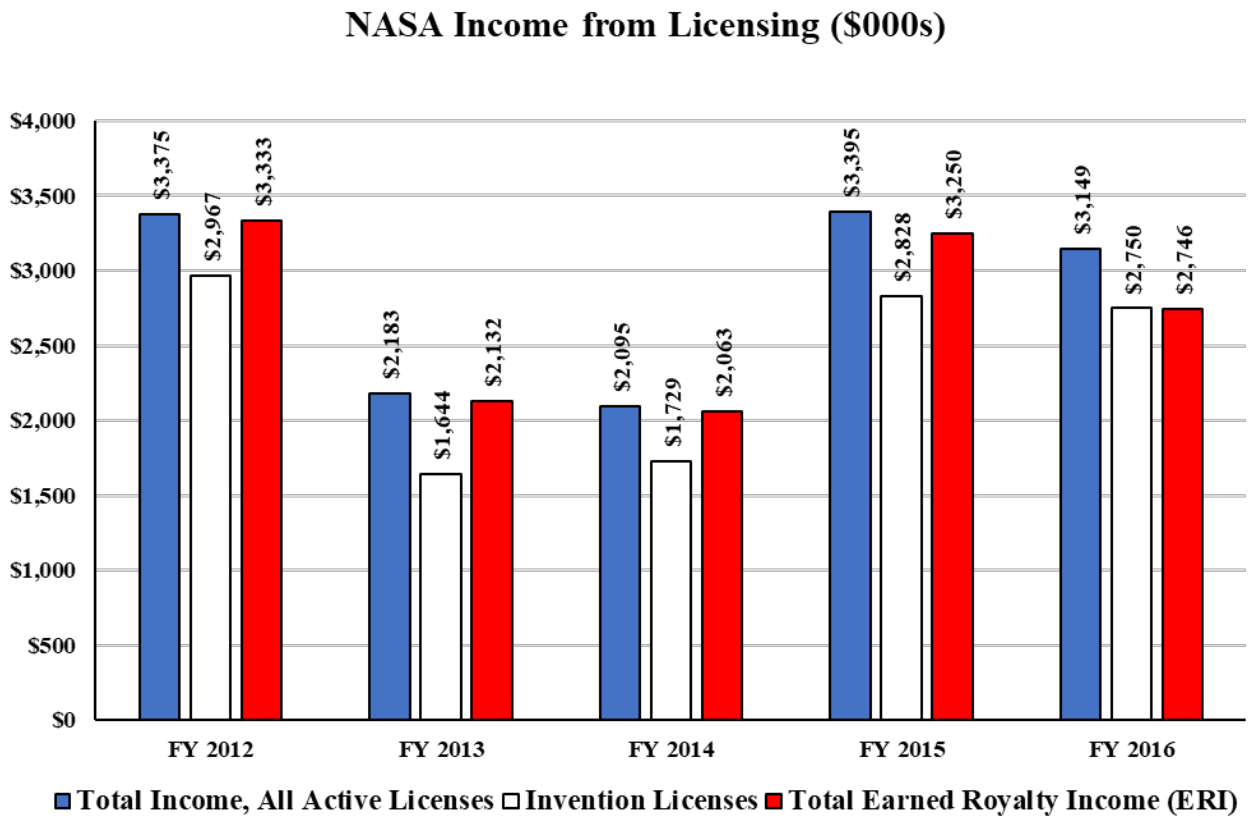
Between FY 2012 and FY 2016, NASA reported that the number of total active licenses increased by 31% from 346 in FY 2012 to 452 licenses in FY 2016 while new licenses increased by 224% to 107. The number of total active invention licenses increased by 31% to 387 while the number of new invention licenses increased by 246% to 97. Total active income-bearing licenses increased by 61% to 245 while the number of income-bearing exclusive licenses increased by 40%, from 10 to 14.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Licenses, Total Active	346	332	349	375	452
New Licenses	33	38	51	74	107
Invention Licenses, Total Active	296	281	297	321	387
New Invention Licenses	28	31	45	69	97
Income Bearing Licenses, Total Active	152	160	176	193	245
Income Bearing Exclusive Licenses	10	11	9	12	14

NASA Income from Licensing

Between FY 2012 and FY 2016, NASA reported that the total income from all active licenses decreased by 7% from $3.4 million in FY 2012 to $3.1 million in FY 2016. The income from invention licenses decreased by 7% to $2.8 million. Total earned royalty income decreased 18% from $3.3 million in FY 2012 to $2.7 million in FY 2016.

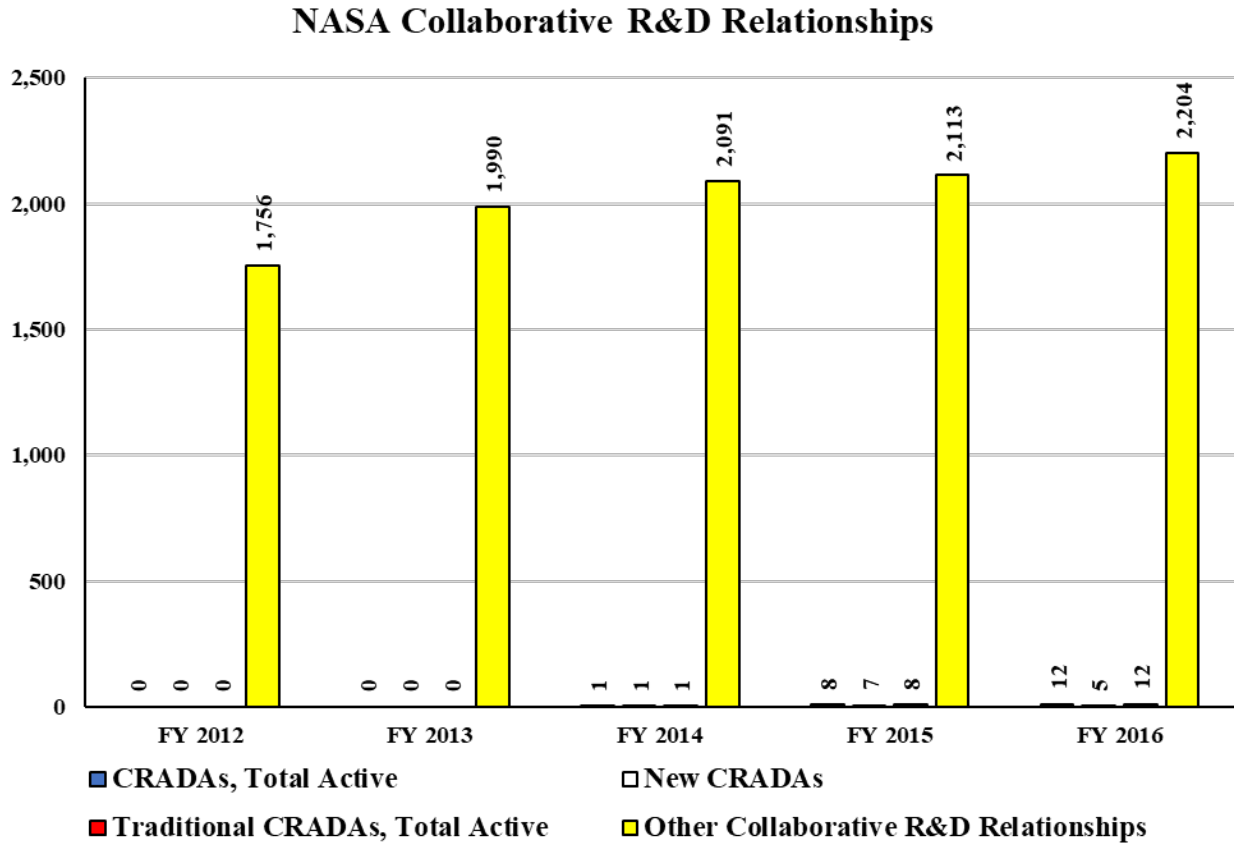


	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Total Income, All Active Licenses	$3,375	$2,183	$2,095	$3,395	$3,149
Invention Licenses	$2,967	$1,644	$1,729	$2,828	$2,750
Total Earned Royalty Income, (ERI)	$3,333	$2,132	$2,063	$3,250	$2,746

NASA Collaborative R&D Relationships

The National Aeronautics and Space Act 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 cooperative research and development agreements (CRADAs) and therefore in this report, Space Act Agreements are included under the category “Other Collaborative Agreements.”

In FY 2016, NASA reported 12 active traditional CRADAs. The number of Space Act Agreements increased 26% from 1,756 agreements in FY 2012 to 2,204 in FY 2016.



	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
CRADAs, Total Active	0	0	1	8	12
New CRADAs	0	0	1	7	5
Traditional CRADAs, Total Active	0	0	1	8	12
Other Collaborative R&D Relationships	1,756	1,990	2,091	2,113	2,204

Other Performance Measures Deemed Important by the Agency

Software Release

NASA reports the following software release data.

	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
New Software Usage Agreements Executed	1,316	1,368	1,685	2,107	2,646
Public Domain Release	29	56	218	303	550
US Release Only	787	665	699	930	1,111
Project Release	247	289	286	399	326
Interagency Release	99	110	146	167	122
NASA Release	104	166	181	174	389

NASA Downstream Success Stories

In 2016, NASA once again produced another issue of the agency's flagship publication, *Spinoff*. This year's book captured the stories of 50 companies from across 22 states. *Spinoff* content is refreshed regularly on the publication's website and routinely featured on NASA's homepage. Spinoff features are promoted to T2's 250,000 social media followers, which contributes to the routine readership of two to three million unique *Spinoff* website visitors per month.

Examples of successful technology transfer stories recently featured in *Spinoff* include:

CMOS Sensors Enable Phone Cameras, HD Video

In the 1990s, Jet Propulsion Laboratory (JPL) engineer Eric Fossum invented what would become NASA's most ubiquitous spinoff—digital image sensors based on complementary metal oxide semiconductors (CMOS). These were significantly smaller and more efficient than the charge-coupled-device imagers of the day and eventually enabled tiny, battery-friendly cell phone cameras, high-definition video cameras—such as those offered by San Mateo, California-based GoPro—and social media as we know it. By 2015, the CMOS market reached nearly $10 billion.

GPS Correction Technology Lets Tractors Drive Themselves

With a license for software created by JPL to stream corrected GPS data and a contract to receive data from JPL's global network of reference stations, Moline, Illinois-based John Deere released StarFire receivers that let tractors drive themselves, were affordable, did not require a local radio tower, and could be used all over the world. Automated guidance reduces the time and resources needed to care for fields and increases crop yield and quality.

Reconfigurable Radio Tracks Flights Worldwide

NASA was looking for a new high-bandwidth, software-reconfigurable radio. Through a 50/50 cost-share cooperative agreement, Glenn Research Center developed one with Harris Corporation, and the final product flew in the International Space Station's Space Communications and Navigation (SCaN) testbed and was honored with an R&D 100 Award. The Palm Bay, Florida-based company used what it built to create its AppSTAR radio, which soon will be tracking airplanes worldwide.

Rocket Technology Stops Shaking in Its Tracks
In testing, the Ares I launch vehicle displayed a serious vibration problem—shaking that resonated dangerously, causing potentially hazardous conditions in the crew capsule right above the booster. Engineers at Marshall Space Flight Center found a solution, creating a brand new, low-cost, lightweight damper that could become the industry standard for buildings, bridges, and many other structures that vibrate or shake. New York City-based Thornton Tomasetti markets the technology to make buildings safer against the wind and from earthquakes.

Orion Video Requirement Advances High-Speed, Compact Cameras
To film parachute deployment on the Orion spacecraft, Johnson Space Center required a high-speed, compact, rugged video camera. Integrated Design Tools (IDT) of Pasadena, California, which specializes in cameras for industrial and scientific markets, such as crash testing, was subcontracted. IDT developed a camera capable of filming up to 1,000 frames per second and backing that data up nearly as fast. All of IDT's "Os" series of cameras now include the high-speed, solid-state memory developed for Orion.

Rechargeable Hearing Aid Batteries Draw from NASA Research
In its early days, NASA spent much effort developing rechargeable silver-zinc batteries, as the pairing offers a higher power-to-weight ratio than any other battery couple. Significant advances in the batteries' durability were made at Glenn Research Center, which ZPower, LLC of Camarillo, California, used as part of its starting point, undertaking years of additional development before releasing its rechargeable hearing aid batteries, the first that can last all day on a single charge.

Laser Imaging Helps Archaeologists Dig Up History
Archaeologists are using tools developed for space missions, like remote scanning with lasers, or lidar, to help search for clues to long-ago history. One company making the scanners is Teledyne Optech, a Canadian company with offices in Henrietta, New York, which most recently designed a lidar instrument for the OSIRIS-REx asteroid return mission managed at Goddard Space Flight Center, and which has incorporated space mission innovations into their commercial offerings.

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 U.S. competitiveness in world markets. In recent years, agencies have engaged in efforts to increase the rate and efficacy of technology transfer activities and thereby improve the economic and societal impact from federal research and development (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 https://www.nist.gov/tpo/agency-technology-transfer-reports.

Statistical data provided in this report indicate that for all agencies covered by this report, between FY 2012 and FY 2016 there has been a 5% decrease in invention disclosures, a 1% increase in patent applications, and a 1% increase in patents issued. In FY 2016, the largest number of federal patents issued involved the technical areas of measurements (11%), biotechnology (8%), electrical machinery, apparatus, energy (7%), pharmaceuticals (7%), other special machines (6%), and computer technology (6%).

Between FY 2012 and FY 2016, total active licenses increased by 7%, new licenses increased by 7%, invention licenses increased by 7%, and new invention licenses increased by 14%. Income-bearing licenses increased by 13%, and exclusive income-bearing licenses increased by 21%.

Between FY 2012 and FY 2016, income from all licensing increased by 7%, income from invention licenses increased by 8%, and total earned royalty income decreased by 9%.

Between FY 2012 and FY 2016, the number of cooperative research and development agreements (CRADAs) increased by 40% while new CRADAs per fiscal year increased by 10%. Traditional CRADAs increased by 56% while other collaborative R&D relationships decreased by 5%.

In FY 2016, federal researchers published 58,609 papers. More than half of these papers were in the fields of biological sciences (26%), medical sciences (23%), and physics (11%). In FY 2016, 15,644 papers cited in U.S. patents were authored or coauthored by federal researchers. Of these papers, 79% involved research in the fields of biological sciences (43%), medical sciences (25%), and chemistry (11%).

Initial effort to determine the number of small businesses involved in federal CRADA agreements reveals that out of the 6,671 traditional, federal CRADA agreements from agencies that tracked small business participation, 19% involve small businesses as participants. Federal agencies also support small businesses through the licensing of technologies. Initial data reveal that of the 8,156 active, federal licenses from agencies that could identify company size, 10% were issued to small businesses.

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 six agencies identifies 100 companies that started between the years of 2012 and 2016 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, CRADAs, and Space Act Agreements, 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 Disclosures and Patenting

Agency	Metric	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
USDA	New Inventions Disclosed	160	191	117	222	244
	Patent Applications Filed	122	157	119	125	109
	Patents Issued	69	65	83	94	60
DOC	New Inventions Disclosed	60	41	47	61	64
	Patent Applications Filed	27	26	25	32	25
	Patents Issued	13	21	19	20	16
DOD	New Inventions Disclosed	1,078	1,032	963	781	874
	Patent Applications Filed	1,013	942	916	884	941
	Patents Issued	1,048	648	670	623	665
DOE	New Inventions Disclosed	1,661	1,796	1,588	1,645	1,760
	Patent Applications Filed	933	944	1,144	949	999
	Patents Issued	676	713	822	755	856
HHS	New Inventions Disclosed	352	320	351	321	320
	Patent Applications Filed	233	230	216	222	269
	Patents Issued	335	428	453	501	579
DHS	New Inventions Disclosed	40	20	36	15	17
	Patent Applications Filed	10	4	5	7	15
	Patents Issued	0	4	3	4	3
DOI	New Inventions Disclosed	10	9	6	7	8
	Patent Applications Filed	3	8	4	8	4
	Patents Issued	3	4	2	3	1
DOT	New Inventions Disclosed	2	13	3	0	0
	Patent Applications Filed	1	5	0	5	0
	Patents Issued	4	1	1	1	1
VA	New Inventions Disclosed	310	282	289	217	239
	Patent Applications Filed	94	106	116	116	104
	Patents Issued	29	31	37	54	54
EPA	New Inventions Disclosed	18	8	5	7	6
	Patent Applications Filed	10	7	9	4	1
	Patents Issued	17	16	5	7	3
NASA	New Inventions Disclosed	1,656	1,627	1,701	1,550	1,554
	Patent Applications Filed	130	150	140	129	129
	Patents Issued	131	118	120	123	103
All	New Inventions Disclosed	5,347	5,339	5,106	4,826	5,086
Federal	Patent Applications Filed	2,576	2,579	2,694	2,481	2,596
Agencies	Patents Issued	2,325	2,049	2,215	2,185	2,341

Federal Licenses

Agency	Metric	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
USDA	Licenses, Total Active	384	400	414	424	441
	New Licenses	34	25	30	35	33
	Invention Licenses, Total Active	341	351	363	359	370
	New Invention Licenses	28	19	28	20	27
	Income Bearing Licenses, Total Active	379	397	412	421	439
	Income Bearing Exclusive Licenses	277	291	299	292	307
DOC	Licenses, Total Active	41	38	38	46	57
	New Licenses	6	7	7	13	15
	Invention Licenses, Total Active	41	38	38	46	57
	New Invention Licenses	6	7	7	13	15
	Income Bearing Licenses, Total Active	23	26	26	31	33
	Income Bearing Exclusive Licenses	10	13	14	16	20
DOD	Licenses, Total Active	520	527	430	560	515
	New Licenses	44	59	24	11	127
	Invention Licenses, Total Active	432	425	297	446	358
	New Invention Licenses	44	59	6	69	57
	Income Bearing Licenses, Total Active	356	264	223	213	194
	Income Bearing Exclusive Licenses	120	na	na	na	218
DOE	Licenses, Total Active	5,328	5,217	5,861	6,310	5,410
	New Licenses	757	568	573	648	621
	Invention Licenses, Total Active	1,428	1,353	1,560	1,336	943
	New Invention Licenses	192	153	171	155	145
	Income Bearing Licenses, Total Active	3,340	3,709	4,215	4,577	3,963
	Income Bearing Exclusive Licenses	344	199	141	98	231
HHS	Licenses, Total Active	1,465	1,426	1,555	1,767	1,750
	New Licenses	231	184	212	279	278
	Invention Licenses, Total Active	1,090	1,069	1,186	1,354	1,721
	New Invention Licenses	192	152	117	232	221
	Income Bearing Licenses, Total Active	809	809	845	843	837
	Income Bearing Exclusive Licenses	24	25	24	11	23
DHS	Licenses, Total Active	0	0	2	4	5
	New Licenses	0	0	0	3	1
	Invention Licenses, Total Active	0	0	2	4	5
	New Invention Licenses	0	0	0	3	1
	Income Bearing Licenses, Total Active	0	0	1	4	1
	Income Bearing Exclusive Licenses	0	0	0	0	0
DOI	Licenses, Total Active	26	20	18	20	22
	New Licenses	1	3	0	3	0
	Invention Licenses, Total Active	24	20	16	18	20
	New Invention Licenses	1	3	0	3	0
	Income Bearing Licenses, Total Active	22	16	14	18	17
	Income Bearing Exclusive Licenses	12	4	5	7	8
DOT	Licenses, Total Active	2	3	1	2	2
	New Licenses	0	1	0	1	2
	Invention Licenses, Total Active	2	3	1	2	0
	New Invention Licenses	0	1	0	0	0
	Income Bearing Licenses, Total Active	2	3	1	2	2
	Income Bearing Exclusive Licenses	0	0	1	0	0

Federal Licenses (continued)

Agency	Metric	FY2012	FY2013	FY2014	FY2015	FY2016
VA	Licenses, Total Active	197	194	197	200	261
	New Licenses	8	9	3	3	1
	Invention Licenses, Total Active	197	194	197	200	260
	New Invention Licenses	8	9	3	3	1
	Income Bearing Licenses, Total Active	9	13	14	16	42
	Income Bearing Exclusive Licenses	9	10	9	11	35
EPA	Licenses, Total Active	42	40	40	37	35
	New Licenses	2	2	6	0	8
	Invention Licenses, Total Active	42	40	40	37	35
	New Invention Licenses	2	2	6	0	8
	Income Bearing Licenses, Total Active	39	35	33	31	31
	Income Bearing Exclusive Licenses	10	9	8	7	7
NASA	Licenses, Total Active	346	332	349	375	452
	New Licenses	33	38	51	74	107
	Invention Licenses, Total Active	296	281	297	321	387
	New Invention Licenses	28	31	45	69	97
	Income Bearing Licenses, Total Active	152	160	176	193	245
	Income Bearing Exclusive Licenses	10	11	9	12	14
All Federal Agencies	Licenses, Total Active	8,351	8,197	8,905	9,745	8,950
	New Licenses	1,116	896	906	1,070	1,193
	Invention Licenses, Total Active	3,893	3,774	3,997	4,123	4,156
	New Invention Licenses	501	436	383	567	572
	Income Bearing Licenses, Total Active	5,131	5,432	5,960	6,349	5,804
	Income Bearing Exclusive Licenses	816	562	510	454	863

Federal Income from Licensing ($000s)

Agency	Metric	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
USDA	Total Income, All Active Licenses	$3,806	$4,386	$4,928	$5,067	$4,784
	Invention Licenses	$3,671	$4,054	$4,733	$4,842	$4,456
	Total Earned Royalty Income, (ERI)	$3,060	$3,354	$3,611	$3,510	$3,633
DOC	Total Income, All Active Licenses	$248	$151	$220	$164	$149
	Invention Licenses	$248	$151	$220	$164	$149
	Total Earned Royalty Income, (ERI)	$248	$151	$220	$164	$149
DOD	Total Income, All Active Licenses	$7,055	$21,575	$11,703	$9,448	$6,205
	Invention Licenses	$6,552	$20,859	$10,890	$8,482	$5,199
	Total Earned Royalty Income, (ERI)	$6,335	$20,438	$7,845	$6,099	$6,205
DOE	Total Income, All Active Licenses	$40,849	$39,573	$37,885	$33,137	$31,149
	Invention Licenses	$36,103	$36,068	$32,869	$28,966	$27,364
	Total Earned Royalty Income, (ERI)	$28,735	$27,669	$23,384	$21,245	$16,273
HHS	Total Income, All Active Licenses	$110,576	$116,448	$137,249	$151,727	$132,833
	Invention Licenses	$108,308	$103,664	$133,814	$147,512	$130,701
	Total Earned Royalty Income, (ERI)	$110,930	$116,601	$116,765	$114,102	$110,193
DHS	Total Income, All Active Licenses	$0	$0	$3	$5	$12
	Invention Licenses	$0	$0	$0	$0	$12
	Total Earned Royalty Income, (ERI)	$0	$0	$3	$5	$12
DOI	Total Income, All Active Licenses	$76	$96	$58	$106	$83
	Invention Licenses	$76	$96	$58	$106	$83
	Total Earned Royalty Income, (ERI)	$65	$96	$58	$106	$82
DOT	Total Income, All Active Licenses	$7	$9	$23	$12	$15
	Invention Licenses	$0	$0	$0	$0	$0
	Total Earned Royalty Income, (ERI)	$7	$9	$23	$12	$15
VA	Total Income, All Active Licenses	$391	$389	$336	$494	$316
	Invention Licenses	$391	$389	$336	$494	$316
	Total Earned Royalty Income, (ERI)	$391	$389	$336	$494	$316
EPA	Total Income, All Active Licenses	$727	$193	$439	$232	$466
	Invention Licenses	$727	$193	$439	$232	$466
	Total Earned Royalty Income, (ERI)	$201	$193	$439	$232	$466
NASA	Total Income, All Active Licenses	$3,375	$2,183	$2,095	$3,395	$3,149
	Invention Licenses	$2,967	$1,644	$1,729	$2,828	$2,750
	Total Earned Royalty Income, (ERI)	$3,333	$2,132	$2,063	$3,250	$2,746
All Federal Agencies	Total Income, All Active Licenses	$167,110	$185,003	$194,939	$203,787	$179,161
	Invention Licenses	$159,043	$167,118	$185,088	$193,626	$171,496
	Total Earned Royalty Income, (ERI)	$153,305	$171,032	$154,747	$149,219	$140,090

Federal Collaborative R&D Relationships

Agency	Metric	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
USDA	CRADAs, Total Active	274	259	267	301	238
	New CRADAs	65	86	60	80	79
	Traditional CRADAs, Total Active	211	211	193	188	161
	Other Collaborative R&D Relationships	14,691	16,199	16,144	14,206	11,854
DOC	CRADAs, Total Active	2,410	2,428	2,359	2,751	2,940
	New CRADAs	2,323	2,289	2,111	2,548	2,607
	Traditional CRADAs, Total Active	154	206	233	365	335
	Other Collaborative R&D Relationships	2,782	2,963	2,981	3,125	3,273
DOD	CRADAs, Total Active	2,400	2,682	2,762	2,148	3,125
	New CRADAs	757	769	671	793	1,061
	Traditional CRADAs, Total Active	1,328	2,682	2,281	1,601	2,297
	Other Collaborative R&D Relationships	0	606	581	1,389	452
DOE	CRADAs, Total Active	742	742	698	732	739
	New CRADAs	184	142	162	188	246
	Traditional CRADAs, Total Active	742	742	698	732	739
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	377	427	532	400	590
	New CRADAs	93	104	98	112	134
	Traditional CRADAs, Total Active	245	313	378	202	391
	Other Collaborative R&D Relationships	0	114	154	150	147
DHS	CRADAs, Total Active	94	114	158	230	343
	New CRADAs	53	76	88	98	114
	Traditional CRADAs, Total Active	89	91	121	200	272
	Other Collaborative R&D Relationships	11	6	31	30	71
DOI	CRADAs, Total Active	379	476	601	825	873
	New CRADAs	284	376	423	586	511
	Traditional CRADAs, Total Active	28	21	35	38	37
	Other Collaborative R&D Relationships	283	322	292	318	319
DOT	CRADAs, Total Active	29	40	51	48	68
	New CRADAs	12	8	10	9	22
	Traditional CRADAs, Total Active	3	3	7	48	62
	Other Collaborative R&D Relationships	14	26	30	35	152
VA	CRADAs, Total Active	1,510	2,181	2,317	2,305	2,613
	New CRADAs	542	453	517	509	502
	Traditional CRADAs, Total Active	1,430	1,982	2,126	2,113	2,359
	Other Collaborative R&D Relationships	0	0	0	0	0
EPA	CRADAs, Total Active	92	112	129	97	103
	New CRADAs	22	51	35	23	44
	Traditional CRADAs, Total Active	63	55	52	50	55
	Other Collaborative R&D Relationships	0	0	0	0	0
NASA	CRADAs, Total Active	0	0	1	8	12
	New CRADAs	0	0	1	7	5
	Traditional CRADAs, Total Active	0	0	1	8	12
	Other Collaborative R&D Relationships	1,756	1,990	2,091	2,113	2,204
All Federal Agencies	CRADAs, Total Active	8,307	9,461	9,875	9,845	11,644
	New CRADAs	4,335	4,354	4,176	4,953	5,325
	Traditional CRADAs, Total Active	4,293	6,306	6,125	5,545	6,720
	Other Collaborative R&D Relationships	19,537	22,226	22,304	21,366	18,472

Appendix B

Technology Area Classifications

Mapping of International Patent Classifications to Technology Area[36]

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.

[36] 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 affected 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.

Measurement – 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[37]

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

[37] Sources: SRI International; Science-Metrix; 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 2016, Appendix Table 5-24. Used with permission.

Psychology: clinical psychology, behavioral and comparative psychology, developmental and child psychology, experimental psychology, human factors, social psychology, general psychology, miscellaneous psychology, psychoanalysis

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, miscellaneous social sciences, science studies, gerontology and aging, social studies of medicine