Federal Laboratory Technology Transfer

Fiscal Year 2017

Summary Report to the President and the Congress

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

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FOREWORD

The Department of Commerce (DOC) is pleased to submit this Fiscal Year 2017 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.

This report fulfills the requirement contained in 15 U.S.C. § 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. James K. Olthoff
Associate Director for Laboratory Programs performing the non-exclusive functions and duties of the Under Secretary of Commerce for Standards and Technology & Director, National Institute of Standards and Technology

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Table of Contents

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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 eight years, agencies have responded to the need to improve technology transfer operations to better address the needs of businesses and especially small businesses that are vulnerable to a slow-moving bureaucratic system. The inter-agency coordination of efforts has led agencies to review their operations and propose new ways to improve 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.

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

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[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.

[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.

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

Each of these agencies has established programs for promoting the transfer and commercialization of technologies developed in its R&D laboratories and has provided the data contained in this report. The DOC's National Institute of Standards and Technology (NIST) prepared and organized this report. An electronic version of this report is available.

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 2017, the total federal budget for R&D was $118,366 million. Of this, $75,958 million (64%) 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, $42,408 million (36%), supported R&D activities that occurred inside federal laboratories. This includes $30,803 million to support intramural activities and $11,606 million to support federally funded R&D centers (FFRDCs). 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.

Federal Obligations for R&D
By Agency FY 2017 ($ million)[4]

	Total R&D	Intramural[(a)]	FFRDCs[(b)]	Intramural and FFRDCs	Percent of Total R&D Budget
All Agencies	$118,366	$30,803	$11,606	$42,408	36%
DoD	$44,873	$15,520	$1,487	$17,007	38%
DOE	$11,705	$1,033	$7,133	$8,167	70%
HHS	$33,770	$7,078	$721	$7,799	23%
NASA	$12,595	$1,785	$1,789	$3,574	28%
USDA	$2,419	$1,529	$0	$1,529	63%
DOC	$1,613	$1,174	$34	$1,208	75%
DOI	$863	$765	$0	$765	89%
VA	$682	$682	$0	$682	100%
DHS	$857	$370	$106	$477	56%
DOT	$949	$212	$84	$296	31%
EPA	$494	$263	$0	$263	53%
Other Agencies	$7,550	$391	$251	$642	9%

(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 2017, DoD spent the largest amount of funding for intramural activities and FFRDCs, $17,007 million (38% of its R&D budget). DOE was second with $8,167 million (70% of its R&D budget) and HHS was third with $7,799 million (23% of its R&D budget).

[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] National Science Foundation (NSF), National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development Fiscal Years 2017-18, Federal Obligations for Research and Development, by Agency and Performer: FY 2017, Table 7.

Federal Technology Transfer Summary

Every federal agency that operates or directs one or more federal laboratories or that conducts research and development is required to prepare and submit an annual report of its technology transfer activities as described in 15 U.S.C. § 3710(f). These reports contain details on each agency's technology transfer program as well as agency plans to use technology transfer to advance the agency's mission and to promote U.S. competitiveness.[5] The following tables summarize federal technology transfer activities for the five-year period from FY 2013 through FY 2017.[6]

[5] A list of agency technology transfer reports

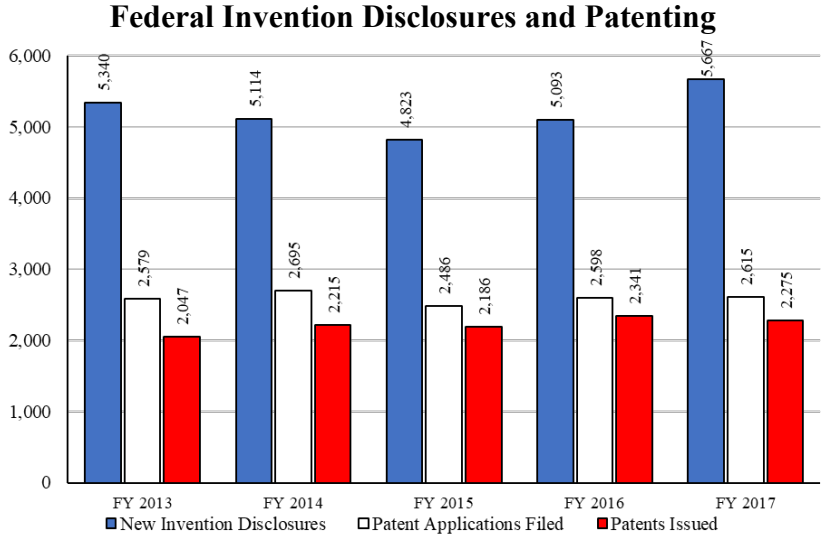
[6] Technology transfer data are routinely adjusted over time to account for new information resulting from changes in reporting procedures, patent decisions, programmatic changes, and other corrections. Throughout this report, data prior to FY 2017 have been adjusted where necessary, to reflect the most accurate estimates for each year reported.

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 2013 and FY 2017, invention disclosures reported by federal agencies increased by 6% to 5,667. Patent applications filed increased by 1% to 2,615, and patents issued increased by 11% to 2,275. DOE reported the largest number of invention disclosures with 1,794 in FY 2017, followed by NASA with 1,690 and DoD with 978. These three agencies accounted for 79% of all invention disclosures reported in this fiscal year.

In FY 2017, DOE reported the largest number of patent applications with 937 and patents issued with 817. DoD was second in both categories with 869 patent applications and 630 patents issued. HHS was third with 289 patent applications and 554 patents issued. These three agencies accounted for 80% of patent applications and 88% of patents issued.

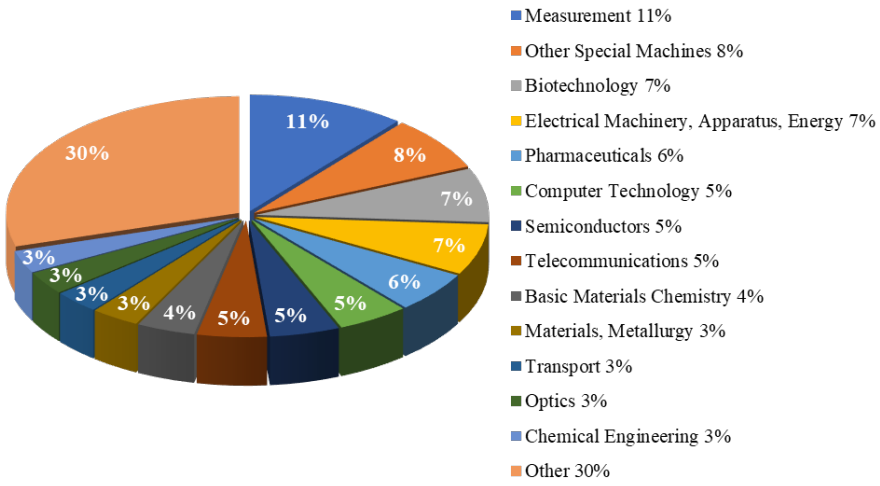


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	5,340	5,114	4,823	5,093	5,667
Patent Applications Filed	2,579	2,695	2,486	2,598	2,615
Patents Issued	2,047	2,215	2,186	2,341	2,275

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 2017. The chart shows the percentage of patents issued to federal agencies by technology area based on a fractional count of patents.[7] In FY 2017, the largest number of federal patents issued involved Measurement (11%) followed by Other Special Machines (8%), Biotechnology (7%), Electrical Machinery, Apparatus, Energy (7%), and Pharmaceuticals (6%), Computer Technology (5%), Semiconductors (5%), Telecommunications (5%), Basic Materials Chemistry (4%), Materials, Metallurgy (3%), Transport (3%), Optics (3%), Chemical Engineering (3%). All other technology area (30%).[8]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2017



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 would not be further developed into commercial products or services otherwise. The terms and conditions under which federal intellectual property is licensed varies based upon many factors, including the extent of development of the technology, the financial resources needed to further develop the technology for consumer use, fields of use, projected market impact, and other factors.

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[7] In this summary, patents are credited on a fractional-count basis (i.e., for patents with assignees from multiple federal agencies, other U.S. institutions, or foreign institutions, each federal agency receives fractional credit based on the proportion of its participating institution(s)). Furthermore, fractioning is used at the level of Internal Patent Classification (IPC) codes to ensure that the sum of patents across technology areas (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 October 2018. Used with permission.

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

Between FY 2013 and FY 2017, total active licenses reported by federal laboratories decreased by 6% from 8,197 in FY 2013 to 7,739 in FY 2017. New licenses increased by 39% from 896 in FY 2013 to 1,247 in FY 2017. Invention licenses increased by 5% to 3,972 while new invention licenses increased by 37% to 597. Invention licenses refers to inventions that are patented or could be patented. Income-bearing licenses decreased by 5% to 5,181, and exclusive income-bearing licenses increased by 36% to 900.

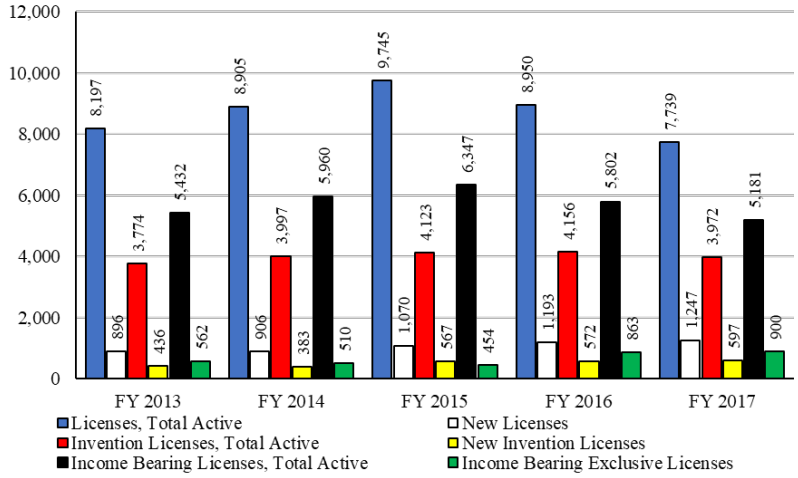
In FY 2017, DOE reported the largest number of total active licenses with 4,045 licenses. HHS was second with 1,806 licenses and DoD was third with 522 licenses. These three agencies accounted for 82% of all licenses reported in FY 2017.

In FY 2017, HHS reported the largest number of invention licenses with 1,354, followed by DOE with 916 and DoD with 514. Together these three agencies accounted for 70% of invention licenses in FY 2017.

In FY 2017, DOE reported the largest number of income-bearing licenses, 3,057, which was significantly higher than all other agencies combined. HHS was second with 907 followed by USDA with 437. Together these three agencies accounted for 85% of income-bearing licenses in FY 2017.

In FY 2017, USDA reported the largest number of income-bearing exclusive licenses with 302, followed by DoD with 196, and DOE with 190. Together these three agencies accounted for 76% of income-bearing exclusive licenses in FY 2017.

Federal Licenses



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	8,197	8,905	9,745	8,950	7,739
New Licenses	896	906	1,070	1,193	1,247
Invention Licenses, Total Active	3,774	3,997	4,123	4,156	3,972
New Invention Licenses	436	383	567	572	597
Income Bearing Licenses, Total Active	5,432	5,960	6,347	5,802	5,181
Income Bearing Exclusive Licenses	562	510	454	863	900

Federal Income from Licenses

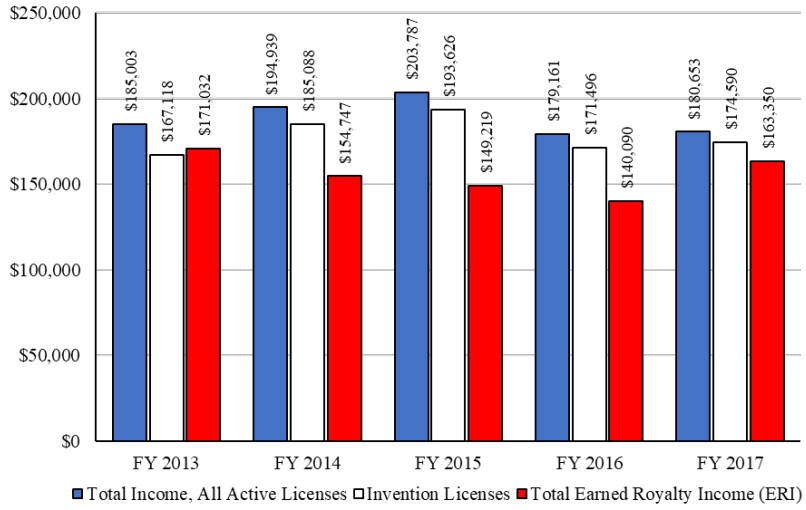
Licensing income includes income received for earned royalties from partners, license issue fees, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee, including patent costs. Between FY 2013 and FY 2017, income from all licensing decreased by 2% to $181 million. Income from invention licenses increased by 4% to $175 million and total earned royalty income decreased by 4% to $163 million.

HHS accounted for the most licensing income with $135 million, followed by DOE with $37 million, and USDA with $6 million. Together these three agencies accounted for 98% of reported licensing income.

HHS accounted for the most invention license income with $133 million, followed by DOE with $33 million, and USDA with $5 million. Together these three agencies accounted for 98% of Invention License Income.

HHS accounted for the most Earned Royalty Income with $136 million, followed by DOE with $13 million, and DoD with $7 million. Together these three agencies accounted for 96% of Earned Royalty Income.

Federal Income from Licensing ($000s)



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$185,003	$194,939	$203,787	$179,161	$180,653
Invention Licenses	$167,118	$185,088	$193,626	$171,496	$174,590
Total Earned Royalty Income, (ERI)	$171,032	$154,747	$149,219	$140,090	$163,350

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.

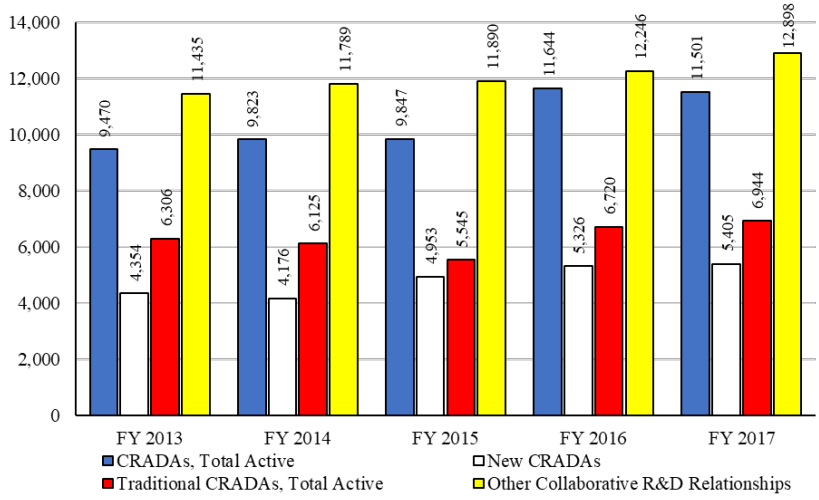
One frequently used mechanism for establishing joint research relationships is the cooperative research and development agreement (CRADA). The CRADA is a multifaceted mechanism that can be used to address several kinds of partnership needs. A "traditional CRADAs" refers to formal collaborative R&D agreements 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 2013 and FY 2017, active CRADAs increased by 21% to 11,501. New CRADA agreements increased by 24% to 5,405. Other collaborative R&D relationships increased by 13% to 12,898.

In FY 2017, DoD reported the largest number of CRADAs with 3,511, followed by DOC with 2,932 and VA with 1,785. USDA reported the largest number of other collaborative R&D relationships with 6,125, DOC was second with 3,181, and NASA was third with 2,174 (Space Act Agreements).

Federal Collaborative R&D Relationships



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	9,470	9,823	9,847	11,644	11,501
New CRADAs	4,354	4,176	4,953	5,326	5,405
Traditional CRADAs, Total Active	6,306	6,125	5,545	6,720	6,944
Other Collaborative R&D Relationships	11,435	11,789	11,890	12,246	12,898

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 gain 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 2013. 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 2014, we divide patents issued in FY 2014 by patents issued in the base year (FY 2013) and then multiply by 100. Using data from the table on page five of this report, the index value for patents issued in FY 2014 is 108.

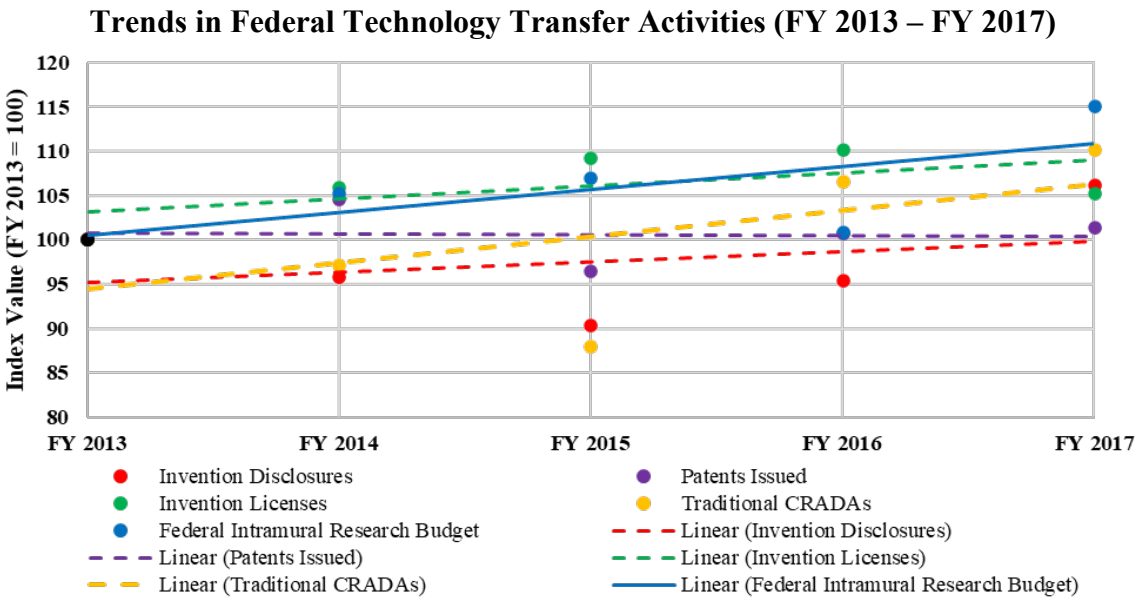
$$Index\ Value_{FY2014} = \frac{2{,}215}{2{,}047}\ x\ 100 = 108$$

Because the index value of 108 is greater than 100, we can interpret this as an 8% increase in patents issued between FY 2013 and FY 2014. In FY 2015, the index value for patents issued is 107 which we can interpret as a 7% increase between FY 2013 and FY 2015.

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 2013.

To show the trend for a given metric, a straight line is positioned in the middle of the plotted values for that metric.[9] 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.

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



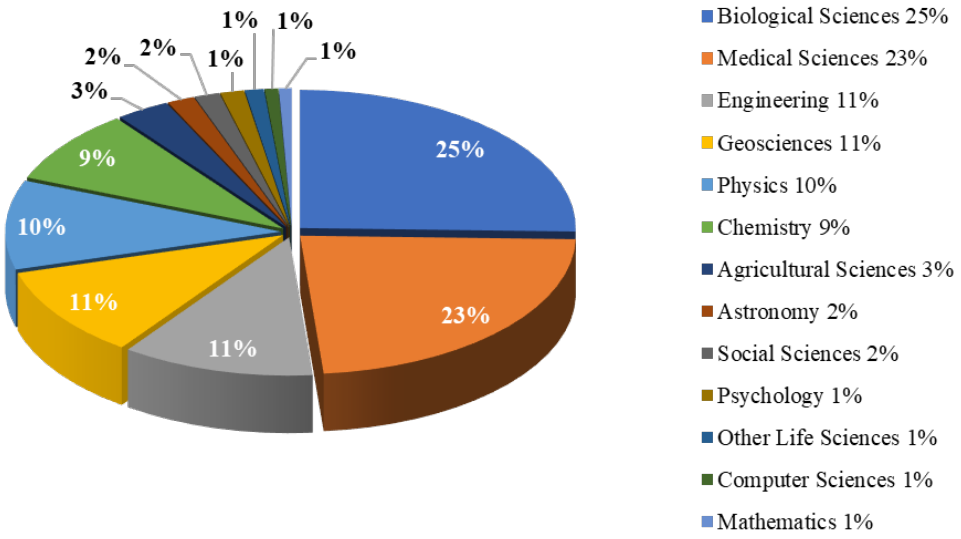
While we continue to see year-to-year variations in various technology transfer metrics (attributable to a number of different circumstances), the trend line plotted for invention disclosures, invention licenses, patents issued, and traditional CRADAs have all increased over a 5-year period despite a slight downward trend in the Federal Intramural Research Budget. This indicates a growing positive trend in federal technology transfer activities over the past five years.

Science and Engineering (S&E) Articles

Although intellectual property has traditionally been tracked in terms 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 2017, Thomson Reuters reports that federal researchers authored or coauthored 56,760 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).[10] By using additional data provided by agencies in their annual reports on technology transfer activities that considers publications not included in the Thomson Reuters' databases, the number of publications increases to 60,063.

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 (25%), Medical Sciences (23%), Engineering (11%), Geosciences (11%), and Physics (10%).[11]

S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: CY 2017



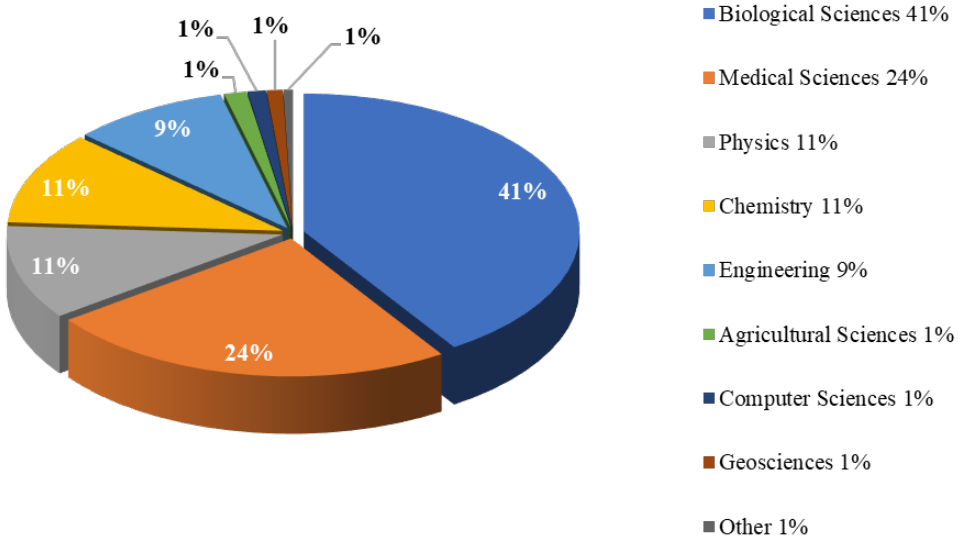
[10] Data prepared by Science-Metrix. Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) classified under Caspar fields using the CHI classification. Articles are classified by the year they entered the database, rather than 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.

[11] 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 October 2018. All rights reserved. Used with permission.

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 2017, more than 18,053 articles authored or coauthored by federal researchers were cited in U.S. patents.[12] Of these, the greatest number of articles addressed research in Biological Sciences (41%), Medical Sciences (24%), Physics (11%), Chemistry (11%), and Engineering (9%).[13]

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2017



[12] 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.

[13] 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 October 2018 and PatentsView accessed in October 2018. 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 nine agencies. This data reveals that out of 6,403 traditional CRADA agreements with these agencies, 1,469 (23%) involve small businesses as participants in FY 2017.

Agency	Number of Active CRADAs Involving Small Businesses FY 2017
DHS	75
DOC	116
DoD	491
DOE	392
DOT	12
EPA	30
HHS	200
USDA	68
VA	85
Total	1,469

Licenses Granted to Small Businesses

In addition to CRADAs, agencies support small businesses through the licensing of technologies. Again, owing to various administrative issues, data from only six agencies are available at the time of this report. This data reveals that out of 6,657 active licenses granted by these agencies in FY 2017, 683 (10%) were issued to small businesses.

Agency	Number of Active Licenses Granted to Small Businesses FY 2017
DOC	19
DOE	227
EPA	2
HHS	195
USDA	155
VA	85
Total	683

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 fewer 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 six agencies identifies 132 companies that started between the years of 2013 and 2017 and have received critical technical support from federal laboratories.

Agency	Number of Startups Supported in FY 2017
DOC	1
EPA	18
HHS	13
USDA	6
VA	85
NASA	9
Total	132

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™)[14] 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.

DoD
The I-Corps DoD program is a partnership with the National Science Foundation to provide DoD-funded researchers with training from experienced entrepreneurs in how to commercialize their innovations. DoD's Basic Research Office (BRO)is also looking to establish bridges that will allow teams who have completed the training to more seamlessly mature innovations into products that may enter DoD programs of record.

NIH
The I-Corps at the National Institutes of Health (NIH) program is focused on educating researchers and technologists on how to translate technologies from the lab into the marketplace. The program provides three-member project teams with access to instruction and mentoring in order to accelerate the translation of technologies currently being developed with NIH and CDC Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding. It is anticipated that outcomes for the I-Corps teams participating in this program will include significantly refined commercialization plans and well-informed pivots in their overall commercialization strategies. Under this program, NIH and 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.

DOE
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,

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

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.

Chapter 2
Agency Performance in FY 2017

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.

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 2017) and several prior years (FY 2013-2017);
- 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.

Department of Agriculture (USDA)

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

Private sector involvement in technology transfer adds the benefits of creating new or expanded businesses, jobs, and economic prosperity. Science-based innovations from USDA intramural research – often developed through public-private partnerships (PPPs) – create new or improved technologies, processes, products, and services that benefit the Nation by increasing productivity, increasing efficiency (keeping costs low), and enhancing global competitiveness for the U.S. agriculture sector. Thus, technology transfer functions are critical to accelerating 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.

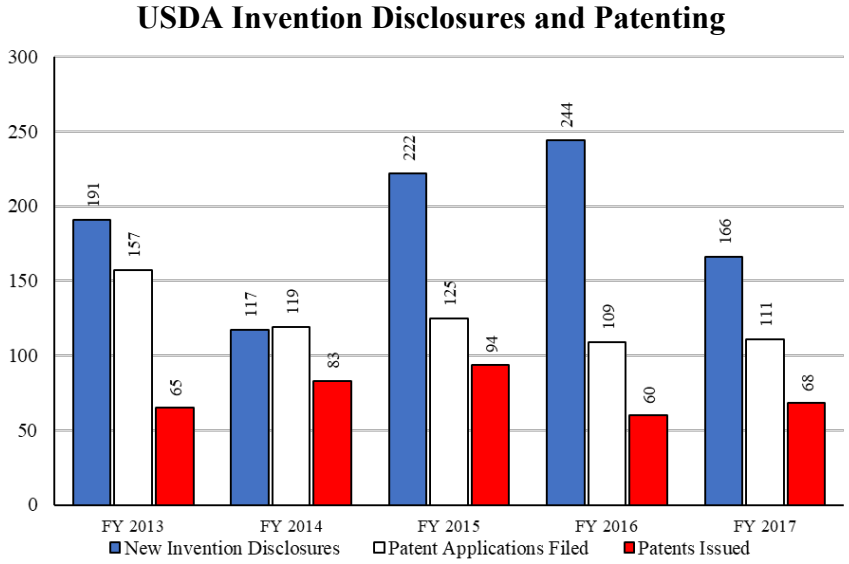
USDA's annual technology transfer report is available online.

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

Agricultural Research Service (ARS)
Animal and Plant Health Inspection Service (APHIS)
Forest Service (FS)

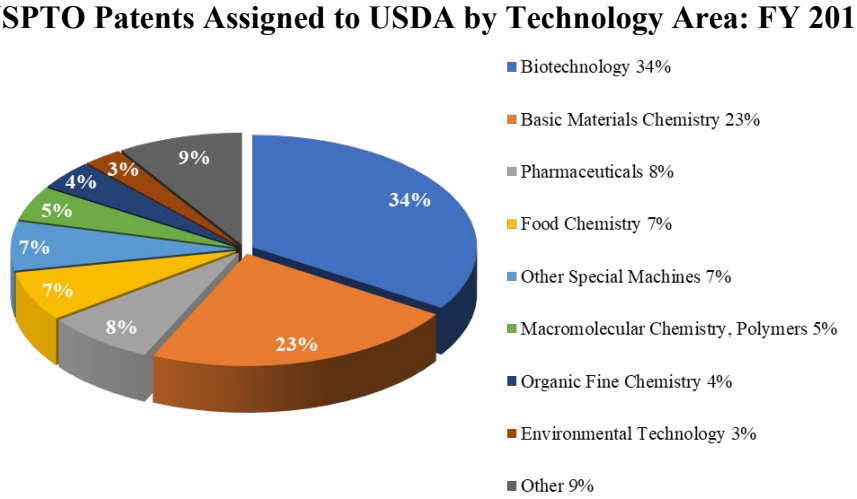
USDA Invention Disclosures and Patenting

Between FY 2013 and FY 2017, invention disclosures received decreased by 13%, from 191 to 166. Patent applications filed decreased 29%. Patents issued increased by 5% from 65 to 68 in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	191	117	222	244	166
Patent Applications Filed	157	119	125	109	111
Patents Issued	65	83	94	60	68

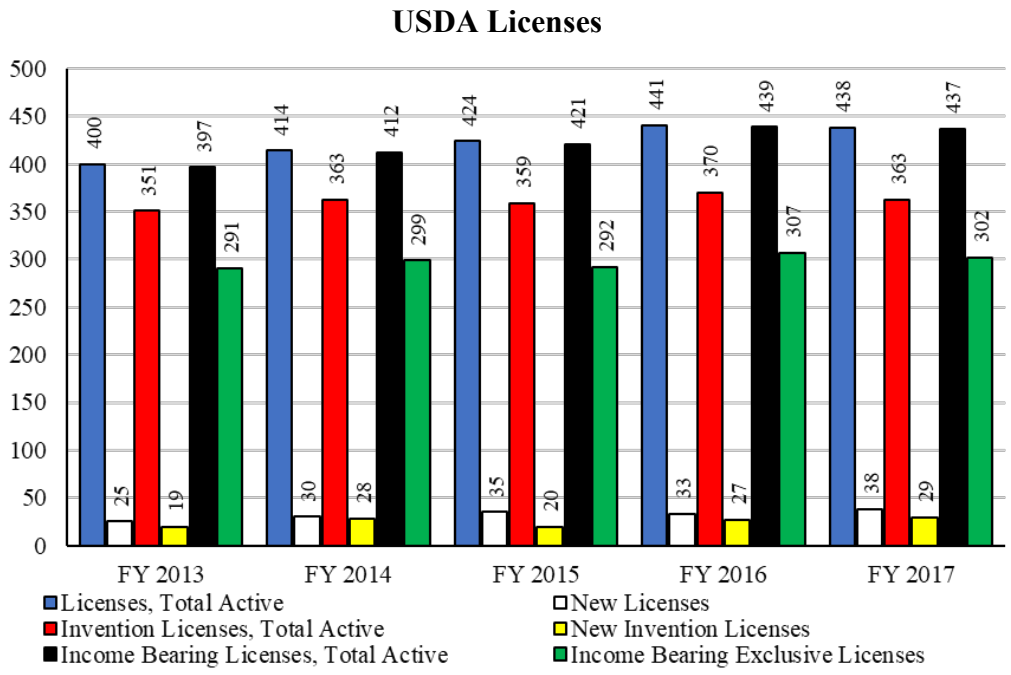
Patents issued to USDA in FY 2017 covered many technology areas including Biotechnology (34%), Basic Materials Chemistry (23%), Pharmaceuticals (8%), and Food Chemistry (7).[15]



[15] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

USDA Licenses

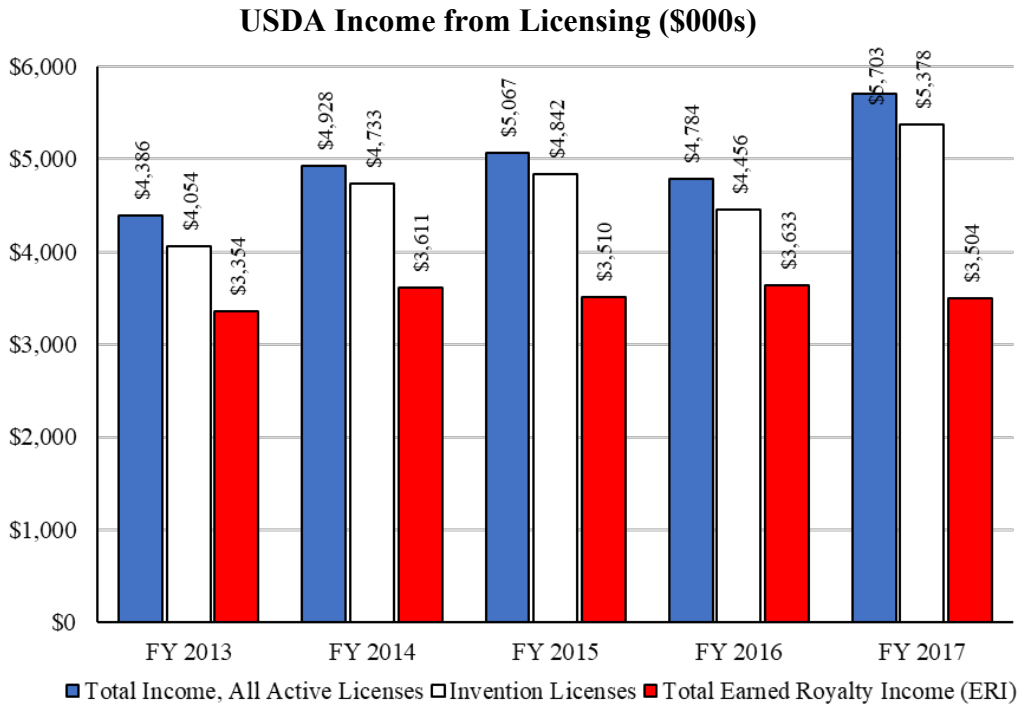
Between FY 2013 and FY 2017, total active licenses increased by 10% to 438 licenses in FY 2017. Total active invention licenses increased by 3% to 363 licenses. Total active income bearing licenses increased 10%, from 397 in FY 2013 to 437 in FY 2017, while income-bearing exclusive licenses increased by 4% to 302.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	400	414	424	441	438
New Licenses	25	30	35	33	38
Invention Licenses, Total Active	351	363	359	370	363
New Invention Licenses	19	28	20	27	29
Income Bearing Licenses, Total Active	397	412	421	439	437
Income Bearing Exclusive Licenses	291	299	292	307	302

USDA Income from Licensing

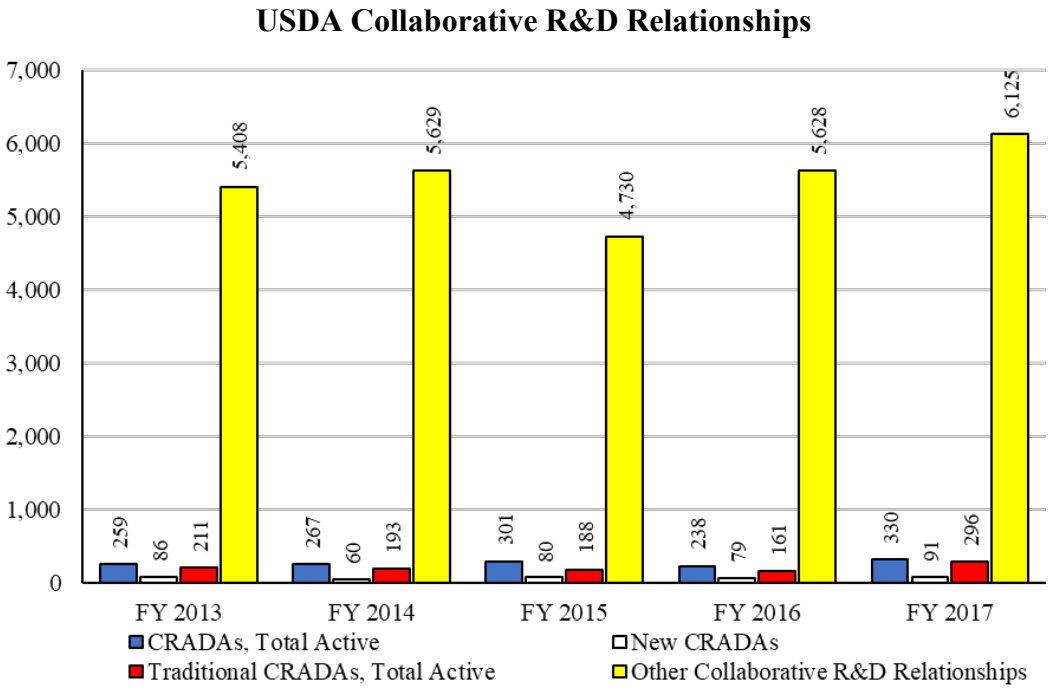
Between FY 2013 and FY 2017, total income from all active licenses increased by 30% to $5.7 million in FY 2017. The income from invention licenses increased by 33% to $5.4 million. Total earned royalty income increased 4% from $3.4 million in FY 2013 to $3.5 million in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$4,386	$4,928	$5,067	$4,784	$5,703
Invention Licenses	$4,054	$4,733	$4,842	$4,456	$5,378
Total Earned Royalty Income, (ERI)	$3,354	$3,611	$3,510	$3,633	$3,504

USDA Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 27% to 330 agreements while new CRADAs increased by 6% to 91. Traditional CRADAs increased by 40% to 296. Other collaborative R&D relationships increased by 13% to 6,125 in FY 2017.[16]



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	259	267	301	238	330
New CRADAs	86	60	80	79	91
Traditional CRADAs, Total Active	211	193	188	161	296
Other Collaborative R&D Relationships	5,408	5,629	4,730	5,628	6,125

[16] In prior reports, USDA reported all agreements that were not CRADAs as "Other collaborative R&D agreements". Beginning in with their FY 2017 agency report, USDA is reporting only agreements that are similar to CRADAs" as "Other collaborative R&D agreements". For USDA, "Other collaborative R&D agreements" includes Trust Fund Cooperative Agreements, Reimbursable Agreements, Material Transfer Research Agreements, Specific Cooperative Agreements and Non-Funded Cooperative Agreements, Challenge Cost-Share Agreements, Collections Agreements, Cooperative Agreements, Inter-agency & Intra-agency Agreements, Joint Venture Agreements, Participating Agreements, Research Cost-Reimbursable Agreements, Research Joint Venture Agreements.

USDA Efforts to Streamline Technology Transfer Operations

- Devised and enhanced a two-way communication mechanism between technology transfer professionals (both at the Office of Technology Transfer (OTT) and area offices), Office of National Programs (ONP), and scientists in the field through the use of technology transfer strategy calls. In FY 2017, OTT conducted more than 300 strategy calls resulting in devising a customized technology transfer strategy to ensure the adoption of research outcomes of each project.
- Worked with ONP, research leaders, and plant breeders to develop a new mechanism for evaluating plant selections/inventions (cultivars, germplasm enhancements, etc.) through a quarterly Plant Protection Committee to ensure the most appropriate mechanism for distributing new plant releases. In FY 2017, 24 plant selections/inventions were reviewed, and decisions were rendered on whether to publicly release the cultivar/germplasm or seek protection as an incentive to commercialization.
- In FY 2016, OTT established an Innovation Fund to enhance the commercial potential of an agricultural solution currently under development at ARS and to enable the adoption of ARS's research outcomes by industry, academia, and other stakeholders. In FY 2017, 76 Innovation Fund applications were received and 29 were funded.

USDA Downstream Success Stories

Forest Service: Development of a Ready-to-Assemble (RTA) Tornado Safe Room Constructed from Cross-Laminated Timber

The growth of the cross-laminated timber (CLT) panel market has made available manufactured wood panels that are ideal for tornado safe rooms and shelters. U.S. Forest Service Forest Products Laboratory engineers have constructed a low-cost safe room prototype out of engineered wood panels that can withstand winds up to 250 mph. The development of a standardized safe room using CLT that is ready to assemble, easy to ship, and quick to fabricate on site would not only increase access to important safety equipment, but also increase the market opportunity for these engineered wood products. A panel connection system is currently being developed and tested that is similar in design (albeit much more heavy duty) to that used in the furniture industry. These doweled fasteners would be simple to install and allow the butting of panels with little field modification. Full-size lateral load tests will be performed on an assembled safe room (8 by 8-by-8 foot in size) to verify the integrity of the developed connection system and the lateral wind pressure resistance of the shelters. A workable RTA safe room constructed from CLT will be verified to resist the forces of the highest rated tornado on the Enhanced Fujita scale (EF-5) and the requirements of the ICC-500 design standard.

Animal and Plant Health Inspection Service (APHIS): Rapid Field Identification of Imported Fire Ants by Immunoassay

The red imported fire ant is an aggressive, highly invasive pest ant species from South America that was introduced into the United States in the 1930s. Damage caused by the red imported fire ant is wide ranging, resulting in physical damage to agricultural commodities, livestock, equipment, and infrastructure (e.g., roads and electrical equipment). These ants inflict a painful, venomous sting that represents the most common form of venom allergy in much of the

Southeastern United States. Costs to control and repair damage caused by red imported fire ants are estimated at 6 billion dollars annually in the United States. In an effort to reduce damage and limit the human-assisted spread of imported fire ants, the USDA imposed quarantine measures (7 CFR 301.81). APHIS is responsible for enforcing the Federal quarantine and works with State governments to regulate the movement of nursery stock, grass sod, hay, soil, and soil-moving equipment possibly contaminated with red imported fire ants. Cargo moved from a quarantined to a non-quarantined area requires certification or inspection to certify that it is free of imported fire ants. When ants are found on the cargo, it is not permitted to enter the non-quarantined region until the ants are identified and determined to not be imported fire ants. Unfortunately, visual identification of fire ants to species is difficult, requiring considerable expertise in ant taxonomy and is prone to error. Indeed, specimens generally have to be shipped to an expert for identification, which can result in prolonged delays of shipment transportation. To support the quarantine and minimize human- assisted spread of the ant, there was a need for a rapid identification tool that anyone in the field could use.

To this end, in 2010 APHIS and ARS collaborated on development of an imported fire ant identification tool. In 2016, work on a lateral flow immunoassay-based field test that could specifically identify red imported fire ant in less than 30 minutes was completed. The scientists then approached their respective ARS and APHIS Technology Transfer specialists who worked together to transfer this new tool from the laboratory to commercial development with a private company. In August 2017, the first commercially produced InvictDetect™ kits were delivered to APHIS, which then began distribution to its stakeholders for field use to identify ant samples.

Agricultural Research Service (ARS): Crispy, Healthy Fruit and Vegetable-Snack Drying System is Commercialized

Currently the hot-air drying of fruit and vegetables is an important U.S. industry worth $50 billion annually but is also the third largest industrial energy user in California. As a solution to substantially reduce energy usage and improve dried produce appearance and flavor, ARS scientists in Albany, California, developed a two-stage, infrared-blanching and hot-air drying system. Crispy, healthy fruit and vegetable snacks were produced at a commercial scale through the support of the California Energy Commission. The project demonstrated the novel drying system technology in producing healthy crispy snacks from carrots, kale, bell peppers, squashes, pears, and apples. This demonstration showed the benefits of the new technology, both in a 75-percent energy savings and a reduction in environmental pollution, while providing new healthy snacks with desirable texture and flavor at an affordable cost. This technology was recently licensed by a private company to produce healthy snacks, while saving energy and water

Agricultural Research Service: Improving the Accuracy of Diagnostic Tests for Bovine Babesiosis

Bovine babesiosis (also known as cattle tick fever) is caused by the protozoan parasites Babesia bovis and B. bigemina. Babesia parasites can be transmitted by ticks to cattle of any age and can result in 90 percent mortality in newly infected adults. Babesiosis was a significant problem in the southern United States until eradication of the tick vector in the 1940s. The United States imports 1 million head of cattle annually from Mexico, where babesiosis and cattle fever ticks are present. Control measures for preventing babesiosis from coming to the United States include treating all arriving cattle with acaricides to eliminate cattle fever ticks. The recent discovery of

acaricide-resistant tick populations capable of transmitting Babesia species and the re-emergence and spread of cattle fever ticks by wildlife on the Texas–Mexico border is increasing the risk that bovine babesiosis will be reintroduced to the United States. ARS scientists in Pullman, Washington, have improved diagnostic testing methods to determine the infection prevalence of bovine babesiosis on the U.S.–Mexico border. This improved test was fully developed in collaboration with a commercial partner and is now available for use.

Agricultural Research Service: Development and Commercialization of a Lactococcus Vaccine for Rainbow Trout

Lactococcus garvieae infection is a major cause of on-farm losses of rainbow trout in Washington State. ARS researchers in Leetown, West Virginia, successfully developed a vaccine against L. garvieae and validated the safety and efficacy of a commercially manufactured version of the vaccine. Field evaluation results demonstrated that vaccination induced a strong antibody response and robust protection against experimental pathogen exposure. Mortality due to L. garvieae was dramatically reduced the first year after vaccination, and the disease has not been detected in vaccinated fish since the program began. The commercial vaccine is in large-scale use at affected farm sites, and 6 million fish have been vaccinated since 2015. The rapid development and implementation of a Lactococcus vaccine prevented substantial rainbow trout losses due to this emerging disease.

Agricultural Research Service: Breeding for Disease Resistance in Nile Tilapia

Worldwide tilapia aquaculture is valued at about $8 billion, and the U.S. aquaculture industry produces nearly 30 million pounds of tilapia per year. However, production is hindered by two bacteria, Streptococcus iniae and S. agalactiae, which are responsible for around $1 billion in annual worldwide losses. ARS scientists in Auburn, Alabama, collaborated with industry partners and verified that tilapia resistance to S. iniae infection is heritable and that selective breeding of superior individuals produced increased disease resistance in subsequent generations. They also demonstrated that resistance to S. agalactiae was also heritable. Tilapia industry breeding programs now select for resistance to the two Streptococcus species, and for increased harvest weights and reduced disease risks in rapidly growing fish. The improved tilapia are being sold throughout the Americas and abroad. Based on current production statistics and available models, representative gains from growing the improved tilapia means $635,000 in additional revenue for the average-size farm. This research helps U.S. fish farmers and paves the way globally for reducing antibiotic use on farms, leading to safer products entering the United States.

Agricultural Research Service: Strawberries Perform Better Under Low Tunnels

Strawberries are economically valuable to farmers and are popular with consumers who expect availability all year long; however, in much of the United States, traditional strawberries produce fruit only 3 to 4 weeks each year. To produce strawberry fruit for several months, farmers need to use a repeat-fruiting strawberry variety that fruits nearly all year long and protect it from mid-summer outdoor conditions. ARS scientists in Beltsville, Maryland, compared the performance of repeat-fruiting strawberries under two different production systems (raised beds with and without low tunnels) to determine the effect of day length, brightness, soil moisture, humidity, and temperature on strawberry yield. They found that higher temperatures under low tunnels, especially in early spring and late fall, resulted in a much longer harvest season. Strawberry yield

increased as light increased, and with temperatures up to about 28°C, above which yields dropped. Further evaluations showed that yields were more strongly associated with soil temperatures than air temperatures. This new discovery will be useful to strawberry growers by helping them increase the length of the strawberry season to match consumer demand. The new discoveries by ARS researchers have been published in scientific journals and presented at grower and professional meetings. Strawberry growers are rapidly adopting the low- tunnel production system.

Agricultural Research Service: Sugarcane Aphid-Resistant Sorghum
Sugarcane aphid has become a major pest in sorghum in the last few years. ARS scientists in Lubbock, Texas, developed two new lines of pollinator sorghum (restorer, or R), designated LBK1 and LBK2 (tested as R.11259 and R.11143), that showed significant tolerance to sugarcane aphid. These two new R lines have been transferred to four seed companies and have been adopted in their breeding programs.

Agricultural Research Service: Two USDA Potato Varieties Chosen by McDonald's for French Fry Production
The retail market for potatoes used for French fries in the United States is approximately $1.5 billion before the added value of retail sales. The quick-service restaurant industry prefers lighter colored French fries with a wider range of storage temperatures that can resist the conversion of starch to sugars, which promotes an unacceptably dark French fry. But breeding and identification of new potato varieties with these enhanced attributes involves careful testing and data collection across several locations and years. ARS scientists in Aberdeen, Idaho, collaborated with the University of Idaho, Washington State University, and Oregon State University to develop suitable potato varieties for the French fry industry. The research team released 'Blazer Russet' in 2005 and 'Clearwater Russet' in 2008, and partnered with growers, processing companies, and the restaurant industry to conduct extensive testing for more than 10 years. McDonald's recently accepted these two varieties for use as their French fries. Both varieties exhibit better culinary characteristics, greater fry recovery, less processing waste, higher marketable yields, more efficient nitrogen use, and greater tolerance to temperature and water stress. They also have fewer tuber defects than industry standard varieties. McDonald's now uses seven potato varieties, four of which originated from the ARS breeding program in Aberdeen.

Agricultural Research Service: Release of Soybean Germplasm Line with Superior Tolerance to High Temperature Stress
High heat (>90°F) damages soybean seed by reducing seed germination and seedling vigor. It also causes seed coat impermeability and green seed discoloration. Unacceptable seed quality and economic loss are major challenges for soybean producers where temperatures are consistently high, such as the Mississippi Delta region. There has been little attention in commercial breeding programs to address the issue, but ARS researchers in Stoneville, Mississippi; Columbia, Missouri; Jackson, Tennessee; and Raleigh, North Carolina, discovered a heat-tolerance gene, and developed and released a maturity group IV soybean germplasm line to seed companies and public breeders. This germplasm line maintains excellent seed germination and high seed quality under elevated temperatures. 'DS25-1' is the first U.S. soybean germplasm release to address heat tolerance in soybean, and it will enable breeding to develop better seed quality in high-temperature stress environments. Commercial and public soybean breeders are

now using DS25-1 in their breeding programs to develop heat-tolerant soybean cultivars for producers. [NP 301, Project 6066-21220-012-00D]

Agricultural Research Service: Technical Assistance for Specialty Crops

The Technical Assistance for Specialty Crops Program (TASC) invested in the development and transfer of innovative USDA post-harvest irradiation phytosanitary treatments for U.S. specialty crops, like fruits, tree nuts, vegetables, and greenhouse and nursery crops. In 2017, TASC funded USDA Agricultural Research Service (ARS)-Hawaii to continue working on a project to develop and transfer such irradiation phytosanitary treatments. Their project involves collaborations with grower groups, exporters, the irradiation industry, and relevant university research groups, resulting in treatment protocols for spotted wing drosophila, light brown apple moth, and European grapevine moth and new information on the radiation-tolerance levels of several invasive ants. ARS-Hawaii also received a TASC grant in 2015 to work on the development and testing of a low-cost cabinet X-ray tube machine for phytosanitary irradiation treatments of sweet cherries. The final designs for a packing line scale X- ray tube machine were developed in collaboration with Applied Energy Devices, LLC, (Albuquerque, NM), and a prototype was tested for dose uniformity, dose rate, and treatment efficiency. Once foreign approvals are finalized, the X-ray tube machine will be used to irradiate sweet cherries for export. These TASC investments in ARS research were critical in helping U.S. exporters preserve a $12 billion annual market for U.S. exports of specialty crops. By collaborating with sister USDA agencies, U.S. universities, and specialty crops industries to develop and commercialize post-harvest phytosanitary irradiation treatments, TASC directly helped to promote the transfer and commercialization of these new technologies and, overall, expand the variety, quantity and value of U.S. specialty crops for export markets. With TASC's support, the development, transfer, application, and commercial value of irradiation phytosanitary treatments are expected to continue increasing over the coming years.

Department of Commerce (DOC)

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

DOC conducts research and development (R&D) in areas of science and technology at the laboratory facilities of NIST, NOAA, and NTIA's 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.[17] 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 helped coordinate and inform ongoing activities across federal agencies and facilitated 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.

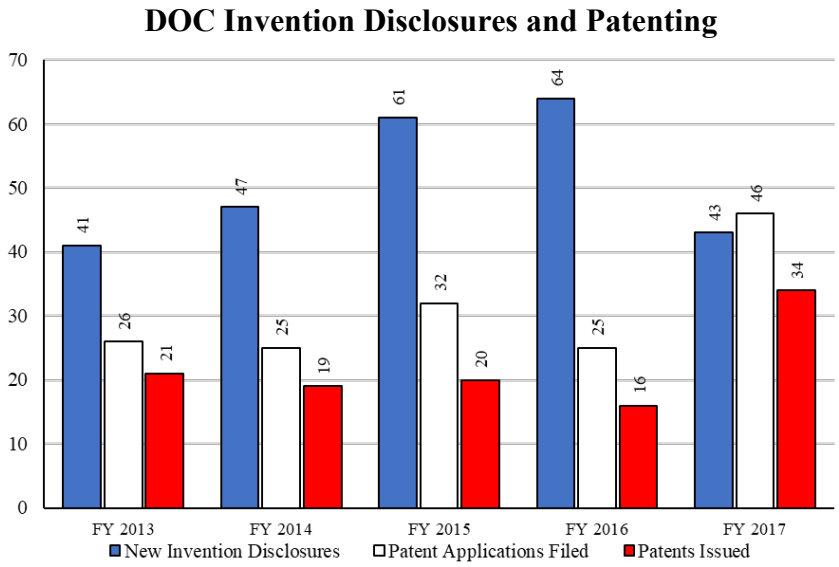
More information about DOC technology transfer is available on the following websites.

NIST | NOAA | ITS

[17] 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.

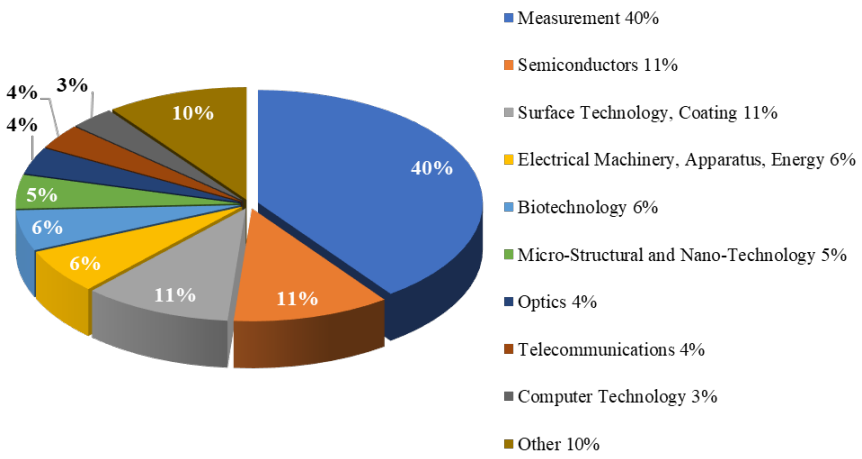
DOC Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions disclosed increased by 5% to 43 disclosures in FY 2017. Patent applications filed increased by 77% to 46, and patents issued increased by 62% to 34.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	41	47	61	64	43
Patent Applications Filed	26	25	32	25	46
Patents Issued	21	19	20	16	34

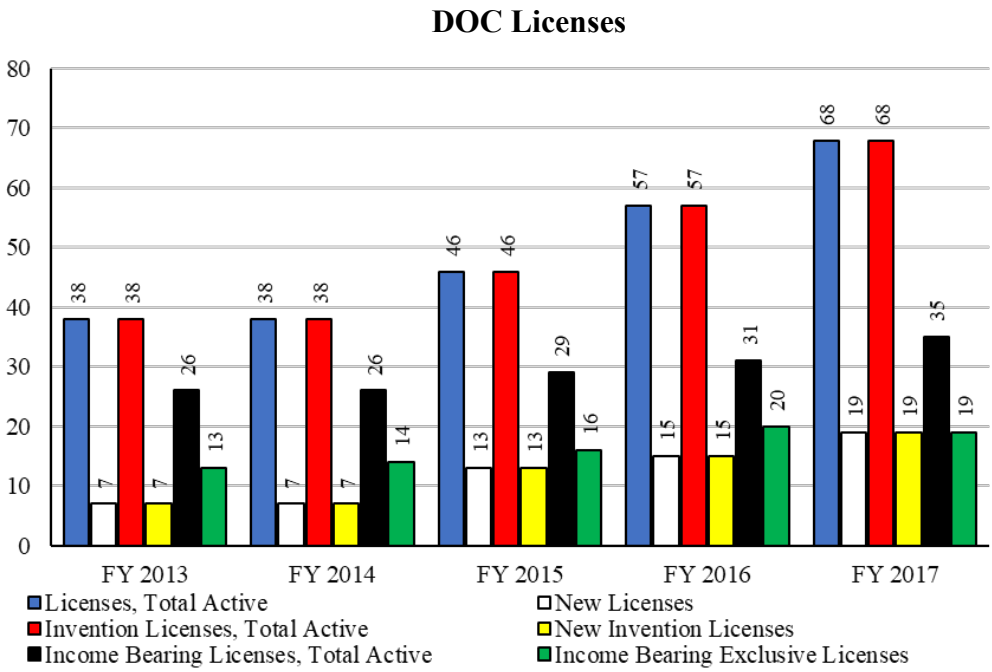
Patents issued to DOC in FY 2017 covered many technology areas including Measurement (40%), Semiconductors (11%), Surface Technology, Coating (11%), and Electrical Machinery, Apparatus, Energy (6%).[18]



[18] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

DOC Licenses

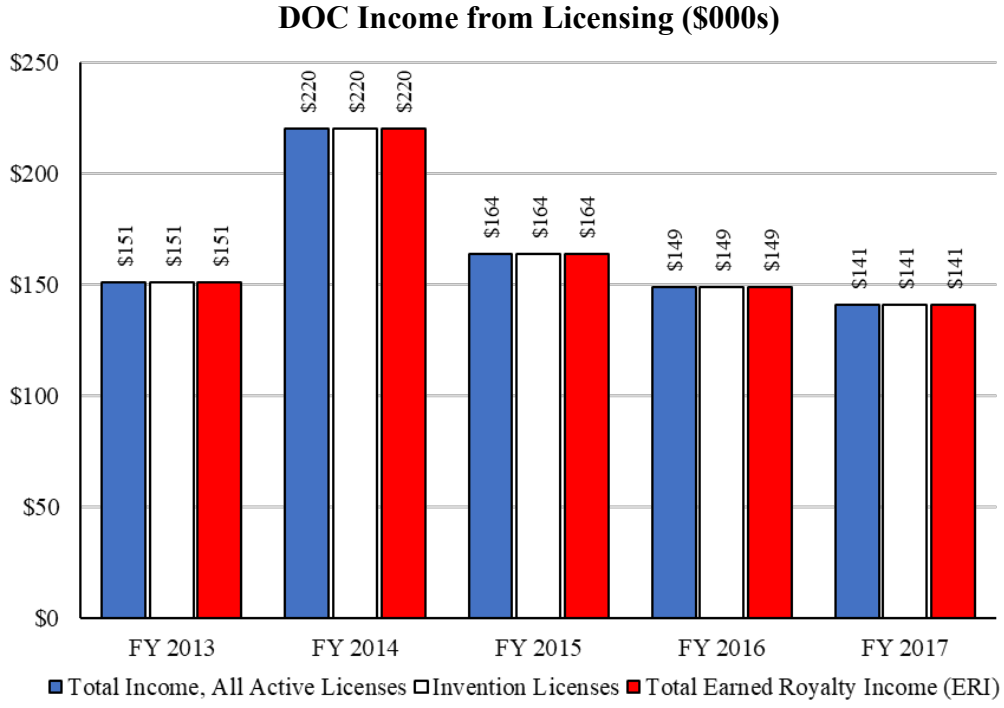
Total active licenses increased by 79% from 38 in FY 2013 to 68 in FY 2017. New licenses increased by 171% to 19. All licenses were invention licenses. Total active income bearing licenses increased by 35% to 35, while income bearing exclusive licenses increased by 46% to 19.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	38	38	46	57	68
New Licenses	7	7	13	15	19
Invention Licenses, Total Active	38	38	46	57	68
New Invention Licenses	7	7	13	15	19
Income Bearing Licenses, Total Active	26	26	29	31	35
Income Bearing Exclusive Licenses	13	14	16	20	19

DOC Income from Licensing

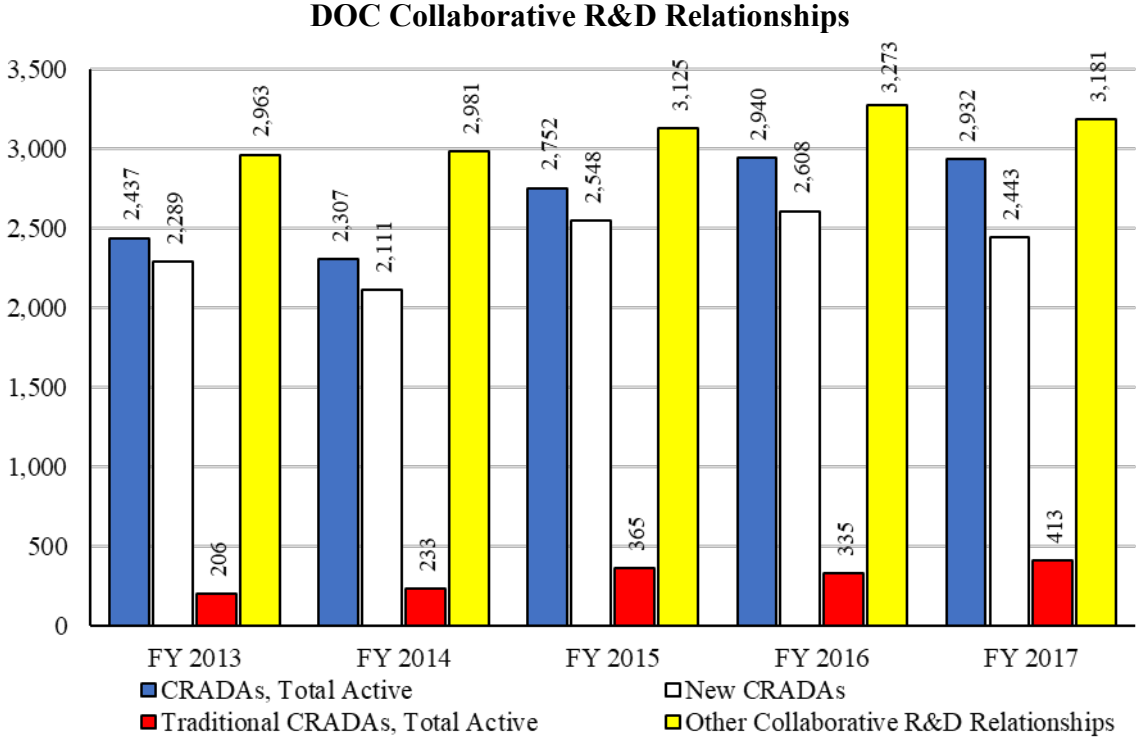
DOC reported that all income from licensing comes from invention licenses. During the five-year period, from FY 2013 to FY 2017, there was a 7% decrease in total income from all active licenses, from $151 thousand in FY 2013 to $141 thousand in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$151	$220	$164	$149	$141
Invention Licenses	$151	$220	$164	$149	$141
Total Earned Royalty Income, (ERI)	$151	$220	$164	$149	$141

DOC Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 20% to 2,932 agreements while new CRADAs increased by 7% to 2,443. Traditional CRADAs increased 100%, from 206 in FY 2013 to 413 in FY 2017. Other collaborative R&D relationships increased by 7% to 3,181.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	2,437	2,307	2,752	2,940	2,932
New CRADAs	2,289	2,111	2,548	2,608	2,443
Traditional CRADAs, Total Active	206	233	365	335	413
Other Collaborative R&D Relationships	2,963	2,981	3,125	3,273	3,181

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. 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 396 days. The average CRADA approval time was 108 days.

DOC Downstream Success Stories

NIST Patents First DNA Method to Authenticate Mouse Cell Lines

Cell lines that have been contaminated or misidentified due to poor laboratory technique and human error lead to inaccurate research studies, retracted publications, and wasted resources. In fact, many scientific funding organizations, such as the National Institutes of Health, now require scientists to verify their cell lines for identity and quality before research grants are awarded. To help address this challenge, NIST is working with partners to design tools, establish datasets, and further develop and standardize NIST's system to authenticate mouse cell lines.

One of the first milestones in NIST's effort is the recently granted U.S. patent (No. 9,556,482) for an authentication method using NIST-identified short tandem repeat (STR) markers (tiny repeating segments of DNA found between genes) for mouse cell lines. The method can be used to verify that a cell line is derived from a particular mouse in the same way forensic experts can confirm the identify of a person using DNA evidence.

NIST partnered with the ATCC (formerly the American Type Culture Collection), a global leader in biological materials management and standards, to further develop the STR technology for authentication and establish the Mouse Cell Line Authentication Consortium. The Consortium will test and validate the patented authentication method.

NIST: New Public-Private Partnership to Develop Standards for Regenerative Medicine

NIST has partnered with the Standards Coordinating Body for Gene, Cell and Regenerative Medicines and Cell-based Drug Discovery (SCB) to develop industry-wide standard methods and protocols for characterizing and manufacturing these cutting-edge therapies, with an aim of accelerating their use as mainstream treatments for a variety of human diseases and injuries.

The field of regenerative medicine manipulates genes, cells, and tissues to repair or replace diseased, damaged, or missing organs, skin, bone, and other cells and tissues. Regenerative medicine has the potential to alleviate the shortage of donor organs and restore appearance and full function to patients who have experienced severe burns or physical trauma.

Because of the complexity of regenerative medicine treatments, they have been slow to transition from the laboratory to the clinic. The traditional measurements of efficacy, potency, purity, and quality that work with traditional pharmaceuticals are not always sufficient for regenerative medicine treatments. To address these issues, NIST and the SCB, a non-profit founded by the 38Alliance for Regenerative Medicine, signed a Memorandum of Understanding, formed a partnership to explore the regenerative medicine industry's needs and develop standards and other products to increase confidence in measurements of gene-and cell-based therapies and manufacturing processes.

NOAA Engineers and More Reliable, Cost Efficient Current Sensor for Mariners

Max Ivanov and Scott Mowery with NOAA's Center for Operational Oceanographic Products and Services install an improved current sensor system on a navigation buoy in Chesapeake Bay. The system transmits real-time current speed and direction observations via satellite to help mariners more safely navigate busy shipping channels. (Photo: NOAA)

Navigating into seaports is now safer and more efficient for mariners thanks to improved NOAA technology that ships rely on to give them information about currents. The Center for Operational Oceanographic Products and Services (CO-OPS) developed a more reliable, cost-saving version of a current sensor system that can now be placed at more remote locations along navigation channels.

The updated Acoustic Doppler Current Profiler (ADCP) system provides real-time current speed and direction observations where many mariners need it most—at U.S. Coast Guard Aids-to-Navigation (ATON) buoys along major shipping channels. Accurate information about ocean conditions helps ship operators protect their cargo and the environment as they navigate narrow channels with increasingly larger vessels.

NOAA: Autonomous Aircraft Support Search and Rescue under CRADA

Launch of the PUMA AE UAS from U.S. Coast Guard Cutter HEALY. Photo: NOAA

The NOAA Unmanned Aircraft Systems (UAS) Program Office, working together with representatives of AeroVironment Inc., conducted a search and rescue exercise, called Arctic Shield, in the waters north of Alaska in order to test the utility of integrating unmanned aircraft into a simulated response incident.

Working from the deck of the U.S. Coast Guard Cutter HEALY, the research team launched a small unmanned aircraft, the AeroVironment Puma, to search for a simulated missing person stranded in icy waters.

Following the launch, the Puma used both its electro-optical and infrared cameras to locate the simulated victim floating in a survival raft on the water approximately one nautical mile away from the ship. The Puma was able to relay the coordinates to the test control center on board the HEALY, which then directed a Coast Guard H-60 and Era Helicopter to the scene. Both helicopters deployed rescue swimmers to simulate recovery and then returned safely to shore. The exercise concluded with a successful net capture of the Puma UAS and a recovery of the survival raft by the HEALY. Much of this mission was conducted under the auspices of a CRADA between NOAA and AeroVironment. The results

from this and other tests will be analyzed by both NOAA and AeroVironment to improve NOAA's operational capabilities and AeroVironment's products for real-life mission-based scenarios.

NTIA ITS: 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 2017, 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 eleven years, the University of Colorado's Research and Engineering Center for Unmanned Vehicles safely and accurately tested collective and autonomous sensing and communication technologies for small unmanned aircraft used for atmospheric science applications such as the study of tornadogenesis.

ITS also uses the Table Mountain test facility to perform independent CTA-2009-B surveillance testing for manufacturers wishing to obtain verification that their equipment meets the requirements to be certified as a NOAA Weather Radio All Hazards receiver. Two companies entered into CRADAs with ITS for this testing in FY 2017.

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.

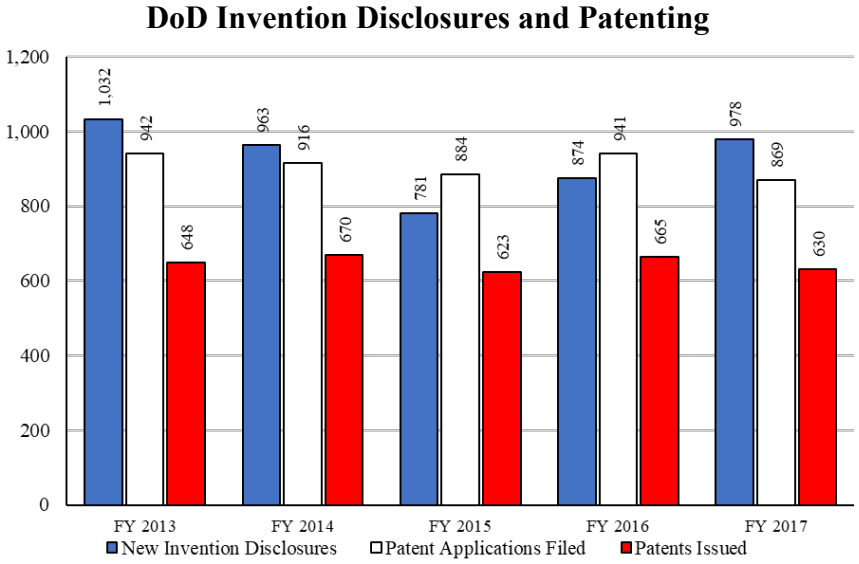
DoD is unique in applying the principles, practices, and tools of technology transfer in the execution of its mission. DoD funds and develops mission-focused technology, and technology transfer statutory authorities enable it to promote and facilitate the commercialization of that technology for both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

DoD Research & Engineering Enterprise
U.S. Army Research Laboratory
Office of Naval Research

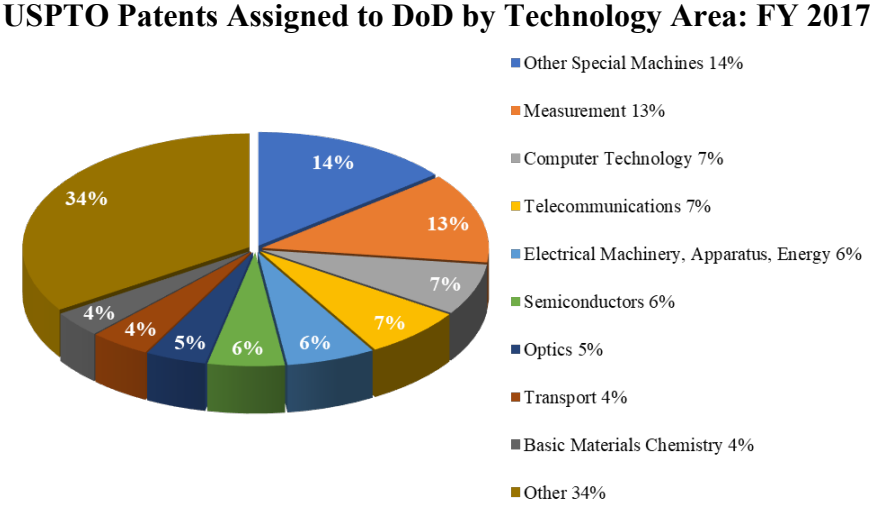
DoD Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions disclosed decreased by 5% to 978 disclosures in FY 2017. Patent applications filed decreased by 8% to 869. Patents issued decreased by 3% to 630 patents.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	1,032	963	781	874	978
Patent Applications Filed	942	916	884	941	869
Patents Issued	648	670	623	665	630

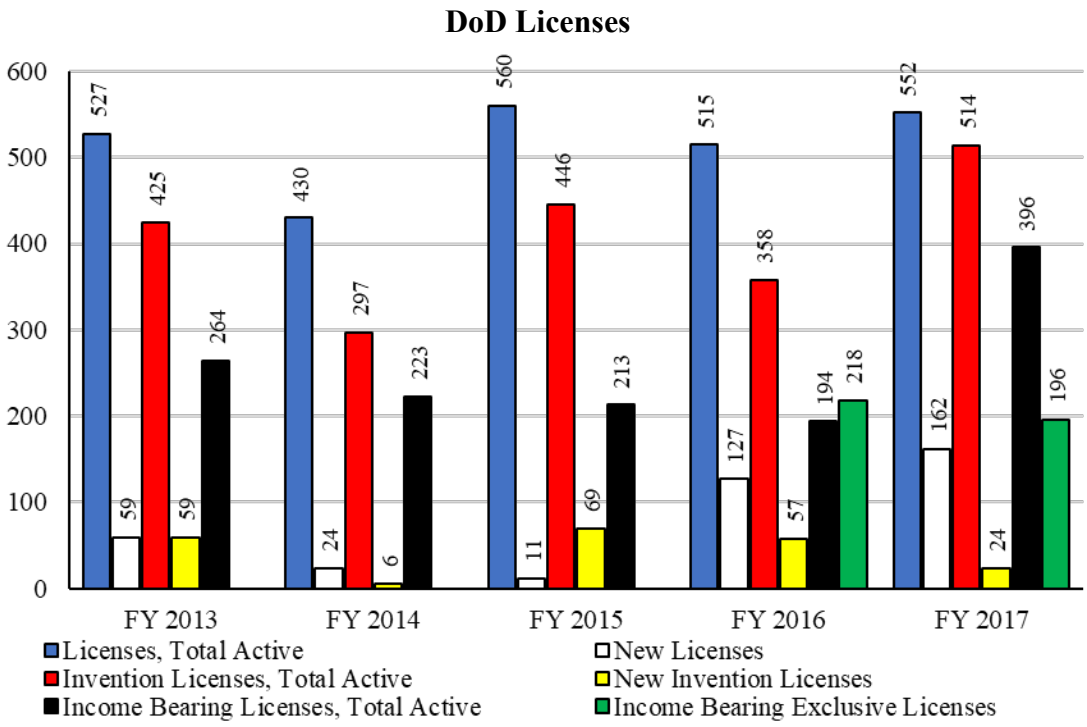
Patents issued to DoD in FY 2017 covered many technology areas including Other Special Machines (14%), Measurement (13%), Computer Technology (7%), and Telecommunications (7%).[19]



[19] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

DoD Licenses[20]

Total active licenses increased by 5% from 527 licenses in FY 2013 to 552 licenses in FY 2017, while new licenses increased 175% to 162. Total active invention licenses increased by 21% to 514, while new invention licenses decreased by 59% to 24. Total active income bearing licenses increased by 50% to 396.

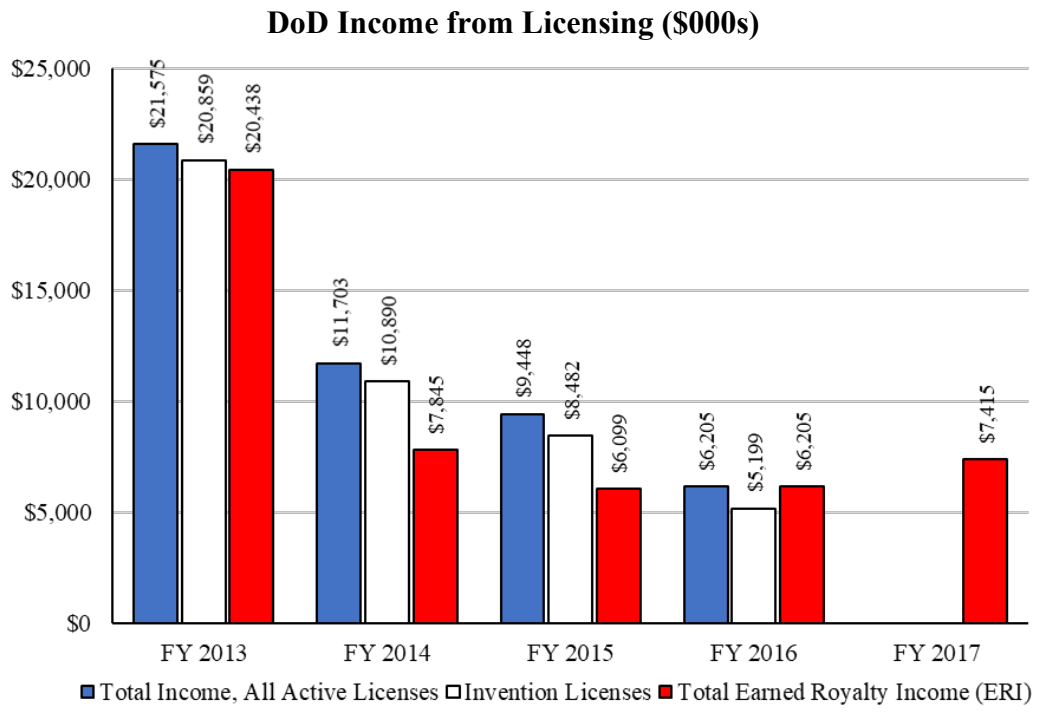


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	527	430	560	515	552
New Licenses	59	24	11	127	162
Invention Licenses, Total Active	425	297	446	358	514
New Invention Licenses	59	6	69	57	24
Income Bearing Licenses, Total Active	264	223	213	194	396
Income Bearing Exclusive Licenses	n.a.	n.a.	n.a.	218	196

[20] DoD was unable to report income bearing licenses exclusive licenses for FY 2013 through FY 2015.

DoD Income from Licensing[21]

In FY 2017, total earned royalty income declined by 64% to $7.4 million.



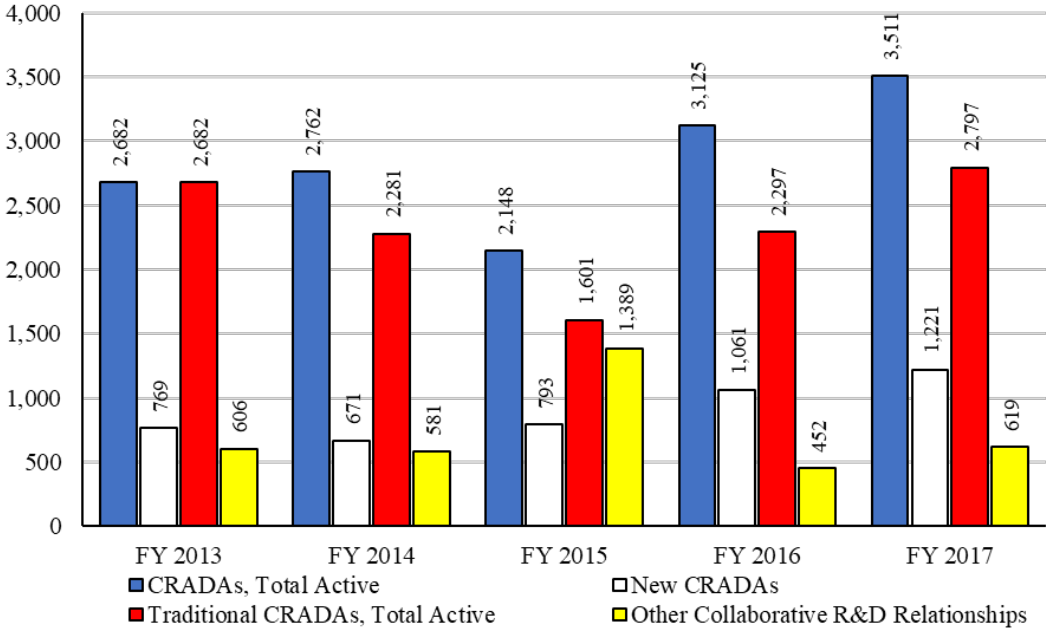
	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$21,575	$11,703	$9,448	$6,205	n.a.
Invention Licenses	$20,859	$10,890	$8,482	$5,199	n.a.
Total Earned Royalty Income, (ERI)	$20,438	$7,845	$6,099	$6,205	$7,415

[21] DoD was unable to report total income or invention license income for FY 2017.

DoD Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 31% to 3,511 agreements, while new CRADAs increased by 59% to 1,221. Traditional CRADAs increased by 4% to 2,797. Other collaborative relationships increased by 2% to 619 in FY 2017.

DoD Collaborative R&D Relationships



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	2,682	2,762	2,148	3,125	3,511
New CRADAs	769	671	793	1,061	1,221
Traditional CRADAs, Total Active	2,682	2,281	1,601	2,297	2,797
Other Collaborative R&D Relationships	606	581	1,389	452	619

DoD Downstream Success Stories

Uniformed Services University of the Health Sciences: Hemostatic Bandages

Controlling hemorrhage is the initial step in first aid, surgery, and field trauma care. The transferred hemostatic bandage technology, co-invented by researchers at the Uniformed Services University of the Health Sciences (USU) and Virginia Commonwealth University (VCU), is a formulation and manufacturing technique for the production of hemostatic bandages comprised of dextran, salmon fibrinogen, and salmon thrombin. The bandages are created through a process of electrospinning dextran and adding fibrinogen and thrombin to the resulting dextran fibers, creating a matrix that promotes hemorrhage control. These fibrin-based dressings provide effective hemostasis in a large-animal model of arterial injury. The use of salmon-derived coagulation proteins allows the manufacture of an effective fibrin bandage at a low cost, and the salmon proteins may enhance healing.

The patented technology provides the base for the platform technology called FASTCLOT® and the subsequent SURGICLOT® hemostasis products developed by St. Teresa Medical, Inc., the licensee of the technology. Dr. Stephen Rothwell, USU scientist and co-inventor of the technology, notified the Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (HJF) about the development of the technology and the entrepreneur who was interested in licensing the technology. In addition, Dr. Rothwell connected the HJF with the academic co-owner of the technology. John E. Baker contributed to the transfer of the technology by facilitating the agreements that permitted HJF to negotiate the related technology agreements. Dr. Mark Scher led the negotiations for the agreements that transferred the technology to St. Teresa Medical.

The transfer of the hemostatic bandage technology employed multiple technology transfer mechanisms, including inter-institutional agreement, nondisclosure agreements, an exclusive license agreement, and a Cooperative Research and Development Agreement. The unique aspect of this transfer was the ability of multiple parties to execute multiple agreements, all within a year and while protecting numerous interests (U.S. Government, academic, nonprofit, and commercial).

The original technology supported the USU mission of serving warfighters in that it was developed to treat battlefield trauma. In transferring this technology to St. Teresa Medical, which has developed a platform technology for hemostatic bandages, USU has supported research and a technology that benefits public health and the common good, as well as supporting the development of a successful startup company.

Navy: CT-Analyst®-Air Plume Contamination Crisis Management System

The U.S. Naval Research Laboratory (NRL) has developed an instantaneous crisis management system that provides more timely and readily comprehensible information to emergency responders. This Navy-patented system, known as Contaminant Transfer Analyst (CT-Analyst®), uses detailed urban geometry and airflow data that can be computer manipulated to predict the potential impact of urban air plume contamination more quickly than other similar modeling systems. Chemical, biological, or radiological (CBR) explosions can release toxic gas plumes, whether by accident or as a result of terrorism. Statistically, three-fourths of fatalities

result from the direct exposure to CBR contaminants within the first 15 minutes of an event, making emergency response times critical. If an effective response begins within 3 to 5 minutes, an estimated 85 percent of those fatalities could be avoided.

CT-Analyst® gives first responders a key advantage, allowing them to spend less time calculating response needs and more time saving lives. The system's database "imagines" every possible scenario, including where you are on the street, where the fire trucks are headed and, more importantly, where you can set up a triage zone or whatever else is needed. It anticipates where the contaminant plume is likely to travel and what zones will be free of contaminants. The NRL team responsible for the successful transfer initially met in 2010 to coordinate and intensify transfer strategies, responding to growing interest in the product outside the Navy laboratory. This effort included the CT-Analyst® inventors from NRL's Laboratory for Computational Physics and Fluid Dynamics, NRL's Technology Transfer Office, and NRL's Office of General Counsel. A partially exclusive patent license agreement was signed in 2013 with Safe Environment Engineering (SEE) of California. Under the SEE agreement, CT-Analyst® has been transferred to a number of first responder communities worldwide, including the city of Los Angeles and countrywide in Kuwait.

In addition, NRL executed two Cooperative Research and Development Agreements (CRADAs) with the University of Hamburg in 2010 and 2014. Most recently, another was executed in May 2016 with the University Graduate Center (UNIK) in Norway. The three CRADAs enabled operational demonstrations of CT-Analyst® in the cities of Hamburg and Oslo. To make the Navy technology available to a wider variety of consumers, NRL's Office of General Counsel has navigated export control issues and entered CT-Analyst® into multiple customized Work for Others Agreements. Onsite demonstrations have consistently substantiated the Navy-patented technology's utility in urban settings. Two examples are the demonstrations during preparations for the 2006 Super Bowl in Detroit and Washington's 2013 presidential inauguration, when the Federal government's All-Hazards Center used CT-Analyst® to provide an initial assessment of airborne contaminant threats.

Navy: Fiber Optic Amplitude Modulated Sensors (FOS)

A suite of Navy-patented fiber optic amplitude modulated sensors (FOS), transferred to industry by the Naval Research Laboratory (NRL), is the up-and-coming game changer within the "Smart Grid" sector of the massive U.S. electric power industry. The innovative sensors accurately measure pressure, strain, temperature, and other parameters capable of monitoring and controlling electrical power generation, distribution, and storage. This Navy technology also has proven its superiority in industrial control systems and is the basis of highly sensitive fiber optic microphones that can detect unmanned aerial vehicles (UAVs) or help the acoustic design of buildings. Assembled in arrays, the high-performance microphones also can diagnose function problems in rotating machinery, computer hard drives, aircraft engines, and other multi-movement components.

The NRL team was responsible for the FOS technology transfer via two patent licensing agreements (PLAs) with Fiber Optic Sensor Systems Technology Corp. (FOSSTEC) of Silver Spring, Maryland, in 2010 and 2013. Both parties recognized that more adaptability had to be built into the technology transfer agreement conditions to meet the ebb-and-flow funding issues

typical of a startup company. They established an exceptionally open and flexible two-way communication that continues today. As a result, NRL helped amend licensing to incorporate the additional research areas that have yielded marketable company products in a much shorter timeframe than that required for the original PLA field restriction to energy grid applications. FOSSTEC spun off its affiliated company, SmartSenseCom, Inc. (SSC) of Silver Spring, Maryland, specifically for the purpose of marketing two product lines (electric power and acoustics/vibration) based on the Navy patented technology, each of which had several products available to customers. The NRL invention has led to relatively inexpensive, yet very precise, sensors that are ideal for applications requiring small size, very low frequency measurement, and/or the absence of electromagnetic noise. The sensors' LED light source provides long life and low power requirements. Other advantages include greater durability and secure transfer of data. The FOS have also performed well in a wide range of hostile environments during testing, showing little signal degradation under temperature fluctuations, water submersion, or chemical environments.

The use of the NRL patents licensed by FOSSTEC distinguishes all SSC products from other sensors on the market, proving simpler, cheaper, and more robust products while yielding very sensitive, consistent measurements. Driving the future market for FOSSTEC's products is the pressing need to upgrade our nation's infrastructure, along with the rise of computerized buildings, smart homes and appliances, and other consumer goods for which sensing will play an important role.

Navy: SiloxoGrip™: A Siloxane-Based Non-Skid Coating

The U.S. Naval Research Laboratory (NRL) invented and transferred a coating to replace traditional epoxy resins with a siloxane-based material that marked a significant advancement in non-skid surface coating technology. The novel coating decreases environmental levels of volatile organic compounds, delivers greater durability, and improves direct adhesion to metals. Through a series of technology transfer efforts, NRL completed a non-exclusive patent license agreement with NCP Coatings, Inc. of Niles, Michigan. The new non-skid coating is commercially available under the company's brand name, SiloxoGrip™, and NCP Coatings has achieved sales in both defense and commercial markets.

Both the NRL and NCP Coatings were collectively responsible for excellence in the technology transfer process. A series of efforts occurred in a relatively short period of time, beginning in 2011 when NRL's Technology Transfer Office established an "Agreement Between Owners of Invention Rights" with a third-party contractor that had inventorship rights in the technology. Under this agreement, the contractor took the lead in patent prosecution and licensing, and in 2012 engaged with NCP Coatings under a nonexclusive license agreement. However, the third-party contractor made the decision to discontinue its involvement in the technology and returned the invention rights to NRL in 2013.

NRL quickly negotiated termination of both the Invention Rights agreement and the existing license between the contractor and NCP. On January 30, 2014, the NRL signed a nonexclusive Navy patent license agreement with NCP Coatings to enable commercialization of the Navy's siloxane-based non-skid surface coating. NRL materials engineers worked closely with the licensee to ensure product compliance with MIL-SPEC requirements, achieving the NAVSEA

Qualification confirmed in September 2015, and met a crucial milestone of the NRL/NCP license agreement. As a result of these dedicated efforts, the Navy can now purchase the non-skid coatings product that originated from its research.

The Navy applies approximately 3.7 million square feet of non-skid coatings each year at an annual cost of over $56 million. The new siloxane-based coatings are more durable (i.e., color retentive, wear- and chemical- resistant); thereby reducing costs through longer service life. The life expectancy of conventional epoxy coatings is 12 to 36 months, whereas the new non-skid coatings are expected to last 60 months or longer. The siloxane non-skid can be roll- or spray-applied due to its lower viscosity, whereas most epoxies are difficult to spray. The new coating also dries to use within 24 hours, reducing the overall number of costly man-hours and downtime required. Increased service life allows ships to remain at sea longer before replacing deck coatings while in port. The reduction in consumption of both fuel and coating materials provides a favorable impact on the Navy's "Great Green Fleet" initiative for energy efficiency.

Interagency Partnership Award – Navy and Federal Law Enforcement Training Center: Scenario Planning and Effects Control System (SPECS)

Warfighters and law enforcement personnel alike are now more effective in the field thanks to the outstanding partnership between the Naval Air Warfare Center Training Systems Division (NAWCTSD) and the Federal Law Enforcement Training Center (FLETC). The long-term collaboration between these agencies has created an extraordinary track record of success, culminating most recently in NAWCTSD's Scenario Planning and Effects Control System (SPECS). This extensible technology suite puts the sights, sounds and smells of conflict in the hands of training instructors, allowing them to create highly immersive environments. The more exposure law enforcement and military personnel have to such realistic stressors, the better able they are to quickly make effective decisions on the battlefield or on the streets.

SPECS was developed through a series of Interagency Agreements beginning in 2009 and continuing today. Several iterations have advanced the software to make it a uniquely powerful technology. For example, its unique sound system allows instructors to select sound effects from multiple sound libraries and, with just a right click of the mouse over a two-dimensional map, prompt the system to automatically mix sounds and select the correct speakers and amplitudes needed for the scenario. Smell generation is just as easy and precise, as is after-action review. Because most, if not all, of law enforcement training scenarios are instructor-led, SPECS was designed to support instructors as operators, as well as to be accessible by a range of instructors with a range of skills. Its combination of government and off -the-shelf components make it both cost-effective and sustainable, while its scalability adapts to law enforcement training facilities of one or two rooms to military tactical training areas spread across miles.

SPECS is now operational within numerous immersive and mixed-reality training environments, including FLETC's Performance Assessment Laboratory, the FLETC Intermodal Training Facility in Glynco, Georgia; the state of Pennsylvania's Northeast Counter Drug Training Center (NCTC); and several U.S. Navy and U.S. Marine Corps facilities. Since 2013, more than 100,000 law enforcement personnel and tens of thousands of warfighters have participated in the immersive training. In addition, SPECS is a component of the U.S. Army Live Training Transformation architecture, expanding its availability exponentially.

The NAWCTSD and FLETC teams driving SPECS bring a wealth of experience and expertise to bear in the advancement of this innovative training program. They have deep resources to draw on—from NAWCTSD's long history of developing and transferring state-of-the-art simulation technology to FLETC's expertise in the influence of special effects on performance. Building on SPECS and their other successes, this outstanding collective effort will continue to break new ground long into the future.

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 address 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.

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,
- Kansas City 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)

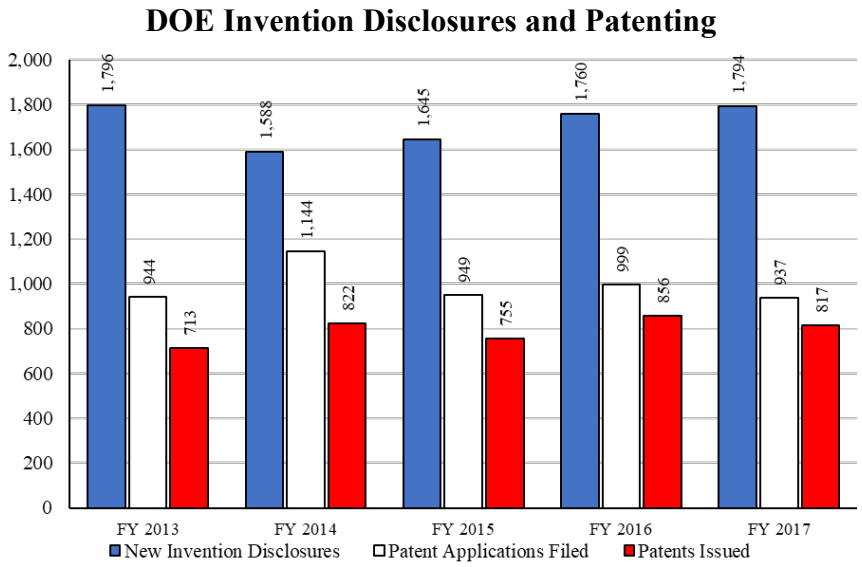
Science and engineering are not linear. DOE's system of National Labs, user facilities, research centers and shared research facilities, makes the pursuit of discovery—and the many solutions that result—both a collaborative enterprise and a shared national resource. Collaboration with industry, academia, 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. OTT works alongside NNSA's Office of Strategic Partnership Programs for technology transfer activities with NNSA laboratories, plants, and sites.

More information about DOE's technology transfer activities is available online with the Office of Technology Transitions and NNSA's website.

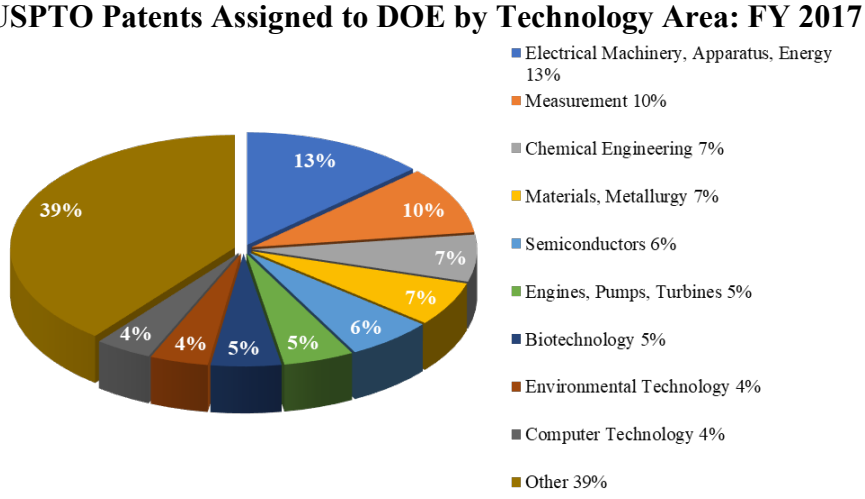
DOE Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions disclosed declined slightly to 1,794 disclosures in FY 2017. Patent applications filed declined by 1% to 937, while patents issued increased by 15% to 817 patents in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	1,796	1,588	1,645	1,760	1,794
Patent Applications Filed	944	1,144	949	999	937
Patents Issued	713	822	755	856	817

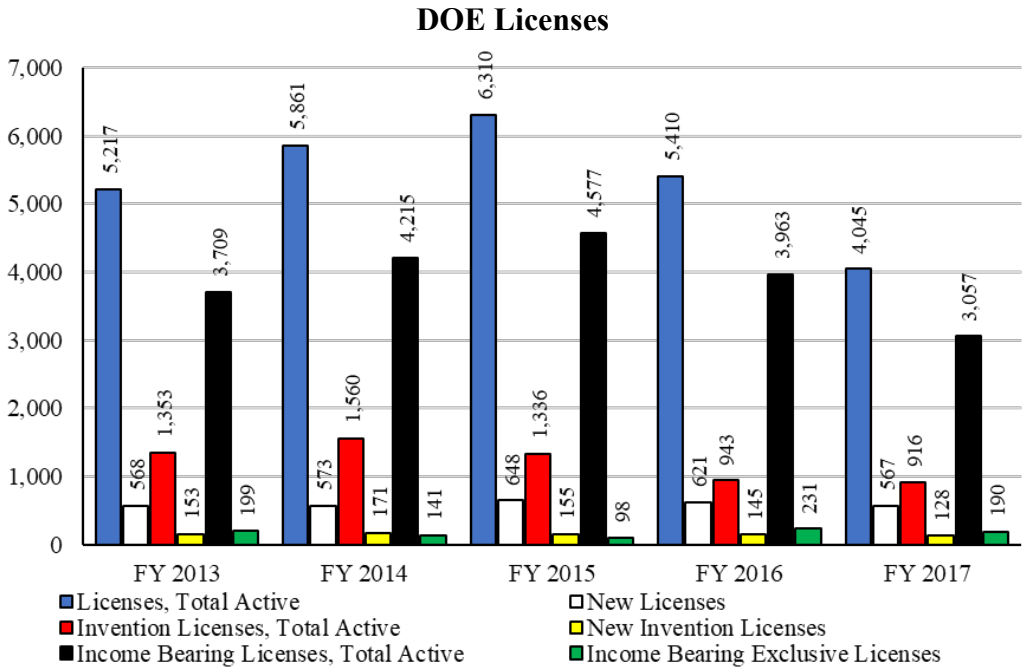
Patents issued to DOE in FY 2017 covered many technology areas including Electrical Machinery, Apparatus, Energy (13%), Measurement (10%), Chemical Engineering (7%), and Materials, Metallurgy (7%).[22]



[22] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

DOE Licenses

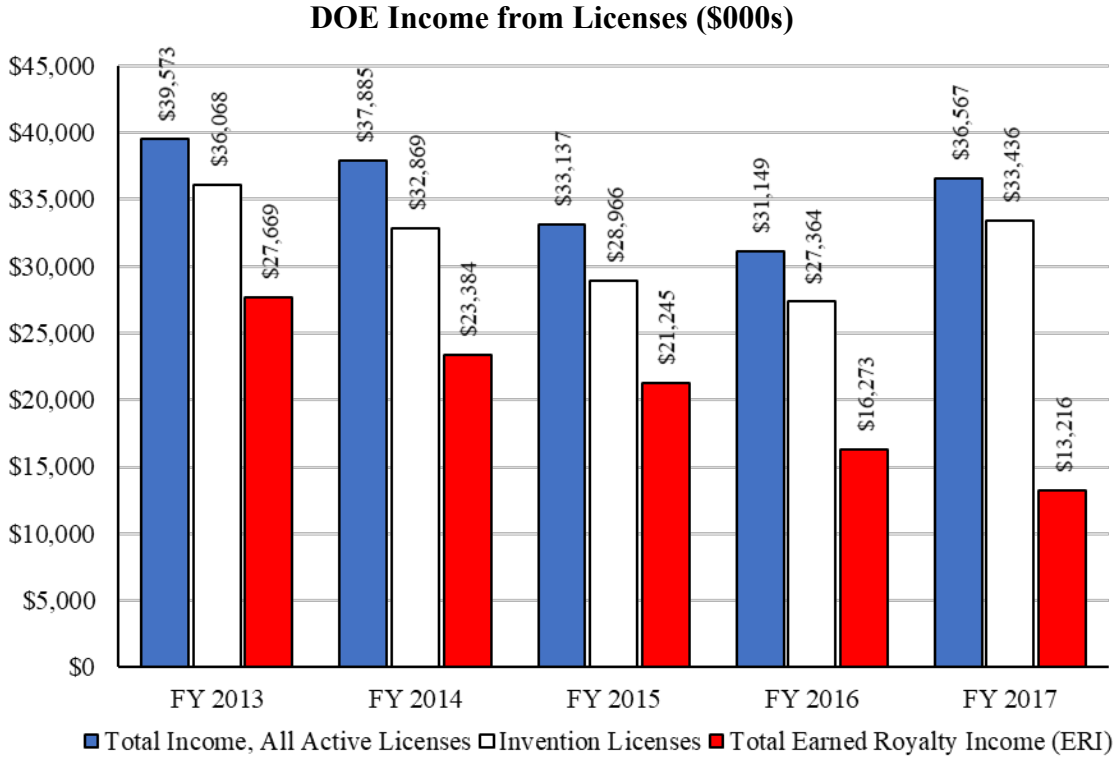
Between FY 2013 and FY 2017, total active licenses decreased by 22% to 4,045 licenses in FY 2017 while new licenses decreased slightly to 567 licenses. Total active invention licenses decreased by 32% to 916 licenses while new invention licenses decreased by 16% to 128. Income bearing licenses decreased by 18% to 3,057 while exclusive income-bearing licenses decreased by 5% to 190.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	5,217	5,861	6,310	5,410	4,045
New Licenses	568	573	648	621	567
Invention Licenses, Total Active	1,353	1,560	1,336	943	916
New Invention Licenses	153	171	155	145	128
Income Bearing Licenses, Total Active	3,709	4,215	4,577	3,963	3,057
Income Bearing Exclusive Licenses	199	141	98	231	190

DOE Income from Licensing

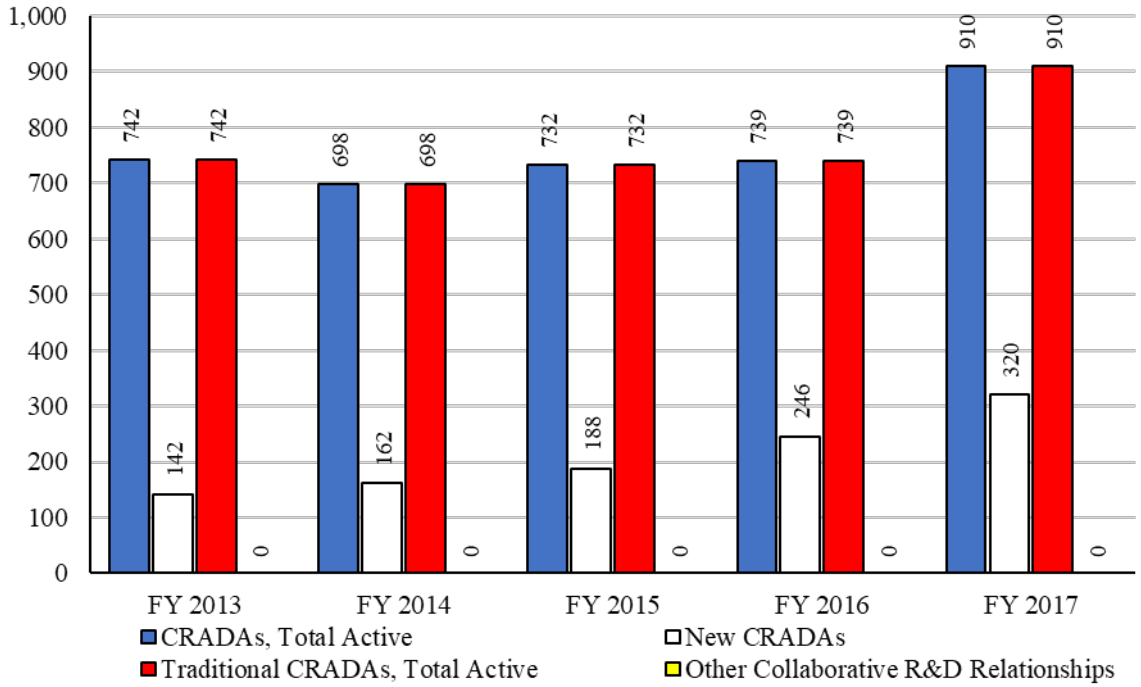
Between FY 2013 and FY 2017, DOE reported that total income from all active licenses decreased by 8% to $36.6 million in FY 2017. The income from invention licenses decreased by 7% to $33.4 million. Total earned royalty income decreased 52% to $13.2 million in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$39,573	$37,885	$33,137	$31,149	$36,567
Invention Licenses	$36,068	$32,869	$28,966	$27,364	$33,436
Total Earned Royalty Income, (ERI)	$27,669	$23,384	$21,245	$16,273	$13,216

DOE Collaborative R&D Relationships

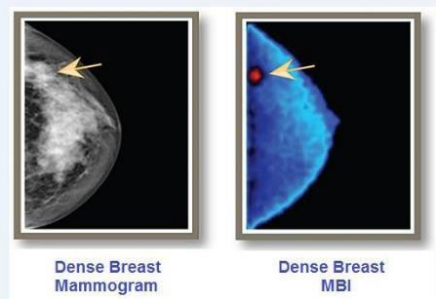
Between FY 2013 and FY 2017, total active CRADAs increased by 23% to 910 in FY 2017. New CRADAs increased by 125% to 320. All CRADAs were traditional CRADAs; therefore, there were not any other collaborative R&D relationships.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	742	698	732	739	910
New CRADAs	142	162	188	246	320
Traditional CRADAs, Total Active	742	698	732	739	910
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

Thomas Jefferson National Accelerator Facility: Nuclear Physics Detector Technology is Powerful Tool in Fight Against Breast Cancer



Known as Molecular Breast Imaging (MBI) or Breast Specific Gamma Imaging (BSGI), the tool is based on gamma-imaging technology developed at the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility in Newport News, VA. MBI is a non-invasive breast imaging procedure that captures the cellular function of breast tissue, complementing mammography in helping to resolve difficult-to-interpret cases.

MBI is designed for situations where mammography is inconclusive and further evaluation is needed, especially when patients have dense breast tissue, implants, multiple suspicious lesions or clusters of microcalcifications, palpable lesions not detected by mammography or ultrasound, post-surgical or post-therapeutic mass, or if they have been taking hormone replacement therapy. MBI relies on the advanced imaging technology of anatomic-specific detectors to detect early-stage cancers. The compact detector developed by Jefferson Lab captures vital tumor information by viewing the metabolism of cancerous lesions in the breast via radiopharmaceutical uptake.

Dilon Technologies licensed the high-resolution gamma imaging technology from Jefferson Lab and used it to develop a company dedicated breast imaging camera. Molecular Breast Imaging is saving lives. Using MBI is an adjunct to mammography results in an almost fourfold increase in invasive cancer detection in women with dense breast tissue. MBI has a higher specificity than MRI and has proven to reduce benign biopsies by 50%. With a negative predictive value of 98%, MBI is the beacon in dense breast tissue. More than 250,000 patients have been screened with BSGI/MBI on a worldwide basis.

Pacific Northwest National Laboratory (PNNL): STARS: Harnessing the Sun to Make Gases and Chemicals

The Solar Thermal Advanced Reactor System (STARS), developed by PNNL, harnesses solar energy to power compact chemical reactors that produce liquids and gases for transportation, electricity generation, and other industrial processes. The U.S. Department of Defense and NASA funded the initial research, followed by the U.S. Department of Energy's (DOE's) SunShot Initiative, which aims to advance American-made solar technologies. STARS team members used DOE's Energy I-Corps training in 2015 to gain insights on marketplace needs and convinced them that a startup was the best way to commercialize the technology.

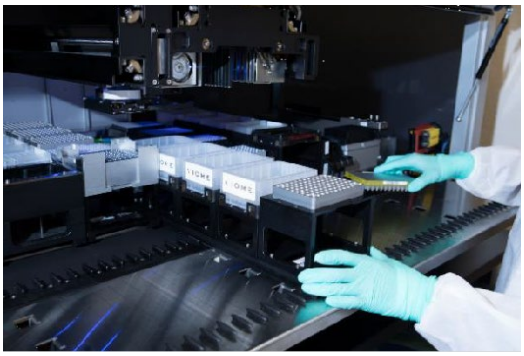
An initial CRADA with Southern California Gas Company helped the startup refine and demonstrate the technology. A second CRADA started in FY2017 is enabling STARS

Technology Corp., Oregon State University, and PNNL to explore ways to reduce the manufacturing cost of STARS components. The CRADA is being funded by DOE, STARS Technology Corp, and the state of Oregon. A third CRADA also began in FY2017 to further refine and test a prototype STARS system in California, funded by DOE's Technology Commercialization Fund and Southern California Gas, with STARS Technology Corp. providing in-kind contributions.

As the first commercial product, STARS Technology Corp. is pursuing hydrogen production for potential industrial use and fuel cell vehicles, followed by methanol and potentially other chemicals. A commercial partner, SoCalGas, is excited about this opportunity because it serves an estimated 21.6 million customers in Southern California, a region well-suited for solar technologies.

Los Alamos National Laboratory: Viome

There are approximately 40 trillion microorganisms living in a human's gut. They help digest food, produce beneficial and harmful chemicals, control infections by pathogens, regulate immune system, and even control emotions.



The Viome automated laboratory environment is able to efficiently process 90 samples at a time without cross-contamination.

Enters Viome, a bacteria-analysis company that examines the microorganisms in users' guts and counsels them on how to keep harmful bacteria at bay. Harnessing technology developed at the Los Alamos National Laboratory in New Mexico, Viome employs artificial intelligence to analyze the digestive tract and its effects on the body's immune and metabolic systems.

Viome was launched with a team of leading entrepreneurs, scientists, and physicians. Viome's Insight kit, the first direct-to-consumer microbiome analysis that sheds light on the active members of a gut microbiome community. Insight can analyze our gut microbiome and provides personalized recommendations for nutrition, supplements, and probiotics, with the goal of improving health and wellness. The at-home Gut intelligence® Test kit uses a stool sample: By analyzing RNA in the stool sample, Viome can get a species-by-species read on the microbial communities in a person's gut including bacteria, viruses, yeast, mold, fungi and parasites. Customers can review the results of the analysis via the Viome app. These results are also factored into a personal wellness profile, using the company's machine learning model (artificial intelligence) for massive and complex biological data.

Viome is the first company to offer wellness as a service, deploying the first direct-to-consumer microbiome analysis that can shed light on the active members of your gut microbiome. Without setting foot in a medical office, a consumer can easily collect the personal samples needed for analysis in the comfort of their own home.

Idaho National Laboratory: Impedance Measurement Box Offers Battery State-of-Health Data in Near Real Time

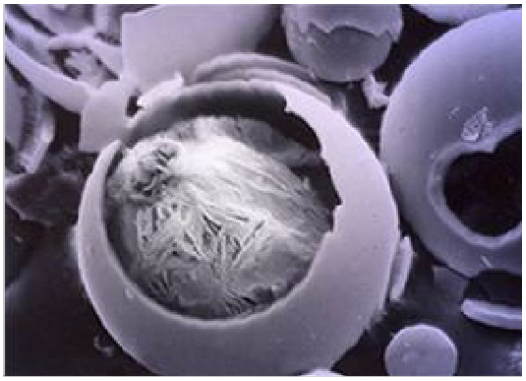
In a joint development project with industry and academia, Idaho National Laboratory's Energy Storage Group have developed the Impedance Measurement Box (IMB), a device that can generate battery impedance data in 10 to 15 seconds.

The Impedance Measurement Box can assess a single battery cell or battery strings, which are commonly used in many consumer applications.

As battery technology becomes more complex and users' expectations become more pronounced, there is a pressing need for highly accurate assessment techniques that can give state-of-health readings in conditions approaching real time. Until now, embedded monitoring has relied on passive measurements of voltage, current and temperature, or on impedance methods that can take as long as 10 minutes. In addition to testing electric vehicle batteries, the IMB diagnostic tool can be used to test batteries for many uses including military, telecommunications, and critical infrastructure. The latest development is a third-generation device, able to assess a 50-volt system, making it applicable for testing on battery modules. The overarching technological purpose of IMB is the development of smarter and better energy storage and management systems that can more accurately detect pending failures, assist with warranty, and enable smarter management for extended battery life.

INL has teamed with Colorado based Dynexus Technology, Inc., to provide the energy storage industry with this first-of-a-kind technology for advanced battery health diagnostics. Under an exclusive licensing agreement, Dynexus will commercialize IMB as an embedded wideband impedance technology for analyzing and forecasting the health, aging and safety characteristics of advanced energy storage devices.

Savannah River National Laboratory (SRNL): Microspheres for Novel Medical Applications



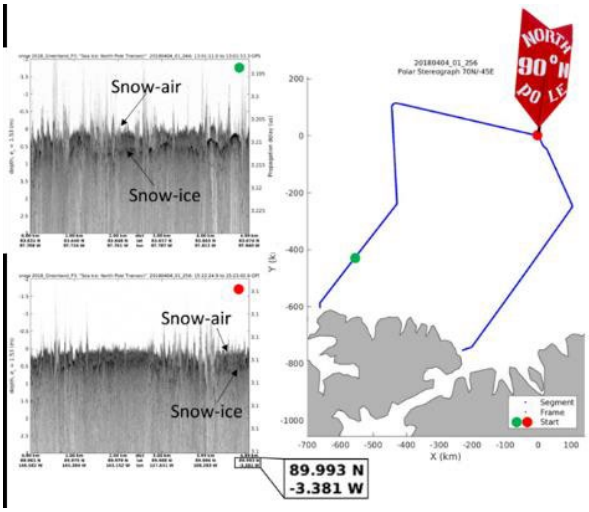
Cross Section of a Porous Walled Hollow Glass Microsphere.

SRNL's Porous Walled Hollow Glass Microspheres were originally developed as part of an improved system for hydrogen isotope separations in tritium production applications. Hollow glass microspheres have been used for years in lightweight filler material, insulation, abrasives, and other applications. The SRNL-developed microspheres are unique because of a network of interconnected pores in the microsphere walls, which allow the tiny microspheres to be filled with, hold and release gases and other materials. Because the glass microspheres provide a protective environment, or cocoon, for their contents, they can be used to hold reactive or flammable absorbents or stored materials, including solids, liquids, or gases. This has the potential to provide a safe method of handling, storing, or delivering a variety

of materials. The microspheres also have an application as part of security inks for anti-counterfeiting purposes.
A modified version of the microspheres could be used to deliver medication on target, releasing the drug at will and on a schedule. SpheroFill, a biomedical startup, will initially focus on developing microsphere-based treatments for voice disorders in older individuals and as tissue filler for cosmetic surgery. The company also plans to develop the technology for muscle and bone repair for military use.
The long-term goal involves cancer treatment. The microspheres ability to deliver a drug specifically and locally can allow for higher doses of a chemotherapy drug, for example, within a very limited area without having the side effects common in a systemic treatment.

Kansas City National Security Campus: Next Generation Radar

One of first projects identified as a new priority by the Kansas City National Security Campus (KCNSC) is developing next generation radar. As general university collaborations proved successful, the concept evolved into a more strategic process for maturing technology and university partnerships with the Radar 2021 Consortium. As part of their partnership with the University of Kansas, the KCNSC Radar Consortium recently investigated the snow and ice sheet thicknesses in the Arctic, Greenland, and the Antarctic by testing a KU/KCNSC radar flying over the North Pole. The National Aeronautics and Space Administration (NASA) P-3 plane measured and charted the snow sheet thickness over 89.993º North at an altitude of 1,500 feet.
Another university partner designed and fabricated a miniaturized agricultural radar that operates in the 22 – 26GHz range using a laminate substrate material as part of the Technology Demonstration Panel (TDP) philosophy that was created within this consortium. A second university team designed and fabricated miniaturized additively manufactured (AM) electrical shields to achieve isolation between signal lines on this radar.



Flight path charted for the North Pole overflight (right) with the corresponding KU/KCNSC radar scans of the snow thickness at the red and green dot locations (left).

This flight was a high-priority mission over sea ice and a repeat of a flight line surveyed yearly since 2013 (Fig. 1). NASA was able to benefit from the greatly increased resolution (less than 2cm, Fig. 2) of the KU/KCNSC Radar, while the KCNSC was able to benefit from flight testing and learning more about the application of some of the newly-developed Radar Consortium technology such as miniaturization and increased power. The first iteration included a miniaturized RF section (~5x smaller), increased power (~10x increase), and stretched processing capability for long-range measurements (>12x airplane altitude increase while maintaining high resolution of <2cm).

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 mission of Technology Transfer at NIH is to facilitate partnerships with a wide array of stakeholders and effectively manage the inventions conceived by scientists working at the NIH, FDA, and CDC. In doing so, NIH Technology Transfer supports the larger NIH mission to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability.

Working on behalf of NIH, FDA and CDC, Technology Transfer offices across NIH apply responsive, and sometimes creative approaches to meet the needs of all parties involved, operating with a goal of moving scientific research and discovery forward for the benefit of public health. Technology Transfer at NIH:

- Protects U.S. intellectual property and the discoveries conceived by NIH, FDA, and CDC intramural researchers. This includes working with researchers to determine if an invention warrants patent protection, overseeing the filing of Employee Invention Reports (EIRs), and coordinating the patenting filing and prosecution process.
- Serves as a bridge through marketing and communications, connecting the inventive discoveries made by scientists in the NIH, FDA, and CDC research programs to commercial partners with the capability of developing these technologies into products and services to benefit public health. Without technology transfer, the full potential of these inventions would not be realized, and the public would not receive the full benefit of these biomedical discoveries.
- Facilitates partnerships with outside parties to allow for joint collaboration.
- Negotiates licenses and collaborative agreements such as CRADAs to ensure the timely development of federal technologies, which contribute to society by driving economic growth and productivity; these collaborations leverage the strengths of each institution to advance basic and clinical research objectives.
- Monitors the development of these technologies to ensure commercialization milestones are reached, products are brought to the market, and royalty fees are paid.
- Facilitates the transfer of thousands of research materials and data into and out of NIH.

NIH's annual technology transfer report is available online.

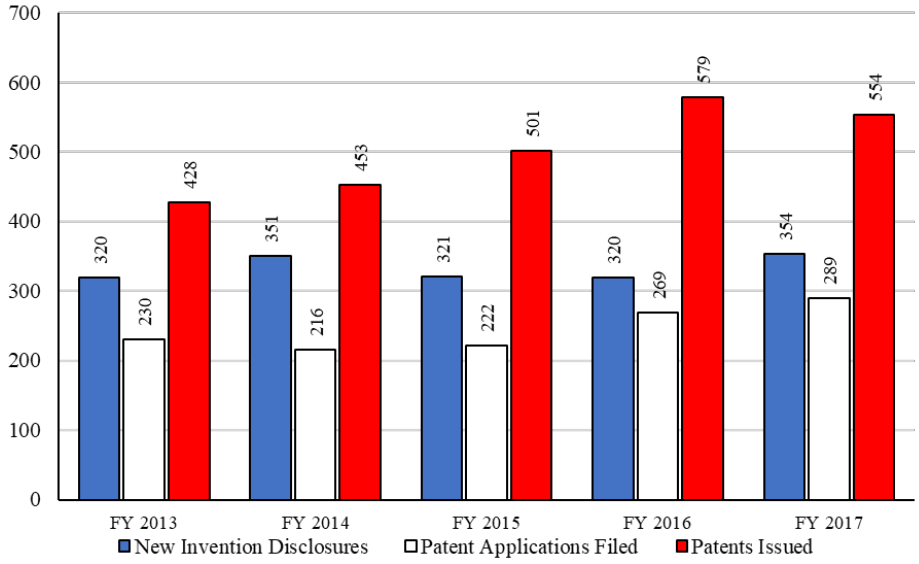
More information about HHS technology transfer activities is available on the following websites:

CDC | NIH | FDA

HHS Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions increased by 11% to 354 disclosures in FY 2017. Patent applications filed increased by 26% to 289, while patents issued increased by 29% to 554 patents.

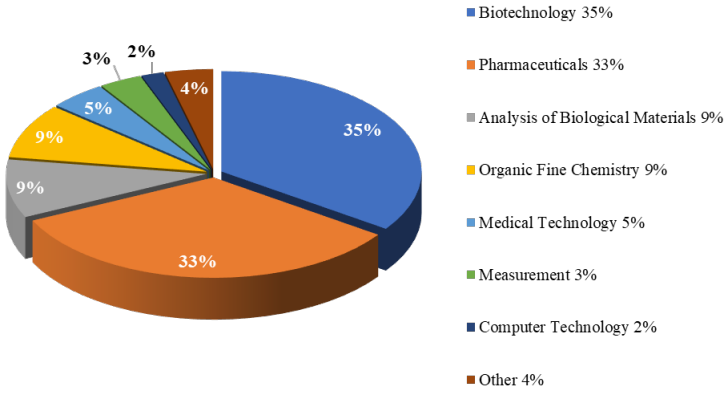
HHS Invention Disclosures and Patenting



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	320	351	321	320	354
Patent Applications Filed	230	216	222	269	289
Patents Issued	428	453	501	579	554

Patents issued to HHS in FY 2017 covered many technology areas including Biotechnology (35%), Pharmaceuticals (33%), Analysis of Biological Materials (9%), and Organic Fine Chemistry (9%).[23]

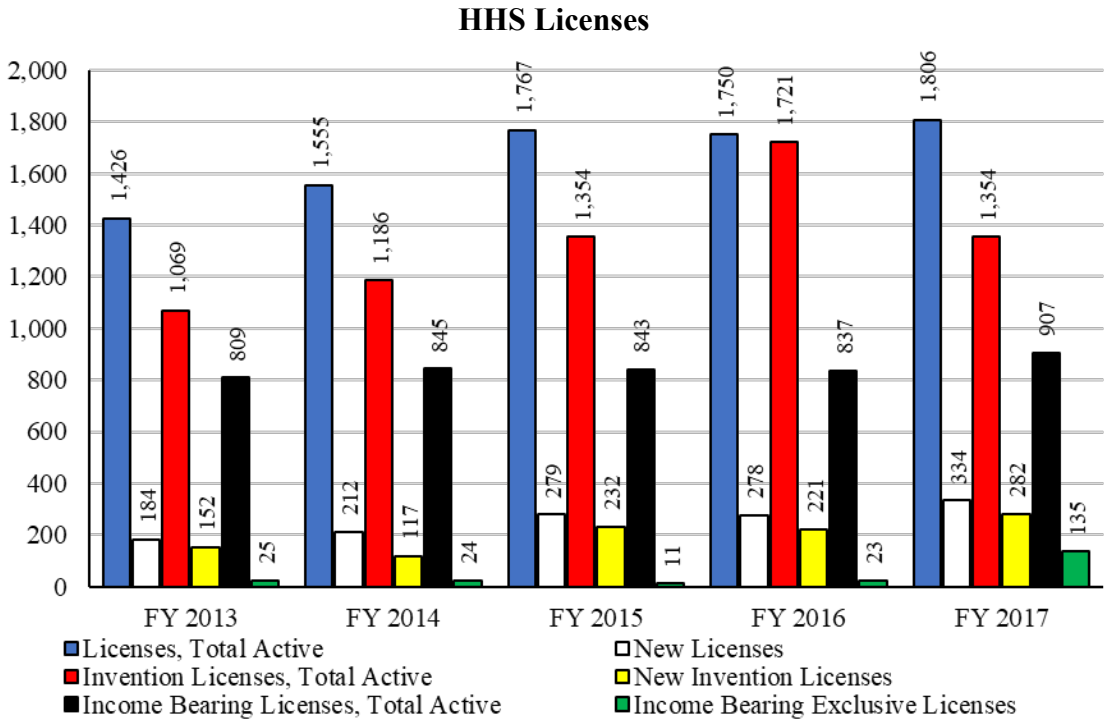
USPTO Patents Assigned to HHS by Technology Area: FY 2017



[23] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

HHS Licenses

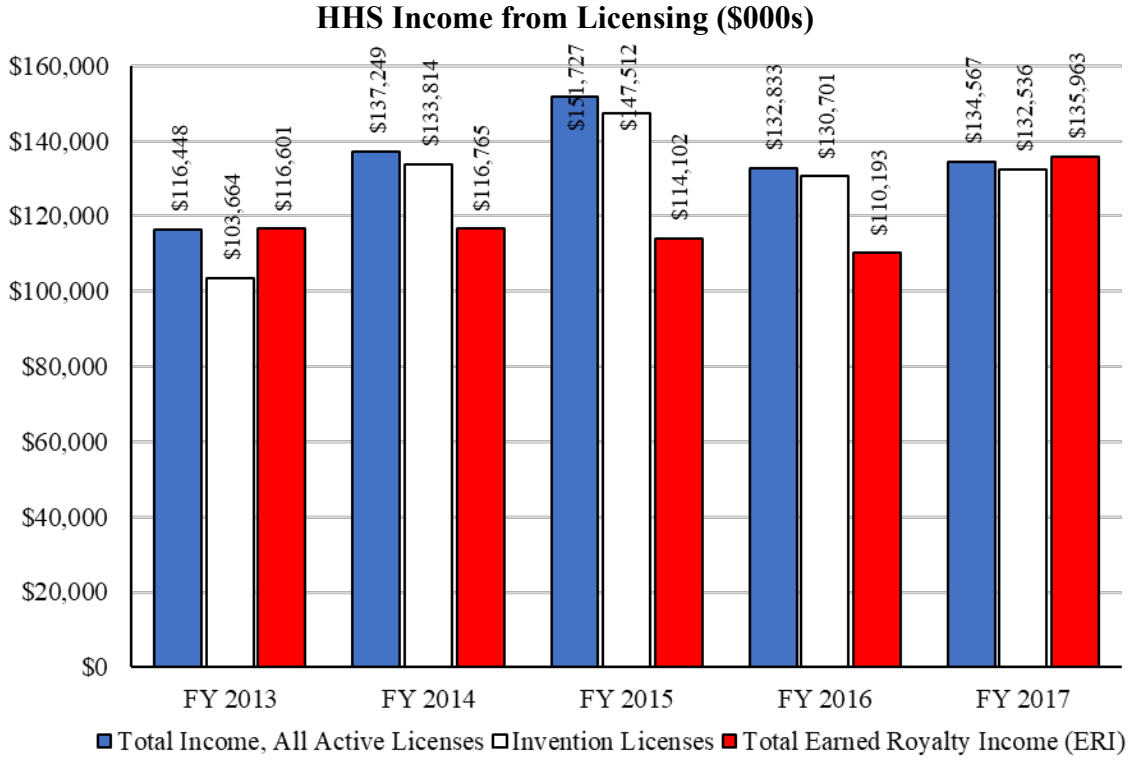
Between FY 2013 and FY 2017, total active licenses increased by 27% to 1,806 licenses in FY 2017. New licenses increased by 82% to 334, total active invention licenses increased by 27% to 1,354 licenses, and new invention licenses increased by 86% to 282. Total active income bearing licenses increased by 12% to 907 while income bearing exclusive licenses increased by 440% to 135 licenses.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	1,426	1,555	1,767	1,750	1,806
New Licenses	184	212	279	278	334
Invention Licenses, Total Active	1,069	1,186	1,354	1,721	1,354
New Invention Licenses	152	117	232	221	282
Income Bearing Licenses, Total Active	809	845	843	837	907
Income Bearing Exclusive Licenses	25	24	11	23	135

HHS Income from Licensing

Between FY 2013 and FY 2017, total income from all active licenses increased by 16% to $134.6 million in FY 2017. The income from invention licenses increased by 28% to $132.5 million, while total earned royalty income increased by 17% to $135.9 million.

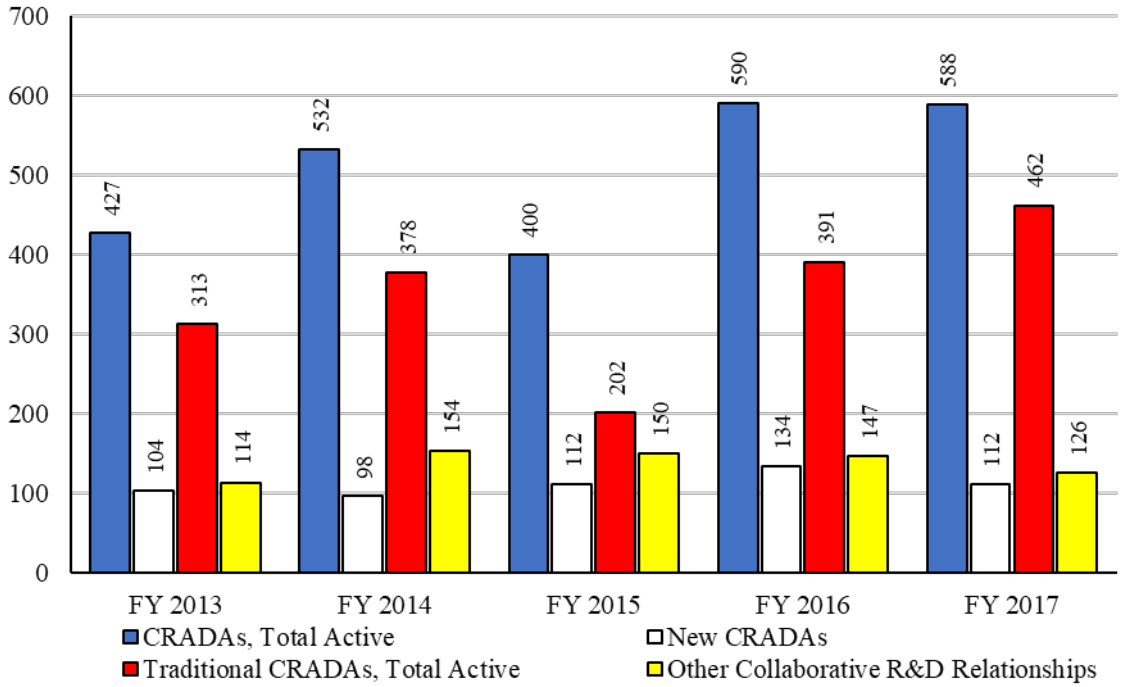


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$116,448	$137,249	$151,727	$132,833	$134,567
Invention Licenses	$103,664	$133,814	$147,512	$130,701	$132,536
Total Earned Royalty Income, (ERI)	$116,601	$116,765	$114,102	$110,193	$135,963

HHS Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 38% to 588 agreements while new CRADA agreements increased by 8% to 112. Traditional CRADAs increased by 48% to 462. Other collaborative R&D relationships increased by 11% to 126.

HHS Collaborative R&D Relationships



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	427	532	400	590	588
New CRADAs	104	98	112	134	112
Traditional CRADAs, Total Active	313	378	202	391	462
Other Collaborative R&D Relationships	114	154	150	147	126

HHS Downstream Success Stories

National Center for Advancing Translational Sciences (NCATS)

Development and Negotiation of Research Collaboration Agreement (RCA) and Inter- Institutional Agreement (IIA) between NCATS and the Universidad Pontificia Catolica (UPC) de Chile for Development of Alzheimer's Compounds
The NCATS Office of Strategic Alliances (OSA) helped establish an RCA for this long standing NCATS National Chemical Genomics Center project. NCATS and UPC investigators have developed two new selective and powerful inhibitors of the Kinase c-Abl, both of which pass the Blood Brain Barrier (BBB) and reduce the progression of cognitive impairment and neurodegenerative pathology of Alzheimer's disease in mice models. NCATS and UPC have developed new Intellectual Property (IP) on these two inhibitors so an Inter-Institutional Agreement (IIA) is being negotiated in order for NCATS to take the lead in filing patents and licensing the compounds. The IIA negotiation has also been an educational and mentorship activity for UPC.

National Cancer Institute (NCI)

FDA Approval of Personalized Cancer Treatment to Cure Deadly Blood Cancers
The NCI, in collaboration with Kite Pharma, Inc., developed a new FDA approved treatment shown to cure several types of deadly blood cancers. This unique therapy utilizes live cells and harnesses the power of a patient's immune system to combat their cancer. A subset of a patient's own immune cells, called T cells, are genetically modified to recognize the cancer cells. The patient's cells are collected, modified, and grown in the laboratory until they number in the billions. These programmed cancer-fighting cells are then re-infused into the patient, armed with the ability to potentially recognize and attack cancer cells. This treatment is a "live therapy" consisting of a single infusion. The target that these engineered cells recognize is called CD-19; it is expressed in B cells, a subset of immune cells.

NCI's Technology Transfer Center (TTC) played a proactive role in this discovery-to-commercialization story. It began with facilitating a partnership with an industry partner strongly committed to advancing this novel approach for the treatment of B-cell Non-Hodgkin Lymphoma (NHL). This led to negotiating a complex, clinical trial CRADA involving both pre-clinical studies and later clinical trials using treatments made under stringent Good Manufacturing Practices (GMP) conditions. Successful development of the technology required effective coordination of diverse, multi-disciplinary programs within and external to the NCI – comprising clinical compliance, regulatory affairs, GMP grade manufacturing, research scientists and TT professionals (including licensing, patenting, and other technology transfer activities).

Kite's expertise enabled further development of the treatment and larger clinical studies in cancer patients. Armed with positive patient data from the early clinical trials, Kite submitted a Biologics License Application (BLA) to the FDA in March 2017 and was granted Priority Review.

The synergy of NCI's scientific/clinical expertise with Kite's clinical, regulatory, manufacturing, operation, and business capabilities was essential to the successful development and commercialization of this therapy and other products to address deadly cancers. Throughout the course of this TT process was a persistence to develop an immunotherapy that could benefit patients who are dying despite all other treatments. This is a significant medical breakthrough for this type of cancer. The impact of the successful clinical results that came out of this transfer was evidenced by the swift FDA approval of the therapy in October 2017.

Potential Therapy for Menkes Disease, Rare Pediatric Disorder, Gets Much Needed Commercialization Partner

In March 2017, NCI TTC helped execute a CRADA and an exclusive patent license between Cyprium Therapeutics, Inc. (Cyprium) and the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD). The CRADA and License represent a significant translational step toward providing therapeutic options for patients with Menkes Disease, a rare genetic condition affecting copper movement through the body. If untreated, Menkes Disease causes death in children as young as three years old.

The CRADA and license agreement are structured to have parallel and complementary provisions that strengthen each other towards the primary objective of obtaining Food and Drug Administration (FDA) approval. The transferred technology includes regulatory assets, such as clinical data sets. It is the result of 20 years of research led by NICHD's Stephen G. Kaler, M.D. With these agreements in place, NICHD and Cyprium will collaborate to further develop the technology, and Cyprium's expertise in regulatory process and commercialization should aid efforts to obtain FDA approval. The collaboration presents a significant opportunity to advance gene therapy.

Data Transfer Agreement Template to Facilitate Data Collection for Melanoma Susceptibility

NCI TTC worked with the NCI Division of Cancer Epidemiology and Genetics (DCEG) and the University of Chicago to develop a Data Transfer Agreement (DTA) template that involves access to 'data in the cloud.' The DTA template is for use among members of the melanoma genetics consortium (GenoMEL), comprised of 10-15 research groups located throughout the world. The University of Chicago controls a private, open-source cloud computing infrastructure to which GenoMEL members will be contributing and from which metadata will be analyzed to identify melanoma susceptibility genes. This collaborative project presents an opportunity to find melanoma susceptibility genes when the data are combined from a large quantity of samples and analyzed by individual groups specialized in an environment with consistent and common workflows. The DTA template includes considerations of human subject data residing in a cloud environment and can be used for future, similar projects.

Low-cost Rotavirus Vaccine in Developing Countries

In 2013, 215,000 diarrheal deaths in children less than 5 years old were caused by rotavirus; most of which were in Asia and Africa, with around 22% in India. Although

rotavirus vaccines are commercially available, affordability is a challenge in developing countries. Children in developing countries are disproportionately at risk of dying from rotavirus-related infection, due in part to inadequate sanitation and inadequate access to intravenous rehydration therapy.

The late Dr. Albert Kapikian and his colleagues at the National Institute of Allergy and Infectious Diseases (NIAID) invented a human-bovine reassortant rotavirus vaccine which offers broad protection against five most common rotavirus serotypes. In addition, this vaccine is stable at room temperature and does not require cold- chain transport, delivery, and storage. In 2005, Serum Institute of India, one of the largest vaccine manufacturers in the world, obtained a patent commercialization license from NIH/NIAID to develop, manufacture and distribute this vaccine as the product called ROTASIIL.

In September 2017, ROTASIIL was found to be very safe, well tolerated, and efficacious in a phase III clinical trial conducted in India. The Drug General Controller of India has reviewed the results of this study and approved the vaccine. The Government of India has subsequently ordered 3.8 million doses of ROTASIIL to use in the Universal Immunization Programme, which serves 26 million children in India. Serum Institute of India has 19 vaccines that are WHO prequalified and supplied to developing countries at low prices. It has the capacity to produce 100 million doses of ROTASIIL and is expected to supply ROTASIIL to other developing countries at low prices.

Develop Mosquito Trap for Control and Surveillance of Mosquitoes Including Carriers of Zika and Other Viruses

Viral and bacterial diseases spread by vectors (e.g., mosquitoes, ticks, and other insects) are a significant public health problem. Dengue, Zika, chikungunya, and yellow fever viruses are predominately transmitted by the *Aedes* species (*aegypti* and *albopictus*) mosquitoes. *Aedes* mosquitoes are adept at spreading these viruses as they have adapted to living in urban environments and feed during the times of day when people are most active.

Researchers within the Division of Vector-Borne Diseases at the CDC began development of a low-cost, pesticide-free method for controlling mosquito populations. The resulting invention is an autocidal gravid ovitrap (AGO trap) that consists of a five-gallon (10 L) plastic bucket with a modified lid containing a capture chamber, which has a glue board specifically designed to trap adult mosquitoes. Water and grass are placed in the bottom of the bucket; the decaying grass provides a natural attractant to pregnant mosquitoes looking for places to lay their eggs. However, once inside the trap, the females cannot successfully lay their eggs and are unable to escape. Other types of mosquito attractants may also be used.

The AGO trap requires no power, no pesticide, and is economical to manufacture. It has also shown efficacy for at least two months without changing the glue board or refilling the water/grass mixture, in marked contrast to weekly application of pesticides that can be unsafe for use around children, pets, and livestock. The AGO trap has been used by

CDC researchers in field trials in Puerto Rican sites since 2011, demonstrating a 60-80% reduction of *Aedes* mosquito populations and a 50% lower prevalence of chikungunya virus in test sites and neighborhood.

Through patent and licensing efforts by NIAID's Technology Transfer and Intellectual Property Office, which manages CDC's invention portfolio, CDC has licensed the related patent rights to a US company. CDC is also seeking additional commercial partners, both foreign and domestic, with the goal of distributing the AGO trap to as many people and communities as possible worldwide.

Sharing Zika Specimens and Diagnostic Technologies to Combat the Epidemic
CDC has transferred Zika virus specimens and CDC-developed diagnostics to support the public health response for the Zika virus outbreak beginning in February 2016. By January 2018, CDC had shipped relevant Zika specimens to approximately 20 countries and 34 U.S. states and territories, and such efforts continue today. The CDC Technology Transfer Office (TTO) consulted and collaborated with interagency specimen sharing efforts as needed in addition to handling 186 transfer agreements - 160 Simple Letter Agreements (SLA) and 26 Material Transfer Agreements - and transfers of its own. The different strains/isolates of the Zika virus are essential to further Zika research, increase knowledge about the virus, and support vaccine and diagnostic test development.

CDC was the first organization to develop and receive an Emergency Use Authorization (EUA) from the Food and Drug Administration (FDA) for a Zika diagnostic assay (the Zika MAC-ELISA), which detects Zika virus antibodies in blood and cerebrospinal fluid. CDC is pursuing patent protection for key components of this assay. CDC has executed licenses with four major reference laboratories for clinical testing of patient samples and has also licensed this technology to a fifth company for mass production of an EUA-compliant kit for use by public health laboratories.

CDC has also developed and obtained an EUA for a PCR-based assay method (called CDC Trioplex) to detect Zika, dengue, and chikungunya viruses in patient samples, which would enable simultaneous, rapid testing of these three mosquito-borne diseases. CDC is pursuing a patenting and licensing strategy similar to that used for the Zika MAC-ELISA, with the ultimate goal of facilitating broad public access to reliable diagnostics for Zika, dengue, and chikungunya viruses simultaneously.

These transfers, memorialized in a variety of transactional agreements, were made possible through the joint efforts of the CDC's TTO and NIAID's Technology Transfer and Intellectual Property Office. The Federal Laboratory Consortium for Technology Transfer (FLC) recognized these important public health accomplishments with its 2017 FLC Excellence in Technology Transfer Award for "Zika Virus Specimens for Research & Development and Diagnostic Technologies."

Development and Manufacture of Rabies Vaccine with Ethiopian Public Health Institute
Rabies is a vaccine-preventable viral disease which occurs in more than 150 countries and territories. Infection causes tens of thousands of deaths every year, with over 95%

occurring in Asia and Africa. 40% of people bitten by suspect rabid animals are children under 15 years of age. Although effective human vaccines and immunoglobulins exist for rabies, these products are not readily available to those in need. Treating a rabies exposure, where the average cost of rabies post-exposure prophylaxis (PEP) is 40 USD in Africa, and 49 USD in Asia, can be a catastrophic financial burden on affected families in low income countries.

CDC has signed a non-exclusive license with Ethiopian Public Health Institute (EPHI) for a rabies virus vaccine strain. EPHI is a non-profit institution of the Ethiopian federal government established to carry out research on priority diseases, nutrition, traditional and modern medicine, and production of vaccines. This license allows EPHI to develop a method of mass production, and then produce and distribute this rabies vaccine to Ethiopian citizens at low cost.

National Institute of Neurological Disorders and Stroke (NINDS)

NINDS Technology Transfer Office negotiated agreements with Pfizer, UCB, GSK and Eisai for the transfer of large epilepsy datasets from previous clinical studies performed independently by these entities. The central goal of the meta-analysis is to study the influence of natural variability of seizures on study outcome. This research will provide clarity on whether the variability in seizure frequency is actually predictable. The study will also provide insight that can guide future clinical studies on epilepsy and the treatment of the disorder.

Under a clinical CRADA negotiated by NINDS Technology Transfer Office and executed in FY 2017, the National Institute of Neurological Disorders and Stroke (NINDS), an institute of NIH, is collaborating with Audentes Therapeutics, Inc. as one site in a multi-site pre-Phase 1 prospective, non-interventional clinical assessment study in X-linked Myotubular Myopathy (XLMTM) subjects aged 3 years and younger (INCEPTUS).

NINDS Technology Transfer Office piloted a six-month agreement lifecycle assessment. This effort required documenting an agreement's movement through every step in the negotiation process and analyzing the data. Through these efforts, the office has established an average agreement lifecycle as the basis on which to assess the effectiveness of future initiatives to improve efficiencies. Additionally, this effort led to the identification of one process element that was changed to increase overall efficiency. The office had a nearly 90% resolution rate for agreements initiated in FY 2017.

Department of Homeland Security (DHS)

The DHS's Office of Research and Technology Applications (ORTA) resides within the Science and Technology Directorate (S&T). The ORTA develops and institutes policies to facilitate technology transfer in accordance with 15 U.S.C. § 3710 in consultation with and assisted by the Office of the General Counsel's Technology Programs Law Division supporting S&T and 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 CRADAs, licensing, and other technology transfer agreements;
- Prepares application assessments for selected R&D projects in which the DHS Laboratory is involved and may have commercial applications;
- Provides and disseminates information on federally owned or originated technologies which have potential application to state and local governments and private industry;
- Prepares and provides an annual report to Congress and the President through submission to NIST;
- Develops training programs on technology transfer and intellectual property for DHS employees; and
- Establishes and implements a royalty and rewards policy.

More information about DHS technology transfer activities is available online.

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[24]. 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 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

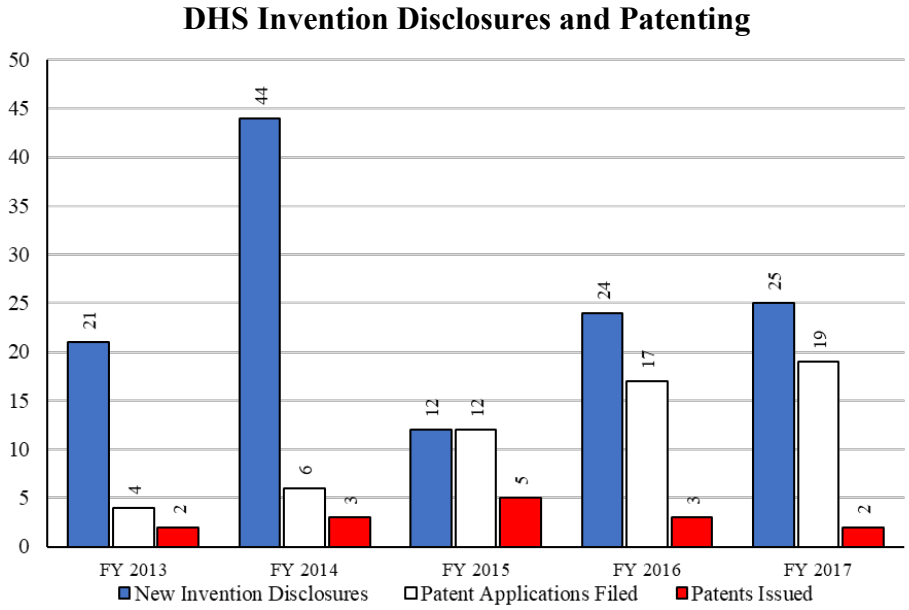
[24] The "Valley of Death" refers to the difficulties entrepreneurs and developers face when trying to fund new, high-risk, early stage technologies and products. Transfer recipients of federal technologies often face the Valley of Death because technologies from federal labs tend to have a low readiness level and require additional funding to support further development and integration costs.

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 online.

DHS Invention Disclosures and Patenting

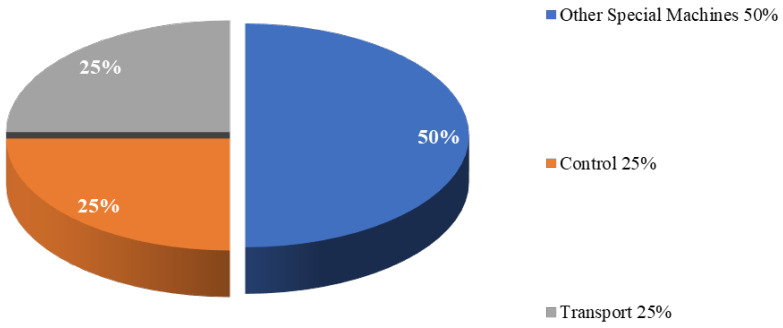
In FY 2017, DHS reported 25 new inventions disclosures, an increase of 19% from FY 2013. DHS filed 19 patent applications, and two patents were issued FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	21	44	12	24	25
Patent Applications Filed	4	6	12	17	19
Patents Issued	2	3	5	3	2

Patents issued to DHS in FY 2017 covered three technology areas: Other Special Machines (50%), Control (25%), and Transport (25%).[25]

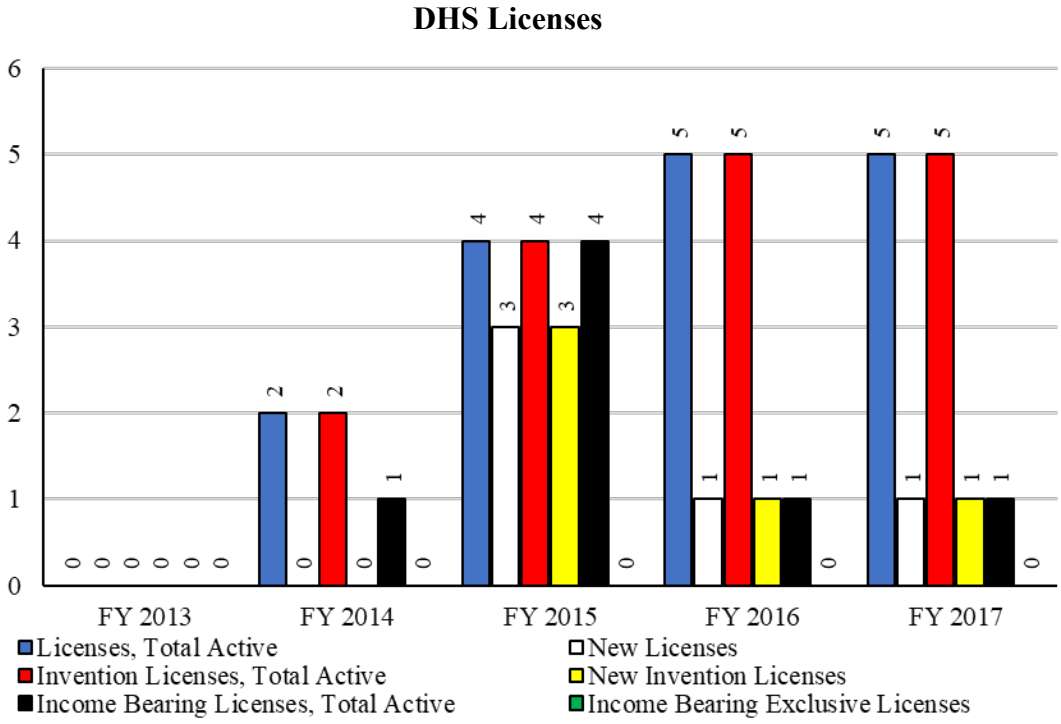
USPTO Patents Assigned to DHS by Technology Area: FY 2017



[25] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

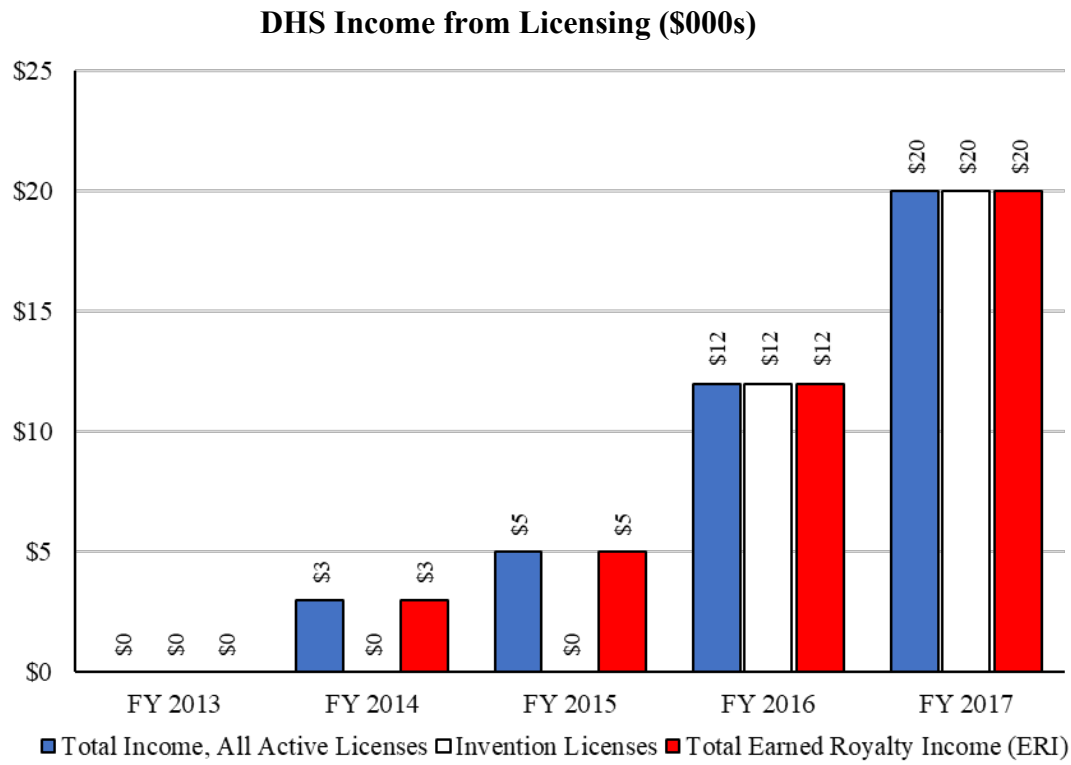
DHS Licenses

In FY 2017, DHS managed 5 active license agreements and executed 1 new license agreement. Out of the 5 active agreements, one was income bearing.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	0	2	4	5	5
New Licenses	0	0	3	1	1
Invention Licenses, Total Active	0	2	4	5	5
New Invention Licenses	0	0	3	1	1
Income Bearing Licenses, Total Active	0	1	4	1	1
Income Bearing Exclusive Licenses	0	0	0	0	0

DHS Income from Licensing
In FY 2017, DHS received a total of $20,000 in licensing income.

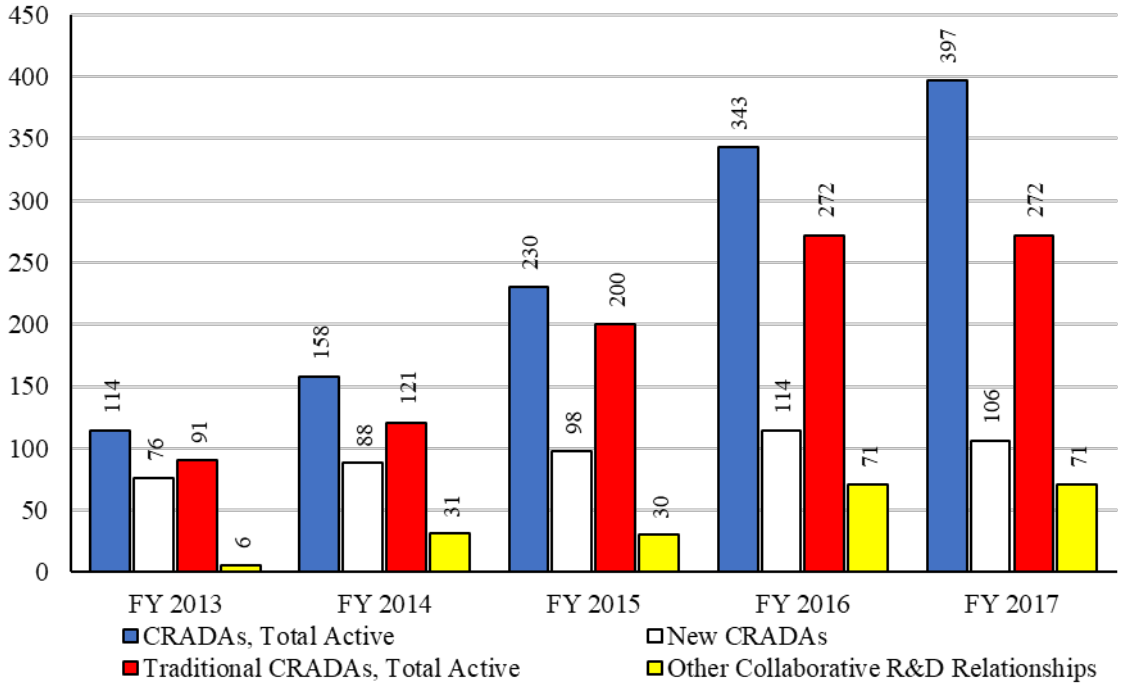


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$0	$3	$5	$12	$20
Invention Licenses	$0	$0	$0	$12	$20
Total Earned Royalty Income, (ERI)	$0	$3	$5	$12	$20

DHS Collaborative R&D Relationships

Total active CRADAs increased by 248% to 397 agreements in FY 2017. New CRADAs increased by 39% to 106 new agreements in FY 2017. Traditional CRADAs increased by 199%, from 91 agreements in FY 2013 to 272 agreements in FY 2017. Other collaborative R&D relationships increased by 1,083% to 71.

DHS Collaborative R&D Relationships

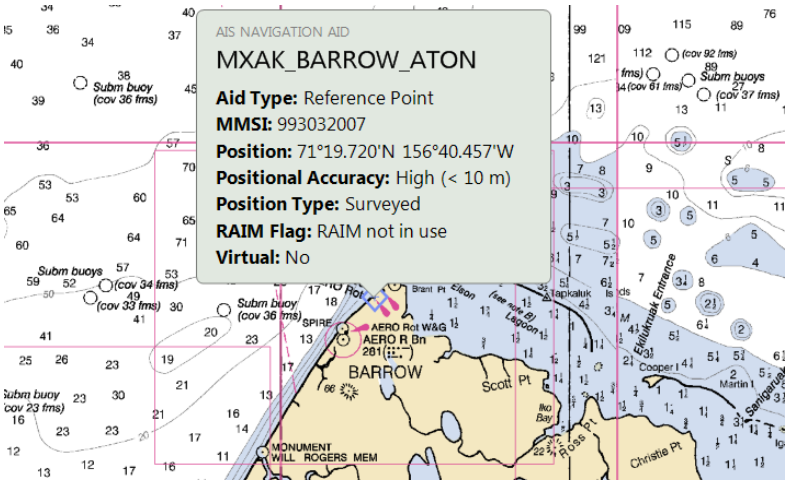


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	114	158	230	343	397
New CRADAs	76	88	98	114	106
Traditional CRADAs, Total Active	91	121	200	272	272
Other Collaborative R&D Relationships	6	31	30	71	71

DHS Downstream Success Stories

Next Generation Arctic Navigational Safety Information System, Project 6211

The U.S. Coast Guard Research and Development Center (RDC) partnered with the Marine Exchange Alaska (MXAK) to transmit critical safety and navigation information to mariners in the Arctic Region. The RDC assisted MXAK in establishing a transmit capability with its deployed Automatic Identification System (AIS). The RDC sponsored MXAK in gaining limited, experimental approval to transmit information over AIS through the CRADA period. The RDC and Coast Guard District 17 were able to use MXAK's AIS infrastructure to transmit vital weather information, navigation safety messages, ice edge information, virtual and synthetic aids to navigation, and other application-specific messages to mariners within range of AIS transmitters.



Rose Point navigation display screen capture of MXAK AtoN transmission in vicinity of Barrow, AK.

This partnership benefitted both the Coast Guard and MXAK by allowing the RDC to utilize an existing public-private AIS system in Alaska to develop a method to gather, manage, and transmit critical safety information to Arctic mariners. The partnership benefitted MXAK by assisting them in developing the capability to process critical information from NOAA, National Weather Service, District 17, and other authorized sources; route the information over their infrastructure; and share the information via the appropriate AIS transmitters. This collaboration supported the following end users: Federal, State, Local and Tribal Public Safety and Law Enforcement (including Coast Guard), Department of Defense, and the commercial market.

Foot-and-Mouth Disease Rapid Diagnostic Test Kit

DHS S&T's Plum Island Animal Disease Center (PIADC) worked with a research consortium of federal agencies, academia, and animal health industry scientists to develop a rapid-response Foot-and-Mouth Disease (FMD) diagnostic kit for use with U.S. livestock. The U.S. Department of Agriculture (USDA) Center for Veterinary Biologics granted a product license for the FMD Virus Antibody Test Kit to S&T/PIADC's CRADA partner, Veterinary Medical Research and Development (VMRD), Inc. in June 2017.

FMD virus is highly contagious in cloven-hoofed animals, including cattle, swine, and sheep. With one in nine Americans employed in the agriculture or allied industries, an FMD outbreak in the U.S. could have catastrophic economic and animal welfare impacts.

With the new kit, diagnostic results are available in 3 hours, as opposed to 18-20 hours for the current gold standard used in laboratories. Diagnostic time matters when thousands of FMD-

susceptible livestock and products are transported within the U.S. daily. In addition, this product is the first FMD diagnostic test licensed and manufactured in the U.S., increasing surge capacity and decreasing response and recovery time in the event of a large FMD outbreak.
VMRD, Inc., a U.S. manufacturer of veterinary diagnostics in Pullman, WA, is selling the high-performance test kit. FMD diagnostic kits are restricted in the United States. Their sale and use can only be to approved laboratories under the supervision or control of the USDA as part of an official USDA control or eradication animal disease program. DHS S&T also granted VMRD an intellectual property license for the test and a patent application has been filed with the U.S. Patent and Trademark Office.

Department of the Interior (DOI)

Technology transfer for the DOI includes a range of activities designed to disseminate scientific and technical information and knowledge between the DOI, other federal agencies 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 the 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 that the DOI took in FY 2017 to advance technology transfer. These range from developing new technologies that would help identify various materials in water to improved methods to measure water quality in high biofouling environments. 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 2017 enacted budget for the DOI included $994.2 million for research and development. The majority of the funding was for applied research ($776.6 million), while basic research and basic development received $54.38 million and $163.3 million, respectively. The programs supported through these funds generate new and improved knowledge, information, and technology, which help the DOI meet its mission objectives and are transferred to resource managers, stakeholders, and the public.

The DOI's bureaus have varying levels of involvement with scientific and technical research and innovation, and technology transfer. In FY 2017, as in previous years, the majority of technology transfer activities reported by the DOI under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS), which is the largest research and development (R&D) organization in the Department, both in terms of budget and personnel. Typically, USGS accounts for over 70 percent of the DOI's R&D budget.

The DOI's scientists, engineers, and other technical personnel advance the state of knowledge related to the resources it manages and ensure that this information is accessible to resource managers, private industry, and the public. The majority of the 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 2017, DOI personnel authored or co-authored over 12,300 reports, books, fact sheets, and other publications, including almost 4,500 scientific publications.

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 15 federal agencies and more than 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.

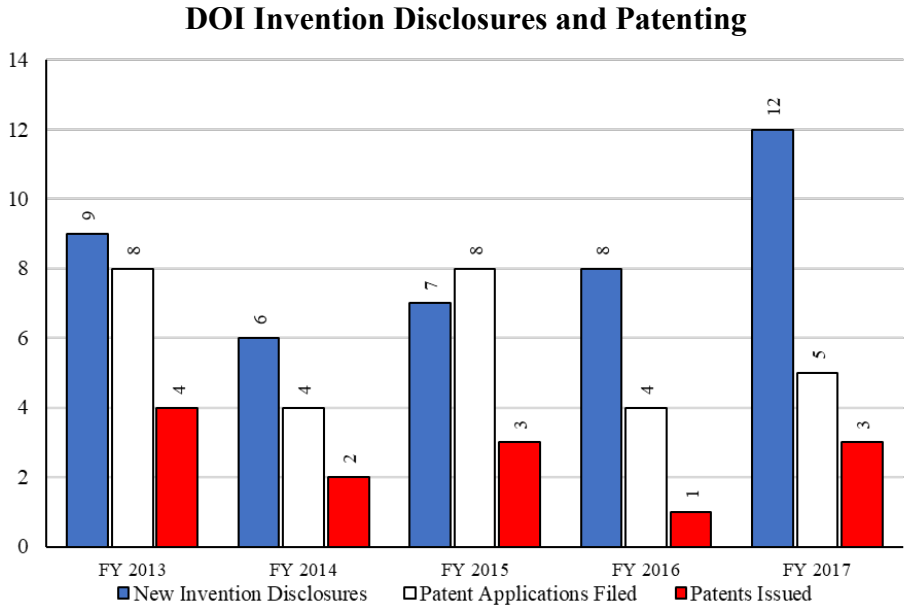
Bureaus that are active in research and development, or have research capabilities that complement U.S. commercial interests, may also utilize technology transfer agreements authorized by the FTTA to join forces with non-Federal partners. Such agreements allow the DOI's bureaus and private sector industries 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. This report focuses primarily on, but is not limited to, aspects of technology transfer related to the FTTA.

DOI's annual technology transfer report is available online.

More information about DOI technology transfer activities is available online.

DOI Invention Disclosures and Patenting

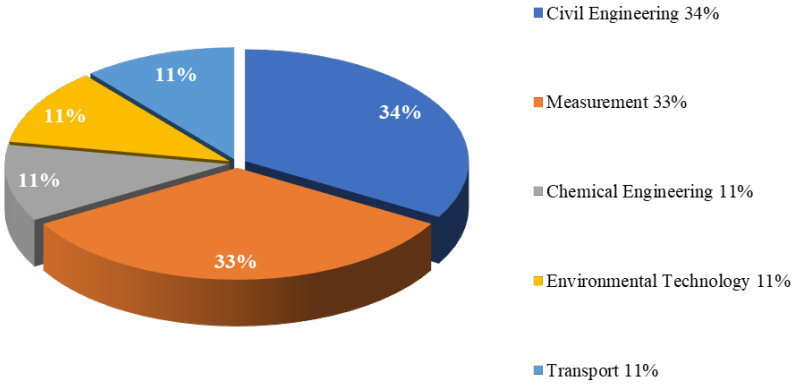
From FY 2013 to FY 2017, new inventions disclosed increased by 33% to 12 disclosures. Patent applications filed decreased by 38% to 5. Patents issued decreased by 25% to 3 in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	9	6	7	8	12
Patent Applications Filed	8	4	8	4	5
Patents Issued	4	2	3	1	3

The patents issued to DOI in FY 2017 covered three technology areas: Civil Engineering (34%), Measurement (33%), and Chemical Engineering (11%).[26]

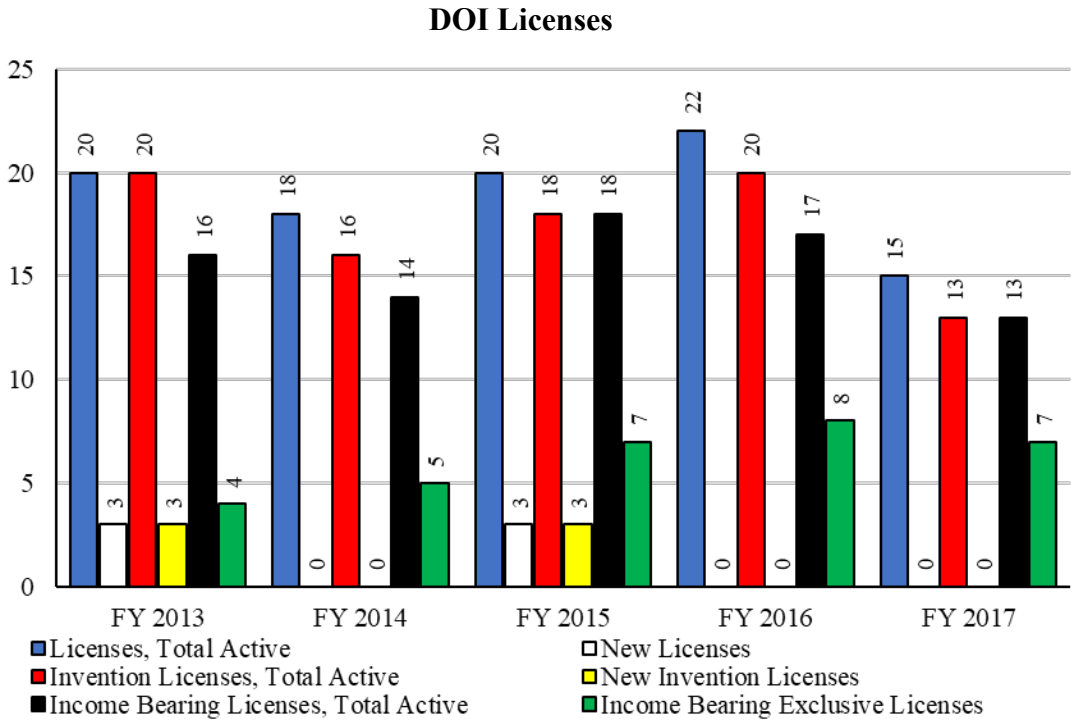
USPTO Patents Assigned to DOI by Technology Area: FY 2017



[26] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

DOI Licenses

From FY 2013 to FY 2017, total active licenses decreased by 25% to 15 licenses in FY 2017. Total active invention licenses decreased by 35% to 13 licenses from FY 2013 to FY 2017, and income-bearing exclusive licenses increased by 75% to seven licenses. There were no new licenses in FY 2017.

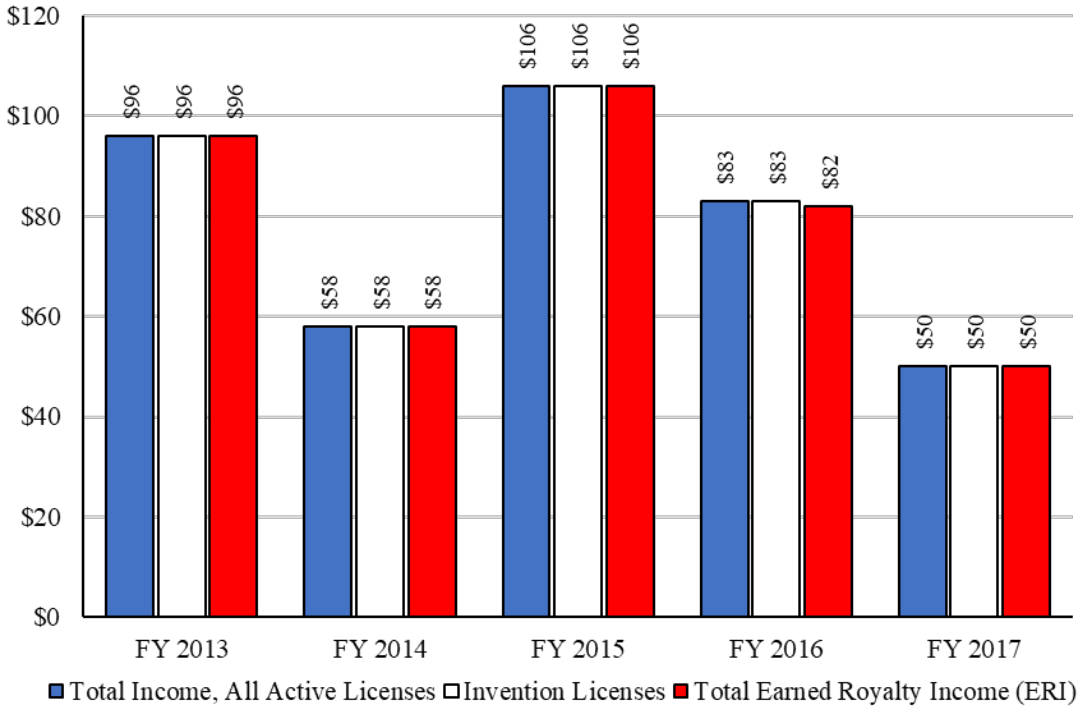


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	20	18	20	22	15
New Licenses	3	0	3	0	0
Invention Licenses, Total Active	20	16	18	20	13
New Invention Licenses	3	0	3	0	0
Income Bearing Licenses, Total Active	16	14	18	17	13
Income Bearing Exclusive Licenses	4	5	7	8	7

DOI Income from Licensing

Between FY 2013 and FY 2017, total income from all active licenses decreased by 48% to $50 thousand in FY 2017. The income from invention licenses increased by the same amount, as all income received came from invention licenses. Total earned royalty income also decreased by 48% to $50 thousand in FY 2017.

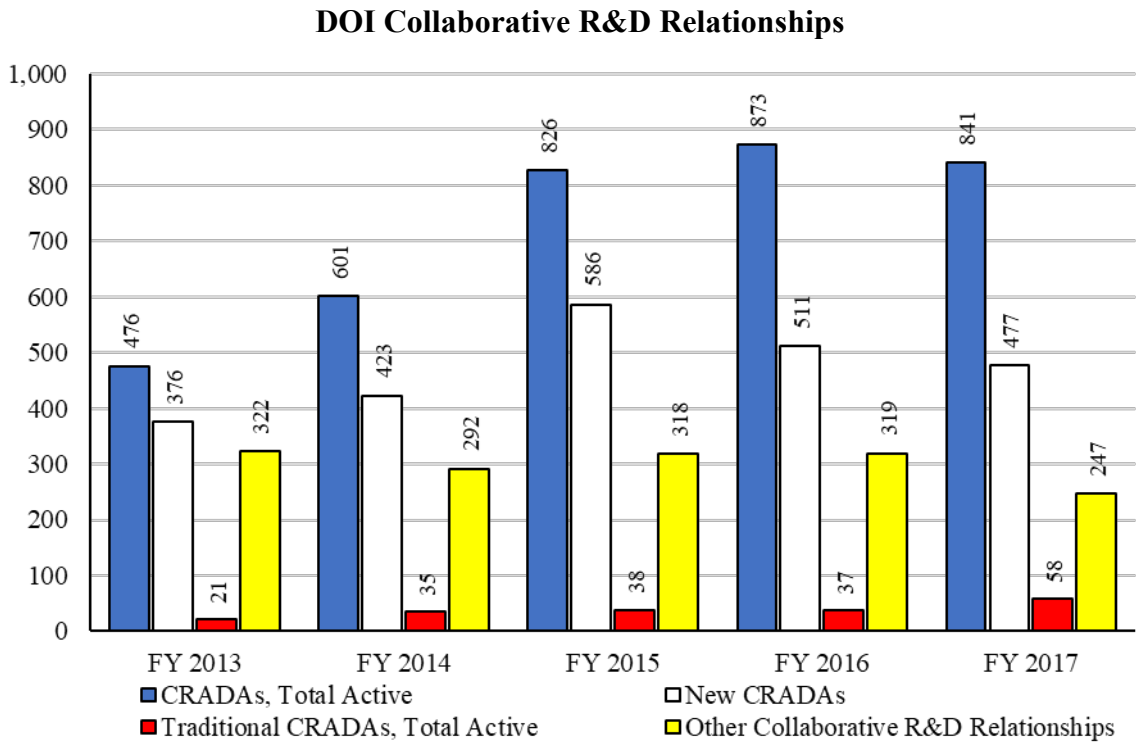
DOI Income from Licensing ($000s)



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$96	$58	$106	$83	$50
Invention Licenses	$96	$58	$106	$83	$50
Total Earned Royalty Income, (ERI)	$96	$58	$106	$82	$50

DOI Collaborative R&D Relationships

From FY 2013 to FY 2017, total active CRADAs increased by 77% from 476 to 841 agreements. New CRADAs increased by 27% to 477 new agreements in FY 2017. Traditional CRADAs increased by 176%, from 21 to 58 agreements. Other collaborative R&D relationships decreased by 23% to 247.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	476	601	826	873	841
New CRADAs	376	423	586	511	477
Traditional CRADAs, Total Active	21	35	38	37	58
Other Collaborative R&D Relationships	322	292	318	319	247

DOI Downstream Success Stories

United States Geological Survey: Inter-American Development Bank – Scientific Information Related to Energy and Mineral Industries in the Caribbean and Latin America (LAC)

USGS and the Inter-American Development Bank (IDB), established a CRADA to collaborate on research, and compile and develop geospatial information related to energy and mineral resources within Latin America and the Caribbean (LAC).

The IDB is the main source of multilateral financing for economic, social, and institutional development in the LAC region through loans, grants, guarantees, policy advice, and technical assistance to public and private sectors of its borrowing member countries. The IDB is seeking to develop knowledge products that contribute to promote sustainability and transparency in the extractive industries in the LAC region. The USGS, with its geotechnical expertise and global understanding of resource geology and extractive industries, is well positioned to provide the science and information needed by the IDB for this effort.

The USGS-IADB joint work effort is taking place in phases. Additional Project Annexes, with specific objectives, tasks, and budget for each phase will be developed and implemented cooperatively. The USGS proposes to expand this collaborative work effort in subsequent phases to include work on a mineral resources inventory and, eventually, water resources and other hydrology projects.

United States Geological Survey: Development of fine-scale temperature models in the Delaware River

Researchers SCUBA dive to deploy fiber-optic temperature sensing cable on the bottom of the river to develop thermal maps of the river bottom. [Photo Credit: Leanne Hanson, USGS]

The USGS entered into a CRADA with the Academy of Natural Sciences of Drexel University to develop models to project temperatures in the Delaware River for use in decision support tools and ecosystem service models.

The Delaware River supports multiple competing water demands including recreation, saltwater repulsion, flood mitigation, and endangered species. USGS researchers at Fort Collins Science Center (FORT) developed the Riverine Environmental Flow Decision Support System (REFDSS) as part of the Department of the Interior's and USGS's WaterSMART initiative to evaluate flow management practices and their effects on aquatic species within the Delaware River Basin. This knowledge will assist managers at the National Park Service and the U.S. Fish and Wildlife Service. The REFDSS models habitat availability for key recreational and ecologically important species at 11 sites in the upper Delaware River Basin, three of which lie within the Upper Delaware Scenic and Recreational River.

1Researchers use unmanned aircraft with mounted thermal cameras to develop temperature maps of the river. [Photo Credit: Leanne Hanson, USGS]

The Delaware River was also selected as one of USGS's focal areas for the Sustaining Ecological Capital program (SEC), designed to incorporate ecosystem services into Federal planning. Researchers from USGS Northern Appalachian Research Laboratory (NARL) and FORT have been collaborating to evaluate the economic benefit of clean water provided by freshwater mussels and incorporate this information into the REFDSS. A critical component to both the USGS-led WaterSMART and SEC initiatives, however, is the effects of stream temperature on the habitat of and ecosystems services provided by freshwater organisms. Funding provided by the William Penn Foundation through Drexel University was awarded to USGS NARL and FORT to:

- Test available technology for collecting high-resolution temperature data;
- Develop predictive high-resolution temperature models for multiple sites;
- Determine thermal tolerances for key aquatic species;
- Determine relationships between temperature and key ecosystem services;
- Incorporate these findings into the REFDSS for use by resource managers.

This thermal research component in the Delaware River will broaden the applicability of the REFDSS as a research and management tool and provide additional sought-after data pertaining to other endangered and invasive species of interest. The ability to incorporate a thermal component into the REFDSS and the SEC through funding from Drexel University will greatly enhance these highly valuable scientific endeavors in the basin and facilitate informed decision making by managers and stakeholders as they relate to both ecology and water quality of the basin.

U.S. Fish and Wildlife Service (FWS) - Fish Technology Centers

Most of the eight Fish Technology Centers (FTCs) were established in 1965 to develop and improve fish culture technology and provide assistance and advice on fish culture to National Fish Hatcheries, other Federal and State agencies, Tribes, other Nations, and the aquaculture industry. The FTCs developed culture techniques and fish diets now used around the world, including dehydrated long-lasting feeds that revolutionized the fish-culture industry. Results of studies conducted by FWS scientists are published in peer-reviewed journals and management recommendations are communicated within the Service and to our partners through conservation science partnerships.

- **Nutrition and Diet Development Laboratories.** These facilities allow for the manufacture of experimental larval, fingerling, and broodstock fish feeds and the testing of many different kinds of ingredients to improve fish nutrition, performance, and

quality. This program also develops specialized diets for use in captive rearing of endangered fish species.

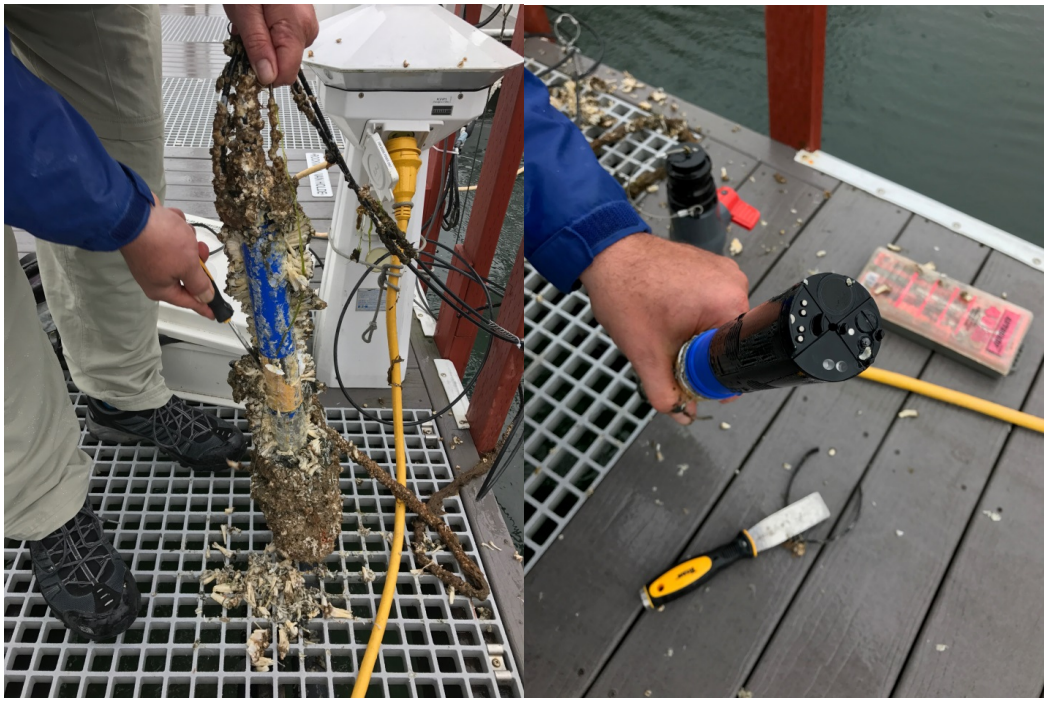
- **Physiology Laboratories**. These laboratories support conservation- and management-related needs of FWS and its partners, including, but not limited to, understanding the physiological needs of fish to support conservation and/or commercial opportunities.
- **Conservation Genetics Laboratories.** These laboratories support conservation and management related needs of FWS and its partners, including, but not limited to: (a) using genetic DNA methods to meet real-time fishery needs to conserve and manage species; (b) assisting with Endangered Species Act status reviews and recovery planning via baseline data on genetic population structures and genetic monitoring and evaluation of listed populations and species; (c) establishing and maintaining genetic tissue/DNA repositories for imperiled species; and (d) characterizing diversity within and among wild populations.
- **Ecology Laboratories.** These laboratories focus on understanding the physiological requirements and tolerances of threatened and endangered species. Less invasive or non-invasive tools, such as measurement of plasma sex steroids and ultrasound, are used to determine gender, stage of sexual maturity, and spawn readiness of individual fish in wild and captive populations of threatened and endangered species. These laboratories also provide contract services to federal and state agencies, universities, and NGOs for a variety of analyses employing these less-invasive tools, as well as blood chemistry analysis, histology, proximate analysis, and radio-immunoassays.
- **Fish Health Centers.** FWS's Fish Health Centers play an integral role in applied science and technical transfer. Their scientists are leaders both nationally and internationally in the diagnosis of wildlife diseases and in the science of aquatic animal health, developing and validating tests that benefit, and are adopted by, the aquaculture industry. Fish Health Centers work closely with Federal, State, Tribal, academic, and NGO partners to promote the scientific management of fisheries and aquaculture by reducing the effects of wildlife pathogens.

U.S. Fish and Wildlife Service (FWS): Aquatic Invasive Species

FWS Aquatic Invasive Species program works to prevent the transfer and introduction of exotic, introduced, non-native, and other potentially harmful species and to develop early detection and rapid response capabilities. For example, the program worked with numerous partners to develop methods for detecting minuscule amounts of free-floating DNA (environmental DNA or eDNA) in water samples to confirm the presence (or absence) of species at levels undetectable by traditional sampling methods. This innovative technology is now being applied widely in monitoring programs and, as it continues to be further developed and refined, will significantly benefit both FWS programs and partners by allowing earlier detections of invasive species. FAC is also applying rapid screening tools it has developed to help determine a species' risk for invasion. Knowledge of both low- and high-risk species will help industry, states, and consumers make responsible choices about which species to acquire and use. In addition, these tools will help state agencies make decisions on potentially invasive species and work with industry to manage risky species in their jurisdictions. For example, Michigan's Public Act 537, established new protections to minimize the risk of invasive species that require, among other things, the use of the Service's risk assessment protocol.

National Park Service (NPS) Device to Facilitate Water Quality Measurement in High Biofouling Environments

The NPS has a CRADA 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 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.



The modified datasonde is removed from a dock on Vashon Island, Puget Sound Washington June 8, 2017. This trial, one of five in different high-fouling environments, showed that the invention can eliminate biofouling in a cold water, high biofouling marine environment. LEFT: The invention is removed from the Puget Sound after a six-month deployment. Inventor Joe Meiman scrapes off a 2 cm thick barnacle growth that totally encapsulated the invention and datasonde. RIGHT: While the six-month exposure to the environment resulted in extreme barnacle growth, the sensors remained clean and functioning within normal ranges. [Photo credit: Joe Meiman, NPS, 2017].

In FY 2017, the CRADA partners installed the invention in five locations representing different fouling environments: warm and cold-water marine biofouling, warm water marine sediment fouling, riverine sediment fouling and lacustrine biofouling. Datasondes modified by the invention were deployed side-by-side with comparable unmodified datasondes, which were maintained at regular intervals (two to four weeks). The modified datasondes were left unattended for a minimum of six months, after which they were retrieved and evaluated for performance. The invention eliminated fouling of the sensors in four of the five tests and reduced it in the fifth test.

Bureau of Reclamation (Reclamation): Testing New Technologies for Hydropower Generation Applications

Since approximately 85 percent of power is generated by thermal and other non-hydro power generation methods, industry is primarily focused on developing and supplying power generation technologies and equipment that are designed specifically for non-hydropower generation applications. As such, Reclamation commonly tries to determine if such technologies and equipment are suitable, or can be modified, for hydropower generation applications. Reclamation is using its in-house developed Hardware-in-the-loop Generator Simulator to test manufacturers speed governor, voltage regulator, and power system stabilizer controllers.

In FY 2017, Reclamation entered into Material Transfer Agreements (MTAs) to receive and test power generation equipment including digital excitation controllers, digital power system stabilizers, and three phase power bridges. Under the MTAs, Reclamation conducted tests to determine their suitability for hydropower generation applications and provided each manufacturer with a report stating what tests were performed and whether the equipment passed or failed the tests.

The MTAs help Reclamation prepare and adapt manufactures' equipment to work properly prior to their installation in hydro facilities. This reduces both engineering time needed to commission the equipment, and lost revenues caused by longer generator outages.

The MTAs have also allowed hydropower manufacturers to gain insights on the feasibility and requirements to manufacture and market their products to the global hydropower generation community. They also gained access to Reclamation's technical expertise and laboratory facilities not readily available in the private sector that are able to test and evaluate technologies for hydropower applications. As one manufacturer put it: "This is like the real power plant environment but without the stress and pressure of commissioning/testing our system on the real generator!" Another manufacturer noted, "Even though our system has undergone rigorous testing by many experts, the Reclamation Hardware-in-the-Loop generator simulator has enabled us to find and resolve some unknown issues with our system before releasing it to the customers!"

Department of Transportation (DOT)

The U.S. Department of Transportation (DOT) is the Federal steward of the Nation's transportation system. DOT consists of multiple modal Operating Administrations (OAs) that 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. DOT's Technology Transfer Program, which is housed in 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.

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 OA conducts mission-specific deployment activities tailored to its mode and type of research. Agency specific technology transfer activities may be found online.

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

- Federal Aviation Administration (FAA): William J. Hughes Technical Center (WJHTC), Atlantic City, NJ, and Civil Aerospace Medical Institute, Oklahoma City, OK;
- Federal Highway Administration (FHWA): Turner-Fairbank Highway Research Center (TFHRC), McLean, VA;
- Office of the Assistant Secretary for Research and Technology (OST-R): John A. Volpe National Transportation Systems Center (Volpe Center), Cambridge, MA;
- National Highway Traffic Safety Administration (NHTSA): Vehicle Research and Test Center (VRTC), East Liberty, OH; and
- Federal Railroad Administration (FRA): Transportation Technology Center, Pueblo, CO.

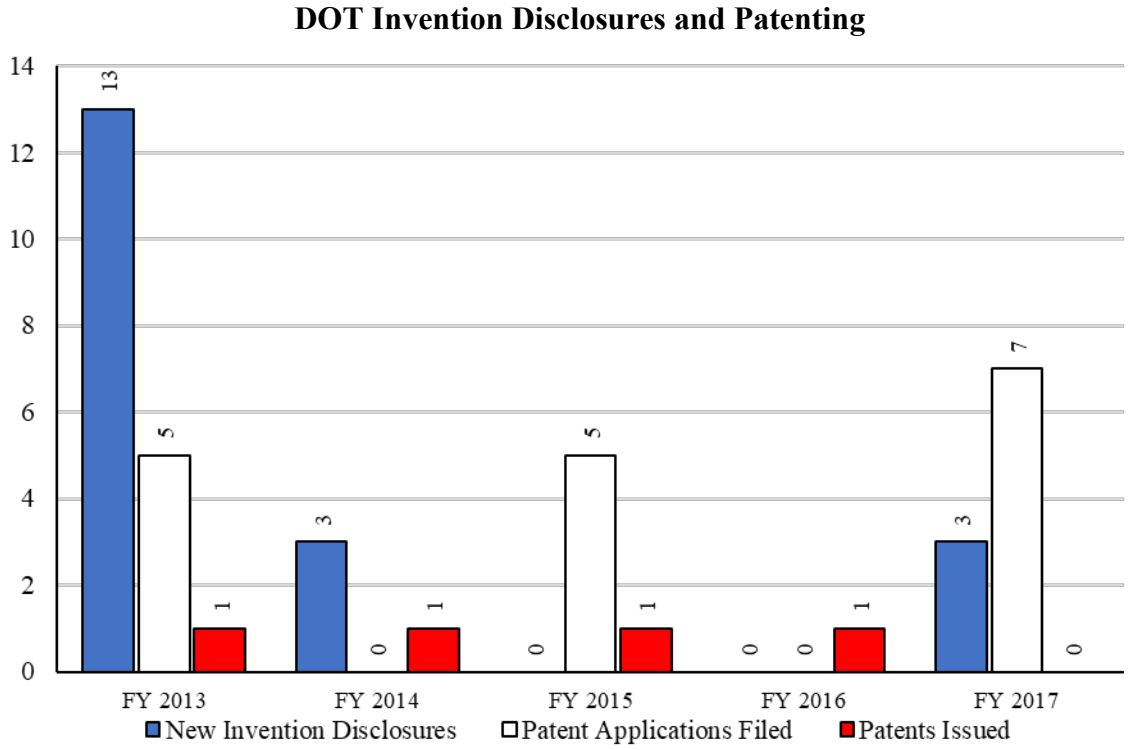
DOT's annual technology transfer report is available online.

More information about DOT's technology transfer activities is available on the following websites.

FAA | FHWA | OST-R | FRA

DOT Invention Disclosures and Patenting

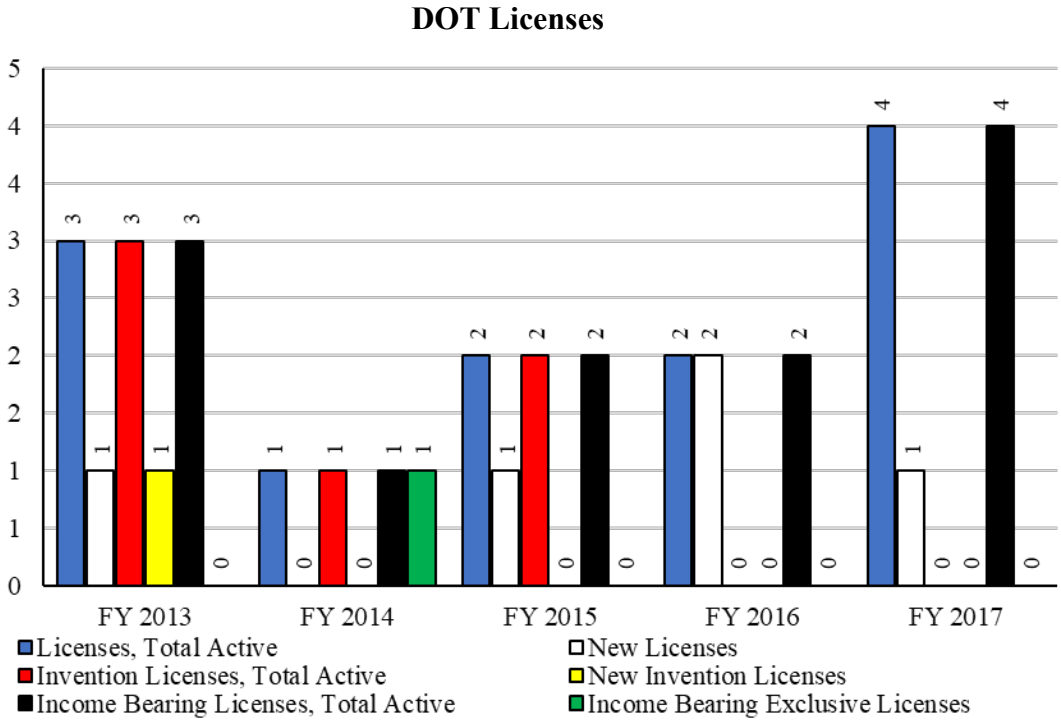
In FY 2017, DOT reported 3 invention disclosures and 7 patent applications. No new patents were awarded.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	13	3	0	0	3
Patent Applications Filed	5	0	5	0	7
Patents Issued	1	1	1	1	0

DOT Licenses

In FY 2017, DOT reported 4 active license agreements. All active licenses were reported as income bearing licenses. There were no new invention licenses reported in FY 2017.

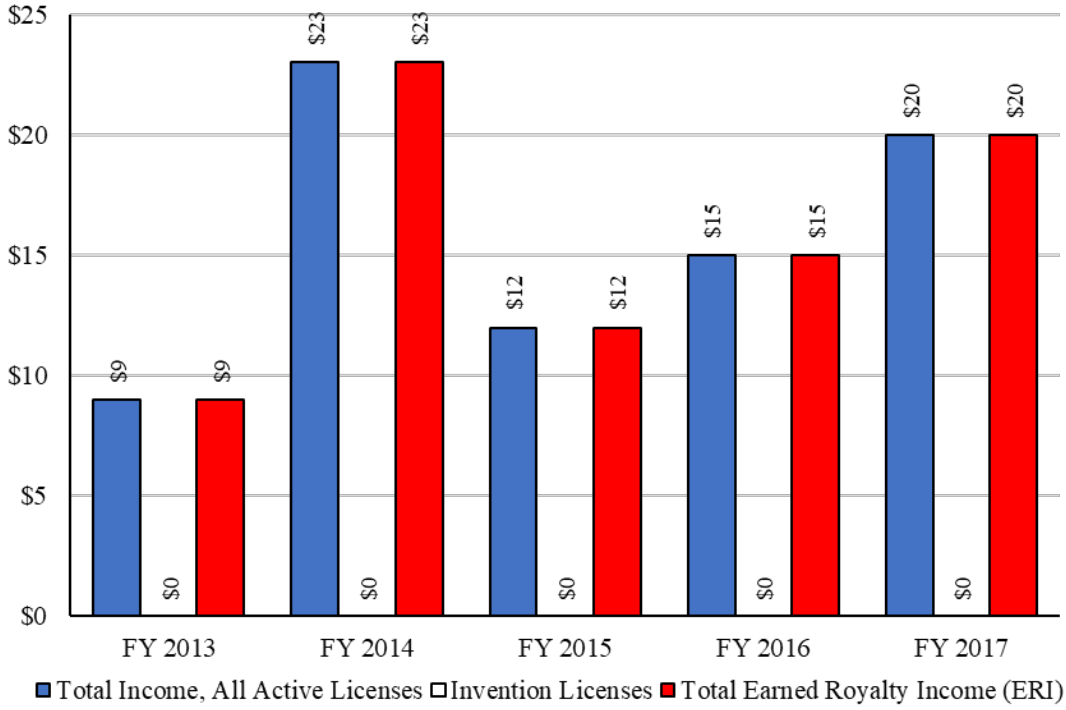


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	3	1	2	2	4
New Licenses	1	0	1	2	1
Invention Licenses, Total Active	3	1	2	0	0
New Invention Licenses	1	0	0	0	0
Income Bearing Licenses, Total Active	3	1	2	2	4
Income Bearing Exclusive Licenses	0	1	0	0	0

DOT Income from Licensing

Between FY 2013 and FY 2017, total income from all active licenses increased by 122%. In FY 2017, DOT reported zero income from invention licenses. Total Earned Royalty Income was reported to be $20 thousand, a 122% increase from FY 2013.

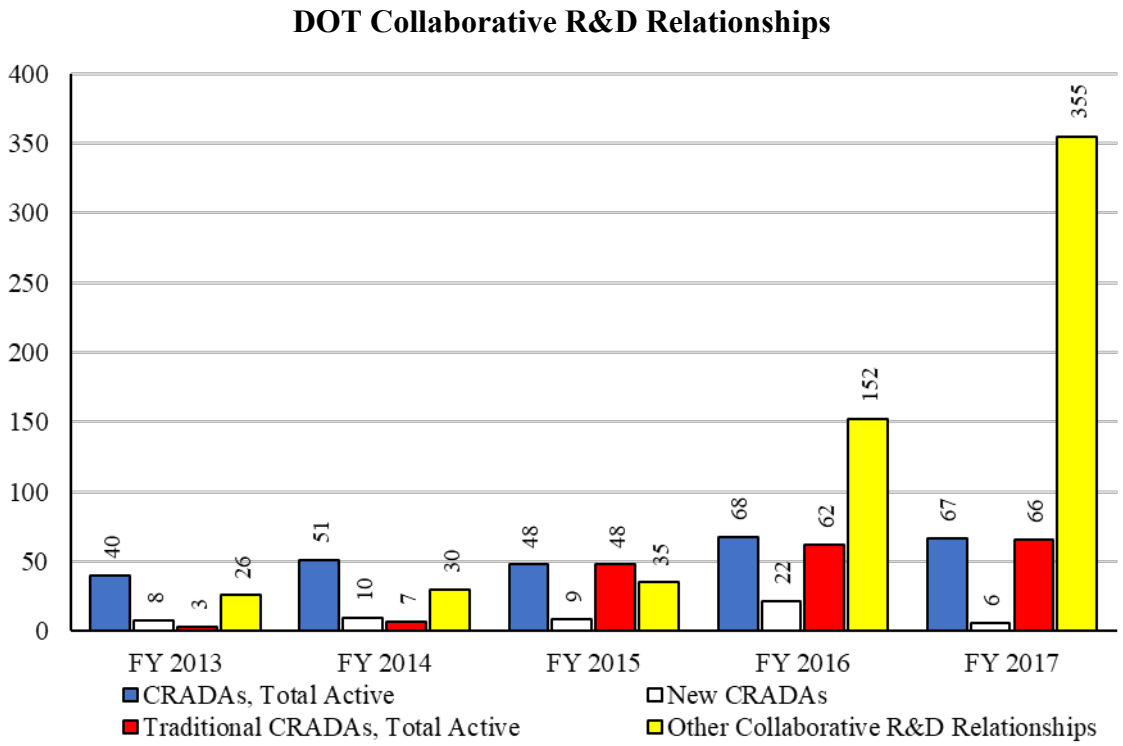
DOT Income from Licensing ($000s)



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$9	$23	$12	$15	$20
Invention Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income, (ERI)	$9	$23	$12	$15	$20

DOT Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 68% from 40 to 67 agreements, while new CRADAs agreements declined by 25% to 6. Traditional CRADAs increased from 3 in FY 2013 to 66 in FY 2017. Other collaborative R&D relationships increased significantly by 1,265% from 26 in FY 2013 to 355 in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	40	51	48	68	67
New CRADAs	8	10	9	22	6
Traditional CRADAs, Total Active	3	7	48	62	66
Other Collaborative R&D Relationships	26	30	35	152	355

DOT Downstream Success Stories

National Highway Traffic Safety Administration (NHTSA): Global Vehicle Target for Automotive Testing

NHTSA collaborated with the European New Car Assessment Program, the Insurance Institute for Highway Safety, vehicle manufacturers, suppliers, and Dynamic Research, Inc., to develop the global vehicle target (GVT). The GVT is a full-sized artificial vehicle designed to look like an actual passenger car to the sensors presently used by automotive safety systems. However, unlike an actual car, the GVT can be repeatedly struck from any approach angle without harm to those performing the tests or the vehicles being evaluated.

GVT (top left) over the LPRV, LPRV (bottom left), and car impacts GVT at 25 mph (right), Source: NHTSA

The GVT is one component of the guided soft target (GST) system designed to safely evaluate crash-avoidance technologies in pre-crash scenarios. The GST system is comprised of the GVT, a low-profile robotic vehicle (LPRV), an operator's base station, and a remotely operated safety steward dead-man switch. Constant wireless communication between the LPRV and base station allow for precise closed-loop control. Collaborators intend to use multiple copies of GVT for future research. NHTSA anticipates using this technology to facilitate exploratory automated vehicle performance evaluations. Specifically, NHTSA will assess traffic jam assist, blind-spot intervention, intersection crash avoidance, and automatic emergency braking system performance. Subsequent results will help facilitate the development of objective test procedures. In the longer term, NHTSA anticipates using the GVT, or multiple GVTs, to safely, accurately, and repeatedly perform complex test scenarios as part of the agency's research test program.

Federal Highway Administration (FHWA): A Mobile Solution for Assessment and Reporting Infrastructure Damage

When disaster strikes, time is of the essence. Every minute, hour, and day matters when making damage assessments in the aftermath of a powerful hurricane, flood, or storm. Technology saves time and can be critical to getting roads and bridges repaired and open to traffic again after a natural disaster, especially when the damage is widespread and difficult to access. FHWA's Emergency Relief and Emergency Relief for Federally Owned Roads programs collaborated with local government and private industry stakeholders to develop an app designed to simplify laborious and time-consuming data collection for FHWA, state DOTs, Federal land management agencies, and Tribal governments. FHWA's Mobile Solution for Assessment and Reporting (MSAR) allows officials to gather field data via mobile device, making the process faster and easier by shortening a process that once took about 18 hours to 20 minutes. FHWA estimates that MSAR will save taxpayers an estimated $1.2 million per disaster.

FHWA's Texas division office, the Texas Department of Transportation (TxDOT), and local public agencies have used MSAR to assess damages and to complete more than 900 reports.

FHWA stakeholders used MSAR to assess damage created by Hurricane Harvey, which caused catastrophic flooding in southeastern Texas in August 2017. During the Hurricane Harvey response, FHWA and TxDOT saved an estimated 17,000 hours of staff time by using MSAR.

Federal Aviation Administration (FAA): Continuous Lower Energy, Emissions, and Noise Program

Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) program, FAA is working with industry to accelerate the development and commercial deployment of environmentally promising aircraft and engine technologies, as well as sustainable alternative fuels. FAA helps the companies in the CLEEN Consortium accelerate their technologies through a crucial phase in their maturation, culminating in full-scale ground and flight test demonstrations and showing readiness for product implementation. At the conclusion of the development effort for a CLEEN technology, each participating company is invested in the technology's success and confident in its maturity to move into product development for entry into service. Once this occurs, the CLEEN technologies will realize their fuel burn, emissions, and noise benefits for years to come.

FAA initiated the first phase of the CLEEN program in 2010 by entering into five-year agreements with five producers of aircraft, aircraft components, or aviation fuels. From 2010 to 2015, the FAA invested a total of $125 million. With the funding match from the five companies, the total investment exceeded $250 million. Several technologies developed by the CLEEN program have been tested and are in use today.

In 2015, FAA initiated a follow-on program, CLEEN II, which continues efforts to achieve the CLEEN goals. CLEEN II, which will run from 2015 to 2020, is a partnership with eight companies or consortia of companies. FAA plans to invest $100 million in CLEEN II, with cost-sharing from the industry partners that will match or exceed the Federal contribution. FAA anticipates that developed CLEEN II aircraft technologies will be on a path for introduction into commercial aircraft by 2026.

Federal Railroad Administration (FRA) Develops Safety System that Detects Potential Soil Erosion Damage

FRA's Research, Development and Technology program developed a new detection system to detect potential soil erosion damage. Many railroad bridge piers are susceptible to damage caused by scour and other changing soil conditions. Scour is the engineering term for the erosion of soil surrounding a bridge foundation (piers and abutments). Bridge scour occurs when fast-moving water around a bridge removes sediment from around the bridge foundation, leaving behind scour holes. These holes (pockets) can seriously compromise the bridge's integrity and cause track outages and even bridge failure if not detected early. The system can continuously measure the structural response of each railroad bridge pier in the U.S. If a dangerous condition is detected, an automatic alert is sent to bridge inspectors.

Since 2012, FRA stakeholders including Union Pacific, BNSF, Canadian Pacific, Metro-North Railroad, Long Island Railroad, Southeast Pennsylvania Transit Authority, and others have installed this technology on bridges. These bridges are located across the continental United States and span vital waterways, such as the Mississippi River, Missouri River, Santa Ana River,

and the Lake Washington Ship Canal. Some bridge owners have also adopted the technology to detect bridge impacts from barges and motor vehicles. Canadian Pacific used the technology to monitor a bridge in 2017 with a large scour pocket, which allowed rail traffic to keep moving safely until the pocket could be filled.

In 2017, the U.S. Army Corps of Engineers installed the detection system on a bridge as part of a project in Southern California. The bridge consists of three lines carrying both freight and passenger trains. The Prado Dam upstream of the bridge will increase its flood flow releases from 10,000 ft^3/sec to more than 30,000 ft^3/sec. The sensors will be left in place after construction to monitor any signs of scour due to the increased flood flow.

Federal Railroad Administration (FRA): Positive Train Location

Positive Train Location (PTL), a multi-year development effort led by FRA, culminated in 2017 with a successful technology transfer to railroads and their suppliers. This system uses global positioning system (GPS) technology that is augmented with inertial sensors to provide locomotive onboard systems with very high-precision train location data even under GPS-challenged environments (e.g., tunnels, urban canyons). This helps prevent train collisions by enabling train systems to determine with a higher degree of confidence which track a train is using while traveling in multiple track territory. As a mechanism for maintaining safe train spacing, the technology is also foundational for the development of rail automation. Under FRA funding and management, the system was conceptualized, prototyped, and tested at the Transportation Technology Center in Pueblo, CO. Currently, the technology is fully transferred from FRA to railroads and suppliers. It is being unit-tested by Union Pacific and BNSF railroads and is expected to be commercially available off-the-shelf in 2018.

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; and
- 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.

For over 90 years, the VA Research program has improved Veterans' lives through scientific discovery, health care innovation, and service delivery. The Office of Research and Development (ORD) is the division within the Veteran's Health Administration which aspires to discover knowledge, develop VA researchers and health care leaders, and create innovations that advance health care for our Veterans and the Nation. The research program within the Department of Veterans Affairs has an illustrious past in which its researchers have won three Nobel prizes in medicine, seven Lasker Awards, one Malcolm Baldrige Quality Award and also created the largest Genomic Medicine sample collection program in the world (the Million Veteran Program).

As of FY17, ORD is headquartered in Washington, DC but includes an estimated 2,500 VA investigators and 10,000 research staff located at over 100 VA Medical Centers nationwide. Over sixty percent of VA Medical Centers have an embedded on-site research program which mirrors the diversity of the VA hospitals in size, scope, and complexity. These research programs receive guidance and competitive intramural funding from VA ORD but manage their research offices and programs independently. VA Research differs from other federal research programs in that it is completely funded with intramural dollars. VA investigators can apply for other federal and private funds, but non-VA employees or appointees cannot receive VA research funding. VA hospitals and research programs work with the Office of Academic Affiliations to partner with academic institutions and universities to broaden available resources for both patient care and research. By partnering with others who have common research interests, ORD is able to leverage resources, deepen innovations and expand the impact of federal research investments.

ORD provides oversight of four research services and three supportive programs, each headed by a director, supervised by the Chief Research and Development Officer (CRADO), who in turn reports to the Deputy Under Secretary for Health for Policy and Services. Together, these offices form a cohesive whole directed to explore all phases of veterans' healthcare needs and interact with a number of world-renowned research centers nationwide. The four research services are as follows:

The Biomedical Laboratory Research & Development Service (BLR&D) conducts research that explores basic biological or physiological principles in humans or animals but does not involve intact human beings. For example, it includes research on animal models and investigations of tissues, blood, or other biologic specimens from humans. The Genomic Medicine Program and the Million Veteran Program are housed within BLR&D.

The Clinical Science Research and Development Service (CSR&D) conducts research which is focused on intact human beings as the unit of examination. Examples include interventional and effectiveness studies, clinical, epidemiological, and technological studies.

The Health Services Research and Development Service (HSR&D) pursues research at the interface of health care systems, patients, and health care outcomes. HSR&D underscores all aspects of VA healthcare; specifically, quality, access, patient outcomes and healthcare costs.

The Rehabilitation Research & Development Service (RR&D) is dedicated to the well-being of America's veterans through a full spectrum of research from approved rehabilitation research projects, through evaluation and commercialization to final clinical application.

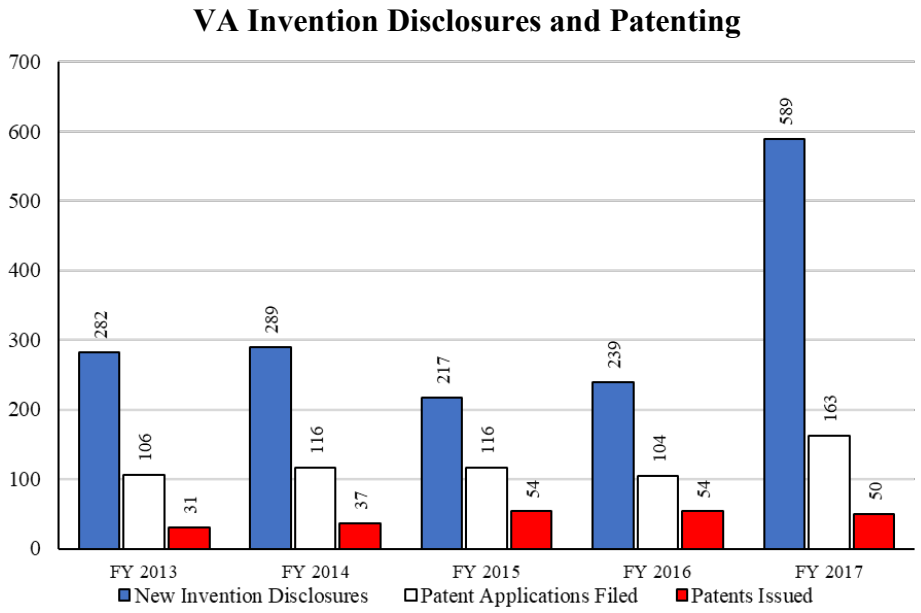
As of FY17, the three supportive programs housed within ORD include VA Technology Transfer, the VA Non-Profit offices, and the Program for Research Integrity Development and Education (PRIDE) which provides oversight and programmatic certification for human research compliance. Each of these supportive programs provide overall support to all ORD services and programs while also supporting field researchers, and in the case of Technology Transfer, supports all VA employees with any inventions.

ORD's mission is focused on improving the future of healthcare for Veterans, and Technology Transfer provides a pathway within VA to move research or employee innovations and inventions from concept to benefitting the veteran, fulfilling Technology Transfer's mission motto of "Bringing Research Advancements for Veterans to Everyone" (BRAVE).

More information about VA technology transfer activities is available online.

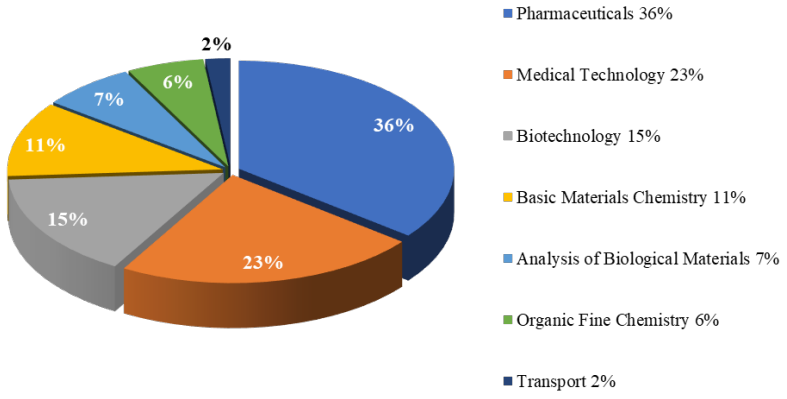
VA Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions disclosed increased by 109% from 282 to 589 disclosures in FY 2017. Patent applications filed increased by 54% to 163, while patents issued increased by 61% to 50 patents.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	282	289	217	239	589
Patent Applications Filed	106	116	116	104	163
Patents Issued	31	37	54	54	50

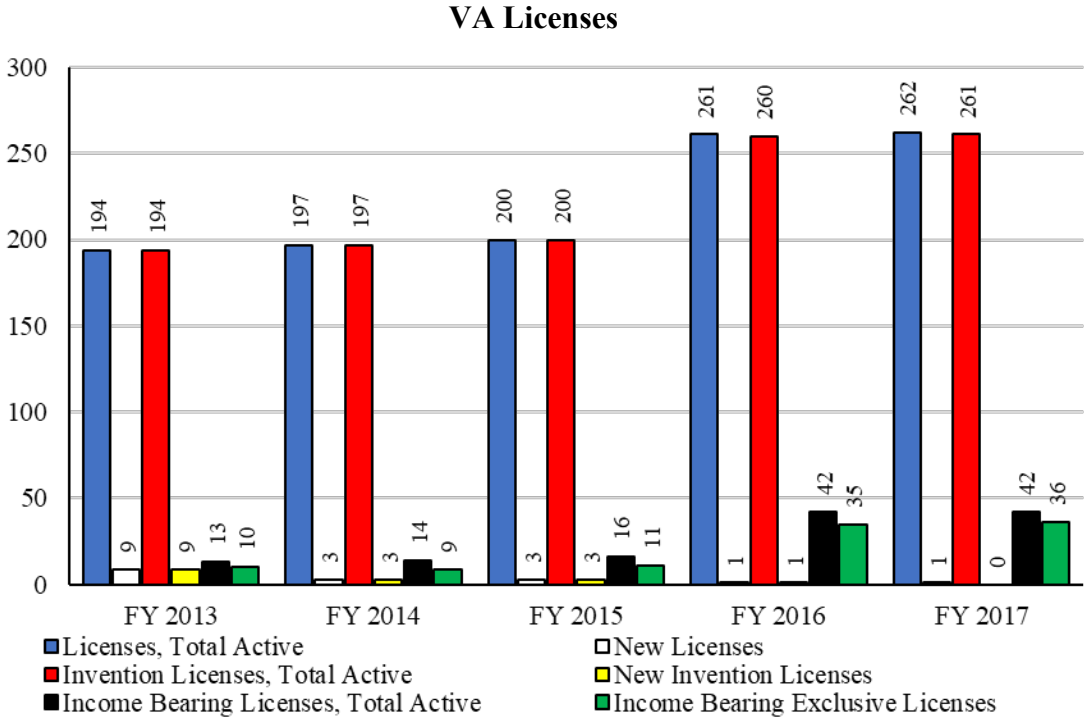
Patents issued to VA in FY 2017 covered many technology areas, including Pharmaceuticals (36%), Medical Technology (23%), Biotechnology (15%), and Basic Materials Chemistry (11%).[27]



[27] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

VA Licenses

Between FY 2013 and FY 2017, total active licenses increased by 35% from 194 to 262 licenses while new invention licenses decreased by 89% to 1. Income bearing licenses increased by 223% to 42 while income bearing exclusive licenses increased by 260% to 36.

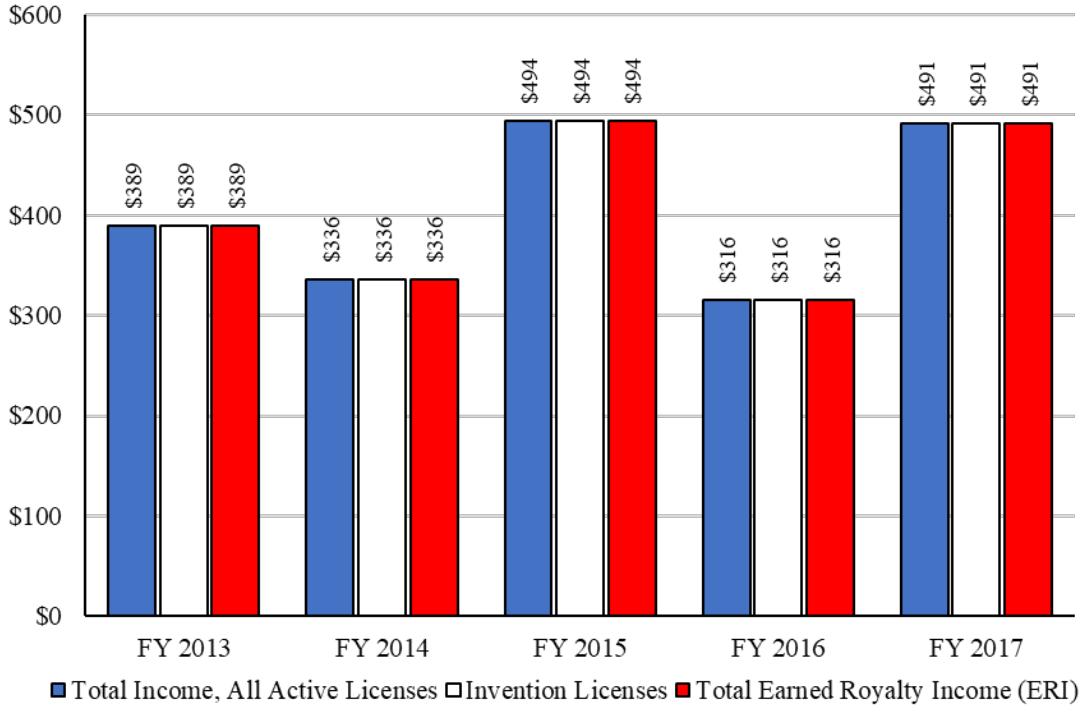


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	194	197	200	261	262
New Licenses	9	3	3	1	1
Invention Licenses, Total Active	194	197	200	260	261
New Invention Licenses	9	3	3	1	0
Income Bearing Licenses, Total Active	13	14	16	42	42
Income Bearing Exclusive Licenses	10	9	11	35	36

VA Income from Licensing

Between FY 2013 and FY 2017, VA reported that total income from all active licenses increased by 26% from $389 thousand to $491 thousand in FY 2017. Income from invention licenses and earned royalty income were the same as income from all active licenses.

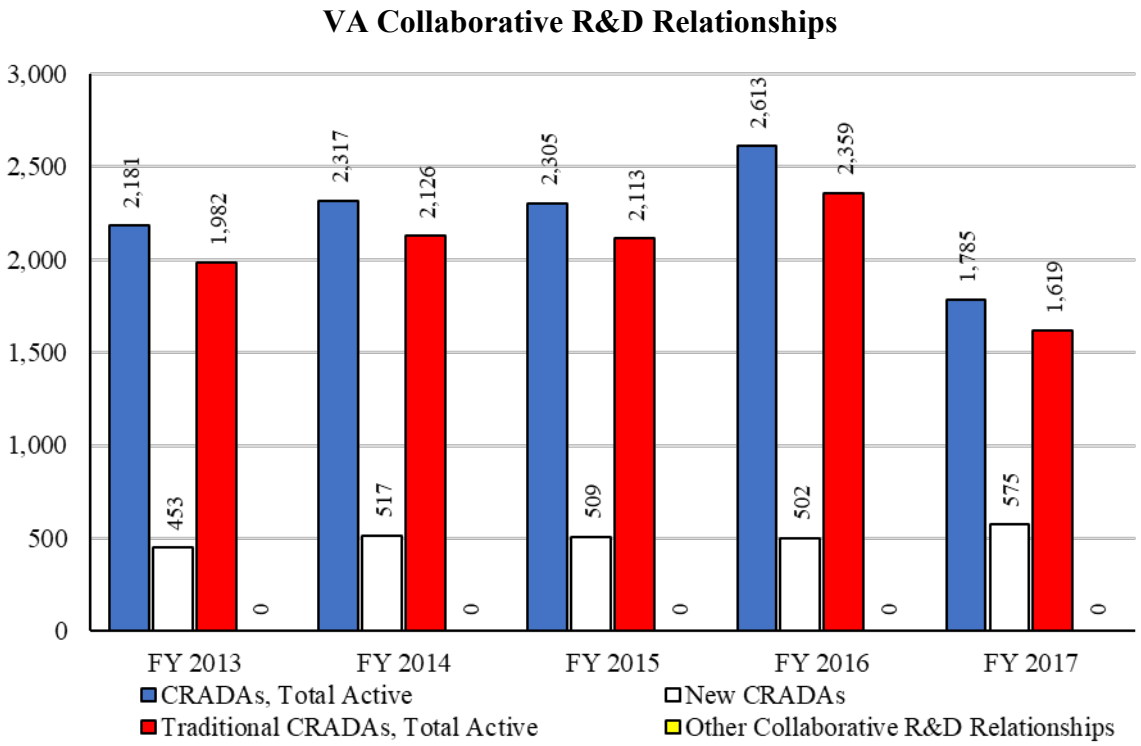
VA Income from Licensing ($000s)



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$389	$336	$494	$316	$491
Invention Licenses	$389	$336	$494	$316	$491
Total Earned Royalty Income, (ERI)	$389	$336	$494	$316	$491

VA Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs decreased by 18% from 2,181 to 1,785 agreements in FY 2017. New CRADAs increased by 27% to 575 new agreements in FY 2017. Traditional CRADAs decreased by 18% from 1,982 in FY 2013 to 1,619 in FY 2017. No other collaborative R&D relationships were reported.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	2,181	2,317	2,305	2,613	1,785
New CRADAs	453	517	509	502	575
Traditional CRADAs, Total Active	1,982	2,126	2,113	2,359	1,619
Other Collaborative R&D Relationships	0	0	0	0	0

VA Efforts to Streamline Technology Transfer Operations

As of FY 2017, the Technology Transfer Program continues to improve existing operations and stakeholder communication in FY 2017 as a continuation of the processes and stewardship instituted by Dr. Kaplan, PhD, JD, PE as the TTP Director, with support from Dr. Ramoni, Chief Research and Development Officer. The 8-member staff of the Technology Transfer Program consists of 5 Technology Transfer Specialists and 3 administrative staff and provides the support for program improvements in both communications and operations as indicated by the table below.

Measure	Metric	FY16	FY17	FY18	FY19	FY20
Reduction of Invention Disclosure (ID) Backlog	% IDs in Backlog	45%	<1%	ATTAINED		
Improved Data Management	% Active IP Fields Being Tracked	40%	80%	85%	>90%	>98%
	% Annual CRADA Reports Received	50%	100%	ATTAINED		

VA Downstream Success Stories

Gene Therapy Cure: Path to Combat Genetic and Viral Diseases

After three years of negotiation, the research program at the White River VA Medical Center has recently entered into a CRADA with a start-up company to leverage the VA's experience with the CRISPr-cas gene editing system. This remarkable discovery provides the possibility of functional gene therapy and a path to cure many genetic and virally caused diseases. The company's initial interest in the White River Research Program arose in part due to the filing by the VA of a patent application directed to the use of CRISPr-cas for the treatment of patients with HIV. The company is funding research at White River in an amount exceeding half a million dollars, with further interest in funding, should the research prove fruitful. TTP continues to engage with these parties, reviewing research goals and addressing the resulting intellectual property issues.

Medication Reconciliation Algorithm

An exclusive license for the MedRec Tool Plus (Navigator Tool) was executed with Avicenna Medical Systems in 2017. This product consists of a series of algorithms, embodied in software applications, to improve medication reconciliation. Currently, medical reconciliation is one of the most onerous and dangerous aspects of patient discharge (and admission). The tool streamlines the process of medication reconciliation, leaves fewer opportunities for error, and provides the patient with a clear and concise medication list upon discharge. The tool has already been put into use in several VA medical centers. It is expected to eventually be implemented across the entire VA. Further, this tool will be marketed to hospitals outside the VA healthcare system and thereby bring revenue into the VA for research reinvestment.

Environmental Protection Agency (EPA)

EPA's 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.

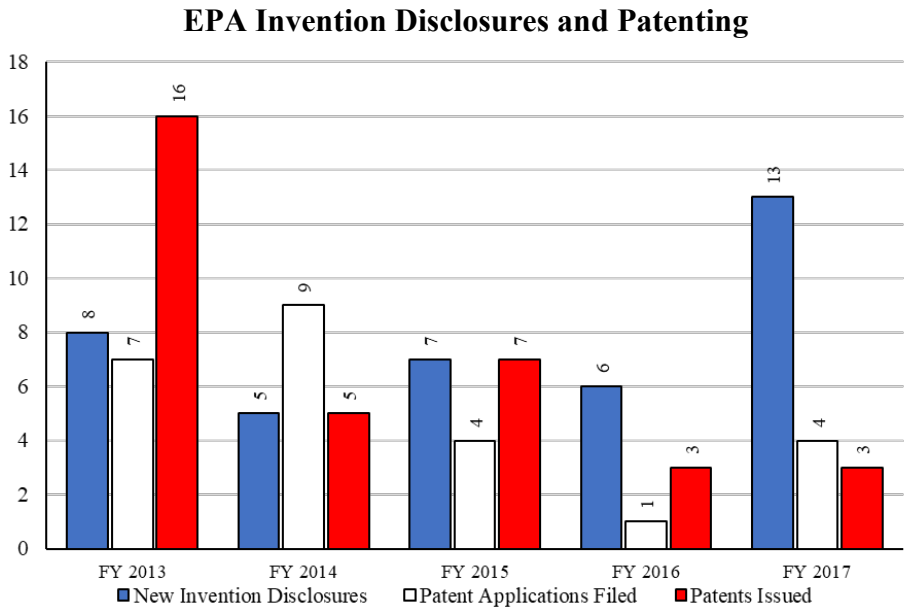
Partners in the FTTA Program have the benefit of collaborating with world-class EPA scientists involved in leading-edge research. Collaboration enhances the quality of research projects and helps move environmental technologies into the marketplace, resulting in better protection of human health and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

EPA's annual technology transfer report is available online,

More information about EPA technology transfer activities is available online.

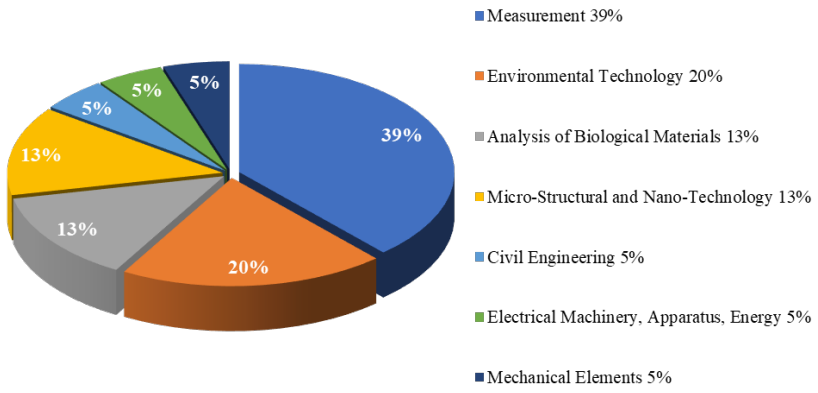
EPA Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions increased by 63%, from 8 disclosures in FY 2013 to 13 in FY 2017. Patent applications filed decreased by 43% to 4, while patents issued decreased by 81% to three patents.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	8	5	7	6	13
Patent Applications Filed	7	9	4	1	4
Patents Issued	16	5	7	3	3

Patents issued to EPA in FY 2017 covered many technology areas including Measurement (39%), Environmental Technology (20%), Analysis of Biological Materials (13%), and Micro-Structural and Nano-Technology (13%).[28]

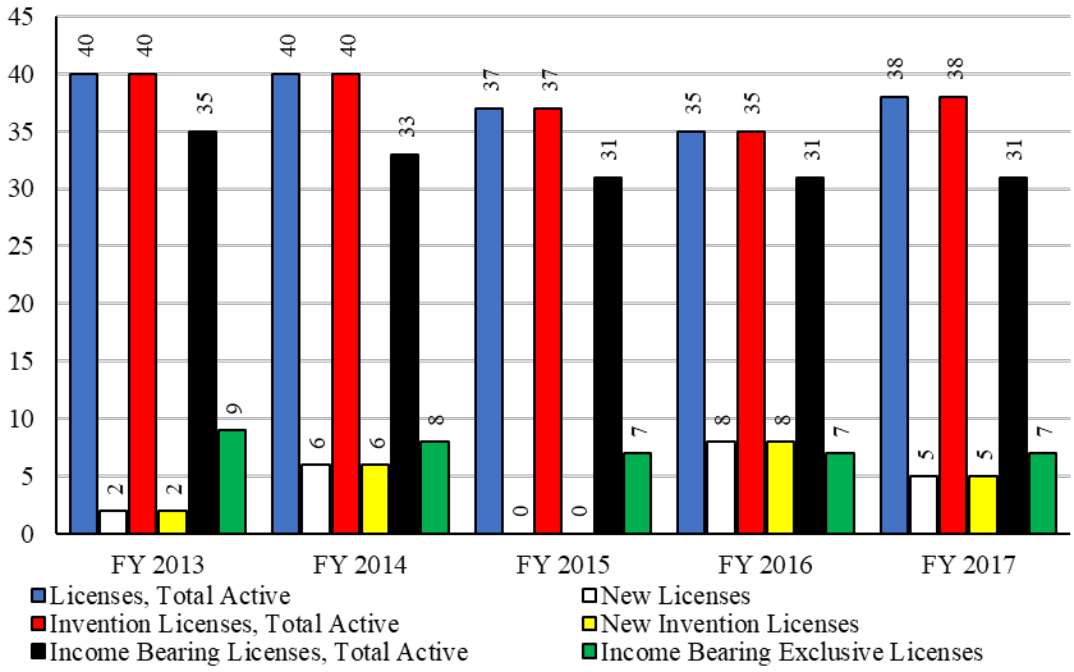


[28] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

EPA Licenses

Between FY 2013 and FY 2017, total active licenses decreased by 5% from 40 licenses in FY 2013 to 38 licenses in FY 2017. New licenses increased by 150% to 5. All active licenses were invention licenses. Income-bearing licenses declined by 11% to 31 while exclusive income-bearing licenses declined by 22% to seven.

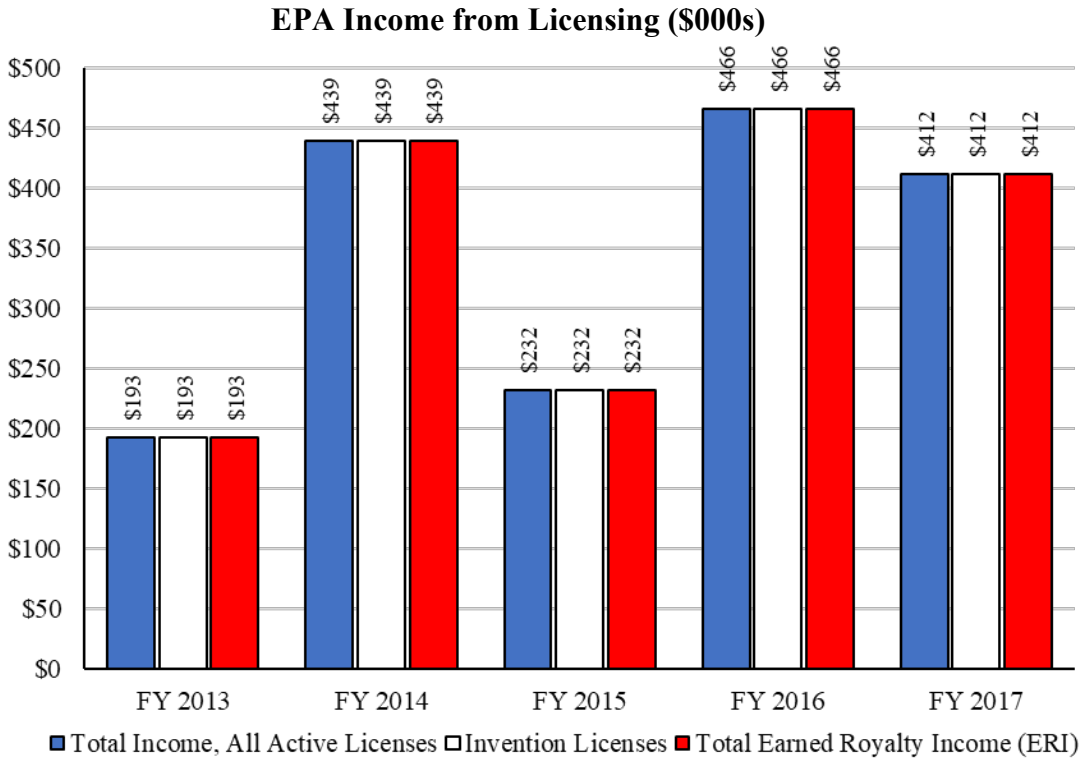
EPA Licenses



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	40	40	37	35	38
New Licenses	2	6	0	8	5
Invention Licenses, Total Active	40	40	37	35	38
New Invention Licenses	2	6	0	8	5
Income Bearing Licenses, Total Active	35	33	31	31	31
Income Bearing Exclusive Licenses	9	8	7	7	7

EPA Income from Licensing

Between FY 2013 and FY 2017, EPA reported that total income from all active licenses increased by 113% from $193 thousand to $412 thousand in FY 2017. All income from licenses came from invention licenses. Total earned royalty income increased 113% from $193 thousand in FY 2013 to $412 thousand in FY 2017.

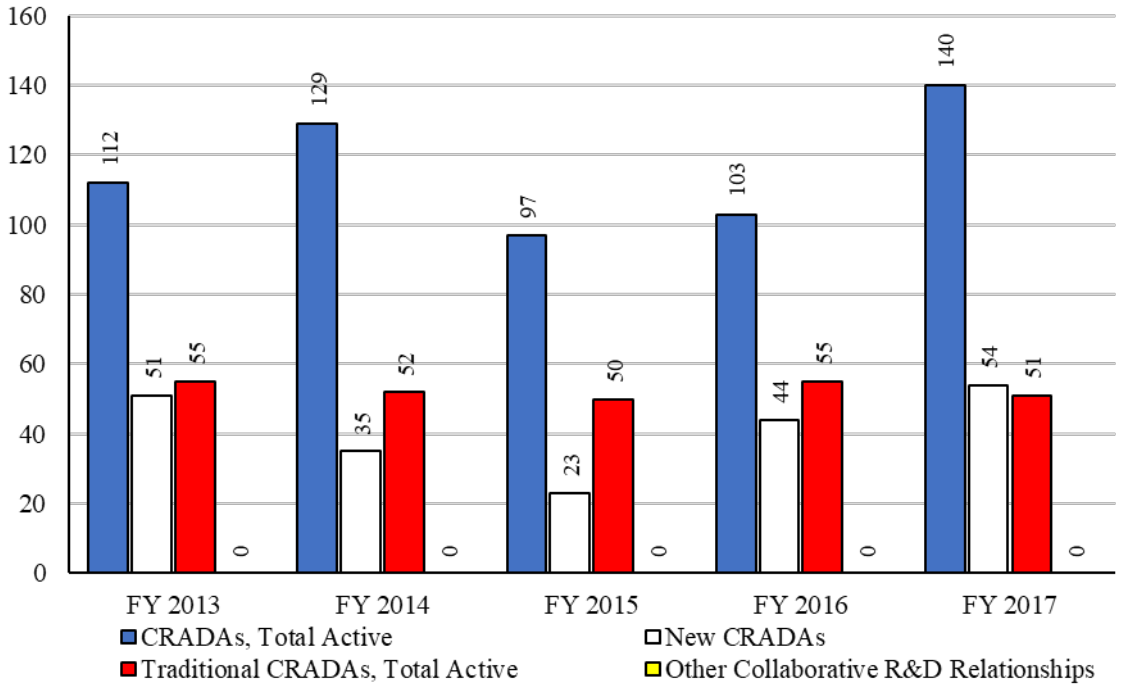


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$193	$439	$232	$466	$412
Invention Licenses	$193	$439	$232	$466	$412
Total Earned Royalty Income, (ERI)	$193	$439	$232	$466	$412

EPA Collaborative R&D Relationships

Between FY 2013 and FY 2017, total active CRADAs increased by 25% to 140 agreements from a previous 112 in FY 2013. New CRADAs increased by 6% to 54 new agreements in FY 2017. Traditional CRADAs decreased by 7%. No other collaborative R&D relationships were reported.

EPA Collaborative R&D Relationships



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	112	129	97	103	140
New CRADAs	51	35	23	44	54
Traditional CRADAs, Total Active	55	52	50	55	51
Other Collaborative R&D Relationships	0	0	0	0	0

EPA Downstream Success Stories

Wildland Fire Research Results: Keeping Timber Slash Piles Dry Reduces Pollutants During Prescribed Burning

Researchers found that prescribed burning of dry piles of post-harvest Douglas-Fir slash (cut timber and timber debris) exhibited significantly lower emissions than wet piles due to better combustion efficiency, according to a study funded by the Oregon Department of Forestry and the EPA through a CRADA.

Polyethylene sheets (PE) have been used on timber slash piles to prevent moisture exposure. Tests from this study suggest that use of PE as a biomass cover to keep slash piles dry results in lower emission factors than those from piles exposed to moisture, which reduces pollutant levels during prescribed burning. Also, burning the PE cover on the pile was found to have no distinctive effect on emissions. These emission factor data results can be used by management and regulatory communities to inform smoke management practices and limit potential hazards related to prescribed burning of slash piles.

EPA Evaluates Effectiveness of Arsenic Water Treatment Systems for Small Communities

Starting shortly after a 2001 lowering of the arsenic drinking water standard, EPA researchers at the National Risk Management Research Laboratory (NRMRL) engaged in a series of CRADAs with small communities to assist with selection and installation of arsenic mitigation technologies, with the benefit of analyzing the capital and operational cost and real-world effectiveness of these systems. During the course of these projects, arsenic treatment technologies were installed at 50 different sites with detailed cost and performance reports published on each system. Over half of the sites utilized adsorptive media systems that utilized 11 different media products. The remainder of the systems were split among four other types of treatment technologies. Flows of the individual systems ranged from 10 to 640 gallons per minute.

In recent years, the EPA researchers followed up with these communities – which include schools, housing developments, and small towns - to check on the effectiveness and longevity of the systems. About 90% of the systems are still in operation after 8-10 years. The researchers found that the ion exchange systems had the most problems and required the greatest operational attention. In general, iron removal systems had the fewest performance and operational problems. The majority of adsorptive media systems, which require the replacement of the adsorptive media when exhausted, continue to operate with about half having switched to a better performing (life) media product.

The value of these CRADAs lies in EPA's expertise to assist small communities with treating arsenic levels above the standard by selecting appropriate arsenic water treatment systems and assisting with their installation. EPA also gained valuable information regarding the stability and effectiveness of these various technologies. A decade after their installation, it is beneficial to see that 90% of the systems are still operating, bringing safer drinking water to these communities. Equally important is the published reports produced by these projects that have been used extensively by other communities and state agencies in selecting the best treatment system to achieve compliance of the arsenic rule.

Bringing Portable Water Treatment to Hurricane-Impacted Puerto Rico

Delivering safe drinking water is a concern around the world, but it is paramount to environmental and human health in developing countries and in disaster-ravaged areas. The EPA has a decades long mandate to protect drinking water sources and to ensure that communities are delivering the highest quality water possible to their customers.

This year hurricanes Harvey, Irma, and Maria significantly impacted Texas, Florida, Puerto Rico, and the U.S. Virgin Islands, and brought to light the importance of providing safe drinking water to those impacted by the storm. Hurricane Maria's impact to Puerto Rico was particularly severe due to the complete power loss and disabling of nearly all the drinking water utilities. In addition to physical damage to the utilities, the storm also caused potentially harmful pollutants to enter source waters.

The EPA has had a long-standing interest in supporting communities in their efforts to rebound from man-made and natural disasters. One area of significant focus has been, and continues to be, on addressing the serious water contamination implications of natural disasters. This focus ensures that a ready supply of safe drinking water is available until the water utilities are up and running again.

The Agency realized there is a need for turnkey, robust water treatment systems that are capable of being transported and quickly set up to provide safe drinking water. In 2015, the EPA entered into a CRADA with WaterStep (Louisville, KY) to develop an affordable, modular, mobile water treatment technology system specifically designed for use in rural areas, in developing countries, and in emergency response efforts. EPA's role in the CRADA has been to provide technical assistance and logistical and environmental sampling and analysis support.

As a result of this CRADA, the Emergency Mobile Water System was designed, and prototypes were built. Within days after Hurricane Maria passed through, multiple Mini Water Treatment Units (Mini) (a version of the Emergency Mobile Water System) were deployed in Puerto Rico. These units are a rapid-deployment option and provide system redundancy for disaster relief organizations, water utilities, or others responsible for providing safe water. Each Mini includes everything needed for quick assembly and operation and can deliver safe drinking water within 30 minutes of set-up. Each unit has a solar panel and a chlorine generator. Even as the country continues to restore power to utilities, the water treatment units can provide up to 10,000 gallons of drinking water per day. The collaborative effort formed by this CRADA has had a significant impact on the communities and the people of Puerto Rico.

National Aeronautics and Space Administration (NASA)

NASA has a well-earned reputation for leading the federal government in technology transfer. From cell phone cameras and memory foam to aerogel insulation and modern truck designs, NASA inventions are ubiquitous in society and stick out in the minds of the public as examples of taxpayer dollars returning spinoff benefits.

As mandated by Congress, as far back as the 1958 Space Act that created the space agency, NASA has worked to ensure that the results of its space and aeronautics activities benefit the whole of humanity. To that end, NASA's Technology Transfer 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 possible. The program processes more than 1,500 new technologies created by NASA innovators (NASA employees and NASA-funded partners' employees) 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.

Technology transfer 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.

Over the past decade, NASA's effective marketing and promotion of its portfolios has led to a steady increase 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. Technology transfer 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 2017

Thanks to recent technology transfer initiatives, NASA enjoyed another year with increasing rates of technology transfer across the board. From a record number of new licenses and software usage agreements to numerous big-impact commercial spinoff success stories, NASA remains on the forefront of government agencies sharing its intellectual property and technology with the private sector.

Invention Disclosure

New Technology Reports are the first step to technology transfer success. They include any invention, discovery, improvement, or innovation that was either conceived or first actually reduced to practice in the performance of NASA work. NASA employees are required to disclose their inventions to NASA, though for various reasons it is a perennial challenge to ensure they are aware of this requirement and follow through with this action.

In order to encourage agency invention disclosures, technology transfer developed and released challenge coins to be awarded to inventors, as well as printing a second and third edition of its popular inventor notebooks (high quality, hard-backed notebooks with graphed and lined paper). Both products are now sought after at NASA and have helped promote awareness of the disclosure process and requirements.

Additionally, the program continues to coordinate agency in reach events, hosting a total of 135 events across all 10 NASA field centers during 2017. These events educated approximately 4,300 innovators on their duty to report new technologies and made them aware of recently developed technology transfer products that make the process simple and efficient. These include, among others:

Innovator Dashboard. A web-based tool for tracking what happens to technologies after 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.

e-NTR. An online application for submitting new technology reports, e-NTR represents a significant improvement on the reporting process. While still under development, the application has already streamlined reporting by guiding users through the experience, eliminating redundant fields in the form, automating tedious aspects of the process, saving in-progress reports, and tracking reports with a user profile that integrates seamlessly with other technology transfer products (such as the Innovator Dashboard).

These and other initiatives undertaken by technology transfer have helped increase civil servant new technology reports, bringing them back to their historical average (approximately 1,700 per year) after a recent dip in reporting.

Patent Licensing

NASA's innovative patent licensing strategy has matured over the course of several years. Since 2010, patent licensing by the agency has increased nearly five-fold. Fiscal year 2017 saw an increase in patent licensing of about 10 percent over the previous year. Currently, there are about 500 active licenses for NASA-patented technologies, with 119 new licenses executed the past year.

Technology transfer 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. This past year NASA filed 165 new patents on technology with an eye toward near-term commercialization.

NASA is still the only federal agency with a consolidated intellectual property portfolio marketing approach. Users can find all available NASA inventions on a single, public-facing, fully searchable website 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.

Individuals and businesses interested in using these NASA technologies can apply for a license through a simple, intuitive, and automated online application system known as ATLAS. Commercial licenses are negotiated on a case-by-case basis, but NASA also offers a few licenses that have low or no up-front costs for startup companies or businesses interested in evaluating a technology before committing to it. Thanks to these special licenses and technology transfer's promotion of agency assets to entrepreneurs, about 30 startups founded in the last three years are building products using NASA technology.

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

Software Release

Today more than ever people are using NASA software to solve their technical challenges. In 2017, software release—that is, acquisitions of software following a request and NASA approval—increased by an astounding 193 percent, part of an overall 473 percent increase in software release since 2011.

A key element of NASA's software release success is the software catalog, which is kept up to date on a single public facing website. As of the end of 2017, the catalog contains 1,058 software packages, 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.

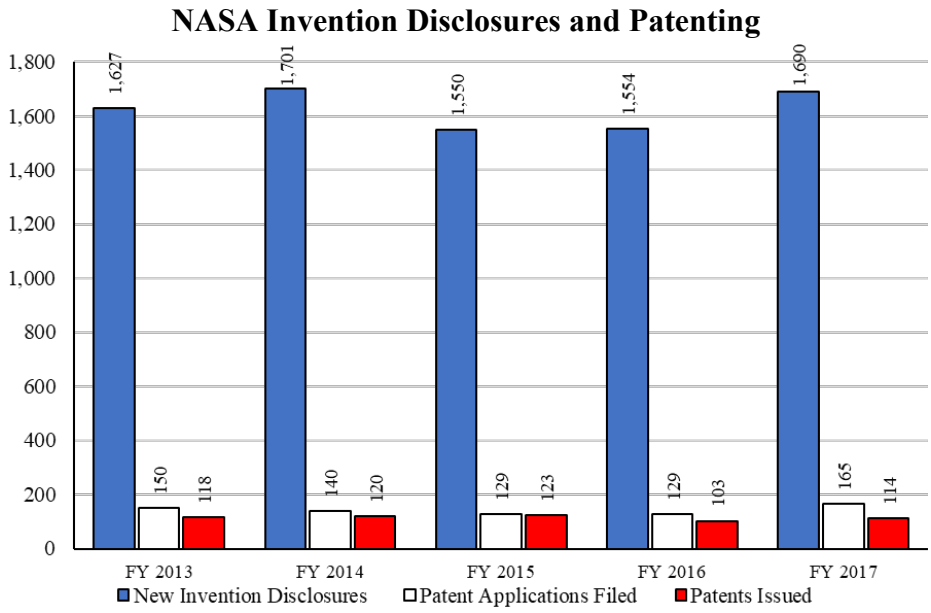
As with new technology reporting, technology transfer supports innovators at NASA by providing products that make it easy and painless to share technology. The Software Release System provides agency software developers with a dashboard to track their code as it moves through the approval process. This system streamlines and standardizes the review process for software across all 10 field centers and increases efficiency by allowing for parallel processing of approvals. (Just a couple of years ago this was a manual, serial, and tedious process.) The new system also improves our ability to track metrics, enabling program specialists to identify and correct problems in the release process in a timely manner.

NASA's annual technology transfer reports are available online.

More information about NASA technology transfer activities is available online.

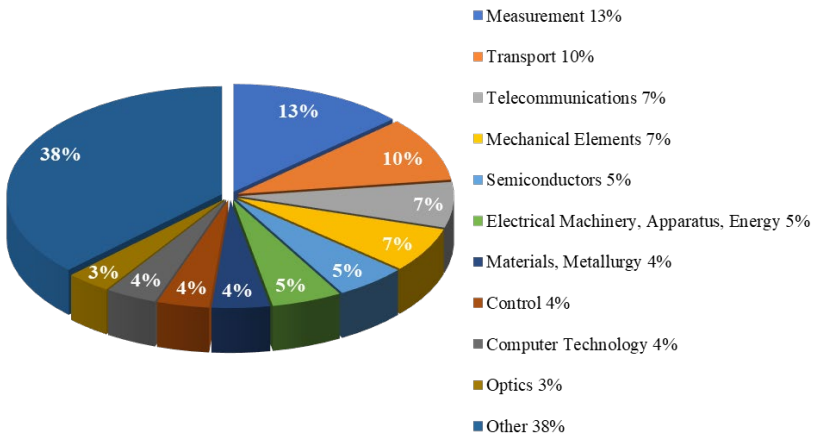
NASA Invention Disclosures and Patenting

Between FY 2013 and FY 2017, new inventions disclosed increased by 4% from 1,627 in FY 2013 to 1,690 disclosures in FY 2017. Patent applications filed increased by 10% to 165, while patents issued decreased by 3% to 114 patents in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Invention Disclosures	1,627	1,701	1,550	1,554	1,690
Patent Applications Filed	150	140	129	129	165
Patents Issued	118	120	123	103	114

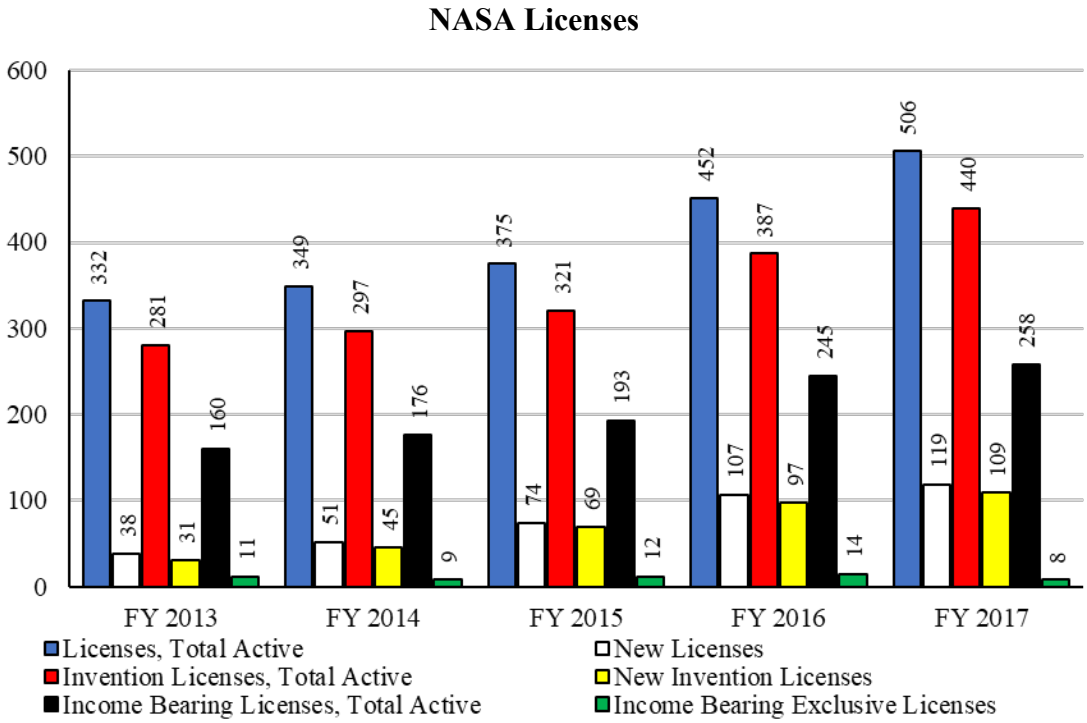
Patents issued to NASA in FY 2017 covered many technology areas including Measurement (13%), Transport (10%), Telecommunications (7%), and Mechanical Elements (7%).[29]



[29] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in October 2018. Used with permission.

NASA Licenses

Between FY 2013 and FY 2017, total active licenses increased by 52% from 332 in FY 2013 to 506 licenses in FY 2017, while new licenses increased by 213% to 119. Total active invention licenses increased by 57% to 440 while new invention licenses increased by 252% to 109. Total active income bearing licenses increased by 61% to 258 while income-bearing exclusive licenses decreased by 27%, from 11 to 8.

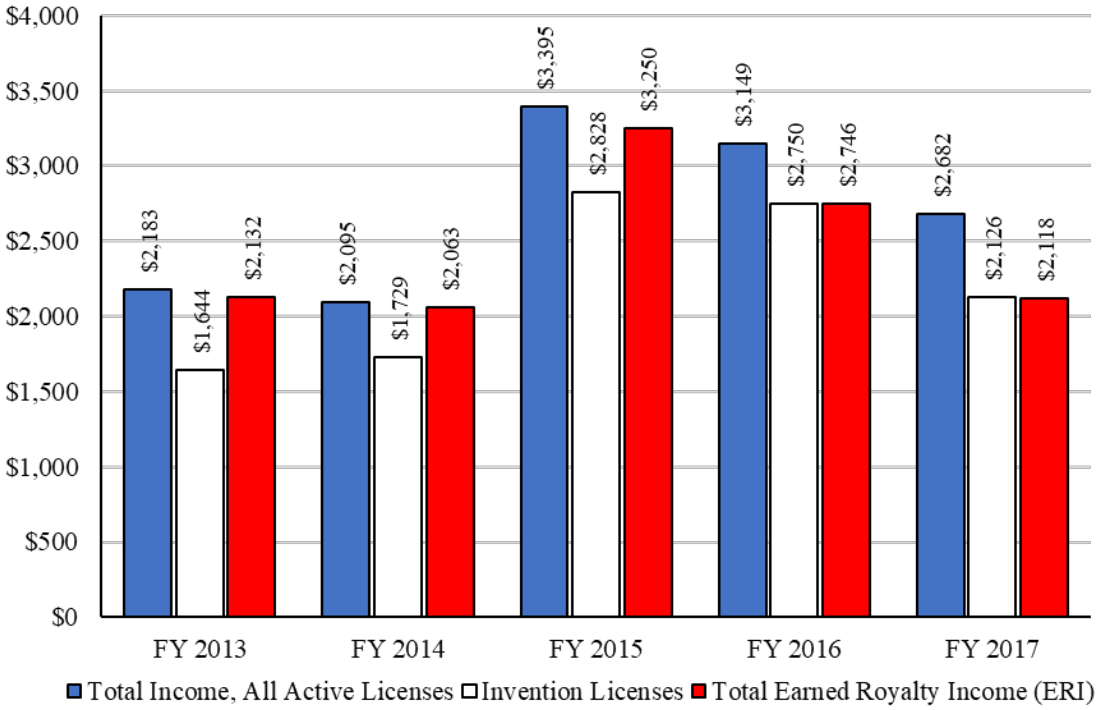


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Licenses, Total Active	332	349	375	452	506
New Licenses	38	51	74	107	119
Invention Licenses, Total Active	281	297	321	387	440
New Invention Licenses	31	45	69	97	109
Income Bearing Licenses, Total Active	160	176	193	245	258
Income Bearing Exclusive Licenses	11	9	12	14	8

NASA Income from Licensing

Between FY 2013 and FY 2017, NASA reported that the total income from all active licenses increased by 23% from $2.2 million in FY 2013 to $2.7 million in FY 2017. The income from invention licenses increased by 29% to $2.1 million. Total earned royalty income decreased by 1% to $2.1 million in FY 2017.

NASA Income from Licensing ($000s)

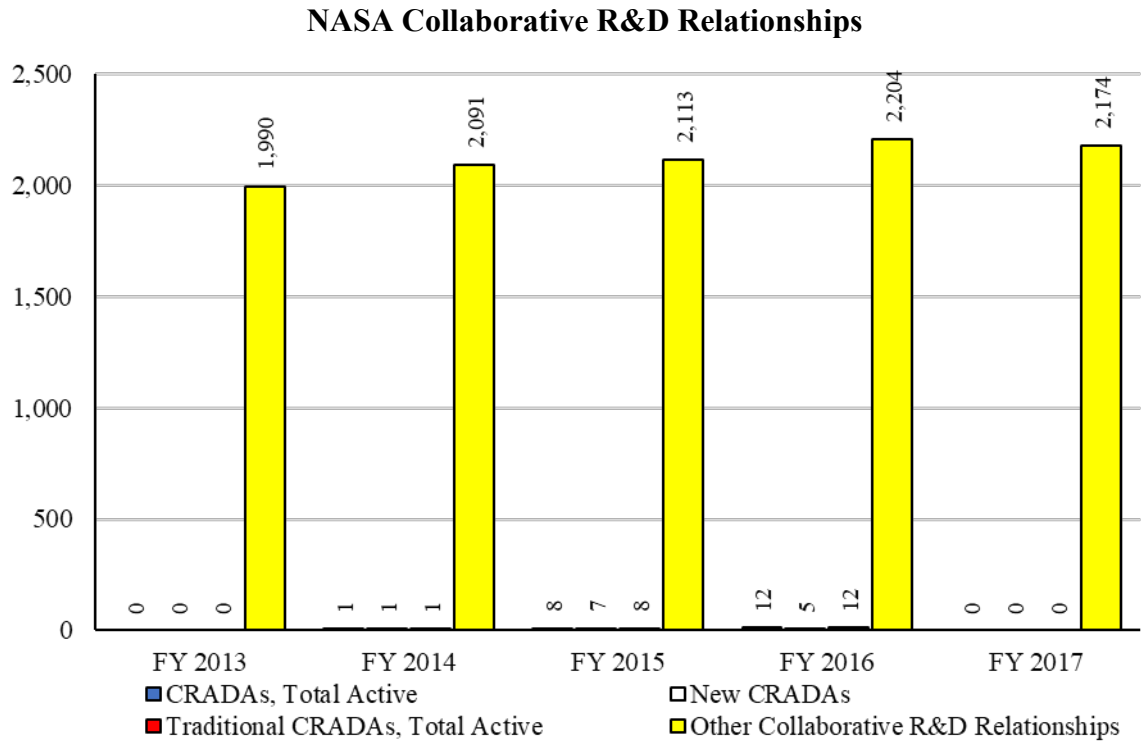


	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total Income, All Active Licenses	$2,183	$2,095	$3,395	$3,149	$2,682
Invention Licenses	$1,644	$1,729	$2,828	$2,750	$2,126
Total Earned Royalty Income, (ERI)	$2,132	$2,063	$3,250	$2,746	$2,118

NASA Collaborative R&D Relationships

The National Aeronautics and Space Act (Space Act), 51 U.S.C. §§ 20101-20164, provides NASA with the unique authority to enter into a wide range of "other transactions," frequently in the form of 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 R&D Relationships."

Between FY 2013 and FY 2017, Space Act Agreements increased 9% from 1,990 agreements in FY 2013 to 2,174 in FY 2017.



	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
CRADAs, Total Active	0	1	8	12	0
New CRADAs	0	1	7	5	0
Traditional CRADAs, Total Active	0	1	8	12	0
Other Collaborative R&D Relationships	1,990	2,091	2,113	2,204	2,174

Other Performance Measures Deemed Important by the Agency

Software Release

NASA reports the following software release data.

Software Usage Agreements	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
New Software Usage Agreements Executed	1,368	1,685	2,107	2,620	5,054
Public Domain Release	56	218	303	549	1,891
US Release Only	665	699	930	1,101	1,463
Project Release	289	286	399	325	391
Interagency Release	110	146	167	120	182
NASA Release	166	181	174	388	660

NASA Downstream Success Stories

Behind the scenes, NASA's Technology Transfer Program is the engine that ensures spinoffs keep spinning. More than 2,000 commercial products have been featured in *Spinoff* since the publication's debut in 1976.

In 2017, *Spinoff* 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 technology transfer's 250,000 social media followers, which contributes to the routine readership of 2–3 million unique *Spinoff* website visitors per month.

Examples of successful technology transfer stories featured in *Spinoff* 2017 include:

CMOS Sensors Enable Phone Cameras, HD Video

In the 1990s, Jet Propulsion Laboratory 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.

GPS Correction Technology Lets Tractors Drive Themselves

With a license for software created by the Jet Propulsion Laboratory (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, didn't 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.

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.

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 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.

Statistical data provided in this report indicate that for all agencies covered by this report, between FY 2013 and FY 2017 there has been a 6% increase in invention disclosures, a 1% increase in patent applications, and an 11% increase in patents issued. In FY 2017, the largest number of federal patents issued involved the technical areas of measurement (11%), other special machines (8%), biotechnology (7%), electrical machinery, apparatus, energy (7%), pharmaceuticals (6%), and computer technology (5%).

Between FY 2013 and FY 2017, total active licenses decreased by 6%, new licenses increased by 39%, invention licenses increased by 5%, and new invention licenses increased by 37%. Income-bearing licenses decreased by 5%, and exclusive income-bearing licenses increased by 60%.

Between FY 2013 and FY 2017, income from all licensing decreased by 2%, income from invention licenses increased by 4%, and total earned royalty income decreased by 4%.

Between FY 2013 and FY 2017, CRADAs increased by 21%, and new CRADAs increased by 24%. Traditional CRADAs increased by 10% and other collaborative R&D relationships increased by 13%.

From September 2016 through December 2017, federal researchers published 60,063 papers. More than half of these papers were in the fields of biological sciences (25%), medical sciences (23%), and engineering (11%) and geosciences (11%). In FY 2017, 18,053 papers cited in U.S. patents were authored or coauthored by federal researchers. Of these papers, 87% involved research in the fields of biological sciences (41%), medical sciences (24%), physics (11%), and chemistry (11%).

Initial effort to determine the number of small businesses involved in federal CRADA agreements reveals that out of the 6,403 traditional, federal CRADA agreements from agencies that tracked small business participation, 23% involve small businesses as participants. Federal agencies also support small businesses through the licensing of technologies. Initial data reveal that of the 6,657 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 132 companies that started between the years of 2013 and 2017 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 Disclosure and Patenting

Agency	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
USDA	New Inventions Disclosed	191	117	222	244	166
	Patent Applications Filed	157	119	125	109	111
	Patents Issued	65	83	94	60	68
DOC	New Inventions Disclosed	41	47	61	64	43
	Patent Applications Filed	26	25	32	25	46
	Patents Issued	21	19	20	16	34
DoD	New Inventions Disclosed	1,032	963	781	874	978
	Patent Applications Filed	942	916	884	941	869
	Patents Issued	648	670	623	665	630
DOE	New Inventions Disclosed	1,796	1,588	1,645	1,760	1,794
	Patent Applications Filed	944	1,144	949	999	937
	Patents Issued	713	822	755	856	817
HHS	New Inventions Disclosed	320	351	321	320	354
	Patent Applications Filed	230	216	222	269	289
	Patents Issued	428	453	501	579	554
DHS	New Inventions Disclosed	21	44	12	24	25
	Patent Applications Filed	4	6	12	17	19
	Patents Issued	2	3	5	3	2
DOI	New Inventions Disclosed	9	6	7	8	12
	Patent Applications Filed	8	4	8	4	5
	Patents Issued	4	2	3	1	3
DOT	New Inventions Disclosed	13	3	0	0	3
	Patent Applications Filed	5	0	5	0	7
	Patents Issued	1	1	1	1	0
VA	New Inventions Disclosed	282	289	217	239	589
	Patent Applications Filed	106	116	116	104	163
	Patents Issued	31	37	54	54	50
EPA	New Inventions Disclosed	8	5	7	6	13
	Patent Applications Filed	7	9	4	1	4
	Patents Issued	16	5	7	3	3
NASA	New Inventions Disclosed	1,627	1,701	1,550	1,554	1,690
	Patent Applications Filed	150	140	129	129	165
	Patents Issued	118	120	123	103	114

Total	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
	New Inventions Disclosed	5,340	5,114	4,823	5,093	5,667
	Patent Applications Filed	2,579	2,695	2,486	2,598	2,615
	Patents Issued	2,047	2,215	2,186	2,341	2,275

Federal Licenses

Agency	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
USDA	Licenses, Total Active	400	414	424	441	438
	New Licenses	25	30	35	33	38
	Invention Licenses, Total Active	351	363	359	370	363
	New Invention Licenses	19	28	20	27	29
	Income Bearing Licenses, Total Active	397	412	421	439	437
	Income Bearing Exclusive Licenses	291	299	292	307	302
DOC	Licenses, Total Active	38	38	46	57	68
	New Licenses	7	7	13	15	19
	Invention Licenses, Total Active	38	38	46	57	68
	New Invention Licenses	7	7	13	15	19
	Income Bearing Licenses, Total Active	26	26	29	31	35
	Income Bearing Exclusive Licenses	13	14	16	20	19
DoD	Licenses, Total Active	527	430	560	515	552
	New Licenses	59	24	11	127	162
	Invention Licenses, Total Active	425	297	446	358	514
	New Invention Licenses	59	6	69	57	24
	Income Bearing Licenses, Total Active	264	223	213	194	396
	Income Bearing Exclusive Licenses	n.a.	n.a.	n.a.	218	196
DOE	Licenses, Total Active	5,217	5,861	6,310	5,410	4,045
	New Licenses	568	573	648	621	567
	Invention Licenses, Total Active	1,353	1,560	1,336	943	916
	New Invention Licenses	153	171	155	145	128
	Income Bearing Licenses, Total Active	3,709	4,215	4,577	3,963	3,057
	Income Bearing Exclusive Licenses	199	141	98	231	190
HHS	Licenses, Total Active	1,426	1,555	1,767	1,750	1,806
	New Licenses	184	212	279	278	334
	Invention Licenses, Total Active	1,069	1,186	1,354	1,721	1,354
	New Invention Licenses	152	117	232	221	282
	Income Bearing Licenses, Total Active	809	845	843	837	907
	Income Bearing Exclusive Licenses	25	24	11	23	135
DHS	Licenses, Total Active	0	2	4	5	5
	New Licenses	0	0	3	1	1
	Invention Licenses, Total Active	0	2	4	5	5
	New Invention Licenses	0	0	3	1	1
	Income Bearing Licenses, Total Active	0	1	4	1	1
	Income Bearing Exclusive Licenses	0	0	0	0	0

Federal Licenses (continued)

Agency	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
DOI	Licenses, Total Active	20	18	20	22	15
	New Licenses	3	0	3	0	0
	Invention Licenses, Total Active	20	16	18	20	13
	New Invention Licenses	3	0	3	0	0
	Income Bearing Licenses, Total Active	16	14	18	17	13
	Income Bearing Exclusive Licenses	4	5	7	8	7
DOT	Licenses, Total Active	3	1	2	2	4
	New Licenses	1	0	1	2	1
	Invention Licenses, Total Active	3	1	2	0	0
	New Invention Licenses	1	0	0	0	0
	Income Bearing Licenses, Total Active	3	1	2	2	4
	Income Bearing Exclusive Licenses	0	1	0	0	0
VA	Licenses, Total Active	194	197	200	261	262
	New Licenses	9	3	3	1	1
	Invention Licenses, Total Active	194	197	200	260	261
	New Invention Licenses	9	3	3	1	0
	Income Bearing Licenses, Total Active	13	14	16	42	42
	Income Bearing Exclusive Licenses	10	9	11	35	36
EPA	Licenses, Total Active	40	40	37	35	38
	New Licenses	2	6	0	8	5
	Invention Licenses, Total Active	40	40	37	35	38
	New Invention Licenses	2	6	0	8	5
	Income Bearing Licenses, Total Active	35	33	31	31	31
	Income Bearing Exclusive Licenses	9	8	7	7	7
NASA	Licenses, Total Active	332	349	375	452	506
	New Licenses	38	51	74	107	119
	Invention Licenses, Total Active	281	297	321	387	440
	New Invention Licenses	31	45	69	97	109
	Income Bearing Licenses, Total Active	160	176	193	245	258
	Income Bearing Exclusive Licenses	11	9	12	14	8

Total	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
	Licenses, Total Active	8,197	8,905	9,745	8,950	7,739
	New Licenses	896	906	1,070	1,193	1,247
	Invention Licenses, Total Active	3,774	3,997	4,123	4,156	3,972
	New Invention Licenses	436	383	567	572	597
	Income Bearing Licenses, Total Active	5,432	5,960	6,347	5,802	5,181
	Income Bearing Exclusive Licenses	562	510	454	863	900

Federal Income from Licensing ($000s)

Agency	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
USDA	Total Income, All Active Licenses	$4,386	$4,928	$5,067	$4,784	$5,703
	Invention Licenses	$4,054	$4,733	$4,842	$4,456	$5,378
	Total Earned Royalty Income, (ERI)	$3,354	$3,611	$3,510	$3,633	$3,504
DOC	Total Income, All Active Licenses	$151	$220	$164	$149	$141
	Invention Licenses	$151	$220	$164	$149	$141
	Total Earned Royalty Income, (ERI)	$151	$220	$164	$149	$141
DoD	Total Income, All Active Licenses	$21,575	$11,703	$9,448	$6,205	n.a.
	Invention Licenses	$20,859	$10,890	$8,482	$5,199	n.a.
	Total Earned Royalty Income, (ERI)	$20,438	$7,845	$6,099	$6,205	$7,415
DOE	Total Income, All Active Licenses	$39,573	$37,885	$33,137	$31,149	$36,567
	Invention Licenses	$36,068	$32,869	$28,966	$27,364	$33,436
	Total Earned Royalty Income, (ERI)	$27,669	$23,384	$21,245	$16,273	$13,216
HHS	Total Income, All Active Licenses	$116,448	$137,249	$151,727	$132,833	$134,567
	Invention Licenses	$103,664	$133,814	$147,512	$130,701	$132,536
	Total Earned Royalty Income, (ERI)	$116,601	$116,765	$114,102	$110,193	$135,963
DHS	Total Income, All Active Licenses	$0	$3	$5	$12	$20
	Invention Licenses	$0	$0	$0	$12	$20
	Total Earned Royalty Income, (ERI)	$0	$3	$5	$12	$20
DOI	Total Income, All Active Licenses	$96	$58	$106	$83	$50
	Invention Licenses	$96	$58	$106	$83	$50
	Total Earned Royalty Income, (ERI)	$96	$58	$106	$82	$50
DOT	Total Income, All Active Licenses	$9	$23	$12	$15	$20
	Invention Licenses	$0	$0	$0	$0	$0
	Total Earned Royalty Income, (ERI)	$9	$23	$12	$15	$20
VA	Total Income, All Active Licenses	$389	$336	$494	$316	$491
	Invention Licenses	$389	$336	$494	$316	$491
	Total Earned Royalty Income, (ERI)	$389	$336	$494	$316	$491
EPA	Total Income, All Active Licenses	$193	$439	$232	$466	$412
	Invention Licenses	$193	$439	$232	$466	$412
	Total Earned Royalty Income, (ERI)	$193	$439	$232	$466	$412
NASA	Total Income, All Active Licenses	$2,183	$2,095	$3,395	$3,149	$2,682
	Invention Licenses	$1,644	$1,729	$2,828	$2,750	$2,126
	Total Earned Royalty Income, (ERI)	$2,132	$2,063	$3,250	$2,746	$2,118

Total	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
	Total Income, All Active Licenses	$185,003	$194,939	$203,787	$179,161	$180,653
	Invention Licenses	$167,118	$185,088	$193,626	$171,496	$174,590
	Total Earned Royalty Income, (ERI)	$171,032	$154,747	$149,219	$140,090	$155,935

Federal Collaborative R&D Relationships

Agency	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
USDA	CRADAs, Total Active	259	267	301	238	330
	New CRADAs	86	60	80	79	91
	Traditional CRADAs, Total Active	211	193	188	161	296
	Other Collaborative R&D Relationships	5,408	5,629	4,730	5,628	6,125
DOC	CRADAs, Total Active	2,437	2,307	2,752	2,940	2,932
	New CRADAs	2,289	2,111	2,548	2,608	2,443
	Traditional CRADAs, Total Active	206	233	365	335	413
	Other Collaborative R&D Relationships	2,963	2,981	3,125	3,273	3,181
DoD	CRADAs, Total Active	2,682	2,762	2,148	3,125	3,511
	New CRADAs	769	671	793	1,061	1,221
	Traditional CRADAs, Total Active	2,682	2,281	1,601	2,297	2,797
	Other Collaborative R&D Relationships	606	581	1,389	452	619
DOE	CRADAs, Total Active	742	698	732	739	910
	New CRADAs	142	162	188	246	320
	Traditional CRADAs, Total Active	742	698	732	739	910
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	427	532	400	590	588
	New CRADAs	104	98	112	134	112
	Traditional CRADAs, Total Active	313	378	202	391	462
	Other Collaborative R&D Relationships	114	154	150	147	126
DHS	CRADAs, Total Active	114	158	230	343	397
	New CRADAs	76	88	98	114	106
	Traditional CRADAs, Total Active	91	121	200	272	272
	Other Collaborative R&D Relationships	6	31	30	71	71
DOI	CRADAs, Total Active	476	601	826	873	841
	New CRADAs	376	423	586	511	477
	Traditional CRADAs, Total Active	21	35	38	37	58
	Other Collaborative R&D Relationships	322	292	318	319	247
DOT	CRADAs, Total Active	40	51	48	68	67
	New CRADAs	8	10	9	22	6
	Traditional CRADAs, Total Active	3	7	48	62	66
	Other Collaborative R&D Relationships	26	30	35	152	355
VA	CRADAs, Total Active	2,181	2,317	2,305	2,613	1,785
	New CRADAs	453	517	509	502	575
	Traditional CRADAs, Total Active	1,982	2,126	2,113	2,359	1,619
	Other Collaborative R&D Relationships	0	0	0	0	0
EPA	CRADAs, Total Active	112	129	97	103	140
	New CRADAs	51	35	23	44	54
	Traditional CRADAs, Total Active	55	52	50	55	51
	Other Collaborative R&D Relationships	0	0	0	0	0
NASA	CRADAs, Total Active	0	1	8	12	0
	New CRADAs	0	1	7	5	0
	Traditional CRADAs, Total Active	0	1	8	12	0
	Other Collaborative R&D Relationships	1,990	2,091	2,113	2,204	2,174

Total	Metric	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
	CRADAs, Total Active	9,470	9,823	9,847	11,644	11,501
	New CRADAs	4,354	4,176	4,953	5,326	5,405
	Traditional CRADAs, Total Active	6,306	6,125	5,545	6,720	6,944
	Other Collaborative R&D Relationships	11,435	11,789	11,890	12,246	12,898

Appendix B

Technology Area Classifications
Mapping of International Patent Classifications to Technology Area[30]

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.

[30] Derived from The World Intellectual Property Organization's International Patent Classification (IPC) Correspondence Table and IPC Searchable Classification Database, Version 2016.01.

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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix C

Fields and Subfields of S&E Publications Data[31]

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

Psychology: clinical psychology, behavioral and comparative psychology, developmental and

[31] 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. Science and Engineering Indicators 2016, Appendix Table 5-24. Used with permission.

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

Addendum – Response to 2018 GAO Licensing Recommendations

In 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)[32]. 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 studies conducted by the FLC, and agency reports, and include that information in its summary reports to Congress." This recommendation aligns with the PMA and is a continuation of long running efforts by the federal interagency technology transfer community. This addendum to the FY17 Federal Technology Transfer Report is included to respond to GAO's recommendation.

Challenges in Federal Patent Licensing

The President's Management Agenda (PMA) set a Cross Agency Priority (CAP) goal to improve the transfer of technology from federally funded research and development (R&D) to the private sector to promote U.S. economic growth and national security. The federal government provides approximately $137 billion annually in both intramural and extramural funding for R&D to help further agencies' missions. Approximately one-third is invested at Federal labs, funding the research that underlies the innovation and technology transfer activities described in this report.

The intellectual property generated by federal laboratory R&D activities has application beyond each agency's immediate, mission-related goals – in accordance with the will of Congress, it is the responsibility of the federal government to ensure the full use of the results of the Nation's investment in R&D[33]. Federal laboratories were given the authority to grant licenses on federally owned inventions in 35 U.S.C. § 209; granting a license "is a reasonable and necessary incentive to call forth the investment capital and expenditures needed to bring the invention to practical application, or otherwise promote the invention's utilization by the public."

NIST, in coordination with the White House Office of Science and Technology Policy, launched the Return on Investment (ROI) Initiative to advance the PMA and its Lab-to-Market (L2M) CAP goal. The ROI initiative's objectives were to assess and streamline the transfer of federally funded technology by identifying critically needed improvements to Federal technology transfer policies and practices through seeking broad input from Federal R&D, intellectual property, and technology transfer stakeholders. On April 27, 2019, NIST published the final ROI green paper as NIST Special Publication 1234[34]. The ROI green paper is a discussion document that provides a summary of key stakeholder inputs and identifies findings by NIST that will help inform future deliberations, decision-making, and implementing actions by the relevant departments and agencies that could further enhance the U.S. innovation engine.

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[32] Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions, June 2018,
[33] 15 U.S.C. § 3710(a)(1)
[34] Return on Investment Initiative to Advance the President's Management Agenda: NIST Special Publication 1234, April 2019

The L2M CAP Goal is executed through five strategies that also form the foundation for the organization of the ROI green paper findings. Strategies 1 and 4 contain NIST Findings that directly relate to licensing challenges identified in the 2018 GAO report.

1. Identify regulatory impediments and administrative improvements in Federal technology transfer policies and practices;
2. Increase engagement with private sector technology development experts and investors;
3. Build a more entrepreneurial R&D workforce;
4. Support innovative tools and services for technology transfer; and
5. Improve understanding of global science and technology trends and benchmarks.

Under Strategy 1, the stakeholder respondents to the ROI request for information (RFI) expressed a general support of federal licensing policies and practices but raised specific issues below. Respondents specifically pointed out the lost opportunity to commercialize software innovations due to the inability to protect copyright of works created by Federal employees (NIST Finding 4). Respondents also reported the lack of clear, uniform policies for the ownership, transfer, and licensing of software and datasets has caused confusion in the market and served as an impediment to commercialization success. Many respondents urged the Federal agencies to identify and implement best practices and uniform policies to facilitate Lab-to-Market licensing. Updating regulations that ensure optimal performance by Federal agencies can serve to address market failures, reduce entry barriers, encourage greater competition, and spur innovation (NIST Finding 6). Additionally, the L2M community will work to address stakeholders' request to develop guidelines for government licensing practices for intellectual property at Federal laboratories to promote commercial use of inventions while maintaining flexibility to tailor the specific financial terms of each license (NIST Finding 8B). Likewise, for clarity, the Federal agencies will clarify the purpose of royalties for licensing at Federal laboratories as a primary method to promote compliance by the licensee to the terms of development and practical application of technology (NIST Finding 8C). NIST is currently reviewing comments submitted in response to a Notice of Proposed Rulemaking published on January 4, 2021 that will, among other efforts, address some of these findings, and will continue to work with the interagency community and the Federal Laboratory Consortium on developing agency best practice resources.

In the Strategy 4 section, RFI respondents note that agency-specific websites can provide some information related to technology transfer but present a challenge for users who are interested in technologies from more than one agency. Resources such as FLC Business have made progress in overcoming these technology silos, but stakeholders indicated a present need for improvements to a centralized repository of technology transfer information and opportunities across all agencies (NIST Finding 14). Stakeholders requested the development of a data portal that is easy for the pubic to access, use, and analyze that has complete information on available technologies for further development and Federal R&D programs, facilities, equipment and tools, expertise, services, and other relevant assets that are available to the public (NIST Finding 14A). Interestingly, there is a need for legislative and regulatory changes to Federal laboratories' reporting requirements on R&D partnership opportunities, facilities, equipment and tools, expertise, services, and other relevant assets, as such reporting is outside the scope of current legislation and regulatory authority (NIST Finding 14B). Access to consolidated information will

inform not only the extramural stakeholder community but will also help inform individual Federal agencies to identify complementary R&D programs, priorities, and assets. NIST is currently working with the FLC to improve FLC Business assets and is evaluating updates to statutory requirements for agencies to provide regular updates to the datasets of available resources.

The report has been used to inform NIST and the White House National Science and Technology Council (NSTC) leadership, as well as contributing to additional milestones in the L2M CAP goal. Ongoing L2M CAP goal and interagency working groups are currently developing assessments of the full range of challenges in federal patent licensing; clarifying the link between patent license financial terms and the goal of promoting commercial use; and facilitating information exchange between the agencies to provide federal laboratories with information on financial terms in comparable patent licenses.