Federal Laboratory Technology Transfer

Fiscal Year 2019

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 2019 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 the 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 has 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, to improve and expand the collection of technology transfer metrics, and to establish 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 Congress informed of the ongoing efforts of federal laboratories to expand 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. Laurie E Locascio
Under Secretary of Commerce for Standards and Technology, &
Director, National Institute of Standards and Technology

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Chapter 1
Overview of Federal Technology Transfer

Many federal agencies conduct research and development (R&D) activities that result in the creation of new technologies. In most cases, these technologies are created to support the 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 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. Collaborative research between federal and non-federal organizations greatly enhances researcher capabilities, core competencies, and creativity by bringing together thousands of highly qualified researchers and world-class research facilities. 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 decade, agencies have responded to the need to improve technology transfer operations to better address the needs of businesses, especially small businesses that are vulnerable to a slow-moving, bureaucratic system. The interagency coordination of efforts has led agencies to review their operations and propose new ways to improve the overall customer experience. These improvements include efforts to streamline operations to open doors to more efficient technology transfer opportunities. Other improvements target the way customers interact with the federal system.

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

Each of these agencies has established programs for promoting the transfer and commercialization of 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

Federal government R&D spending supports a wide variety of agency-specific missions, such as military objectives, health and human services issues, energy development, space exploration, and so forth. In FY 2019, the total federal budget for R&D was $142,424 million. Of this, $91,682 million (64%) was used to support R&D activities that occurred outside the federal laboratories. This includes funding for grants, cooperative agreements, and similar instruments.[3] The remainder, $50,742 million (36%), supported R&D activities that occurred inside federal laboratories. This includes $39,313 million to support intramural activities and $11,430 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 2019 ($ million)[4]

	Total R&D	Intramural[(a)]	FFRDCs	Intramural and FFRDCs	Percent of Total R&D Budget
All Agencies	$142,424	$39,313	$11,430	$50,742	36%
DoD	$58,780	$20,315	$831	$21,145	36%
HHS	$39,191	$7,753	$516	$8,270	21%
DOE	$14,376	$1,052	$7,411	$8,463	59%
NASA	$13,570	$4,145	$2,321	$6,466	48%
USDA	$2,637	$1,644	$0	$1,644	62%
DOC	$1,535	$1,102	$10	$1,112	72%
VA	$1,508	$1,437	$0	$1,437	95%
DOT	$1,013	$190	$0	$190	19%
DOI	$827	$695	$0	$695	84%
DHS	$647	$180	$20	$200	31%
EPA	$485	$249	$1	$251	52%
Other Agencies	$7,856	$552	$320	$871	11%

(a) Intramural activities cover costs associated with the administration of intramural and extramural programs by federal personnel as well as actual intramural performance.

[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 2019-20, Federal Obligations for Research and Development, by Agency and Performer, FY 19, Table 7. https://ncses.nsf.gov/pubs/nsf21329

In FY 2019, DoD spent the largest amount of funding on intramural activities and FFRDCs with $21,145 million (36% of its R&D budget). The DOE was second with $8,463 million (59% of its R&D budget) and HHS was third with $8,270 million (21% of its R&D budget).

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 2015 through FY 2019.[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 2019 have been adjusted where necessary to reflect the most accurate estimates for each year reported. The data in this report are accurate per the reporting agencies as of July 21, 2022. The data presented in this report may differ from individual agency reports submitted for FY 2019 if the agencies have updated those data after the agency report was submitted.

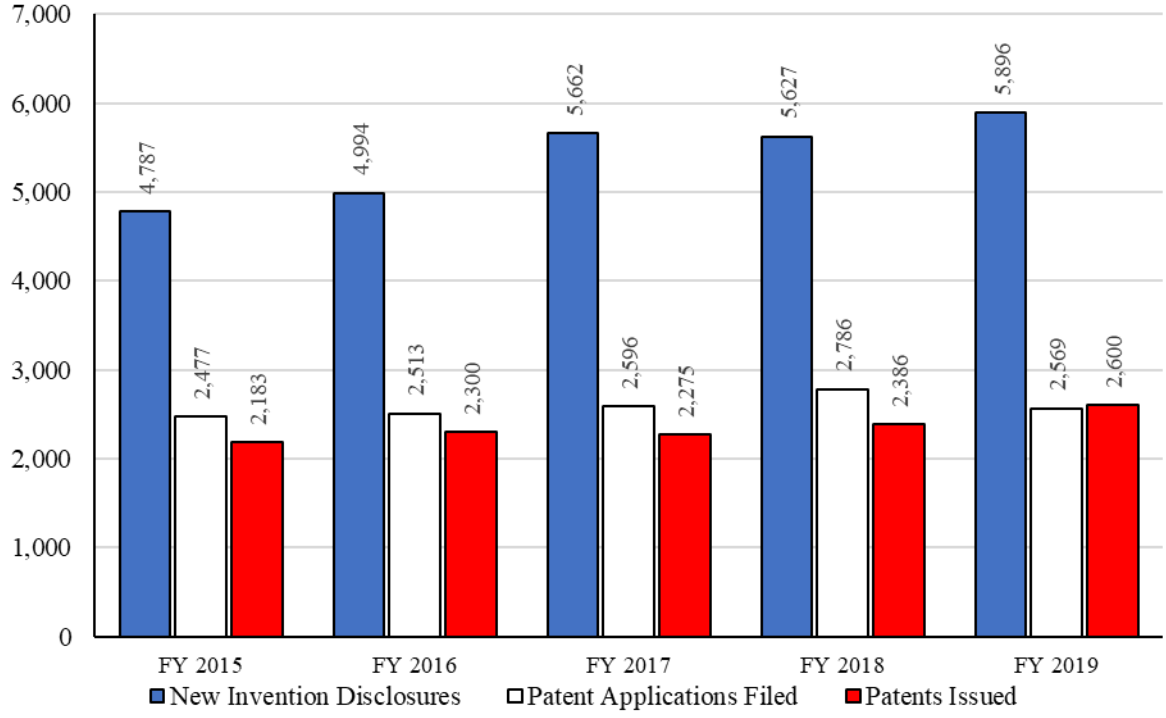
Federal Invention Disclosures and Patenting

The protection of intellectual property can be vital to attracting 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 2015 and FY 2019, invention disclosures reported by federal agencies increased by 23% to 5,896. Patent applications filed increased by 4% to 2,569, and patents issued increased by 19% to 2,600. DOE reported the largest number of invention disclosures with 1,891 in FY 2019, followed by NASA with 1,841 and DoD with 839. These three agencies accounted for 67% of all invention disclosures reported in this fiscal year.

In FY 2019, DoD reported the largest number of patent applications with 955, followed by DOE with 837 and VA with 274. These three agencies accounted for 81% of patent applications in FY 2019. DOE reported the largest number of patents issued in FY 2019 with 919, followed by HHS with 708 and DOD with 653. These three agencies accounted for 88% of reported patents issued in FY 2019.

Federal Invention Disclosures and Patenting

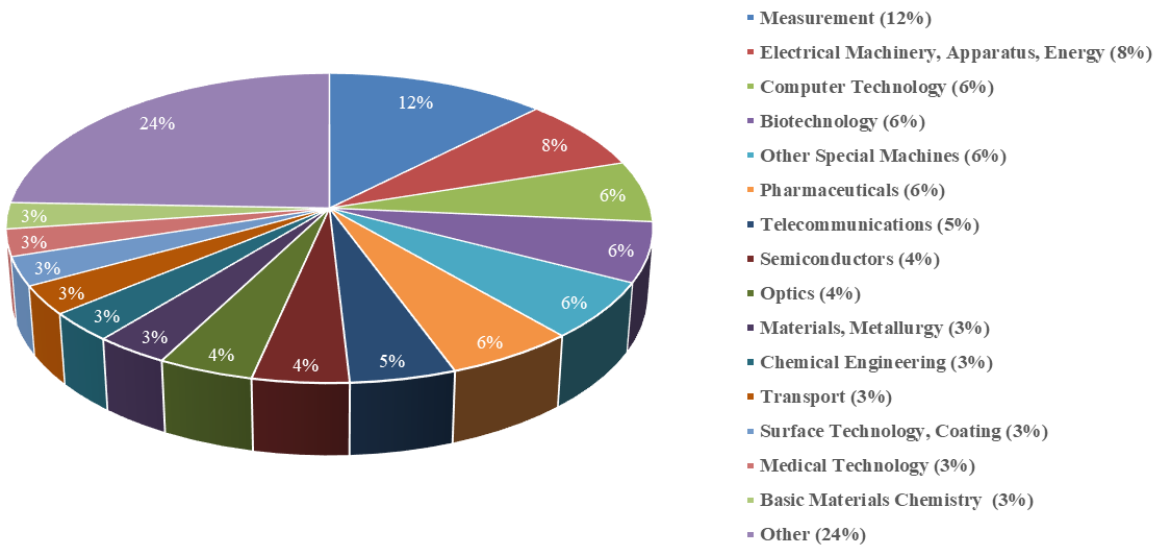


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	4,787	4,994	5,662	5,627	5,896
Patent Applications Filed	2,477	2,513	2,596	2,786	2,569
Patents Issued	2,183	2,300	2,275	2,386	2,600

Technical Area Summary of U.S. Federal Agency Patents

The chart below uses data from the U.S. Patent and Trademark Office (USPTO) to illustrate the technical areas covered by patents issued to federal agencies in FY 2019. The chart shows the percentage of patents issued to federal agencies by technology area based on fractional count patents.[7] In FY 2019, the largest number of federal patents issued involved Measurement (12%) followed by Electrical Machinery, Apparatus, Energy (8%), Computer Technology (6%), Biotechnology (6%), Other Special Machines (6%), Pharmaceuticals (6%), Telecommunications (5%), Semiconductors (4%), Optics (4%), Materials, Metallurgy (3%), Chemical Engineering (3%), Transport (3%), Surface Technology, Coating (3%), Medical Technology (3%), Basic Materials Chemistry (3%), and Other (24%).[8]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2019



[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 June 2019. Used with permission.

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

Federal Licenses[9]

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 contribute to competitiveness and domestic economic growth. The ability to grant licenses to the nonfederal sector helps protect, utilize, or further develop federally conceived 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.

Between FY 2015 and FY 2019, total active licenses for agencies for which all data were available decreased by 13%, from 9,548 in FY 2015 to 8,289 in FY 2019.[10] New licenses for agencies for which all data were available increased by 12% from 1,126 in FY 2015 to 1,257 in FY 2019.[11] Total active invention licenses for agencies for which all data were available decreased by 3%, from 3,909 in FY 2015 to 3,805 in FY 2019.[12] New invention licenses for agencies for which all data were available increased by 1%, from 566 in FY 2015 to 572 in FY 2019.[13] Invention licenses refers to inventions that are patented or could be patented. Income-bearing licenses decreased by 17%, from 6,337 in FY 2015 to 5,235 in FY 2019. Exclusive income-bearing licenses for agencies for which all data were available increased by 58%, from 562 in FY 2015 to 890 in FY 2019.[14]

In FY 2019, DOE reported the largest number of total active licenses with 4,640 licenses. The HHS was second with 1,933 licenses and DoD was third with 575 licenses. These three agencies accounted for 86% of all licenses reported in FY 2019.

In FY 2019, HHS reported the largest number of invention licenses with 1,472, followed by DOE 822 and NASA with 529. Together these three agencies accounted for 72% of invention licenses in FY 2019.

[9] Data for some agencies were not available for this report. Data for FY 2018 and FY 2019 values for total active licenses, new licenses, total active invention licenses, and new invention licenses were not available for VA. Data for FY 2018 values for total active invention licenses and new invention licenses, were not available for DoD. Data for FY 2018 values for total active invention licenses, new invention licenses, and income bearing exclusive licenses were not available for DOI.

[10] Total active licenses for all agencies, including those for which some data were unavailable, decreased by 15%, from 9,748 in FY 2015 to 8,289 in FY 2019.

[11] New licenses for all agencies, including those for which some data were unavailable, increased by 11%, from 1,129 in FY 2015 to 1,257 in FY 2019.

[12] Total active invention licenses for all agencies, including those for which some data were unavailable, decreased by 7% from 4,109 in FY 2015 to 3,805 in FY 2019.

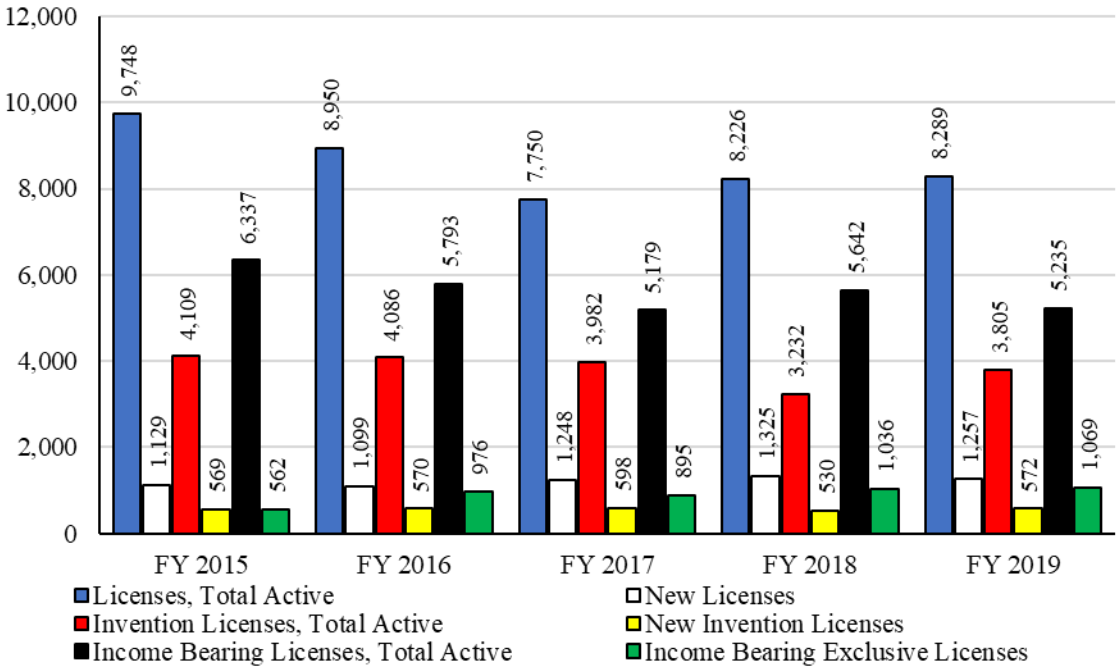
[13] New invention licenses for all agencies, including those for which some data were unavailable, increased by 1% from 569 in FY 2015 to 572 in FY 2019.

[14] Income bearing exclusive licenses for all agencies, including those for which some data were unavailable, increased by 90%, from 562 in FY 2015 to 1,069 in FY 2019.

In FY 2019, DOE reported the largest number of income-bearing licenses, 2,749. The HHS was second with 1,001 followed by USDA with 522. Together these three agencies accounted for 82% of income-bearing licenses in FY 2019.

In FY 2019, USDA reported the largest number of income-bearing exclusive licenses with 334, followed by VA with 245, and DoD with 179. Together these three agencies accounted for 71% of income-bearing exclusive licenses in FY 2019.

Federal Licenses[15]



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	9,748	8,950	7,750	8,226	8,289
New Licenses	1,129	1,099	1,248	1,325	1,257
Invention Licenses, Total Active	4,109	4,086	3,982	3,232	3,805
New Invention Licenses	569	570	598	530	572
Income Bearing Licenses, Total Active	6,337	5,793	5,179	5,642	5,235
Income Bearing Exclusive Licenses	562	976	895	1,036	1,069

Federal Income from Licenses[16]

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 2015 and FY 2019, income from all licensing decreased by 55% to $92 million. Income from

[15] This figure shows values for all agencies, including those for which some data were unavailable.
[16] Data for some agencies was not available for this report. DoD was unable to provide values for total income for all active licenses and income from invention licenses for FY 2017 and FY 2018.

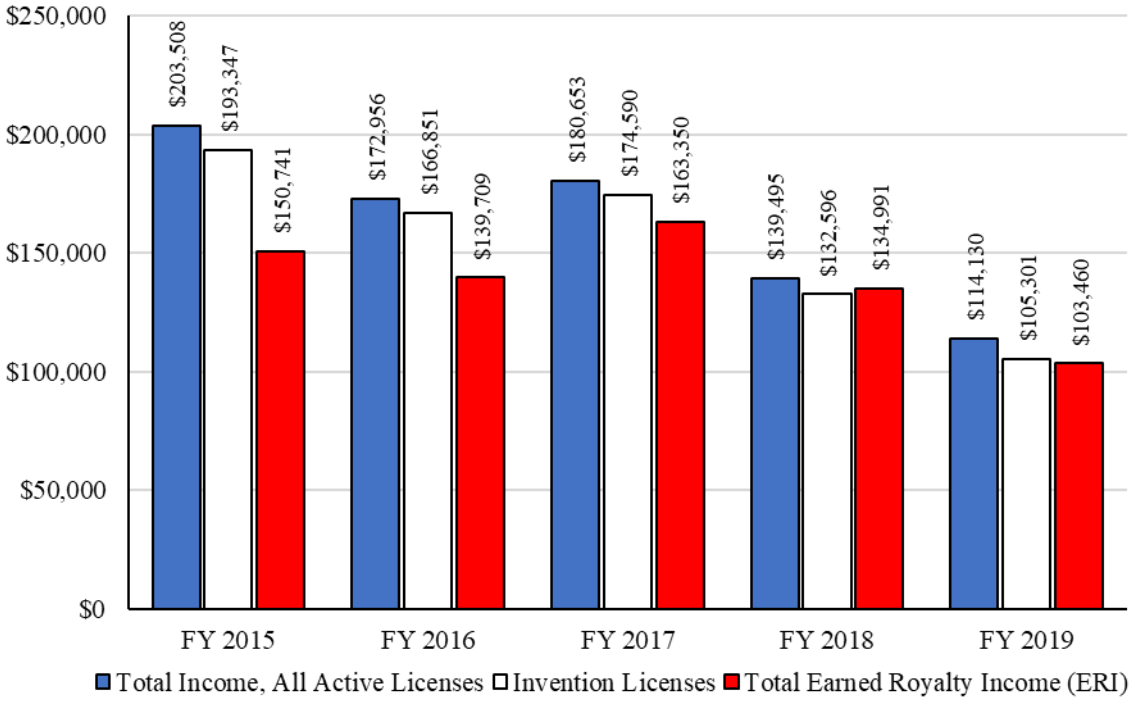
invention licenses decreased by 55% to $87 million and total earned royalty income decreased by 31% to $103 million.

The HHS accounted for the most licensing income with $79 million, followed by DoD with $6 million, and USDA with $4 million. Together these three agencies accounted for 95% of reported licensing income.

The HHS accounted for the most invention license income with $76 million, followed by USDA with $3 million, and DoD with $3 million. Together these three agencies accounted for 95% of Invention License Income.

The HHS accounted for the most Earned Royalty Income with $79 million, followed by DOE with $10 million, and DoD with $7 million. Together these three agencies accounted for 88% of Earned Royalty Income.

Federal Income from Licenses ($000s)[17]



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$203,508	$172,956	$180,653	$139,495	$114,130
Invention Licenses	$193,347	$166,851	$174,590	$132,596	$105,301
Total Earned Royalty Income, (ERI)	$150,741	$139,709	$163,350	$134,991	$103,460

[17] This figure shows values for all agencies, including those for which some data were unavailable.

Federal Collaborative R&D Relationships[18]

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. They also 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. "Traditional CRADAs" refer 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.

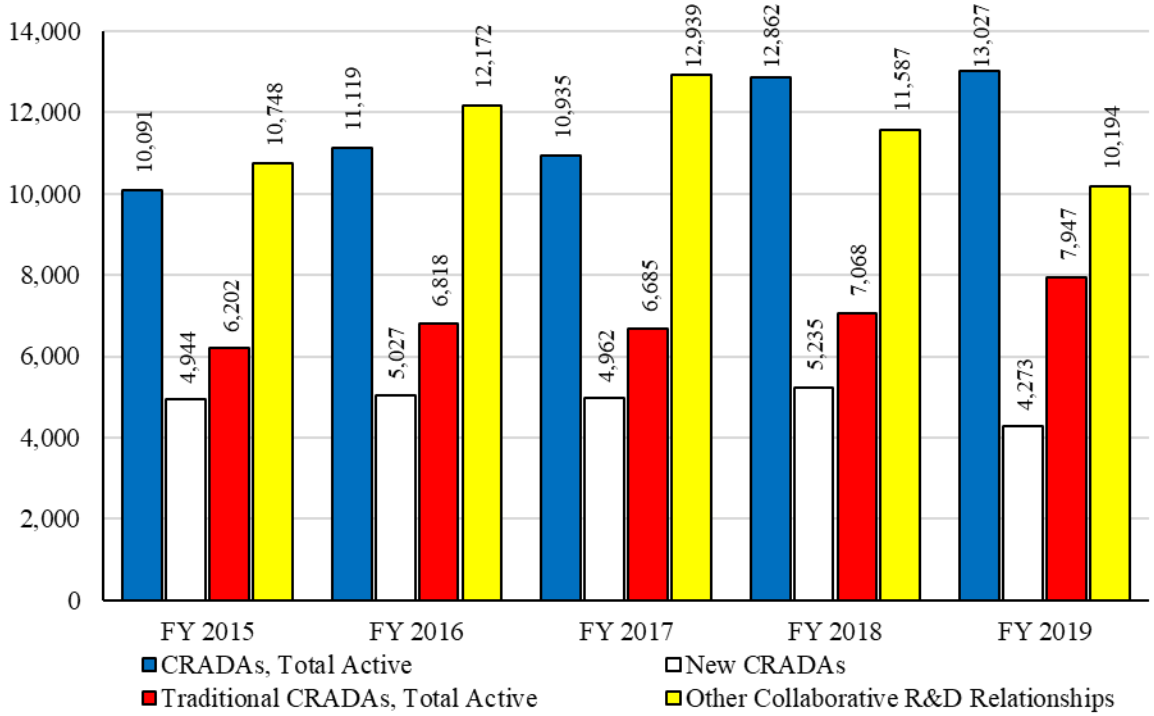
In addition to CRADAs, agencies have other specific authorities that also facilitate cooperative R&D relationships, such as Space Act Agreements from NASA, or other transaction authorities.

Between FY 2015 and FY 2019, active CRADAs increased by 23% to 13,027. New CRADA agreements decreased by 16% to 4,273. Other collaborative R&D relationships decreased by 5% to 10,194.

In FY 2019, DoD reported the largest number of CRADAs with 6,090, followed by DOC with 2,564 and VA with 1,688. The DOC reported the largest number of other collaborative R&D relationships with 3,431, with DoD reporting 2,322, and NASA reporting 1,967 (Space Acts Agreements).

[18] Data for some agencies were not available for this report. DHS was unable to provide values for other collaborative R&D relationships for FY 2018 and FY 2019.

Federal Collaborative R&D Relationships[19]



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	10,091	11,119	10,935	12,862	13,027
New CRADAs	4,944	5,027	4,962	5,235	4,273
Traditional CRADAs, Total Active	6,202	6,818	6,685	7,068	7,947
Other Collaborative R&D Relationships	10,748	12,172	12,939	11,587	10,194

Science and Engineering (S&E) Articles

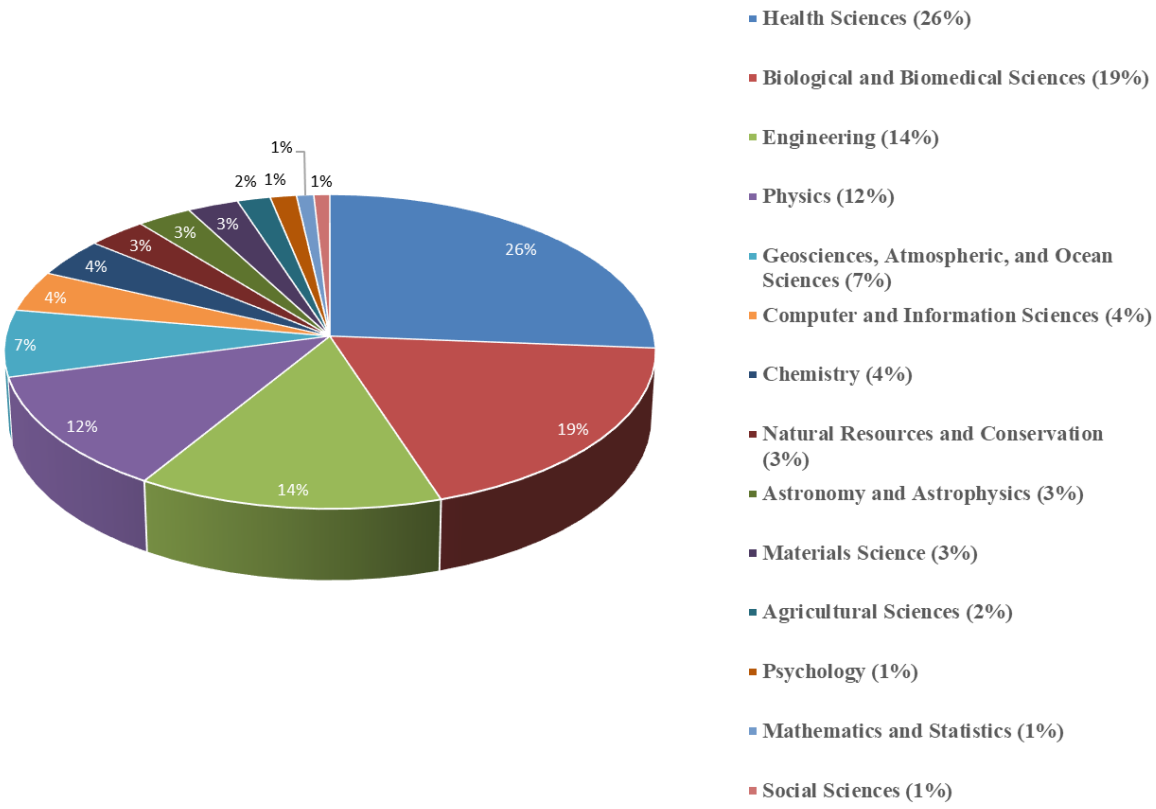
Although intellectual property has traditionally been tracked in terms of patents, licenses, and collaborative efforts, most federal research results are transferred through publication of S&E articles. Unfortunately, a uniform tracking system for S&E articles across all federal agencies does not exist. However, data from Elsevier's Scopus 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 this database. For example, in 2019, Elsevier reported that federal researchers authored or coauthored 70,108 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).[20]

[19] This figure shows values for all agencies, including those for which some data were unavailable.

[20] 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 2019 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.

The Elsevier database provided 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 Health Sciences (26%), Biological and Biomedical Sciences (19%), Engineering (14%), Physics (12%), and Geosciences, Atmospheric, and Ocean Sciences (7%).[21]

S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: CY 2019



Citations within U.S. Patents

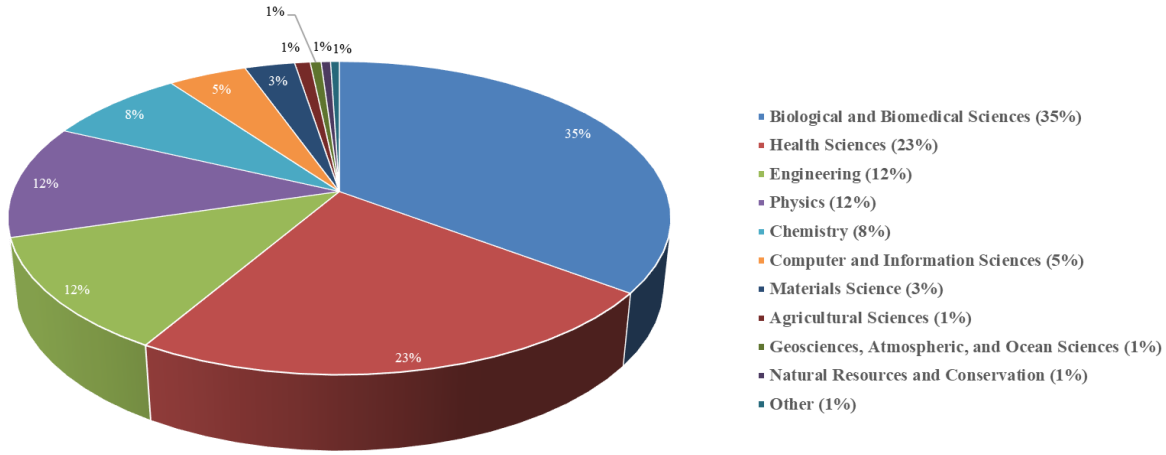
Elsevier data also provides insight into the commercial relevance of S&E articles authored by federal researchers through the number of articles cited in U.S. patents. In FY 2019, more than 20,344 articles authored or coauthored by federal researchers were cited in U.S. patents.[22] Of

[21] Articles are credited on a whole-count basis. Source: Data prepared by Science-Metrix using the Scopus (Elsevier) accessed in September 2020. Used with permission.

[22] 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

these, the greatest number of articles addressed research in Biological and Biomedical Sciences (35%), Health Sciences (23%), Engineering (12%), Physics (12%), and Chemistry (8%).[23]

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2019



Efforts to Enhance Technology Transfer Outcomes and Entrepreneurship

Federal agencies have been involved in activities to streamline the technology transfer process, promote awareness of technology transfer, enhance the effectiveness of technology transfer activities, and develop new metrics to better quantify technology transfer impacts.

The Innovation Corps Program

In 2011, the National Science Foundation (NSF) established the Innovation Corps (I-Corps™)[24] 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. The 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

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.

[23] 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 Scopus (Elsevier) accessed in September 2020 and PatentsView accessed in September 2020.

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

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 to 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). The NREL leads curriculum development and execution, recruits program instructors and industry mentors, and assembles teams from the following national labs:

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

Other agencies have incorporated I-Corps™ into their programs. The 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, their 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.

The 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 to the marketplace. By placing venture capital-sponsored entrepreneurs at key national laboratories, DOE aims to accelerate laboratory technology transfer, further enabling start-up entrepreneurs to work directly with the laboratories and bridge the gap between leading scientific and business talent. Technology assessments and proposing business structures to commercialize promising technologies can be conducted on site. 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.

The USDA's Agricultural Research Service (ARS) has six 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.

The 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. The 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 2019

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. For each agency, this report considers three main topic areas:

- Statistical data on the agency's technology transfer activity levels for a number of measures (e.g., cooperative R&D relationships, invention disclosures and patenting, and intellectual property licensing) for the most recently closed fiscal year (FY 2019) and several prior years (FY 2015-2019);
- Streamlining activities at each agency to lower administrative burden and make technology transfer more accessible; and
- 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.

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. Although 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 R&D investments, creating economic activity, job creation, and sustainable economic development.

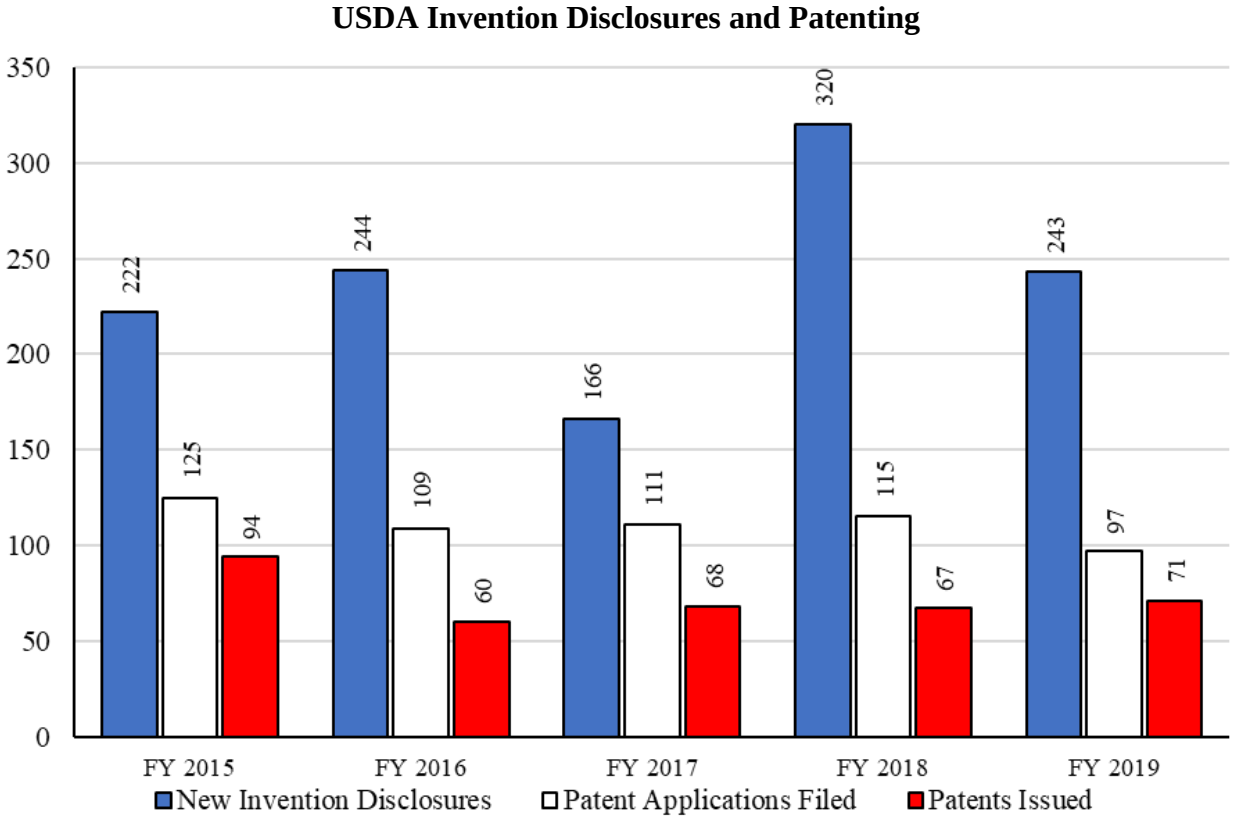
The Agriculture Research Service (ARS) has been delegated authority by the Secretary of Agriculture to administer the patent program for ARS, review CRADAs, and administer technology licensing programs for all intramural research conducted by USDA. These activities are housed in the Office of Technology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

The USDA's FY 2019 annual report is available online and covers technology-transfer activities and metrics for the USDA, Agricultural Marketing Service (AMS), Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), Economic Research Service (ERS), Foreign Agricultural Service (FAS), Food Safety and Inspection Service (FSIS), Forest Service (FS), National Agricultural Statistics Service (NASS), National Institute of Food and Agriculture (NIFA), Natural Resources Conservation Service (NRCS), and Rural Development (RD).

More information about USDA's technology transfer activities is available on the following websites:
Agricultural Research Service (ARS)
Animal and Plant Health Inspection Service (APHIS)
Forest Service (FS)

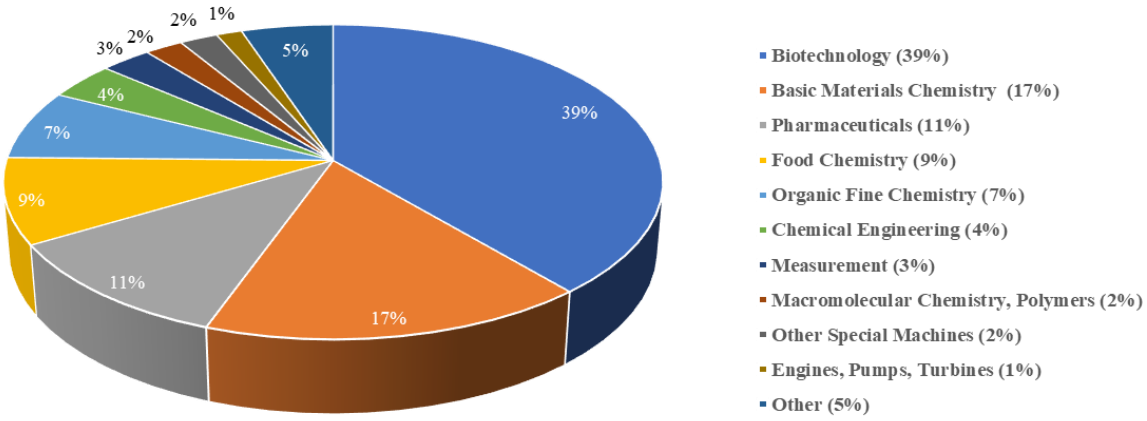
USDA Invention Disclosures and Patenting

Between FY 2015 and FY 2019, invention disclosures received increased by 9%, from 222 to 243. Patent applications filed decreased 22%, from 125 in FY 2015 to 97 in FY 2019. Patents issued decreased by 24% from 94 in 2015 to 71 in FY 2019.



Patents issued to USDA in FY 2019 covered many technology areas including Biotechnology (39%), Basic Materials Chemistry (17%), Pharmaceuticals (11%), Food Chemistry (9%) and Organic Fine Chemistry (7%).[25]

USPTO Patents Assigned to USDA by Technology Area: FY 2019

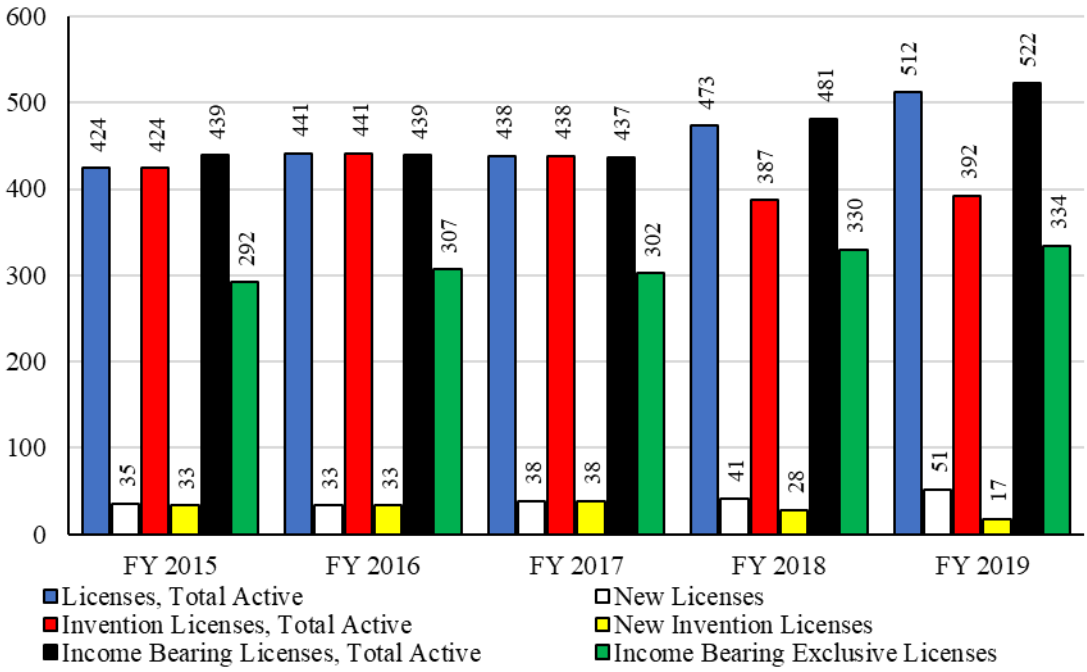


[25] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView accessed in January 2022. Used with permission.

USDA Licenses

Between FY 2015 and FY 2019, total active licenses increased by 21% to 512 licenses in FY 2019. Total active invention licenses decreased by 8% to 392 licenses. Total active income bearing licenses increased 19%, from 439 in FY 2015 to 354 in FY 2019, while income-bearing exclusive licenses increased by 14% to 334.

USDA Licenses

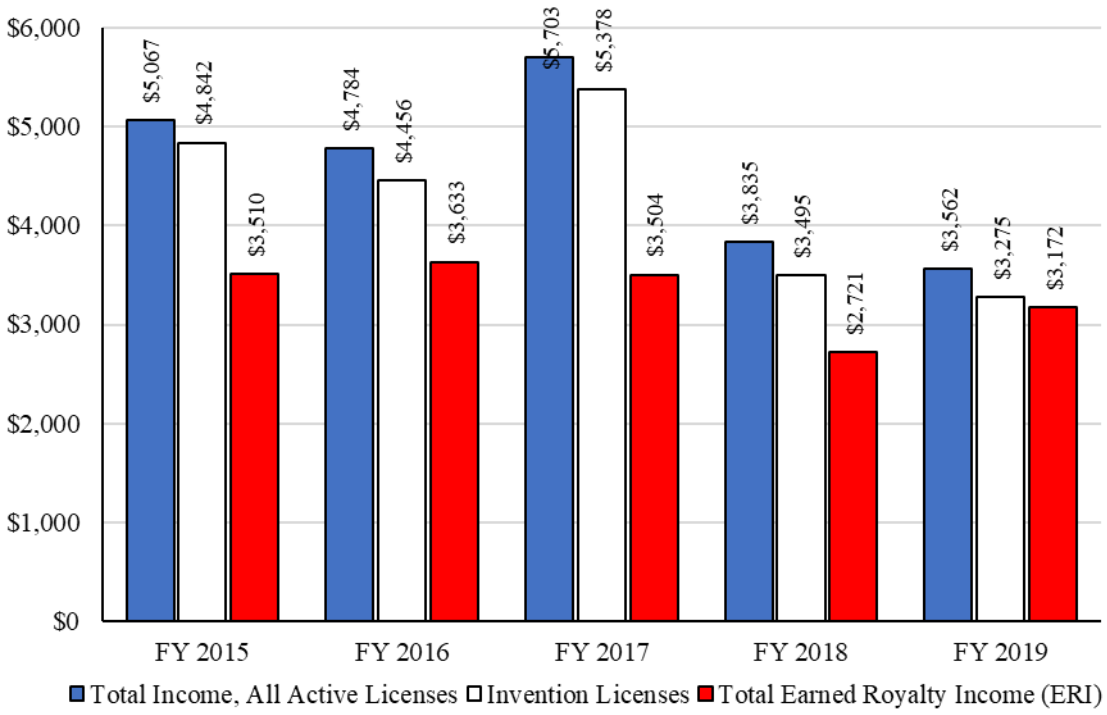


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	424	441	438	473	512
New Licenses	35	33	38	41	51
Invention Licenses, Total Active	424	441	438	387	392
New Invention Licenses	33	33	38	28	17
Income Bearing Licenses, Total Active	439	439	437	481	522
Income Bearing Exclusive Licenses	292	307	302	330	334

USDA Income from Licensing

Between FY 2015 and FY 2019, total income from all active licenses decreased by 30% to $3.6 million in FY 2019. The income from invention licenses decreased by 32% to $3.3 million. Total earned royalty income decreased by 10% from $3.5 million in FY 2015 to $3.2 million in FY 2019.

USDA Income from Licensing ($000s)

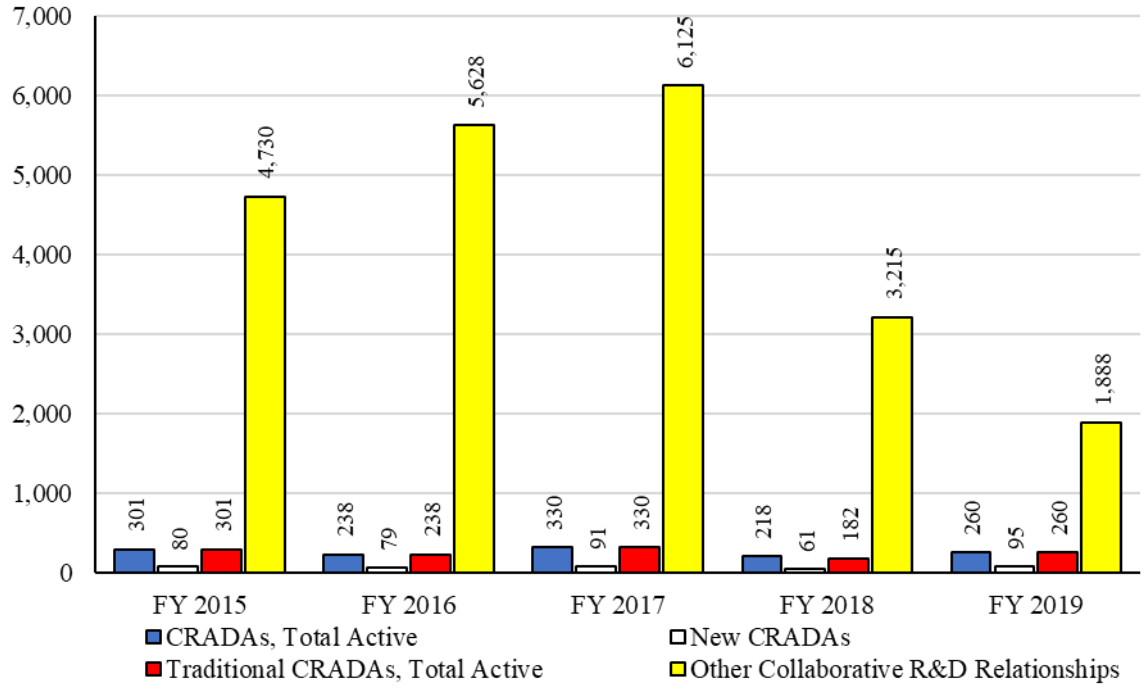


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$5,067	$4,784	$5,703	$3,835	$3,562
Invention Licenses	$4,842	$4,456	$5,378	$3,495	$3,275
Total Earned Royalty Income, (ERI)	$3,510	$3,633	$3,504	$2,721	$3,172

USDA Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs decreased by 14% to 260 agreements while new CRADAs increased by 19% to 84. Traditional CRADAs decreased by 14% to 260. Other collaborative R&D relationships decreased by 60% to 1,888 in FY 2019.[26]

USDA Collaborative R&D Relationships



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	301	238	330	218	260
New CRADAs	80	79	91	61	95
Traditional CRADAs, Total Active	301	238	330	182	260
Other Collaborative R&D Relationships	4,730	5,628	6,125	3,215	1,888

[26] In prior reports, USDA reported all agreements that were not CRADAs as "Other collaborative R&D agreements." Beginning 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

- The Economic Research Service continued to enhance and update its website. Upgrades made this fiscal year provided improved performance (website is faster, more resilient), security, and efficiency in publishing. New features included economic analysis, including highlights and implications, of the Agriculture Improvement Act of 2018 (Farm Bill); simpler, more intuitive navigation; enhanced functionality for mobile users; and improved data dissemination, with new, more interactive user interfaces and new data APIs (Application Programming Interfaces) to enhance information delivery to customers. ERS's concerted efforts also improved on-time posting 3.5 percentage points to 95% and website Section 508 Accessibility by 45 percentage points.
- The National Institute of Food and Agriculture (NIFA) administers the USDA Small Business Innovation Research (SBIR) program. In FY 2019, NIFA promoted SBIR funding opportunities to USDA intramural research Cooperative Research and Development Agreement (CRADA) partners through a partnership between NIFA's SBIR program and the Agricultural Research Service (ARS) Office of Technology Transfer (OTT).
- The RD continues to enhance its web presence to make information and programs more accessible to the public, as well as to concentrate outreach efforts to ensure that businesses and communities in greatest need have access to the necessary resources to be competitive.

USDA Downstream Success Stories

Agricultural Marketing Service (AMS): Pesticide Data Program

The Pesticide Data Program (PDP) is a national pesticide residue monitoring program and produces the most comprehensive pesticide residue database in the United States. Since 1991, PDP has tested 126 different commodities for over 640 different pesticide residues. In FY 2019, PDP tested over 10,000 samples and generated over 2.5 million data points. All data are available to the public electronically by way of the PDP website and customized reports are generated when requested. The Environmental Protection Agency uses the data to assess dietary risks from pesticide exposure and determine which pesticides can continue to be used in domestic agricultural production. It also uses the data to harmonize U.S. pesticide tolerance levels with international levels. The Food and Drug Administration uses the data to enhance its surveillance of imported foods. State public health and environmental agencies use the data to fulfill their consumer protection commitments. Growers and distributors use the data to resolve trade issues. PDP data was also submitted to the Codex Alimentarius Committee to assist in benchmarking international Maximum Residue Levels (MRLs) as real-life data (in place of theoretical data), contributing to more accurate MRL estimates.

Animal and Plant Health Inspection Service (APHIS): Automated Aerial Bait Delivery to Control Brown Treesnakes.

Previous work has shown that invasive brown treesnake populations on Guam can be reduced by aerially delivering baits treated with 80 mg of acetaminophen to snake-infested areas. However, preparing the baits manually and applying them over large landscapes is labor and time intensive. Thus, Wildlife Service (WS), National Wildlife Research Center (NWRC), and the U.S. Department of the Interior collaborated with Applied Design Corporation (Boulder, CO) to engineer an automated bait manufacturing and delivery system.

The core technology is an aerially delivered biodegradable "bait cartridge" designed to tangle in the tree canopy, making the acetaminophen bait available to treesnakes and out of reach of terrestrial non-target species. When mounted on a rotary-or fixed-wing aircraft, the automated dispensing module can broadcast bait cartridges at a maximum rate of four per second. NWRC researchers and WS Operations experts conducted the first evaluation of this system on Guam in July 2016 and demonstrated that this system can significantly reduce brown treesnake abundance after a single treatment. The WS Guam State Office now uses this system operationally to reduce the snake population within 55-hectares of forest surrounded by a snake-proof barrier on Guam.

The goal of this work is to evaluate the possibility of using the system to eradicate snakes within the enclosure and provide a snake-free habitat for conservation restoration purposes. From October 2018 to June 2019, WS Operations and NWRC conducted multiple bait applications at this site, resulting in a greater than 80- percent decrease in snake activity. Further applications will continue to drive brown treesnake numbers within the enclosure toward zero. For the first time, land managers have a tool that can drastically reduce snake numbers throughout large areas, improving biosecurity and encouraging hopes for the eventual recovery of Guam's native species.

APHIS: Biological Control of Asian Citrus Psyllid, the Vector of Citrus Greening Disease
The Asian citrus psyllid (ACP) has invaded citrus-growing areas in the United States and is a vector of a bacterium that causes citrus greening disease or Huanglongbing (HLB). A key component to a management program is aggressive control of ACP vector. Tamarixia radiata is a species-specific ectoparasitoid of the ACP that was imported from Pakistan after satisfying APHIS PPQ permitting requirements for field release in Texas. The PPQ Mission Laboratory developed the technology to mass produce and release T. radiata using a field insectary cage approach for the biological control of ACP in south Texas. Since the project began in 2011, nearly 11 million beneficial insects have been produced by the Mission Lab for field release in Texas, Louisiana, and Mexico border areas. Assessments of areawide management efforts in south Texas indicate an overall reduction in ACP populations of 90percent since initiation of the program in 2011. The biocontrol rearing technology was also transferred to partners in California, which have now developed the capacity to release over 3 million parasitoids per year.

Agricultural Research Service (ARS): New freezing technology retains fresh-like fruit quality when thawed
Freezing is a well-established technology used to prolong seasonal fruit and vegetable shelf-life. However, current freezing technologies (both slow and fast) rupture cells, resulting in juice loss when thawed, which leads to suboptimal flavor, juice content, and texture qualities. Together with colleagues at the University of California–Berkeley, ARS scientists in Albany, California, investigated a technology first developed to preserve human organs for transplanting called isochoric (constant volume) freezing to extend the shelf life of food products and maintain their physical and nutritional properties. The researchers evaluated isochoric freezing to preserve the quality of sweet cherries and found the technology resulted in thawed fruit that were indistinguishable from fresh cherries in terms of juice loss, texture, structure, ascorbic acid content, and antioxidant activity. The isochoric method also uses 70 percent less energy compared with conventional freezing methods. These findings promise to transform the $54

billion U.S. frozen foods market by enabling frozen products that are thawed to have extended shelf-life and fresh-like taste, texture, juiciness, and nutrition.

Forest Service (FS): Wood Waste Put to Work
Biochar, or wood waste, is a porous carbon substance that results from burning wood in the absence of oxygen. It is typically created when burning chunks of wood are covered by ash, soil or a lid, which insulates the coals and starves them of oxygen. This fire remnant provides a valuable addition to soil for agriculture and gardening purposes as well as contributing to overall forest health. Despite its usefulness, biochar is difficult to produce in large quantities for agricultural, forestry, or commercial use. With healthy forests in mind, the Rocky Mountain Research Station (RMRS) and Air Burners, Inc. teamed up to optimize biochar production for the marketplace. RMRS has partnered with the Air Burners, Inc. through a cooperative agreement to help find a solution to this problem. The company's commercial fireboxes, used for processing wood and vegetative waste, are being modified to produce high-quality biochar.

Food Safety and Inspection Service (FSIS): Use of Information Technology Systems to Share Information
FSIS continued the phased expansion of Public Health Information System (PHIS) Export Module, which allows industry to file electronic export applications and receive electronic certification. On May 20, 2019, FSIS added an additional 21 countries to the export component, as part of phase 2 of the rollout. In addition, FSIS made several updates to the import module of PHIS, which enables inspection program personnel (IPP) to conduct import reinspection more efficiently and effectively.

FSIS continued efforts to develop and maintain automated data exchange capabilities with Customs and Border Protection (CBP). To date, over 182 customs brokers are participating in the FSIS data exchange, and 72 percent of all import applications received by FSIS are now filed electronically. FSIS continues outbound message capabilities in Automated Commercial Environment (ACE), which provides messages back to importers on the status of shipments being re-inspected by FSIS. FSIS also developed and implemented the capability for customs brokers to submit corrections to previously submitted electronic applications when needed.

National Agricultural Statistics Service (NASS): Geospatial Products
NASS completed its 48-State Cropland Data Layer (CDL) in 2010 for the 2018 crop year, making 11 years of national CDL's available. This layer provides information on the crops planted and is useful in land cover, animal habitat, and watershed monitoring; soils utilization analysis' agribusiness planning; addressing biodiversity, crop intensity, and agricultural sustainability concerns; environmental research; and the remote sensing and GIS value-added industry. NASS continued to provide its 48-State VegScape, which is a geospatial data service offering automated updates of vegetative condition at daily, weekly, and biweekly intervals. The 48-State Crop Frequency Layers were released in 2019 for the 2018 crop season. The Crop Frequency Layers identify crop specific planting frequency and are based on land cover information derived from the 2008 through 2017 CDL. Currently, these are produced for corn, soybeans, wheat, and cotton.

Geospatial decision support products were derived and provided for rapid response to assess flooded areas and identify potential crop losses caused by Hurricanes Barry and Dorian, as well as flooding in the Midwest during the spring of 2019. The geospatial data products were derived from remotely sensed satellite and meteorological information obtained from NASA, European Space Agency (ESA), and National Oceanic Atmospheric Administration (NOAA). The estimates of crop and pasture hay inundation were provided to the NASS Agricultural Statistics Board for decision support. Crop inundation raster layers were shared with the USDA Operations Center Emergency Programs Division to be included in their mapping efforts. The disaster assessment reports, maps, crop inundation raster layers, metadata and a methodology report were posted on the NASS website for public dissemination.[27] Final reports, excluding in-season crop and pasture hay estimates, were posted on the NASS web site for public use.

National Institute of Food and Agriculture (NIFA): Specialized Lure and Pheromone Application Technology (SPLAT)

ISCA Technologies is a California-based company that has received a number of SBIR awards to develop integrated pest management (IPM) solutions that are based on the use of semiochemicals or natural pheromones where the effect is specific to the targeted pest. They have developed a product called Specialized Lure and Pheromone Application Technology (SPLAT), which is a flowable wax-like emulsion that can be applied by hand from a paint gun or mechanically by sprayer (including from planes). The company has great organic chemistry expertise and they have synthesized a number of different semiochemicals and pheromones. One of their products is designed to disrupt mating in the gypsy moth. The Forest Service uses this product exclusively in their program to combat the spread of the gypsy moth, and it has been sprayed on hundreds of thousands of acres. Other products area targeted to the control of the mountain pine beetle, which has destroyed millions of acres of pine trees in the west, and the Asian Citrus Psyllid, which is the key vector for citrus greening. The company has grown from just a few people to over 20 full-time employees and annual revenues have increased to over 7 million.

Natural Resources Conservation Service (NRCS): Conservation Assessment Ranking Tool (CART)

The newly developed Conservation Assessment Ranking Tool (CART) modernizes and streamlines NRCS's conservation planning and program delivery, reduces workload on field staff, and improves the customer experience by creating an efficient application process. The tool combines and analyzes geospatially-referenced data and site-specific information provided by the landowner within a decision support system (DSS) framework. CART will assist NRCS conservation planners to identify the most likely resource concerns associated with the landscape and farm operation and the suite of potentially applicable conservation practices. The tool will provide the landowner with a robust context within which they can identify the most appropriate mix of conservation activities that will meet their objectives while addressing the relevant natural resource concerns. This informed conversation will lead to wider acceptance of conservation planning recommendations and increased adoption of conservation management practices on the ground. Soils and related data and information are key components of CART. In FY 2019, a team of soil scientists and other technical professionals developed a suite of web services that provide real-time soils data to CART v1.0. In addition, they developed a suite of soil-based

[27] https://www.nass.usda.gov/Research_and_Science/Disaster-Analysis/index.php

interpretations that will help planners and land owner/operators to identify the likelihood that resource concerns are present in a selected management area. NRCS staff will use this information to inform field visits, on-farm assessments, and farmer discussions. These focused efforts will lead to more efficient and effective identification of priority resource concerns that can be addressed in collaboration with NRCS. Soil scientists and other technical specialists throughout the Nation continue to collaborate on additions and improvements that will be included in future versions of CART.

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. The 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. The DOC pursues these objectives through policies and programs directed at strengthening the nation's economic infrastructure, facilitating the development of cutting-edge science and technology, providing critical scientific information and data, and managing national resources.

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

In addition to the technology transfer efforts of DOC laboratories, DOC is responsible for coordinating technology transfer activities across federal agencies. The DOC coordinates the Interagency Working Group for Technology Transfer (IAWGTT) through NIST facilitation in interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency transfer programs.[28] The NIST also serves as the host agency for the Federal Laboratory Consortium (FLC), which provides a forum for federal labs to develop strategies and opportunities for linking technologies and expertise with the marketplace, as well as serving as the Executive Secretariat for the National Science and Technology Council's Lab-to-Market subcommittee.

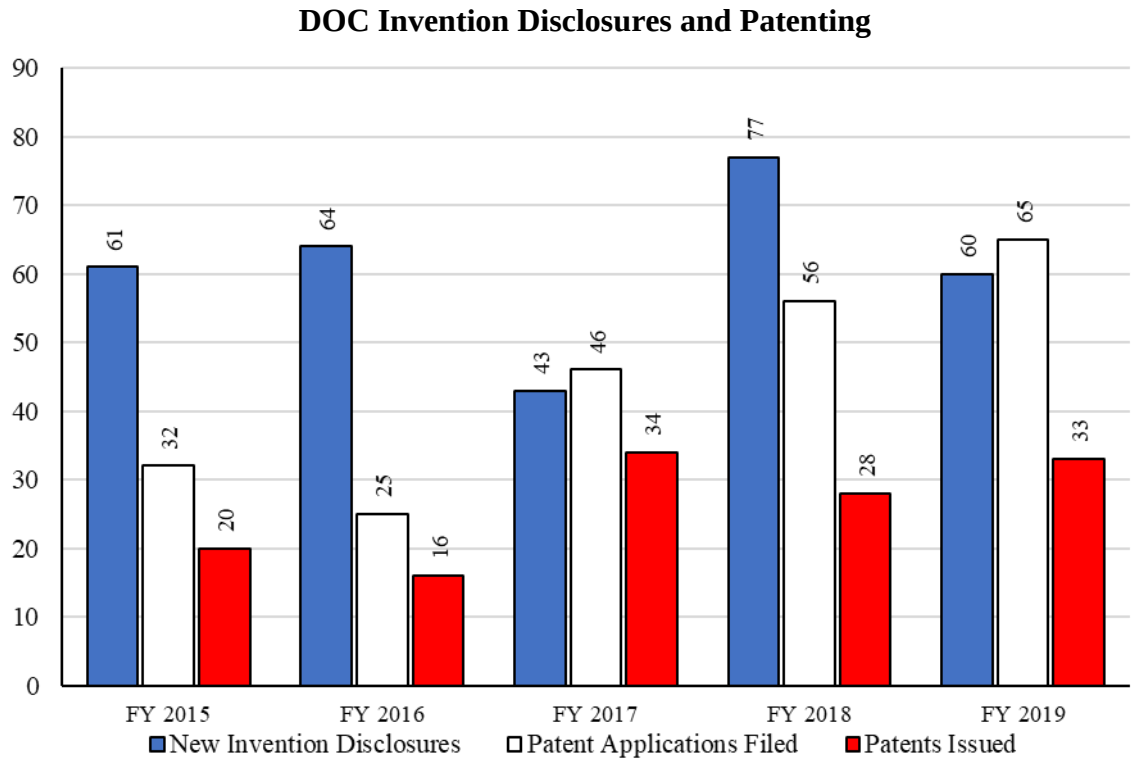
More information about DOC technology transfer is available on the following websites.

NIST | NOAA | ITS

[28] 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

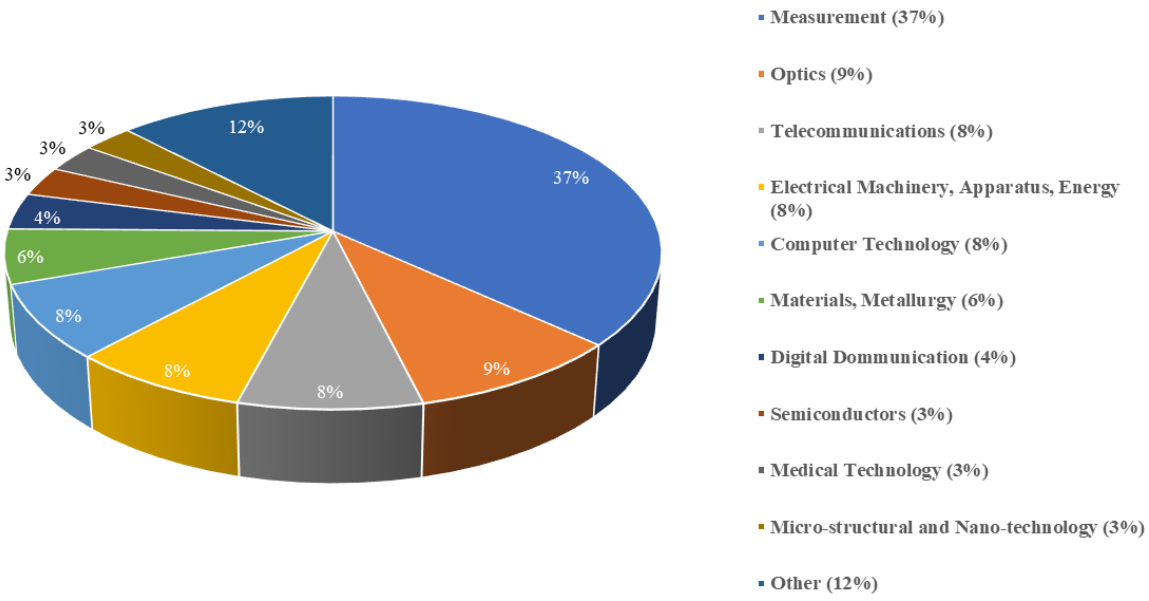
Between FY 2015 and FY 2019, new inventions disclosed decreased by 2% to 60 disclosures in FY 2019. Patent applications filed increased by 103% to 65, and patents issued increased by 65% to 33.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	61	64	43	77	60
Patent Applications Filed	32	25	46	56	65
Patents Issued	20	16	34	28	33

Patents issued to DOC in FY 2019 covered many technology areas including Measurement (37%), Optics (9%), Telecommunications (8%), Electrical Machinery, Apparatus, Energy (8%), and Computer Technology (8%).[29]

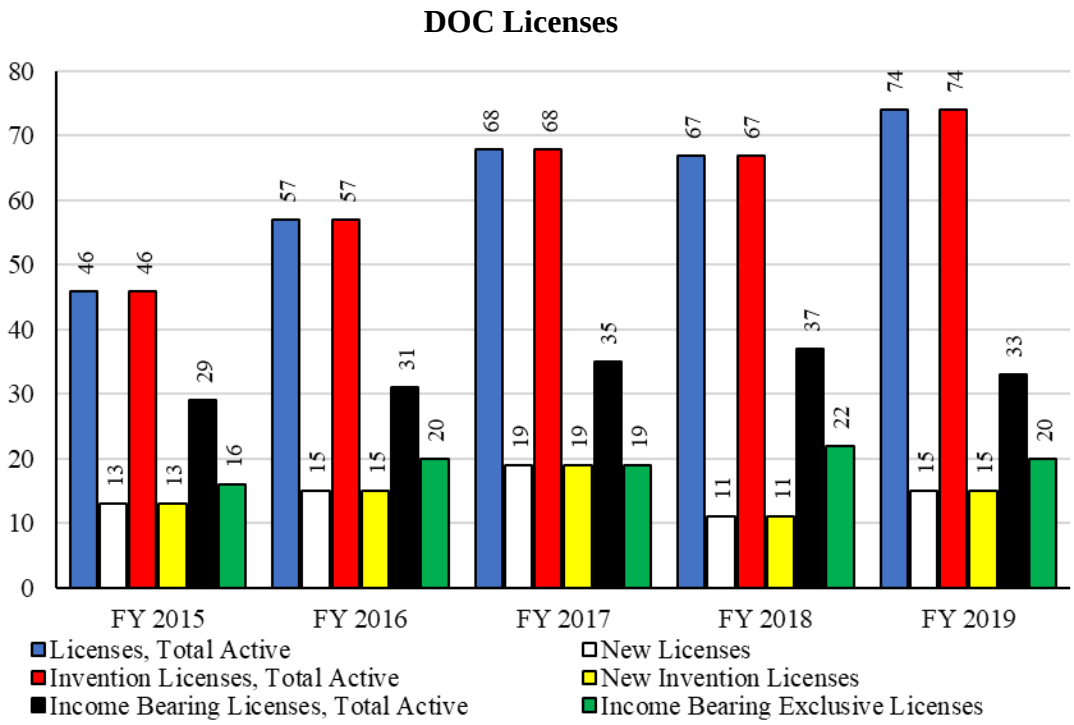
USPTO Patents Assigned to DOC by Technology Area: FY 2019



[29] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView accessed in January 2022. Used with permission.

DOC Licenses

Total active licenses increased by 61% from 46 in FY 2015 to 74 in FY 2019. New licenses increased by 15% to 15. All licenses were invention licenses. Total active income bearing licenses increased by 14% to 33, while income bearing exclusive licenses increased by 25% to 20.

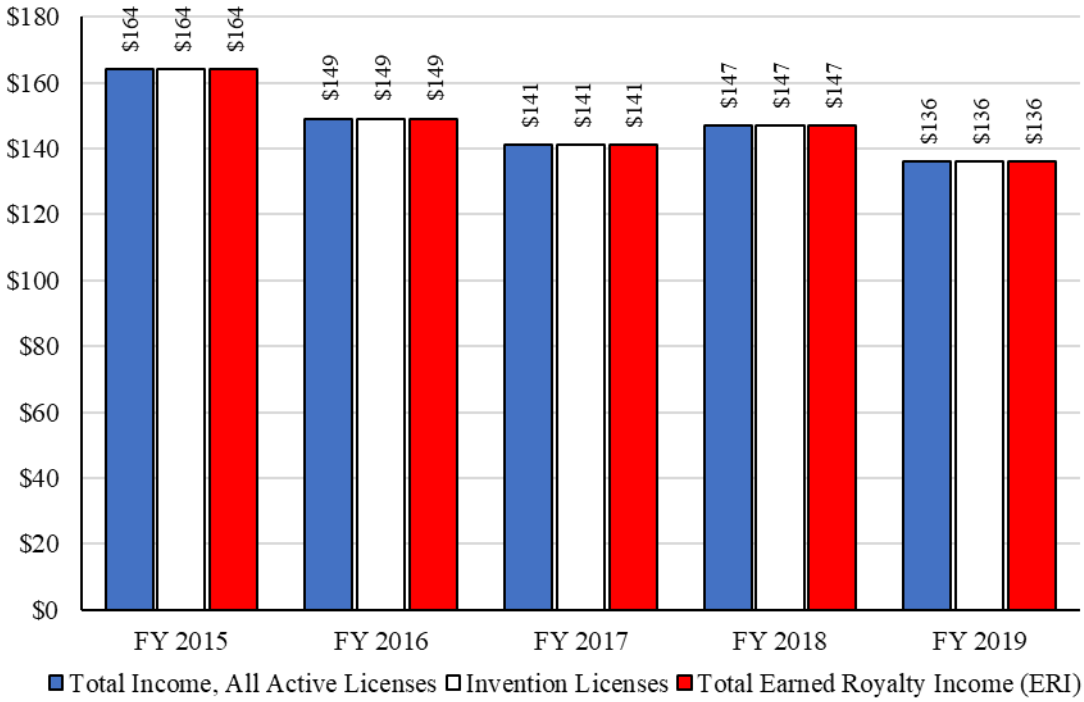


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	46	57	68	67	74
New Licenses	13	15	19	11	15
Invention Licenses, Total Active	46	57	68	67	74
New Invention Licenses	13	15	19	11	15
Income Bearing Licenses, Total Active	29	31	35	37	33
Income Bearing Exclusive Licenses	16	20	19	22	20

DOC Income from Licensing

DOC reported that all income from licensing comes from invention licenses. During the five-year period, from FY 2015 to FY 2019, there was a 17% decrease in total income from all active licenses, from $164 thousand in FY 2015 to $136 thousand in FY 2019.

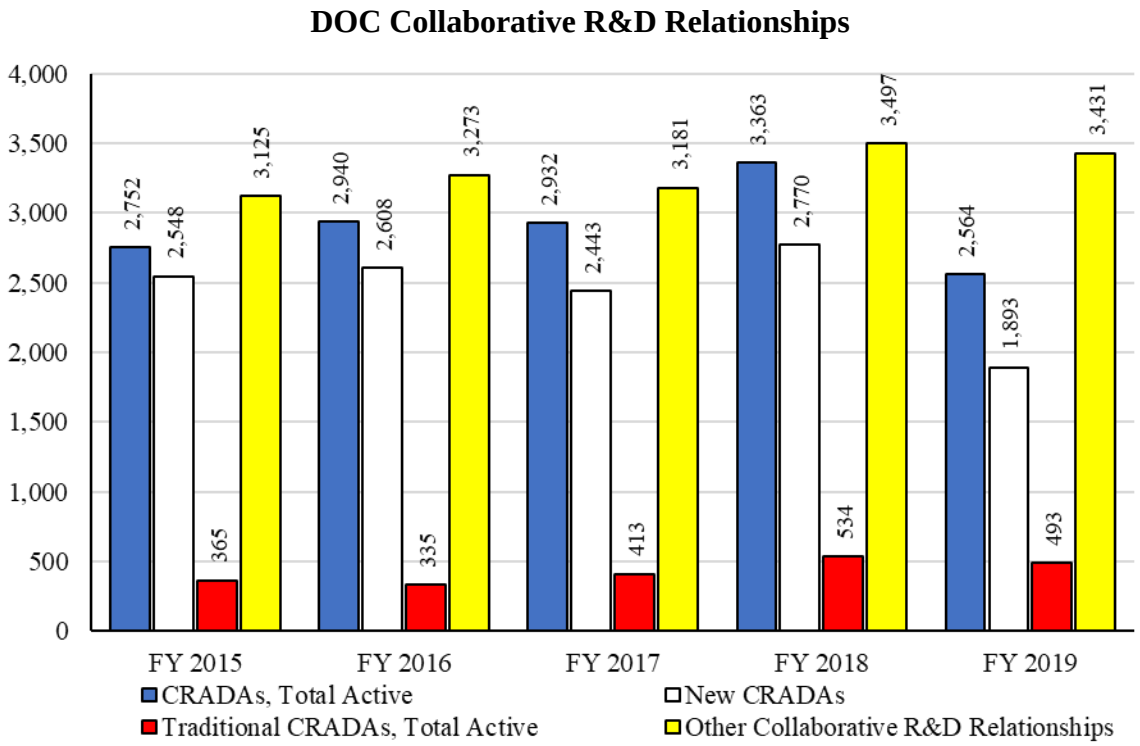
DOC Income from Licensing ($000s)



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$164	$149	$141	$147	$136
Invention Licenses	$164	$149	$141	$147	$136
Total Earned Royalty Income, (ERI)	$164	$149	$141	$147	$136

DOC Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs decreased by 7% to 2,564 agreements, while new CRADAs decreased by 26% to 1,893. Traditional CRADAs increased 35%, from 365 in FY 2015 to 493 in FY 2019. Other collaborative R&D relationships increased by 10%, from 3,125 in FY 2015 to 3,431 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	2,752	2,940	2,932	3,363	2,564
New CRADAs	2,548	2,608	2,443	2,770	1,893
Traditional CRADAs, Total Active	365	335	413	534	493
Other Collaborative R&D Relationships	3,125	3,273	3,181	3,497	3,431

Efforts to Streamline Technology Transfer Operations
The NIST has undertaken several efforts to streamline and simplify the technology transfer process. It revised its standard CRADA to expedite review of these documents and reduce the overall size of these documents by approximately one third. The NIST also implemented several new licensing programs to encourage small businesses to participate. These programs lay out terms in advance to ease concerns of small businesses about overall costs. It is conducting detailed analysis of the flow of documents to understand where significant delays occur within the system. In many cases, these delays are with the partner and NIST does not have direct control. However, by continued efforts to identify and understand issues experienced by partners, NIST expects to identify new ways to simplify and streamline technology transfer practices. In FY 2019, 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 408 days. In FY 2019, the average CRADA approval time was 129 days.

DOC Downstream Success Stories

NIST: FLOC Takes Flight: First Portable Prototype of Photonic Pressure Sensor
In collaboration with industry, researchers from NIST have made the first portable prototype of the Fixed Length Optical Cavity (FLOC), a device that uses light to measure pressure with higher accuracy and precision than most commercial pressure sensors. This newest version is a milestone on the journey toward the creation of a device that could revolutionize the way pressure is measured with potential uses by many industries, particularly semiconductor chip and aircraft manufacturing.

In 2017, NIST and MKS Instruments, Inc. of Andover, Massachusetts, signed a CRADA to take a laboratory scale version of the FLOC and create a smaller, more robust prototype that more closely resembles a commercial product. Thanks to the CRADA work, the joint NIST and MKS team has now successfully demonstrated a prototype version small enough to fit into two suitcases, NIST physicist Jay Hendricks said.

“MKS Instruments brings over 50 years of pressure measurement, optical and laser experience to this project, and we are honored to have been selected by NIST to work with them on this important and prestigious development,” said Phil Sullivan, CTO of MKS’s Pressure and Vacuum Measurement Solutions business. “We anticipate that this work will lead to a new wide-range, compact pressure measurement standard.” Robust, portable FLOC sensors could potentially reduce the cost of producing semiconductor chips such as those used in smartphones, as well as decreasing the cost of air travel. This is because both the chip manufacturing and aerospace industries rely on pressure measurements.

The FLOC measures pressure by measuring subtle differences in the frequency of light passing through two physical channels called optical cavities: a reference channel in vacuum and a test channel filled with a gas whose pressure is being measured.

In their partnership, NIST and MKS staff assembled the two-channel cavity at the heart of the prototype, while MKS managed the engineering of a miniaturized version of the system. “We built the national standard version of the FLOC, which is designed to operate in a highprecision laboratory,” Hendricks said. “But we turned to industry under a CRADA to speed up the

engineering and miniaturization work that needs to go into making something rugged, stable, transportable, low-power and able to work in a variety of different environments.

NIST: Researchers Explore Using SIM Cards for Secure Public Safety Data Transmission
In April 2019, NIST's Public Safety Communications Research (PSCR) division - in partnership with the First Responder Network Authority (FirstNet), IBM, and Nok Nok Labs - launched a prize challenge program targeted at exploring whether the SIM cards common in many commercial mobile phones could be used as storage containers for public safety application credentials.

Recognizing Public Safety's need for convenient, standards-based, twofactor authentication, PSCR engaged qualified contestants in a three phase Prize Challenge over the course of six months. Challenge teams completed the following phases:

- Phase 1 – Concept Paper: Successful contestants documented a clear understanding of the contest objectives and proposed an approach to securely store and then use first responder authentication credentials on a SIM card.
- Phase 2 – File Stored on SIM Card: Successful contestants demonstrated, via video webinar and screen share, their process of provision, storage of the file on the SIM card, and navigation through the SIM card file structure to the file's location.
- Phase 3 – Verified Authentication: Successful contestants demonstrated their mobile application's ability to access credentials stored on the SIM card and authenticate to FIDO2 services, which were provided in this prize competition by our challenge partners at Nok Nok Labs and IBM.

Participating teams were awarded prizes at each phase of the challenge with up to $100,000 in total available prizes. The judging panel announced challenge winners October 23, 2019, after performing the final evaluation of contestants' mobile applications, source code, hardware devices with SIM cards, and instructions. The judging panel and subject matter experts included individuals from APCO International, First Responder Network Authority, Motorola Solutions, Qualcomm, Texas Department of Public Safety and NIST PSCR.

NOAA: Saildrone – Uncrewed Surface Vehicle (USV)
Scientists and researchers have traditionally relied upon large research vessels for oceanographic data collection and monitoring activities. The data these vessels provide improve the scientific understanding of physical, chemical and biological aspects of the ocean. It also contributes to scientific disciplines whose work intersects with ocean processes, such as meteorology and climatology. The data have an array of practical applications, such as improving weather forecasts and aiding in species management. However, these vessels can be costly and have other drawbacks as well. For example, they require time for scheduling and planning voyages and can cause research restrictions due to their size and maneuverability. Despite these drawbacks, the information these vehicles provide is imperative and unavailable from conventional platforms (e.g., inside major hurricanes), so the search for a better method ensued.

The California-based company, Saildrone, Inc., sought collaboration with NOAA's Pacific Marine Environmental Laboratory (PMEL) to maximize the scientific applications of the wind-powered, unmanned surface vessel (USV) they developed.

The data collected by saildrones generates a variety of ecosystem service benefits. For example, the data can be used to enhance NOAA fisheries' capabilities, allowing better management of fisheries for species health, preservation, or public consumption. The data improve geospatial coverage of carbon intake by the ocean, which can be used to inform processes like ocean acidification and its impacts on plants and animals. Also, saildrones can augment the ability to detect oil spills; helping spur spill response to minimize negative impacts to ocean organisms and ecosystems.

The development of the saildrone has generated significant economic impacts for the company and the State of California that filter out to the country. Internally, the CRADA helped Saildrone, Inc. increase private investment due to the perceived scientific rigor associated with NOAA's involvement in product development, helping achieve over $90 million in direct, private investment into the technology. The influx of product interest and sales helped Saildrone, Inc. expand its workforce from 8 to over 100 employees since June 2014. The manufacturing of saildrones, which occurs entirely in the US, has also created jobs stretching from advanced manufacturing to advanced engineering, and the economic impact trickles outward to supply chains across the nation.

Saildrone, Inc. credits the CRADA knowledge-sharing process with accelerating company research and development. The collaboration with NOAA has also added a layer of product legitimacy for investors, given the agency's reputation for conducting rigorous science.

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 2019, additional capabilities were added to the Table Mountain test facilities in support of NOAA's Radio Frequency Interference Monitoring System (RFIMS) program. ITS helped NOAA develop the technical specifications for a Request for Proposals to develop, produce, install, and maintain a radio frequency interference monitoring system to mitigate the risk of potential interference by commercial wireless carriers that are slated to begin sharing the spectrum with NOAA satellite operations in 2020. Work began on the installation of a 6.5 m Geostationary Operational Environmental Satellite (GOES) receiver dish to support Meteorological Satellite Testbed activities. A 2.4 m Earth Station satellite dish capable of capturing Polar Operational Environmental Satellite (POES) satellite imagery was previously installed to test the degree of interference that could be tolerated, with a robust command and control system to command, verify, and log interference transmitted to RFIMS candidate solutions under test. A Spectrum Survey System (SSS) has been used over the past two years to prototype near-real time monitoring, data collecting, and reporting methods that might be used by RFIMS. This system can also be used to analyze potential sharing concerns in other frequency bands.
- In FY 2019, 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 to facilitate 4D sight through a ground-to-space sensing column with unmanned aircraft systems (UAS) operating in the atmosphere integrated with ground-based and space-based observation systems. These capabilities are intended to be applied for myriad of purposes ranging from improved climate and weather forecasting to better-informed government policymaking.

Department of Defense (DoD)

The Defense Laboratory Office (DLO) provides overall policy guidance for and oversight of department-wide technology transfer efforts. The 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.

The DoD is unique in applying the principles, practices, and tools of technology transfer in the execution of its mission. The 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 technologies 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.

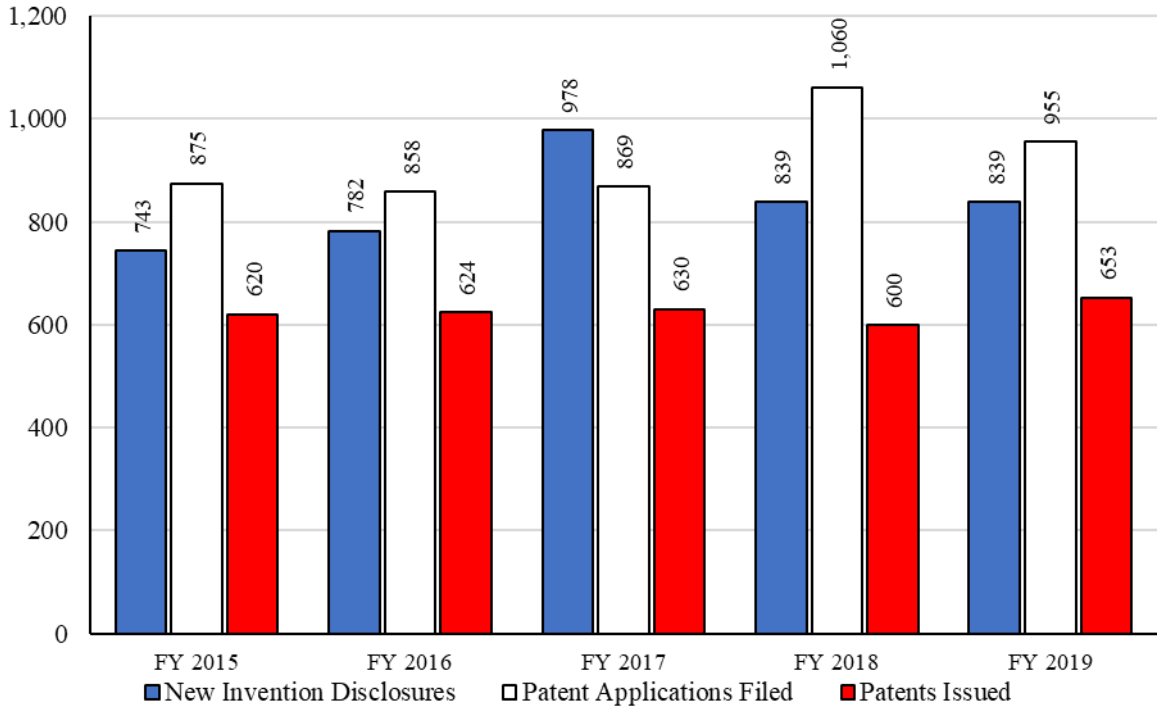
Each of the Military Services, DoD Agencies, and Office of the Secretary of Defense (OSD) maintain technology transfer websites to inform the public and make available general information.

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

DoD Invention Disclosures and Patenting

Between FY 2015 and FY 2019, new inventions disclosed increased by 13%, from 743 disclosures in FY 2015 to 839 disclosures in FY 2019. Patent applications filed increased by 9%, from 875 in FY 2015 to 955 in FY 2019. Patents issued increased by 5%, from 620 patents in FY 2015 to 653 patents in FY 2019.

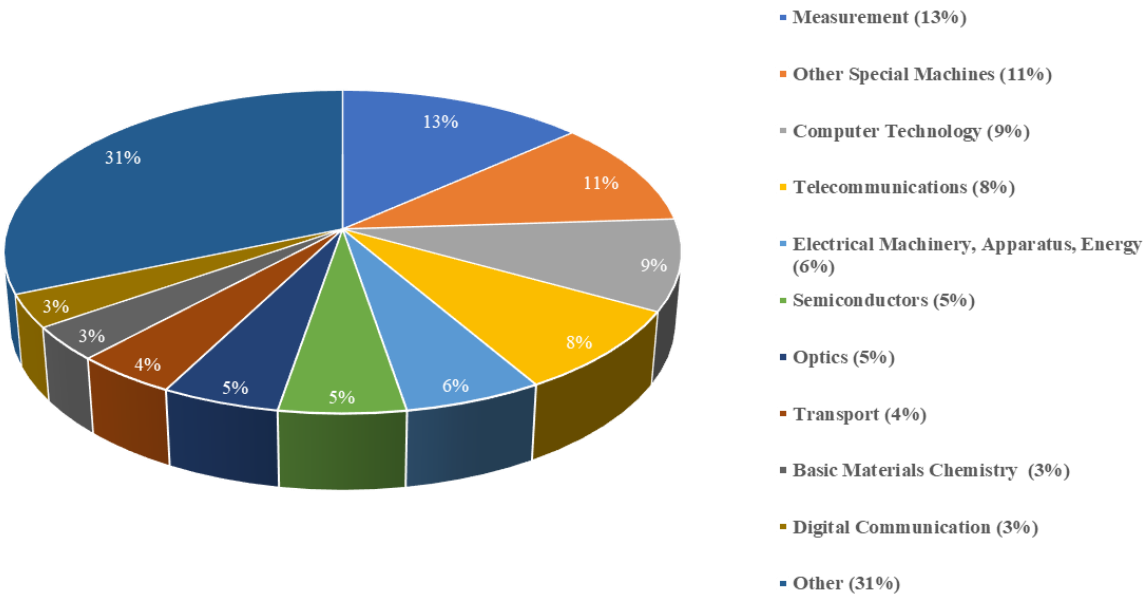
DoD Invention Disclosures and Patenting



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	743	782	978	839	839
Patent Applications Filed	875	858	869	1,060	955
Patents Issued	620	624	630	600	653

Patents issued to DoD in FY 2019 covered many technology areas including the top categories of Measurement (13%), Other Special Machines (11%), Computer Technology (9%), Telecommunications (8%), and Electrical Machinery, Apparatus, Energy (6%).[30]

USPTO Patents Assigned to DoD by Technology Area: FY 2019

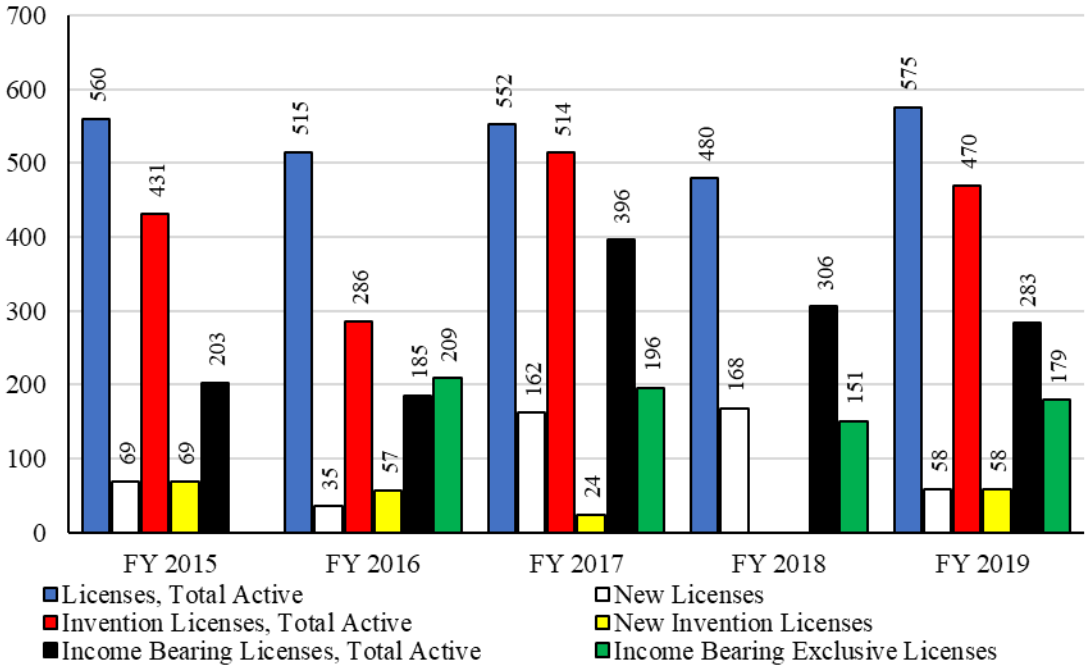


[30] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DoD Licenses[31]

Total active licenses increased by 3%, from 560 licenses in FY 2015 to 575 licenses in FY 2019, while new licenses decreased by 16%, from 69 in FY 2015 to 58 in FY 2019. From FY 2015 to FY 2019, total active invention licenses increased by 9% to 470 and new invention licenses decreased by 16% to 58. From FY 2015 to FY 2019, total active income bearing licenses increased by 39% to 179.

DoD Licenses

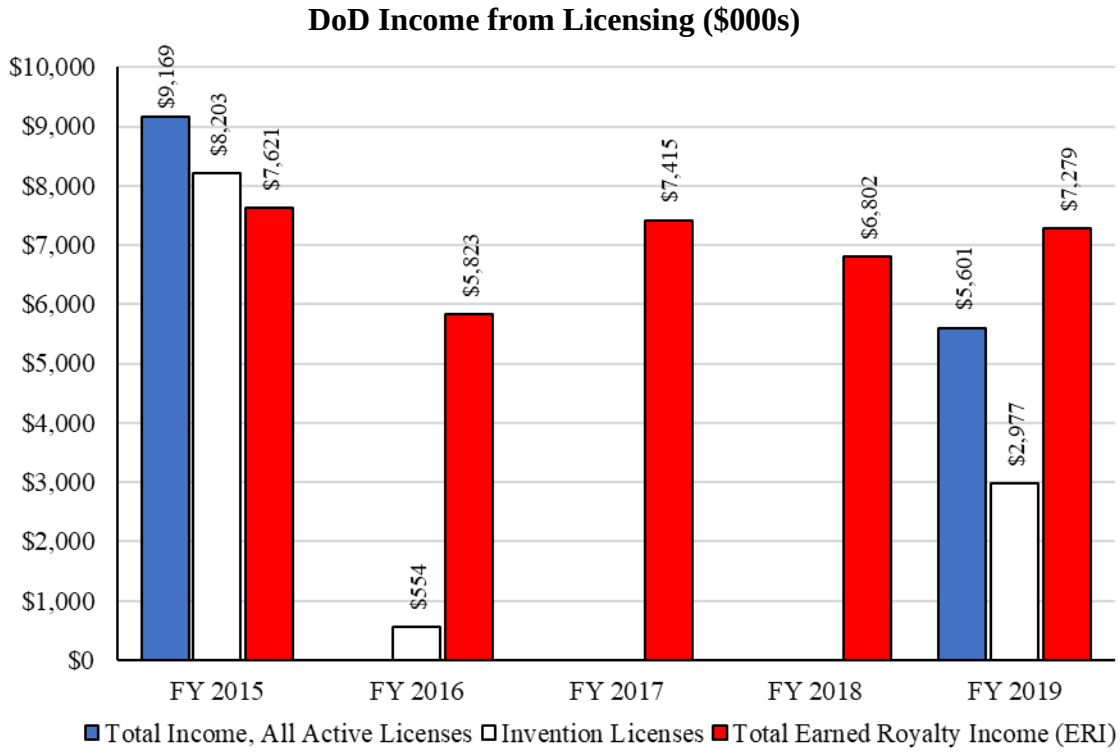


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	560	515	552	480	575
New Licenses	69	35	162	168	58
Invention Licenses, Total Active	431	286	514	n.a.	470
New Invention Licenses	69	57	24	n.a.	58
Income Bearing Licenses, Total Active	203	185	396	306	283
Income Bearing Exclusive Licenses	n.a.	209	196	151	179

[31] DoD was unable to report data for Income Bearing Exclusive Licenses for FY 2015, Invention Licenses, Total Active for FY 2018, and for New Invention Licenses for FY 2018.

DoD Income from Licensing[32]

From FY 2015 to FY 2019, total earned royalty income decreased by 39% to $5.6 million. Income from Invention Licenses decreased by 64%, from $8.2 million in FY 2015 to $3.0 million in FY 2019. Total Earned Royalty Income decreased by 4%, from $7.6 million in FY 2015 to $7.3 million in FY 2019.

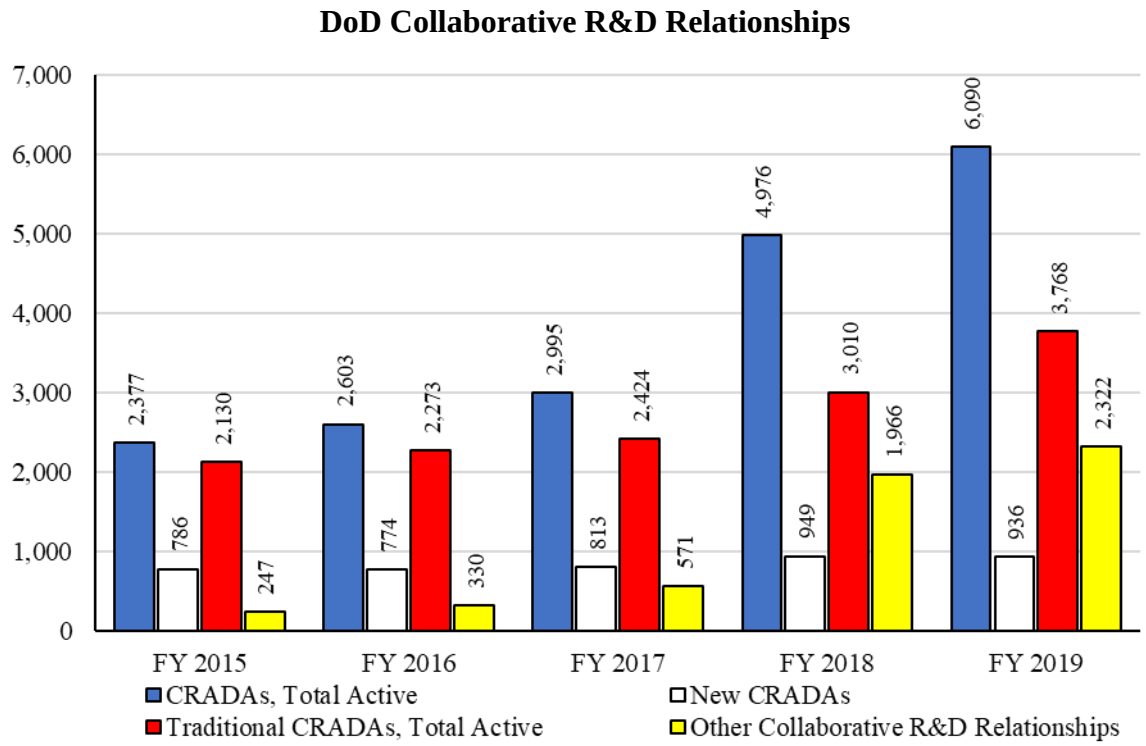


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$9,169	n.a.	n.a.	n.a.	$5,601
Invention Licenses	$8,203	$554	n.a.	n.a.	$2,977
Total Earned Royalty Income, (ERI)	$7,621	$5,823	$7,415	$6,802	$7,279

[32] DoD was unable to report data for Total Income, All Active Licenses for FY 2016 through FY 2018 or Invention License Income for FY 2017 and FY 2018.

DoD Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs increased by 156%, from 2,377 in FY 2015 to 6,090 in FY 2019, while new CRADAs increased by 19%, from 786 in FY 2015 to 939 in FY 2019. Traditional CRADAs increased by 77%, from 2,130 in FY 2015 to 3,768 in FY 2019. Other collaborative relationships increased by 840%, from 247 in FY 2015 to 2,322 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	2,377	2,603	2,995	4,976	6,090
New CRADAs	786	774	813	949	936
Traditional CRADAs, Total Active	2,130	2,273	2,424	3,010	3,768
Other Collaborative R&D Relationships	247	330	571	1,966	2,322

DoD Downstream Success Stories

Air Force: FEMORPH Section 801 Software License: First in Department of Defense
Each part in a modern warplane's engine is a complex, costly, and mission-critical component. By developing modeling and simulation software to assess irregularities in turbine blades, the U.S. Air Force Research Laboratory Aerospace Systems Directorate (AFRL/RQ) created a new approach and software package to determine which mission-critical parts are within fault tolerances, thereby providing opportunities for substantial cost savings and improved readiness within the Air Force—and beyond.

Developed by AFRL/RQ engineer Dr. Jeff Brown, FEMORPH brings advanced modeling and simulation (M&S) computational models to bear on one of the most mission-critical parts of a warplane—the turbine blades powering its engines. By comparing precise turbine blade measurements against historical data to answer mission-critical questions involving their airworthiness, remaining life and risk of failure, FEMORPH provides repair facilities with better information, increasing the number of repairable parts, extending their usable life, reducing costs, and ultimately resulting in more airworthy planes for the warfighter.

Dr. Brown also recognized the software's potential to help the original equipment manufacturers (OEMs) who create the parts identify manufacturing and repair deviations, resulting in reduced defects and manufacturing costs. Initial conversations with engineers at turbine blade manufacturer Pratt & Whitney improved FEMORPH's capabilities and ultimately resulted in the first technology transfer using a new software licensing approach within the Department of Defense, as established in Section 801 of the 2014 National Defense Authorization Act.

Licensing support and feedback from OEM manufacturers are allowing Dr. Brown and AFRL/RQ to further refine the software and develop new modules for different processes, including different repair approaches such as blending, which will yield further benefits for warfighters over time. Beyond aerospace, the computational models embodied by FEMORPH also have a significant potential role in quality control in virtually any advanced manufacturing industry involved in the creation and maintenance of mission-critical parts, which could ultimately help sustain the nation's overall economic competitiveness as a manufacturer of complex, high-value equipment in a variety of sectors.

Army: Solid Decontamination (Decon) Blend
The Army-patented Solid Decontamination (Decon) Blend offers superior capability to neutralize biological and chemical threats such as nerve gas, opioids, and anthrax pathogens. A collaborative research team created by the U.S. Army Combat Capabilities Development Command Chemical Biological Center (CCDC CBC) developed and tested the dry decontamination blend as part of the Army laboratory's ongoing search for easily deployed advanced countermeasures against harmful chemical and biological agents. It is effective against a broad spectrum of microorganisms and chemicals that have the potential to harm military and civilian populations.

The CCDC CBC team was largely responsible for transferring the Decon technology to a new startup company, MQM Solutions, Inc., of Cleveland, Ohio, which was created specifically to

commercialize the Army technology. A Patent Licensing Agreement (PLA) and Cooperative Research and Development Agreement (CRADA), both signed in early 2019, quickly led to further research and development and field testing to yield the Army-patented decontaminant now on the commercial market.

The speed with which the Decon tech transfer succeeded was exceptional by any measure. The two partners signed the CRADA January 30, 2019, the patent licensing agreement February 25, and, in June MQM Solutions sold its first Decon-based commercial product. The impressive timeline of Decon's transition to commercial on-the-shelf product not only personified the CBC's technology transfer (T2) culture of agile responsiveness, it also reflected the laser-focus determination of the MQM cofounders and their resolute belief in the technology's value to commercial users. Both partners in this transfer quickly seized the opportunities presented, refusing to allow a promising but neglected technology to languish unused.

The unique Decon chemical formulation—now available in packets as a dry powder easily reconstituted with any water source—reduces weight and volume by 90 percent compared to most conventional liquid decontamination products like hypochlorite solutions (bleach) or hydrogen peroxide-based products. The Decon technology also addresses other problems with available decontaminant liquids, namely, the use, storage, and transport of such liquids create logistical and HAZMAT challenges. Many are typically corrosive to multiple materials, can prove less efficacious, exhibit unsatisfactory materials compatibility (e.g., plastics, paints), require measuring multi-part additions to activate, mandate special packaging, or are unstable without controlled transportation and storage systems.

The need for an effective, more advanced, and efficient decontaminant was great. The Army CCDC CBC and its industry partner, MQM Solutions, answered the call in record time.

Army: Safeguarding Warfighter Access to Next-Generation Munitions through Wastewater Technology

A multi-agency team that included personnel from the U.S. Army Engineer Research and Development Center (ERDC); the U.S. Army Armament Research, Development and Engineering Center (ARDEC); the Program Executive Office – Ammunition (PEO AMMO); the U.S. Army Joint Munitions Command (JMC); and students and faculty from the U.S. Military Academy's (USMA) Systems Engineering Department collaborated to streamline and modernize the treatment technologies of new insensitive munitions (IMs) formulations at load-and-pack (LAP) industrial base operations and to transfer their technologies to the U.S. Army and the private sector.

Initially, the team started working together to solve simple process control and plant operation issues associated with the caustic, pH 3, IM production water, i.e., the IM water was degrading the transfer plumbing and becoming a potential operations issue. The team successfully developed and transitioned an innovative application of a process to replace high-cost sorptive treatment of wastewater. To overcome the obstacle of the IM material's high water solubility, the team developed two new steps to be incorporated into the treatment process. They strategically designed these two steps together to cost-effectively remove most of the contaminants from the IM wastewater, leaving the last step only for removing trace amounts of the contaminants.

The team worked on this effort, with an initial assessment of the new munitions constituents and the implications of these new materials for LAP operations and installations such as Iowa Army Ammunition Plant (IAAAP), Crane, and McAlester Army Ammunition Plant (MCAAP). The impacted sites included both government-owned and government-operated (GOGO) and government-owned and contractor-operated (GOCO) industrial base facilities. Research and development progressed from benchtop experiments, to laboratory pilot treatment systems, to field-deployed treatment systems, and required operational modifications to accommodate the new explosive fills.

Best management practices (BMPs) were established for the handling of IM production water and process wastewater in a safe and environmentally sustainable manner. These BMPs include a cost-effective and environmentally safe process water treatment system that has been incorporated into full-scale operations at LAP ammunition plants. The team's innovative treatment technology significantly reduced treatment costs from $6.00 per gallon to $0.55 per gallon.

Through their intensive, multidimensional approach to technology transfer, the team transitioned their effective research and development technology to ammunition plants performing load and pack on an industrial scale, guaranteeing the economic viability of these plants—thereby ensuring that our nation's warfighters receive the most effective and the safest equipment to accomplish their critical missions.

Navy: LED Air Warning System (LAWS)

First Responder public safety divers (PSDs) often conduct dive missions in environments characterized by zero visibility. These poor visibility conditions make it virtually impossible to read air pressure gauges, even with auxiliary illumination, resulting in divers being unable to effectively monitor their remaining air supply during missions. Because the situation is so perilous, loss of life for PSDs in these conditions is not uncommon. The majority of PSD communities use a device with a single light emitting diode (LED) indicator light that alerts only when air supply is critically low, essentially amounting to a "warning of last resort."

The LED Air Warning System (LAWS) has changed that, providing a clear visual display of a diver's air pressure (even in zero visibility conditions) over the duration of a dive. The LAWS technology is effective, affordable, integrates with existing equipment, and meets a critical need in the PSD community. LAWS also has a direct commercial application for recreational diving, scientific diving (e.g., for research and scientific study), and commercial industries such as oil exploration, offshore construction, underwater inspection and maintenance, and underwater photography and videography.

A team at the Naval Surface Warfare Center, Panama City Division (NSWC Panama City) brought their unique experience, expertise, creativity, and innovation to address the challenge and create a successful technology transfer. Dennis Gallagher, NSWC Panama City Office of Research and Technology Applications (ORTA) representative, played the leading role, bringing together critical players and driving the transfer from concept to commercialization. Gallagher led the implementation of a string of different and complementary partnerships among federal

government, industry, and academia partners, including a Cooperative Research and Development Agreement, two Education Partnership Agreements, and a commercial licensing agreement.

Gallagher pulled together a team of five scientists and engineers from different disciplines at key points in the transfer process. Together, these individuals used their collective expertise to satisfy design and functionality requirements, reduce complexity, and reduce costs in the final product design, driving the technology's development and ultimate transfer.

LAWS will provide increased safety and new capability for PSDs. The commercial potential for the technology is significant, with a potential sales projection of 8,000-15,000 units in the U.S. alone. The international diver market also holds great commercial potential, and commercial partner Interspiro already operates in nine countries on four continents. LAWS hit the "grand slam" of technology transfer. A federally developed technology was transitioned to a new product with direct application to the military user, first responders, and the private sector.

Department of Energy (DOE)

DOE is one of the largest supporters of technology transfer within the federal government. DOE 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 U.S. security and economic growth through transformative science and market solutions. By creating globally competitive industries in the United States, the DOE enables significant cost-savings for industries and consumers and creates jobs for Americans.

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 not found anywhere 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. The following are among the many things that the national laboratories do:

- Conduct research of the highest caliber in physical, chemical, biological, 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 at its National Laboratories and sites of some of the nation's most advanced R&D facilities. These state-of-the-art facilities are shared with the science community worldwide and offer some technologies and instrumentation that are not available anywhere else.

DOE Offices, Laboratories and facilities that are actively engaged in technology transfer include the following:

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)

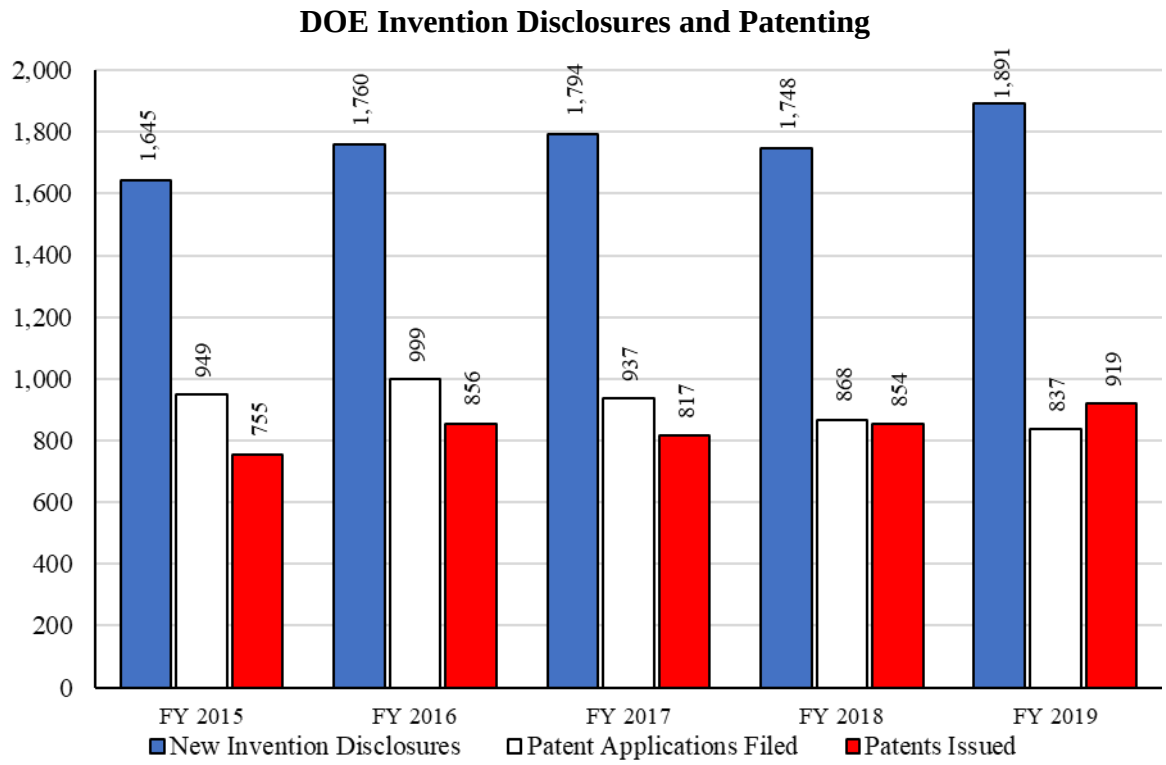
Science and engineering are not linear. DOE's system of National Laboratories, user facilities, research centers and shared research facilities, makes the pursuit of discovery—and the many solutions that result—both a collaborative enterprise and a shared national resource. Collaboration with industry, 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 R&D portfolio to advance the economic, energy, and national security interests of the nation. The 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 Laboratories and sites to foster partnerships that will bring innovations from the labs into the marketplace. The 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

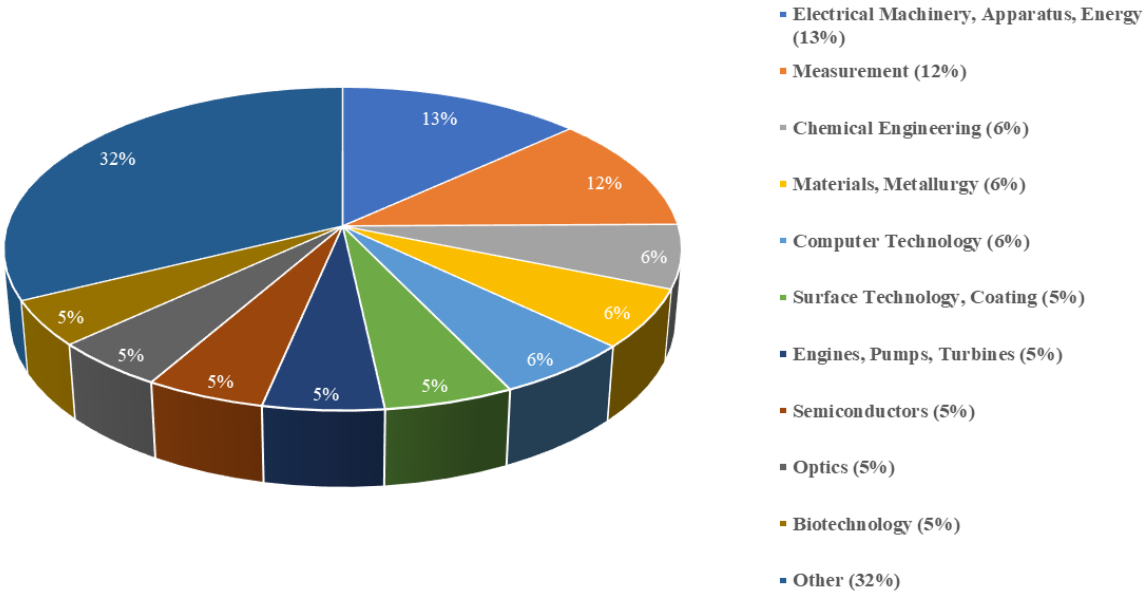
Between FY 2015 and FY 2019, new inventions disclosed increased by 15%, from 1,645 in FY 2015 to 1,891 disclosures in FY 2019. Patent applications filed declined by 12%, from 949 in FY 2015 to 837 in FY 2019, while patents issued increased by 22%, from 755 in FY 2015 to 919 patents in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	1,645	1,760	1,794	1,748	1,891
Patent Applications Filed	949	999	937	868	837
Patents Issued	755	856	817	854	919

Patents issued to DOE in FY 2019 covered many technology areas including Electrical Machinery, Apparatus, Energy (13%), Measurement (12%), Chemical Engineering (6%), Materials, Metallurgy (6%), and Computer Technology (6%).[33]

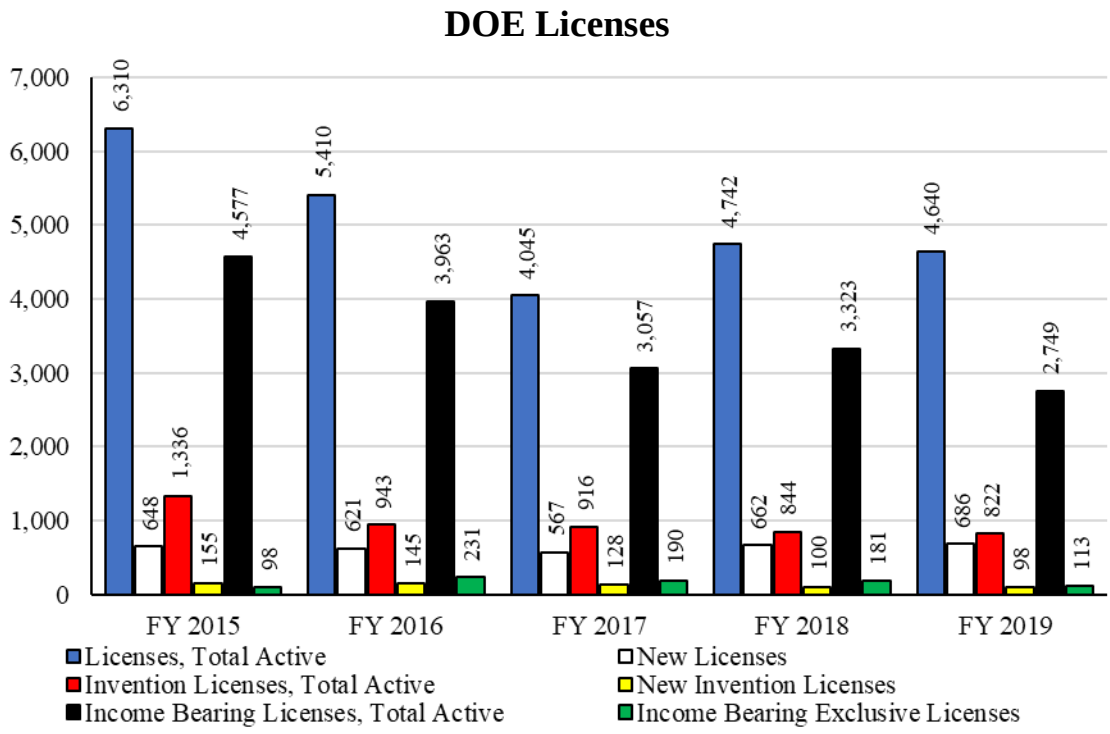
USPTO Patents Assigned to DOE by Technology Area: FY 2019



[33] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DOE Licenses

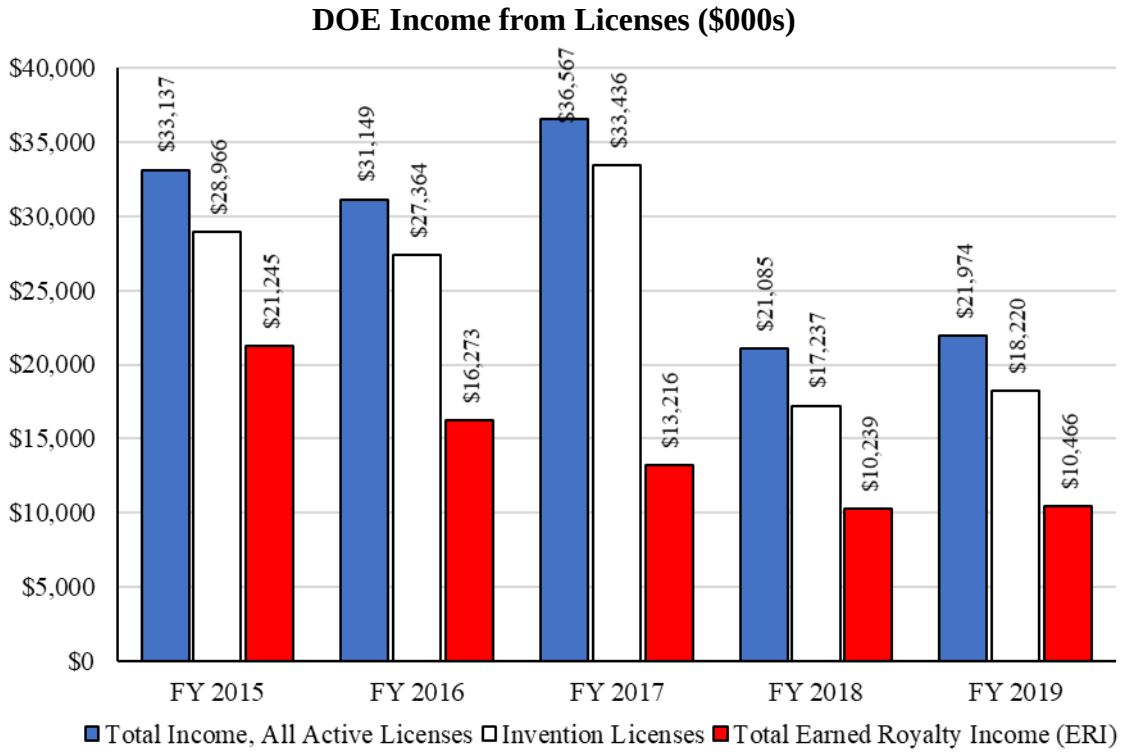
Between FY 2015 and FY 2019, total active licenses decreased by 26%, from 6,310 in FY 2015 to 4,640 in FY 2019. New licenses increased by 6%, from 648 in FY 2015 to 686 in FY 2019. Invention licenses decreased by 38%, from 1,336 in FY 2015 to 822 in FY 2019. New invention licenses decreased by 37%, from 155 in FY 2015 to 98 in FY 2019. Income bearing licenses decreased by 40%, from 4,577 in FY 2015 to 2,749 in FY 2019 and income bearing exclusive licenses increased by 15%, from 98 in FY 2015 to 113 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	6,310	5,410	4,045	4,742	4,640
New Licenses	648	621	567	662	686
Invention Licenses, Total Active	1,336	943	916	844	822
New Invention Licenses	155	145	128	100	98
Income Bearing Licenses, Total Active	4,577	3,963	3,057	3,323	2,749
Income Bearing Exclusive Licenses	98	231	190	181	113

DOE Income from Licensing

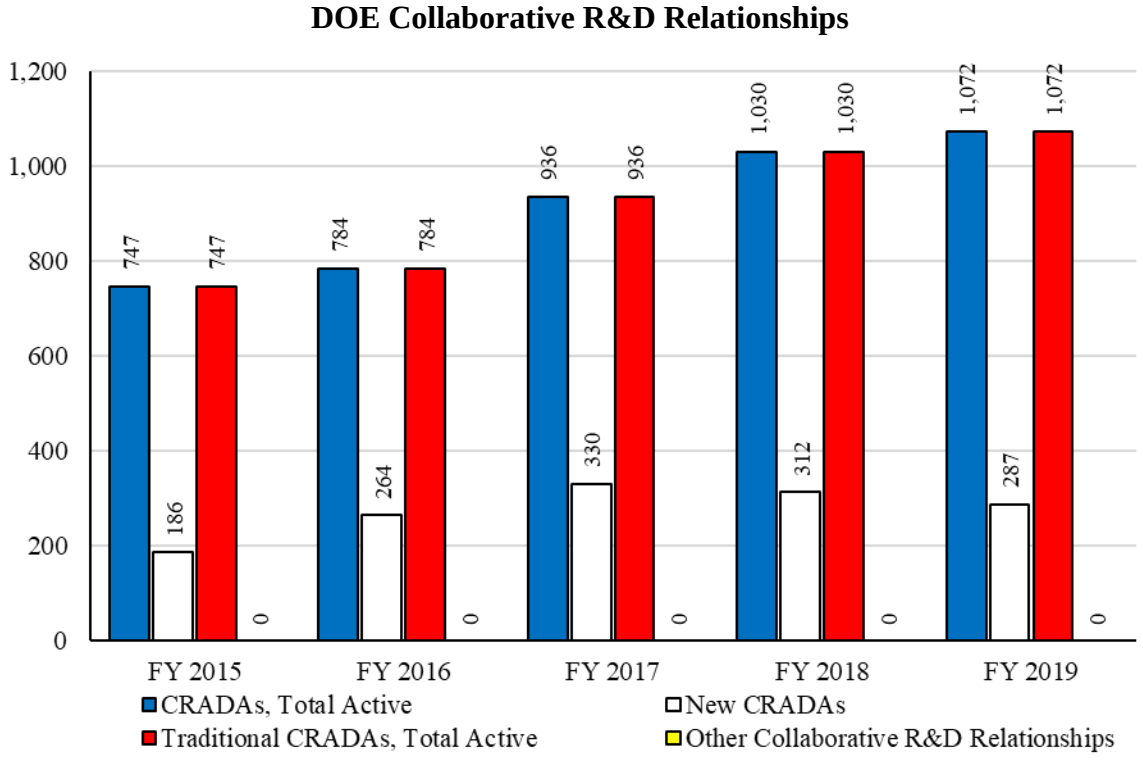
Between FY 2015 and FY 2019, DOE reported that total income from all active licenses decreased by 34%, from $33.1 million in FY 2015 to $22.0 million in FY 2019. Income from invention licenses decreased by 37%, from $29.0 million in FY 2015 to $18.2 million in FY 2019. Total earned royalty income decreased 51%, from $21.2 million in FY 2015 to $10.5 million in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$33,137	$31,149	$36,567	$21,085	$21,974
Invention Licenses	$28,966	$27,364	$33,436	$17,237	$18,220
Total Earned Royalty Income, (ERI)	$21,245	$16,273	$13,216	$10,239	$10,466

DOE Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs increased by 43%, from 747 in FY 2015 to 1,072 in FY 2019. New CRADAs increased by 54%, from 186 in FY 2015 to 287 in FY 2019. Traditional CRADAs increased by 43%, from 747 in FY 2015 to 1,072 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	747	784	936	1,030	1,072
New CRADAs	186	264	330	312	287
Traditional CRADAs, Total Active	747	784	936	1,030	1,072
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

Brookhaven National Laboratory (BNL): Auto-Induction Media
Using an auto-inducing media to increase production of expression strains to produce large amounts of life saving proteins. The T7 protein expression system developed by Dr. Studier from BNL has shaped the field of recombinant DNA technology. The T7 RNA polymerase is so active that a small basal level of T7 polymerase can lead to substantial expression of target protein even in the absence of added inducer. If the target protein is sufficiently toxic to the host cell, then the auto induction of the target protein due to the small basal level of T7 polymerase will pose a substantial challenge in the establishment of the target plasmid in the expression host. Dr. Studier addressed this challenge by formulating growth media recipes and protocols that allow for reliable growth of T7 expression strains to saturation with little or no induction.

Using the T7 protein expression system, researchers in academia and industry have used E.coli to express several human proteins, including Insulin to treat diabetes. The yields of target protein using the autoinduction media is typically several-fold higher than that obtained by conventional IPTG induction. EMD Millipore is currently manufacturing and selling the auto induction media to academic institutions, biotech and pharmaceutical companies. The media is being used by biotech companies and pharma to express life-saving proteins including enzymes and therapeutics.

The growth media and protocols developed for use with the T7 expression system, are applicable to other existing expression systems inducible by IPTG or arabinose and potentially to any expression system with an inducer whose action is blocked by glucose. The simplicity of the protocol in using the auto-inducing media allows for efficient screening of many clones in parallel for expression and solubility, as cultures have only to be inoculated and grown to saturation.

Idaho National Laboratory (INL): Unique Software Offers Tool for Securing Transmission Grid at Maximum Efficiency
Using algorithms that incorporate weather monitors utility system data and computational fluid dynamics to provide real time ampacity ratings of power lines.

Coordinating with a CFD program from WindSim, the INL team developed General Line Ampacity State Solver (GLASS), which offers the ability to blend data from weather monitors and electric utility system data with CFD-enhanced weather analysis algorithms.

In recognition of its potential to strengthen and secure the power grid, GLASS was named a finalist for the 2017 R&D 100 Awards. INL has also received a Technology Commercialization Fund award from the U.S. Department of Energy Office of Technology Transfer. In 2018 and 2019, INL plans to refine the GLASS software with another industry partner, testing endurance and possibilities for commercialization.

In its seven-year evolution, GLASS has undergone three formal peer reviews and two merit reviews. More than 70 people from around the world, representing the utility industry, academia,

and local, state and federal government, came to Idaho Falls Nov. 7–8 for an INL-hosted Dynamic Line Rating workshop.

Since 2010, INL has collaborated with Idaho Power Company on dynamic line rating concepts, and recently finished a full instrumentation of two test beds with weather stations and line rating software in Idaho. With GLASS, Idaho Power has been gathering weather data and the ability to calculate steady state, transient, and what INL calls "true dynamic liner rating" ampacities. The next step is ramping up the software to calculate forecasted line ampacities and temperatures. INL also has completed a cooperative research and development agreement with AltaLink LLC—Alberta, Canada's largest regulated electric transmission company—on a field study of four transmission line segments in support of a wind project's expansion request.

Kansas City National Security Campus (KCNSC): Next Generation Radar
One of first projects identified as a new priority by 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 (KU), 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.

This flight was a high-priority mission over sea ice and a repeat of a flight line surveyed yearly since 2013. NASA was able to benefit from the greatly increased resolution (less than 2cm) 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).

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.

Argonne National Laboratory (ANL): Argonne helps Aramco Research Center-Detroit Slash Engine and Fuel Design Time and Cost
In 2017, Argonne scientists and engineers pinpointed engine designs for a given fuel using the Mira supercomputer at the heart of the Argonne Leadership Computing Facility, a Department of Energy Office of Science User Facility.

The Argonne approach "reduced design time from months to weeks," said Sibendu Som, group leader and principal computational scientist at Argonne. This significant reduction in design time translated to significant cost savings.

With Mira's supercomputing prowess, Argonne's Virtual Engine Research Institute and Fuels Initiative (VERIFI) team simulated more than 2,000 engine design combinations. The simulations were conducted with design scenarios from the Aramco Research Center-Detroit, one of three U.S.-based research centers operated by Saudi Aramco's North American subsidiary, Aramco Services Company. The work was conducted as part of a Strategic Partnership Project (SPP).

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 HHS 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, HHS technology transfer supports the larger HHS mission—to enhance the health and well-being of all Americans, by providing for effective health and human services and by fostering sound, sustained advances in the sciences underlying medicine, public health, and social services—and the missions of:

- CDC—to protect America from health, safety and security threats, whether diseases start at home or abroad, are chronic or acute, curable or preventable, human error or deliberate attack, CDC fights disease and supports communities and citizens to do the same to increase the health security of our nation;
- FDA—to protect the public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biological products, and medical devices; by ensuring the safety of our nation's food supply, cosmetics, and products that emit radiation; by regulating the manufacturing, marketing, and distribution of tobacco products; by speeding medical product innovations; and by enhancing the Nation's counterterrorism capability; and,
- NIH—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 HHS 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 HHS does the following:

- 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 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 HHS.

The NIH's annual technology transfer report is available online.

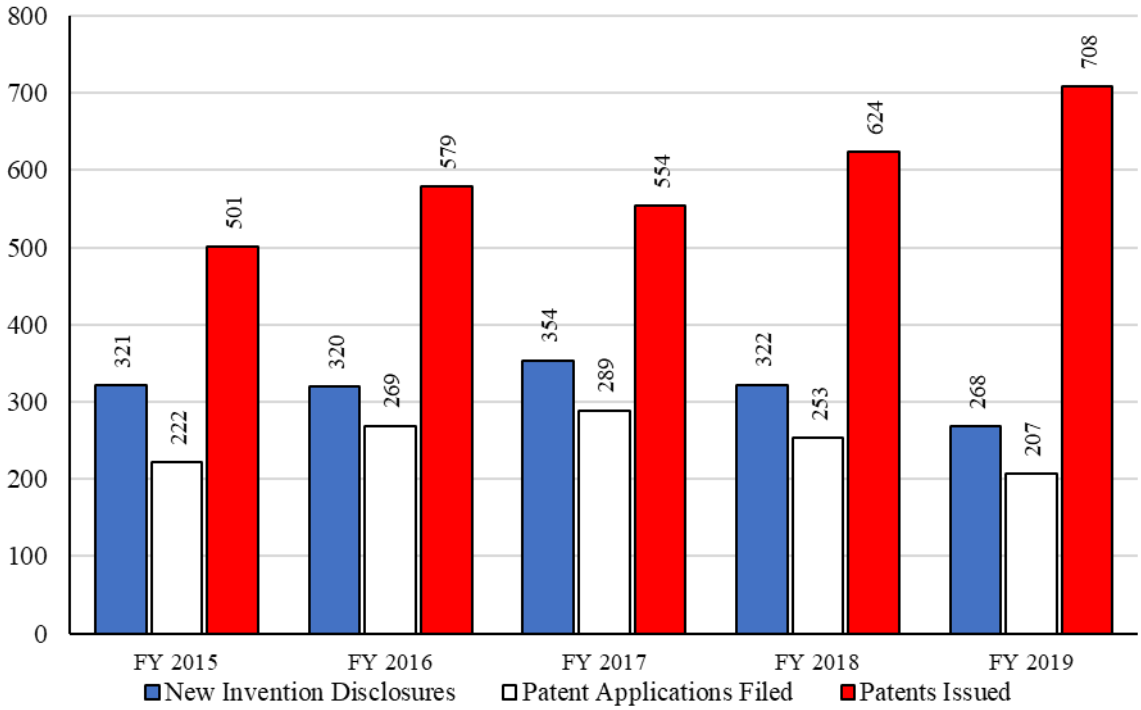
More information about HHS technology transfer activities is available on the following websites:

CDC | NIH | FDA

HHS Invention Disclosures and Patenting

Between FY 2015 and FY 2019, new invention disclosures decreased by 17%, from 321 in FY 2015 to 268 disclosures in FY 2019. Patent applications filed decreased by 7%, from 222 in FY 2015 to 207 in FY 2019, while patents issued increased by 41%, from 501 in FY 2015 to 708 patents in FY 2019.

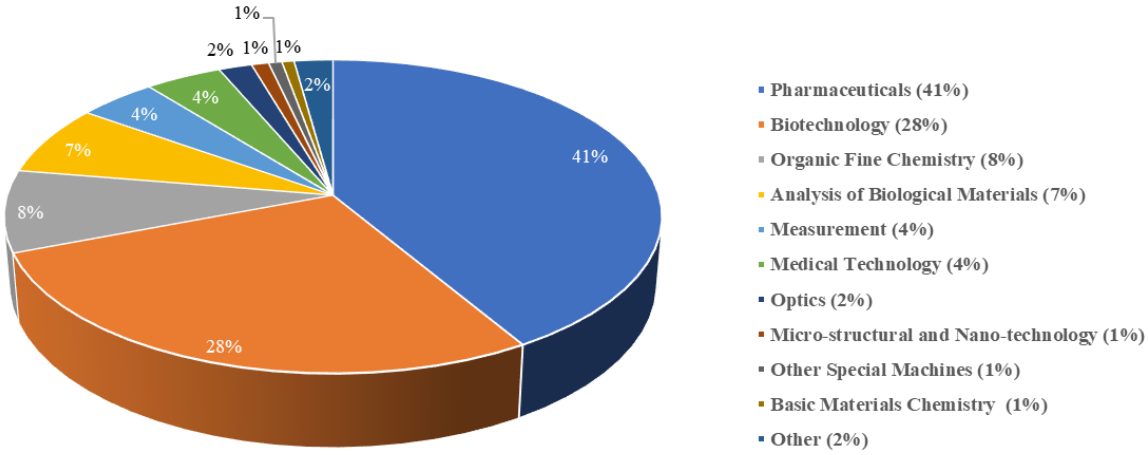
HHS Invention Disclosures and Patenting



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	321	320	354	322	268
Patent Applications Filed	222	269	289	253	207
Patents Issued	501	579	554	624	708

Patents issued to HHS in FY 2019 covered many technology areas including Pharmaceuticals (41%), Biotechnology (28%), Organic Fine Chemistry (8%), Analysis of Biological Materials (7%), and Measurement (4%).[34]

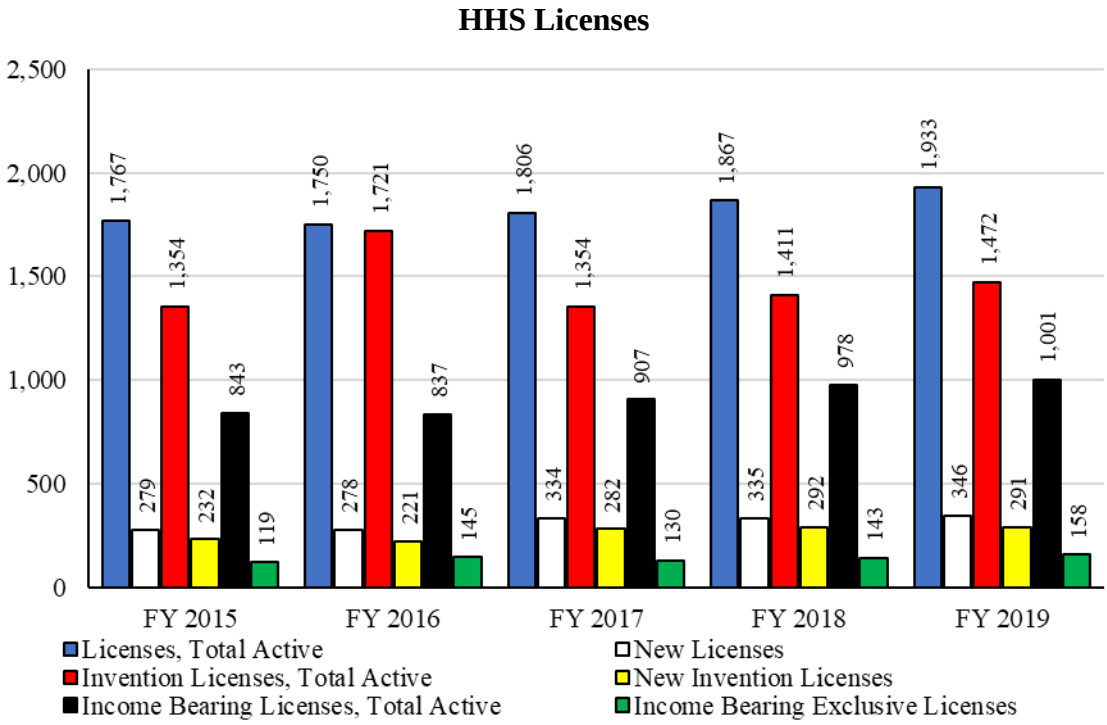
USPTO Patents Assigned to HHS by Technology Area: FY 2019



[34] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

HHS Licenses

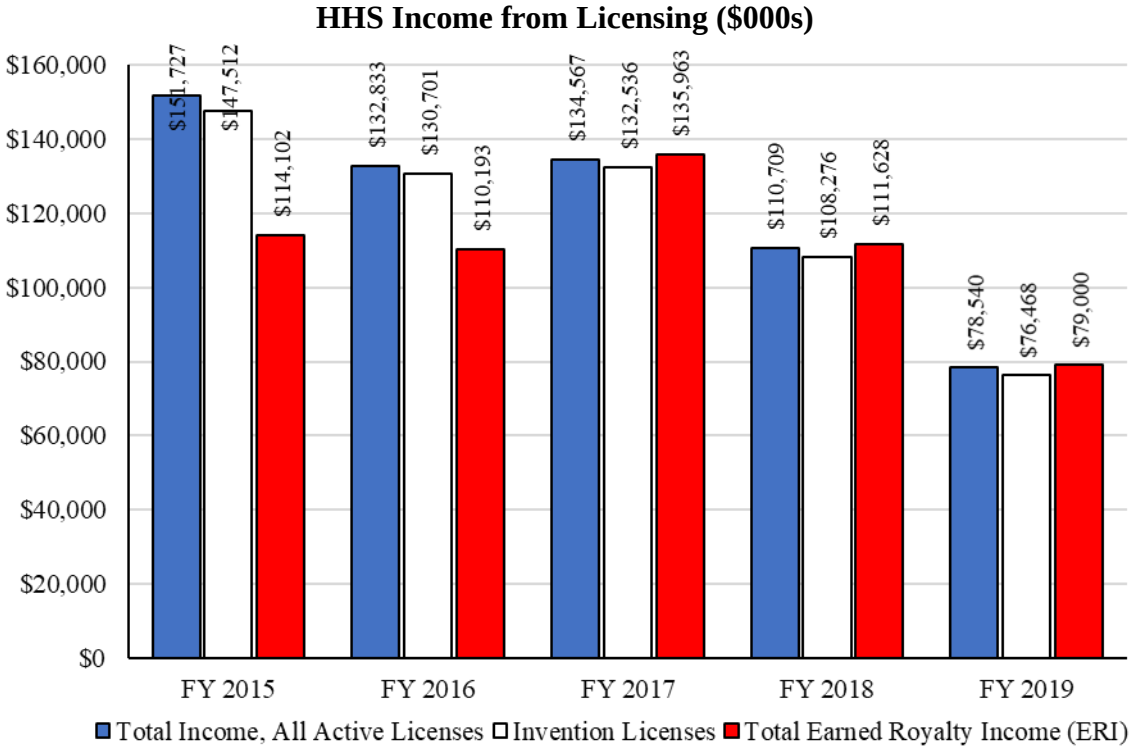
Between FY 2015 and FY 2019, total active licenses increased by 9%, from 1,767 in FY 2015 to 1,933 licenses in FY 2019. New licenses increased by 24%, from 279 in FY 2015 to 346 in FY 2019. Total active invention licenses increased by 9%, from 1,354 in FY 2015 to 1,472 licenses in FY 2019. New invention licenses increased by 25%, from 232 in FY 2015 to 291 in FY 2019. Total active income bearing licenses increased by 19%, from 843 in FY 2015 to 1,001 in FY 2019. Income bearing exclusive licenses increased by 33%, from 119 in FY 2015 to 158 licenses in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	1,767	1,750	1,806	1,867	1,933
New Licenses	279	278	334	335	346
Invention Licenses, Total Active	1,354	1,721	1,354	1,411	1,472
New Invention Licenses	232	221	282	292	291
Income Bearing Licenses, Total Active	843	837	907	978	1,001
Income Bearing Exclusive Licenses	119	145	130	143	158

HHS Income from Licensing

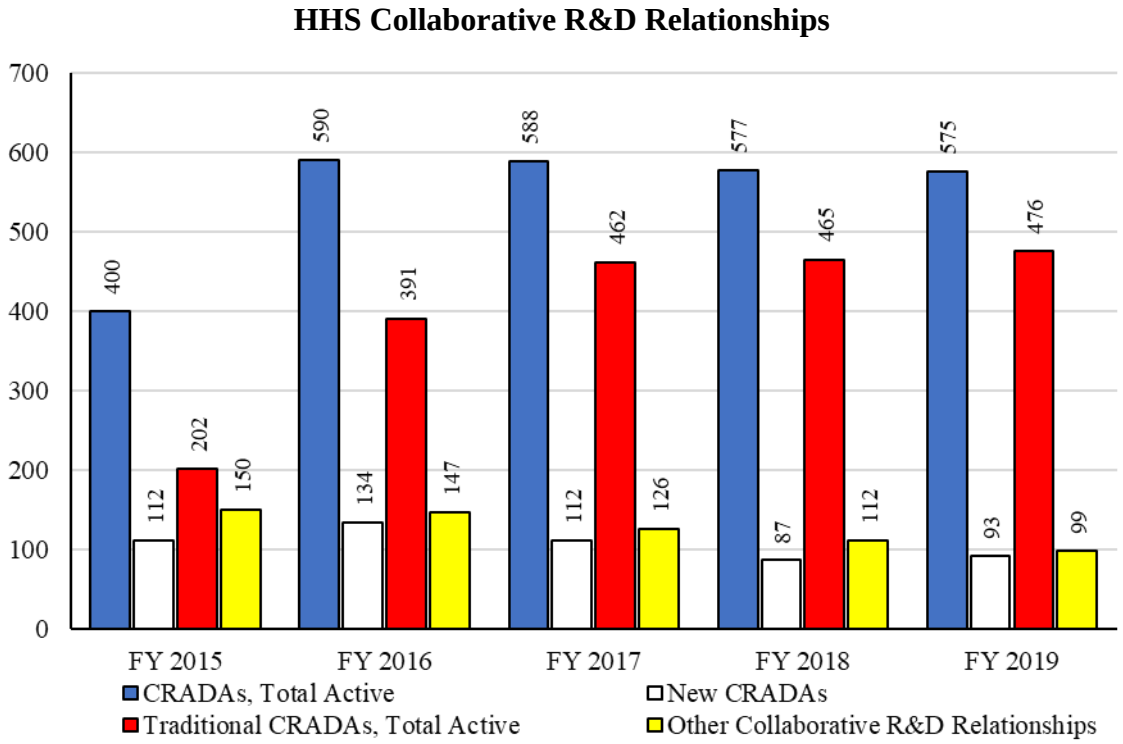
Between FY 2015 and FY 2019, total income from all active licenses decreased by 48%, from $151.7 million in FY 2015 to $78.5 million in FY 2019. The income from invention licenses decreased by 48%, from $147.5 million in FY 2015 to $76.5 million in FY 2019. Total earned royalty income decreased by 31%, from $114.1 million in FY 2015 to $79.0 million in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$151,727	$132,833	$134,567	$110,709	$78,540
Invention Licenses	$147,512	$130,701	$132,536	$108,276	$76,468
Total Earned Royalty Income, (ERI)	$114,102	$110,193	$135,963	$111,628	$79,000

HHS Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs increased by 44%, from 400 in FY 2015 to 575 in FY 2019. New CRADA agreements decreased by 17%, from 112 in FY 2015 to 93 in FY 2019. Traditional CRADAs increased by 136%, from 202 in FY 2015 to 476 in FY 2019. Other collaborative R&D relationships decreased by 34%, from 150 in FY 2015 to 99 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	400	590	588	577	575
New CRADAs	112	134	112	87	93
Traditional CRADAs, Total Active	202	391	462	465	476
Other Collaborative R&D Relationships	150	147	126	112	99

HHS Downstream Success Stories

National Cancer Institute (NCI): Breakthrough Therapy Designation for Pomalidomide for the Treatment of HIV-Positive Kaposi Sarcoma
In May 2019, the FDA granted Breakthrough Therapy designation to POMALYST® (pomalidomide) for the treatment of patients with human immunodeficiency virus (HIV)-positive Kaposi sarcoma who have previously received systemic chemotherapy, as well as patients with HIV-negative Kaposi sarcoma.

NCI entered into a CRADA with Celgene in 2011 to study Celgene's proprietary compound pomalidomide as a potential therapeutic for Kaposi sarcoma. The Breakthrough Therapy designation was granted by the FDA on the basis of the results of a clinical study performed under the CRADA by a team led by Dr. Robert Yarchoan, of the HIV and AIDS Malignancy Branch within NCI's Center for Cancer Research. Pomalidomide is a therapeutic drug that can treat cancer through several mechanisms. Pomalidomide can help treat cancer by blocking certain factors that promote tumor growth or by stimulating the immune system to attack tumor cells. It also prevents the growth of new blood vessels that help cancer grow. In clinical trials, researchers wanted to see if pomalidomide could treat Kaposi sarcoma, a rare and potentially fatal skin cancer. Because Kaposi sarcoma may be associated with HIV infection, researchers wanted to determine if pomalidomide was a safe and effective treatment for Kaposi sarcoma in people with or without HIV. TTC's Wendy Patterson, J.D. manages the ongoing CRADA with Celgene.

NCI: Tumor-Infiltrating Lymphocyte (TIL) Therapy Advances from Lab to Patients
In May 2019, the FDA granted breakthrough therapy designation for advanced cervical cancer to Iovance Biotherapeutics, an NCI CRADA partner, for their promising tumor-infiltrating lymphocyte therapy (LN-145) technology. This milestone is an important step in advancing tumor-infiltrating lymphocytes (TIL) research conceived by NCI's Dr. Steven Rosenberg and moving this breakthrough type of cancer treatment from the lab to clinical trials and ultimately, to patients with recurrent, metastatic, or persistent cervical cancer who have progressed on or after chemotherapy. This type of cancer is very aggressive and the prognosis for patients after metastases is very bleak. Following the FDA breakthrough therapy designation announcement, Iovance announced that it will open a new manufacturing facility to support manufacturing of TIL technologies. The new 136,000 square foot production facility is anticipated to "ultimately create employment opportunities for several hundred individuals in Philadelphia once at full capacity. Iovance expects to invest approximately $75 million over three years for equipment and construction of the manufacturing suites."

In 2011, NCI formed a CRADA partnership with Lion Technologies, a startup company strongly committed to moving this new class of treatment through FDA approval and commercialization. The technology from the Rosenberg lab of the NCI Center for Cancer Research (CCR) Surgery Branch, uses T cells that are naturally found in a patient's tumor, called TILs. TILs that best recognize the patient's tumor cells in laboratory tests are identified and selected, isolated and grown to large numbers in the laboratory. The tumor recognizing cells are then activated by treatment with immune system signaling proteins called cytokines and infused into the patient's bloodstream. This treatment is a "live therapy" consisting of a single infusion of TIL. The

complex collaboration with Iovance is managed by NCI TTC Technology Transfer Managers, Drs. Aida Cremesti and Andrew Burke.

National Institute of Allergy and Infectious Disease (NIAID): CRADA – Use of Kymab Mouse Model for Vaccine Development

Scientific researchers often use mouse models as an early means to assess vaccine candidates ahead of human clinical trials. However, promising results in mice do not necessarily indicate that the vaccine candidate will be effective in humans due to differences in the immune systems of mice and that of humans.

For this reason, NIAID researchers have long sought access to a mouse model with an immune system that is humanized (commonly termed "humanized mice"). Accessing such humanized mice has not been possible because many of these models are tightly controlled by commercial entities that require the retention of ownership rights to any new inventions realized through use of their humanized mice. Such ownership is not consistent with laws, regulations and policies applicable to NIH.

Kymab Limited (Kymab) has developed a humanized mouse model by inserting the entire human immunoglobulin variable-gene repertoire into the mouse genome to engineer Kymouse™ mice. In 2016, the Bill & Melinda Gates Foundation ("BMGF") funded Kymab to develop vaccines and therapeutic antibodies to pathogens of infectious diseases.

As a UK-based company, Kymab had no experience working with the U.S. government or with the statutes and regulations that govern NIAID's activities. To overcome this obstacle, TTIPO negotiated three CRADAs in 2018 that enabled the use of Kymouse™ model to evaluate and develop new vaccine candidates against influenza, HIV and Respiratory Syncytial Virus (RSV), with agreement terms consistent with Federal laws and regulations as well as NIH policies.

National Institute of Mental Health (NIMH): ASQ Suicide-Screening Questions Toolkit

The National Institute of Mental Health (NIMH) is the lead federal agency for research on mental disorders and its mission is to transform the understanding and treatment of mental illnesses through basic and clinical research, paving the way for prevention, recovery, and cure.

Suicide is a global public health problem and the second leading cause of death for young people ages 10-24 worldwide. Suicide is also a major public health concern in the United States. According to the Centers for Disease Control and Prevention (CDC), more than 5,900 youths killed themselves in 2015. Even more common than death by suicide are suicide attempts and suicidal thoughts. NIMH is working on two fronts to address this public health issue: early detection and rapid-acting treatments.

The Indian Health Service (IHS) in partnership with NIMH are collaborating to promote and implement universal suicide screening in IHS emergency departments, using NIMH's Ask Suicide Question (ASQ) toolkit and will be working to develop further training and specific educational materials for IHS/Tribal/Urban providers in the near future.

The Indian Health Service, an agency within the Department of Health and Human Services, is responsible for providing federal health services to American Indians and Alaska Natives. Its mission is to raise their health status to the highest possible level. The IHS provides a comprehensive health service delivery system for American Indians and Alaska Natives.

The ASQ toolkit is a free resource for medical settings (emergency department, inpatient medical/surgical units, outpatient clinics/primary care) that can help nurses or physicians successfully identify youth at risk for suicide. The ASQ is a set of four screening questions that takes 20 seconds to administer. In an NIMH study, a "yes" response to one or more of the four questions identified 97% of youth (aged 10 to 21 years) at risk for suicide. By enabling early identification and assessment of young patients at high risk for suicide, the ASQ toolkit can play a key role in suicide prevention.

Centers for Disease Control and Prevention (CDC): Protecting Healthcare Workers by Detecting Contamination from Hazardous Antineoplastic Drugs

Antineoplastic drugs, also known as anticancer drugs or chemotherapy, are used in the treatment of many types of cancer. While these drugs are lifesaving to patients, they must be handled with care by healthcare workers. Exposure from contaminated surfaces and drug vials can cause skin problems, birth defects, reproductive issues, and increased risk of various cancers. NIAID TTIPO has helped to improve the handling of these drugs by leveraging patenting and licensing expertise to advance the development and commercialization of new rapid detection kits. [35]

Currently, an estimated 8 million U.S. healthcare workers are potentially exposed to antineoplastic drugs. Traditional sampling methods to test for surface contamination produce results in several weeks, involve significant expense, and require analysis in a laboratory. Centers for Disease Control and Prevention (CDC) researchers at the National Institute for Occupational Safety and Health (NIOSH) developed technology to rapidly detect three commonly used antineoplastic drugs. (The technology is applicable to many types of antineoplastic drugs.) CDC initially developed the lateral flow immunoassay that allows sampling of surfaces to assess drug contamination.

CDC NIOSH's Research to Practice (r2p) Office, CDC's Technology Transfer Office (TTO), and the CDC Team at NIAID Technology Transfer and Intellectual Property Office (TTIPO) leveraged multiple mechanisms, resources, and activities to successfully transfer this technology, including patent protection, a conference presentation, marketing at additional conferences and via websites, multiple agreements and two licenses.

CDC NIOSH's partners at Becton, Dickinson, and Company (BD) licensed, further developed, and incorporated the technology into a portable device. The resulting tool, the BD™ HD Check system, can analyze samples for doxorubicin and methotrexate (two common chemotherapy drugs) and provide reliable results in less than 10 minutes. It empowers healthcare workers to test surfaces when and where needed — and quickly determine the level of contamination in areas where hazardous antineoplastic drugs are present.

[35] 2019 Federal Laboratory Consortium (FLC) National Award: Excellence in Technology Transfer and 2019 FLC Southeast Regional Award: Excellence in Technology Transfer Project of the Year

In April 2018, BD launched the HD Check system in the U.S. to strong interest from the pharmacy and nursing communities. BD expects to make the product commercially available in Europe, Japan, Canada, and Australia. NIOSH and BD are continuing research to incorporate additional hazardous drugs in the rapid detection kits.

BD launched the BD™ HD Check system, the first and only rapid hazardous drug detection system, in the U.S. in April 2018. The commercial product reflects a successful transfer of a CDC NIOSH technology.

Department of Homeland Security (DHS)

As the designated DHS Office of Research and Technology Applications (ORTA; 15 USC §3710(b)), the Technology Transfer and Commercialization Program (T2C) manages technology transfer and commercialization activities for the Department, including DHS Components and the DHS laboratory network. T2C works directly with the DHS Office of General Counsel Technology Programs Law Division (OGC-TPLD) to protect, manage and license DHS intellectual property. T2C also has delegated responsibility for establishing research collaborations and partnerships through Cooperative Research and Development Agreements (CRADAs) and providing additional resources or support to develop and move technologies from lab to market.

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

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

Partnership Intermediaries
Partnership Intermediary Agreements (PIAs) are a special technology transfer tool authorized under 15 U.S.C. §3715. PIAs allow agencies to leverage the expertise and resources of a partnership intermediary (PI) to achieve the agency's technology transfer and commercialization goals and objectives. DHS had not effectively used this tool in the past.

In FY 2019, T2C established the first fully funded PIA with MilTech, which was established by Montana State University in CY 2004. MilTech is an authorized PI supporting the technology transfer and commercialization functions for U.S. government agencies. MilTech aids DHS by promoting the transfer and commercialization of DHS-funded technologies quickly, reliably, and cost effectively. To do this, MilTech relies upon their nationwide network of research partners and subject matter experts to conduct market analyses, licensee and manufacturer scouting, technology evaluations and assessments, prototyping, and manufacture expertise projects to provide DHS project managers with information that is key to moving DHS-funded solutions to the marketplace.

MilTech provided an orientation briefing to DHS S&T personnel to internally promote the PIA's capabilities and identify potential project opportunities. DHS program managers discussed potential PIA projects with MilTech staff and collaborated to develop specific project statements of work for seven new PIA projects ranging from scouting for suppliers, licensee scouting, technology evaluation, commercialization planning, and prototyping.

Commercialization Accelerator Program (CAP)
In FY 2019, DHS expanded its tech-to-market program, the TTP previously focused on cybersecurity, and rebranded it as the Commercialization Accelerator Program (CAP). Under CAP, the program's mandate was expanded to include critical infrastructure security, data analytics, screening and detection, and first responder technologies.

CAP bridges the gap between federally funded research and the marketplace, addressing the "Valley of Death" problem, and selects technologies from various federal laboratories, including Department of Energy's (DOE) national laboratories, Department of Defense's (DoD) affiliated laboratories, FFRDCs, and University Affiliated Research Centers (UARCs). This enables CAP

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.”

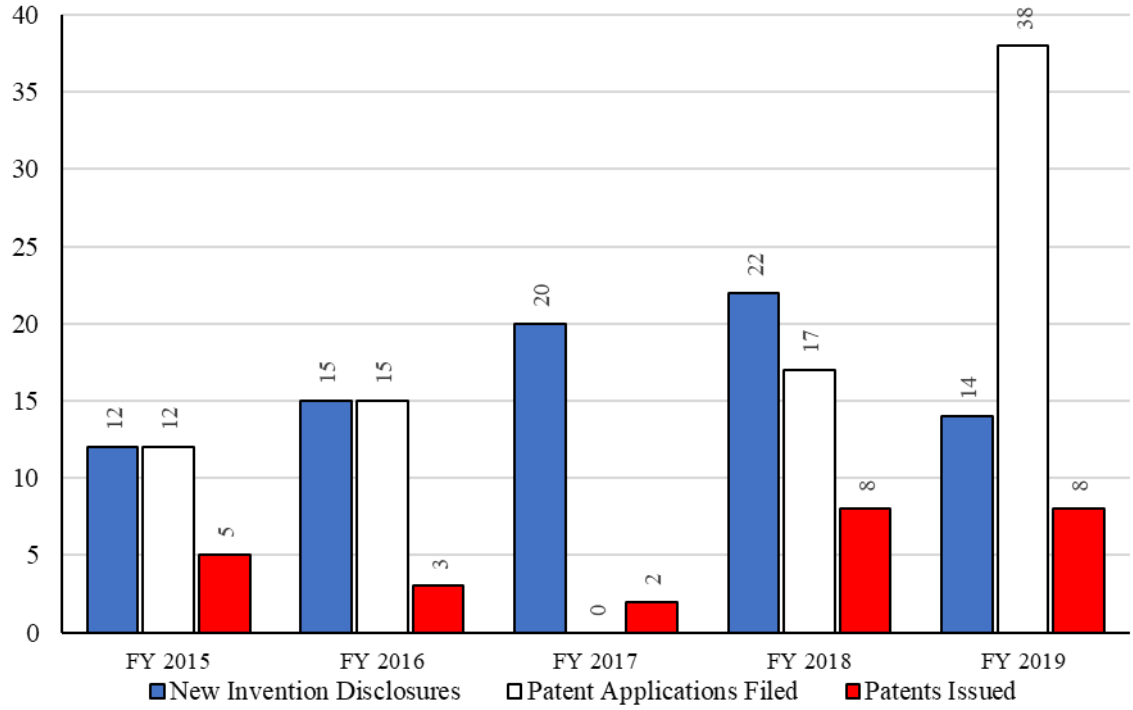
CAP technologies go through a structured technology transfer process designed to increase their technology maturities and market readiness. In addition to providing funding specifically intended to support technology maturation and market readiness activities, CAP offers commercialization and entrepreneurship training and resources to researchers; 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 and market validation and targeting. Through outreach efforts, the CAP program will introduce these technologies to investors, developers, and integrators who can license the technologies and turn them into commercially viable products.

T2C works across the revitalized S&T matrixed organizational structure and uses its tools and mechanisms to promote the delivery of technology solutions supported through DHS S&T funding. This model allows S&T to leverage its science, engineering, and business engagement capabilities more rapidly to innovate and field solutions.

DHS Invention Disclosures and Patenting

In FY 2019, DHS reported 14 new inventions disclosures. From FY 2015 to FY 2019, DHS reported a 217% increase in patent applications filed with 12 in FY 2015 38 in FY 2019. Patents issued increased by 60%, with 5 in FY 2015 and 8 in FY 2019.

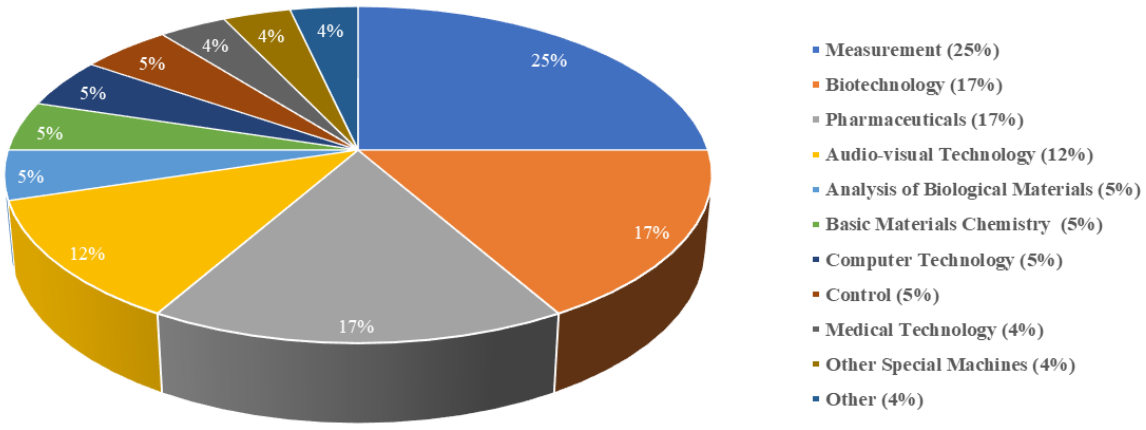
DHS Invention Disclosures and Patenting



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	12	15	20	22	14
Patent Applications Filed	12	15	0	17	38
Patents Issued	5	3	2	8	8

Patents issued to DHS in FY 2019 covered multiple technology areas including Measurement (25%), Control (14%), Biotechnology (17%), Pharmaceuticals (17%), Audio-visual Technology (12%), and Analysis of Biological Materials (5%).[36]

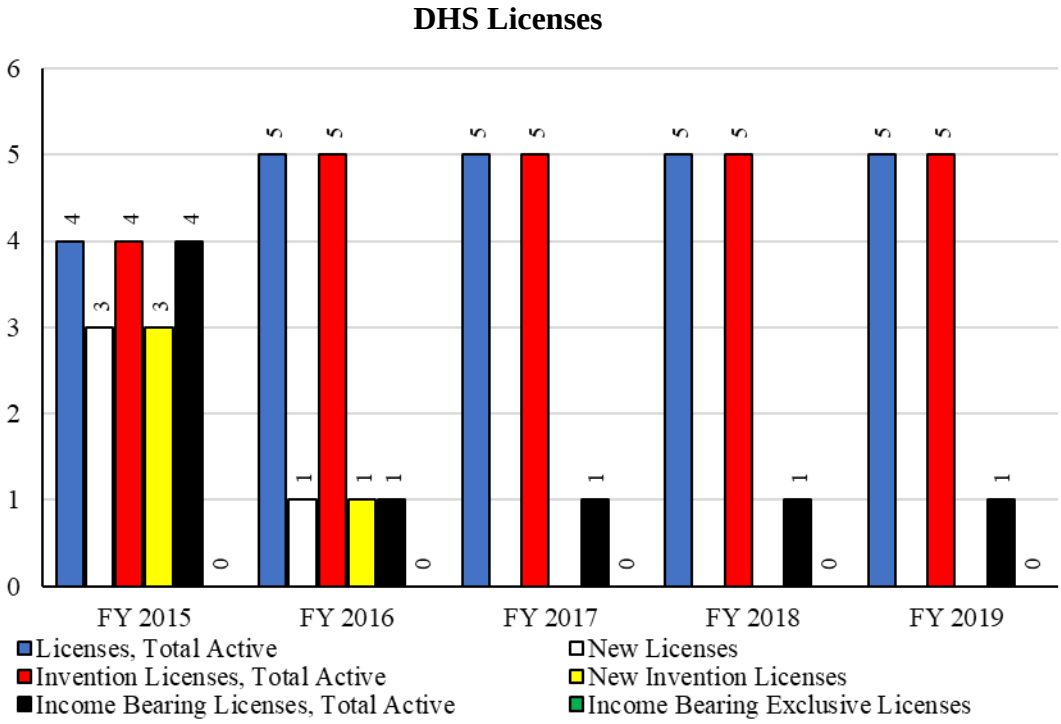
USPTO Patents Assigned to DHS by Technology Area: FY 2019



[36] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DHS Licenses

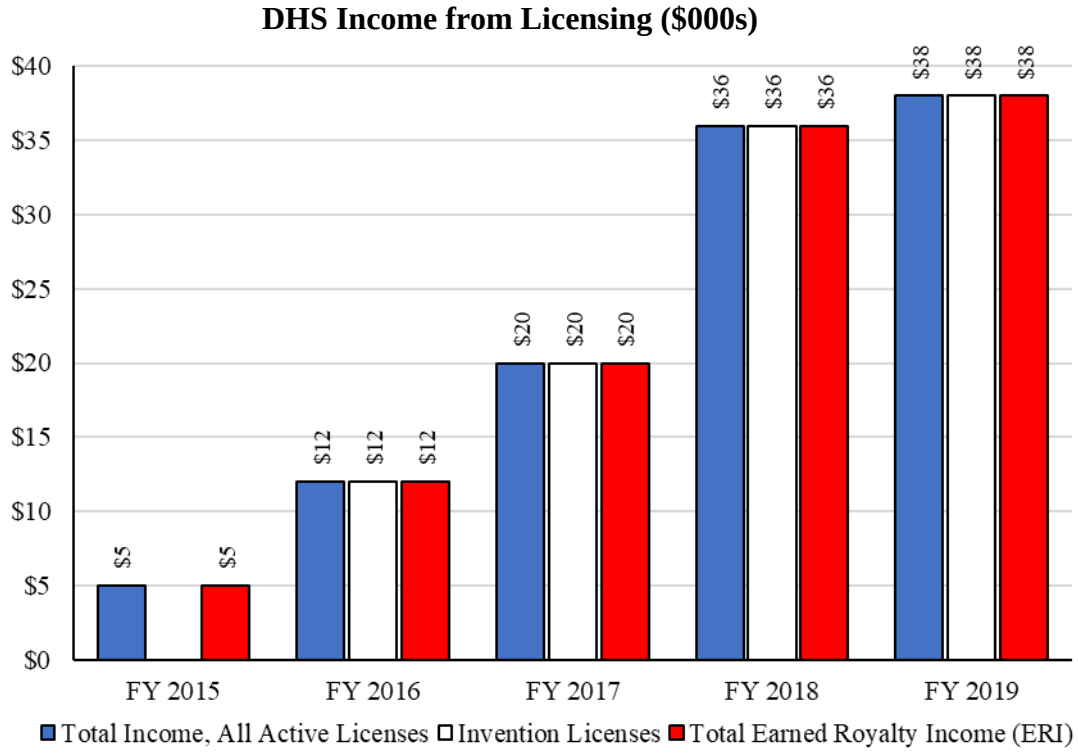
In FY 2019, DHS managed 5 active license agreements. Out of the 5 active agreements, two was income bearing.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	4	5	5	5	5
New Licenses	3	1	0	0	0
Invention Licenses, Total Active	4	5	5	5	5
New Invention Licenses	3	1	0	0	0
Income Bearing Licenses, Total Active	4	1	1	1	1
Income Bearing Exclusive Licenses	0	0	0	0	0

DHS Income from Licensing

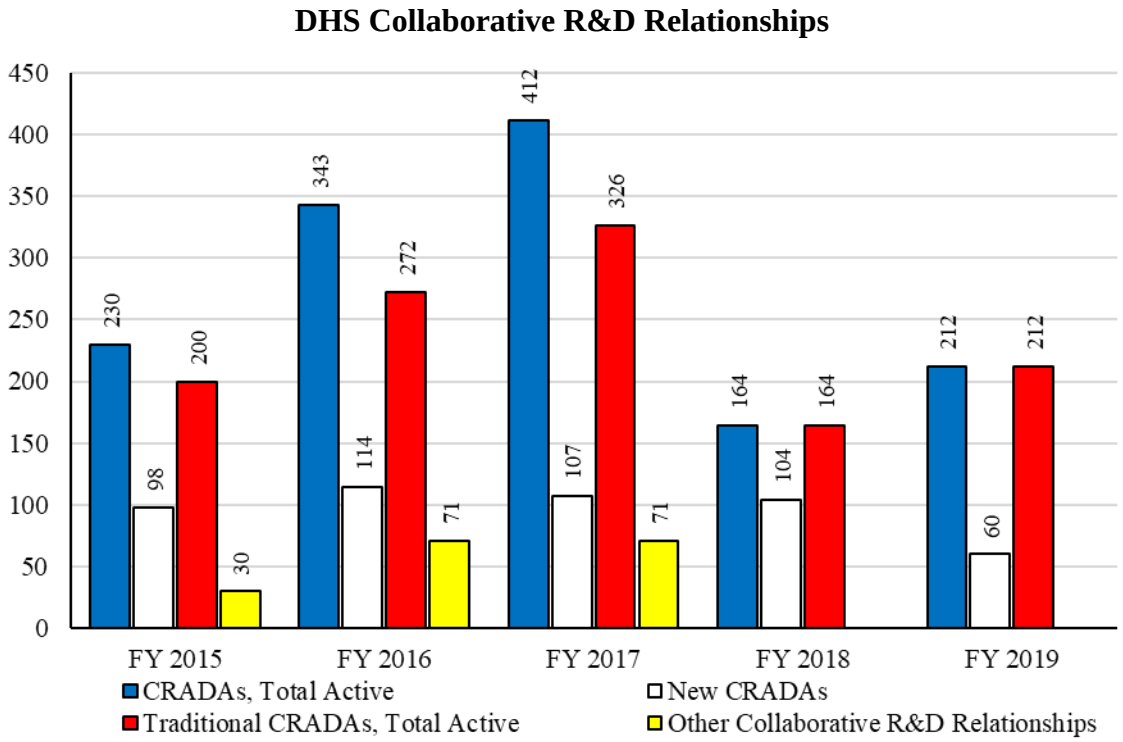
From FY 2015 to FY 2019, DHS reported a 660% increase in Total Earned Royalty Income from $5 thousand in FY 2015 to $38 thousand in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$5	$12	$20	$36	$38
Invention Licenses	$0	$12	$20	$36	$38
Total Earned Royalty Income, (ERI)	$5	$12	$20	$36	$38

DHS Collaborative R&D Relationships[37]

Total active CRADAs decreased by 8%, from 230 in FY 2015 to 212 in FY 2019. New CRADAs decreased by 39%, from 98 in FY 2015 to 60 in FY 2019. Traditional CRADAs increased by 6%, from 200 in FY 2015 to 212 in FY 2019.



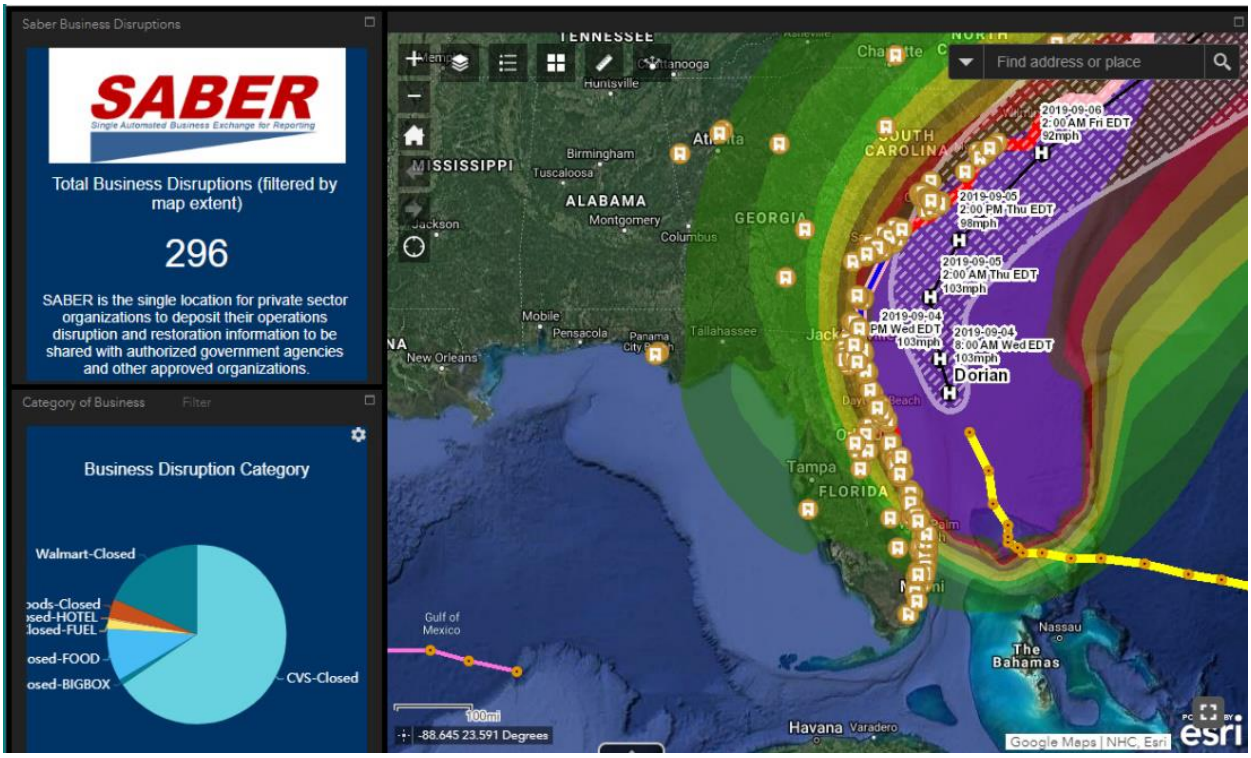
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	230	343	412	164	212
New CRADAs	98	114	107	104	60
Traditional CRADAs, Total Active	200	272	326	164	212
Other Collaborative R&D Relationships	30	71	71	n.a.	n.a.

[37] DHS was unable to report values for other collaborative R&D relationships for FY 2018 and FY 2019.

DHS Downstream Success Stories

S&T-Funded SABER Helps Communities Get Back to Business During and After Disasters

In recent years, severe storm surges, flooding, mass power outages, and other natural or man-made emergencies and disasters have affected businesses in myriad ways. When these disasters strike, the Homeland Security Enterprise relies on real-time data to effectively help businesses—and in turn, private citizens—recover and get back on their feet. This data is provided by a tool called the Single Automated Business Exchange for Reporting, better known as SABER. Originally created by the private sector, SABER is now a free open-source reporting software, publicly available thanks to funding from DHS S&T.



Source: U.S. DHS.

SABER is an ArcGIS application developed by DHS. During the 2019 hurricane season, in the aftermath of Hurricane Barry in Louisiana, the Federal Emergency Management Agency (FEMA) used business status information data from SABER to prioritize their responses and recovery efforts and determine which organizations needed federal aid.

SABER is a crucial tool for helping organizations maintain or resume their operations both during and after a disaster. Users upload their business status information via the web or mobile application with the knowledge that federal aid organizations such as FEMA are monitoring SABER and have the resources to immediately respond to and provide aid for any type of crises that they may be experiencing.

Because all this information is so vital, DHS S&T felt that it should be expanded to include more status and needs data from private businesses. SABER is continuing to grow and improve by

refining its critical information sharing services and expanding its reach into both the private and public sectors of business and government.

SABER currently has 130,000 organizations in more than 30 states across the U.S. that utilize its services to report their business status during emergencies. By the end of 2020, both DHS and SABER hope to have 300,000 organizations across the U.S. utilizing SABER to share their business status and provide effective and targeted aid to each other during emergencies and disasters.

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; provide scientific and other information about those resources; and honor trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

This section describes the actions that the DOI took in FY 2019 to advance technology transfer. These range from developing new technologies that would help identify various substances in water to improved methods to measure water quality in high biofouling environments. These activities demonstrate the innovation, expertise, and dedication of the department'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 Department's bureaus have varying levels of involvement with scientific and technical research, innovation and technology transfer. In FY 2019, as in previous years, the majority of technology transfer activities reported by the Department under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS), which is the largest R&D organization in the Department in terms of both budget and personnel. Typically, USGS accounts for more than 60% of the Department'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 general public. The vast 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 2019, DOI personnel authored or co-authored more than 9,800 reports, books, fact sheets, and other publications, including more than 3,200 articles in scientific journals and 4,800 abstracts and data releases.

Bureaus also use other conventional approaches to share scientific and technical resources and expertise, with universities and other entities to address resource management issues. For example, 7 DOI bureaus are active participants in the network of 17 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.

In addition, some bureaus and/or offices have offered prizes to help develop new or improve existing technologies. The bulk of the prize competition activities at DOI are undertaken by the

Bureau of Reclamation's Water Prize Competition Center (WPCC). From FYs 2017–2018, DOI bureaus completed, had underway, or launched 15 prize competitions, which included 14 from the WPCC, and 1 jointly offered by the National Invasive Species Council, DOI's Office of Hawaiian Affairs, and other DOI bureaus. The Bureau of Reclamation alone plans to launch 17 more competitions over the next few years.

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. This can strengthen the 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.

FY 2019 Accomplishments

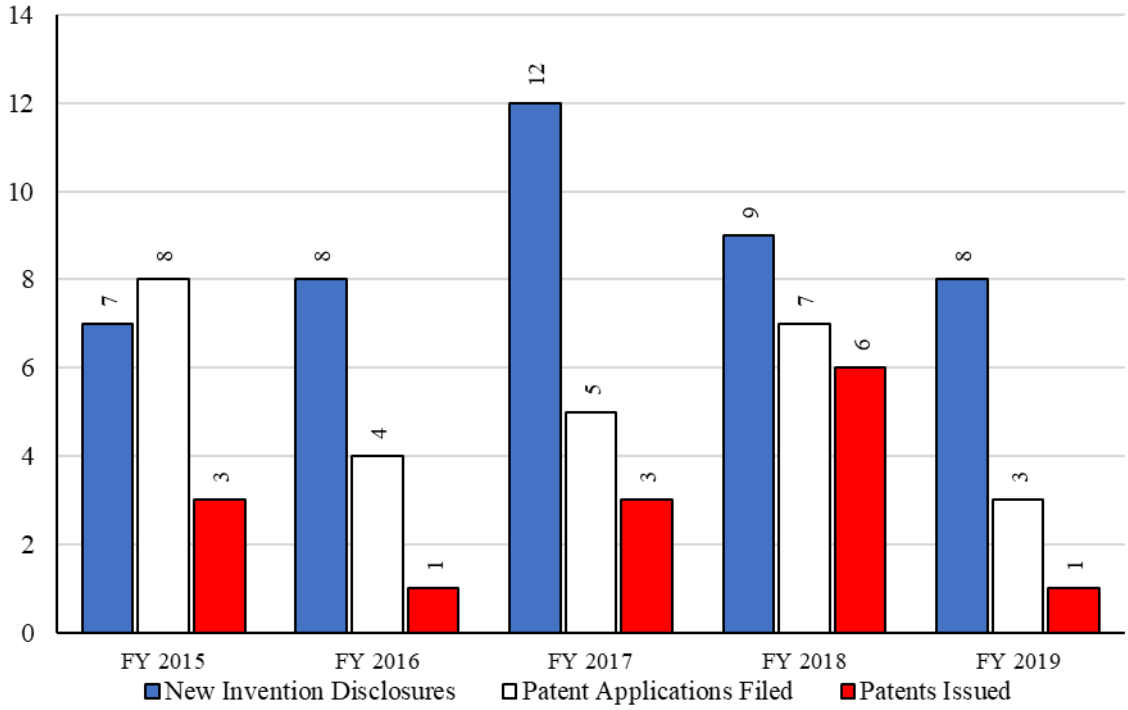
During FY 2019, the DOI's scientific, technical, and engineering personnel continued to engage in a broad range of cooperative activities to develop and disseminate innovative technologies, including—

- Publishing more than 9,800 reports, books, fact sheets, and other publications, including more than 3,200 articles in scientific journals and 4,800 abstracts and data releases.
- Collaborating on 470 CRADAs, of which 352 were initiated in FY 2019. In addition, the department engaged in at least 269 other collaborative R&D relationships.
- Engaging in 425 nontraditional CRADAs, such as material use and facility use agreements, under the FTTA.
- Disclosing eight new inventions, three new patent applications were filed, and one new patent was awarded.
- Managing eighteen active patent licenses for inventions and other intellectual property, earning about $42,000 collectively.

DOI Invention Disclosures and Patenting

From FY 2015 to FY 2019, new inventions disclosed increased by 14%, from 7 in FY 2015 to 8 in FY 2019. Patent applications filed decreased by 63%, from 8 in FY 2015 to 3 in FY 2019. Patents issued decreased by 67%, from 3 in FY 2015 to 1 in FY 2019.

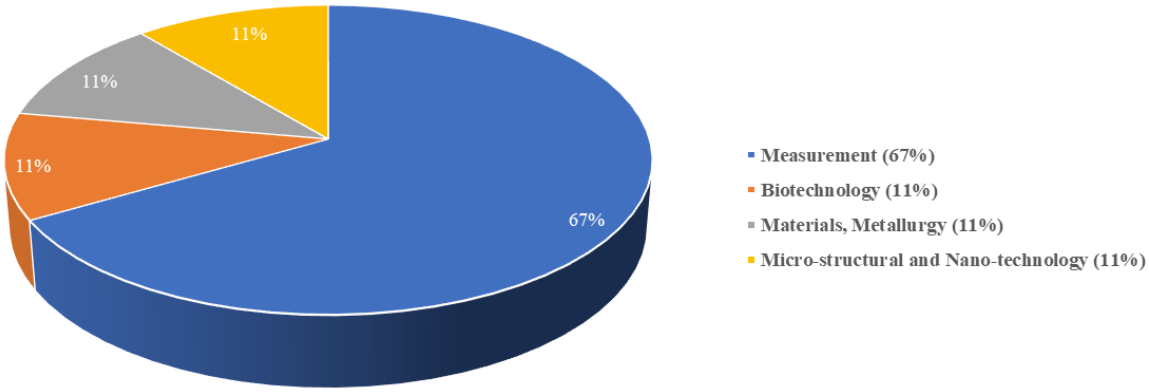
DOI Invention Disclosures and Patenting



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	7	8	12	9	8
Patent Applications Filed	8	4	5	7	3
Patents Issued	3	1	3	6	1

The patents issued to DOI in FY 2019 covered multiple technology areas including the following: Measurement (67%), Biotechnology (11%), Materials, Metallurgy (11%), and Micro-structural and Nanon-technology (11%).[38]

USPTO Patents Assigned to DOI by Technology Area: FY 2019

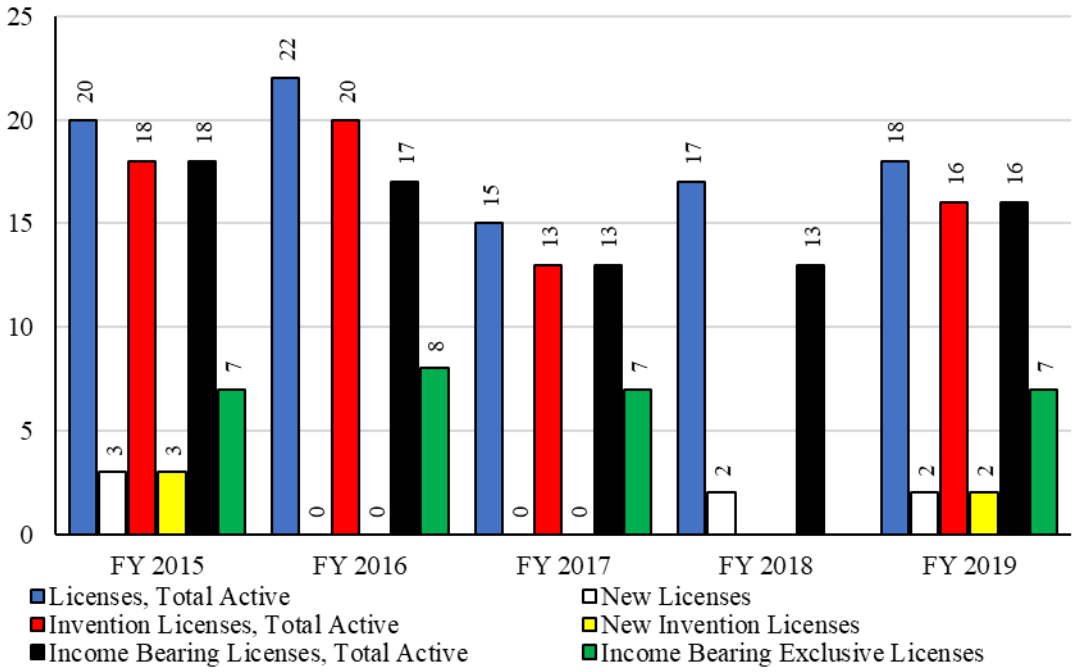


[38] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DOI Licenses[39]

From FY 2015 to FY 2019, total active licenses decreased by 10%, from 20 in FY 2015 to 18 licenses in FY 2019. New invention licenses decreased by 33%, from 3 in FY 2015 to 2 in FY 2019. DOI reported 2 total active invention licenses and 2 new invention licenses in FY 2019. Total active income bearing licenses decreased by 11%, from 18 in FY 2015 to 16 in FY 2019.

DOI Licenses



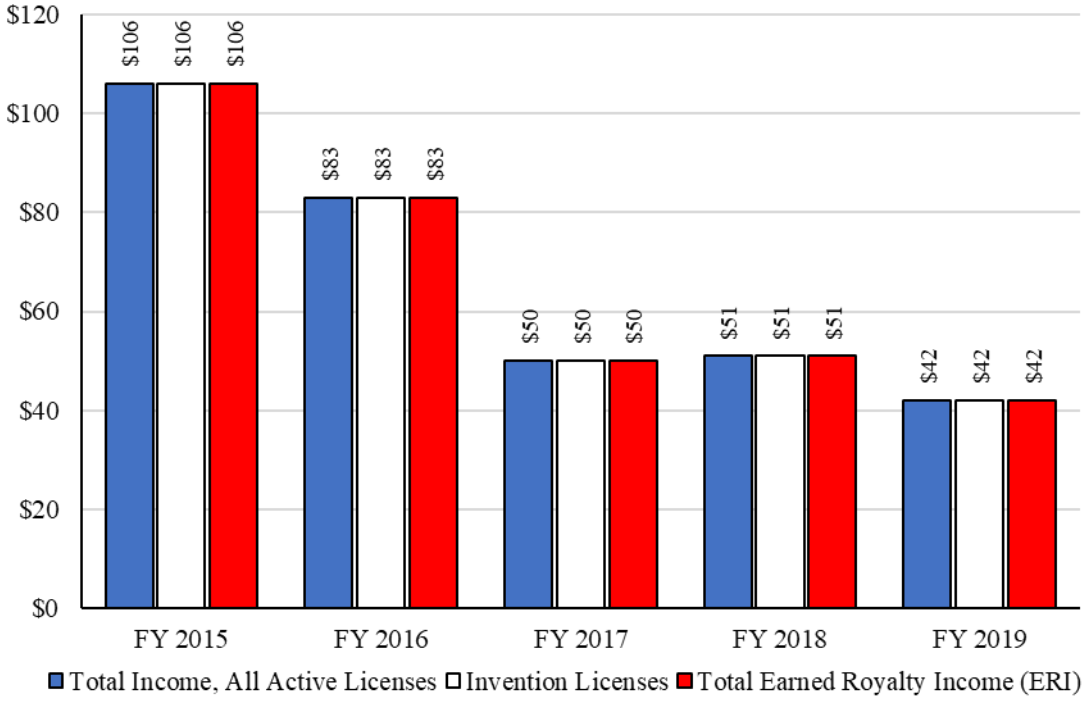
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	20	22	15	17	18
New Licenses	3	0	0	2	2
Invention Licenses, Total Active	18	20	13	n.a.	16
New Invention Licenses	3	0	0	n.a.	2
Income Bearing Licenses, Total Active	18	17	13	13	16
Income Bearing Exclusive Licenses	7	8	7	n.a.	7

[39] DHS was unable to provide information on Invention Licenses, Total Active; New Invention Licenses; and Income Bearing Exclusive Licenses for FY 2018.

DOI Income from Licensing

Between FY 2015 and FY 2019, total income from all active licenses decreased by 60%, from $106 thousand in FY 2015 to $42 thousand in FY 2019. 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 60%, from $106 in FY 2015 to $42 thousand in FY 2019.

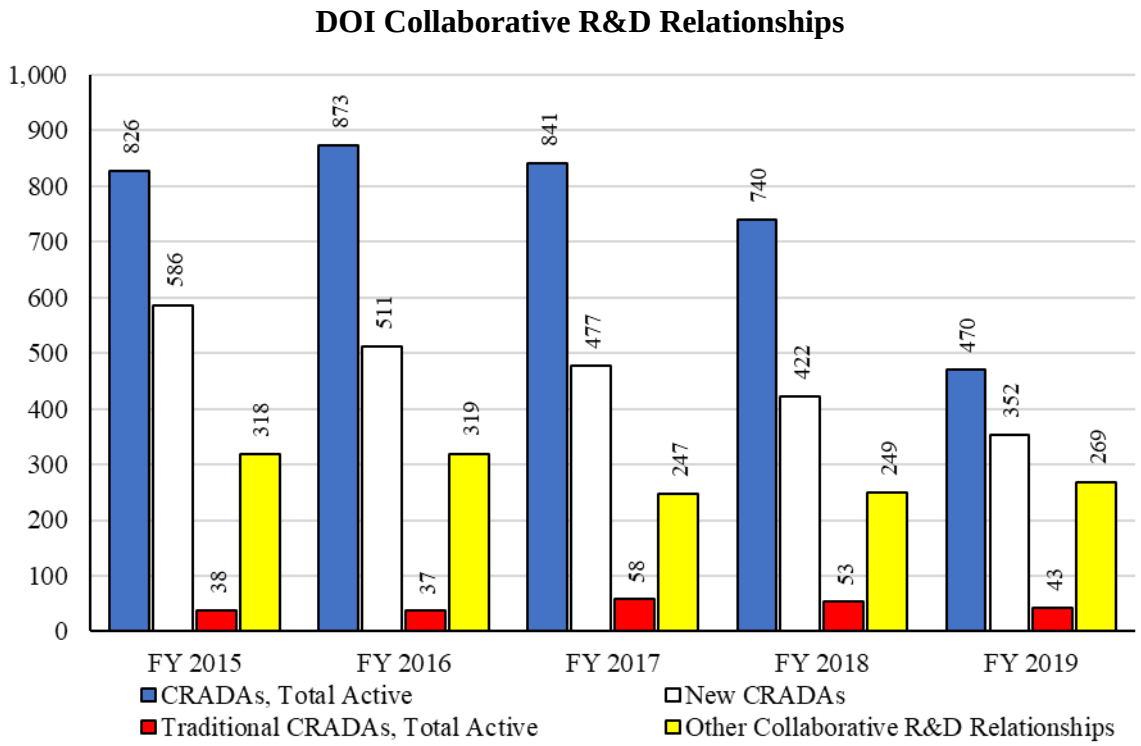
DOI Income from Licensing ($000s)



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$106	$83	$50	$51	$42
Invention Licenses	$106	$83	$50	$51	$42
Total Earned Royalty Income, (ERI)	$106	$83	$50	$51	$42

DOI Collaborative R&D Relationships

From FY 2015 to FY 2019, total active CRADAs decreased by 43%, from 826 in FY 2015 to 470 agreements in FY 2019. The number of new CRADAs decreased by 40%, from 586 in FY 2015 to 352 in FY 2019. Traditional CRADAs increased by 13%, from 38 in FY 2015 to 43 agreements in FY 2019. Other collaborative R&D relationships decreased by 15%, from 318 in FY 2015 to 269 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	826	873	841	740	470
New CRADAs	586	511	477	422	352
Traditional CRADAs, Total Active	38	37	58	53	43
Other Collaborative R&D Relationships	318	319	247	249	269

DOI Downstream Success Stories

United States Geological Survey: Sea Lamprey Control Program

Sea lamprey, a parasitic fish species that is nonnative to the Great Lakes, preys on a wide variety of large Great Lakes fish, such as lake trout, brown trout, lake sturgeon, lake whitefish, Chinook and coho salmon, and steelhead (rainbow) trout.[40] The USGS Upper Midwest Environmental Sciences Center (UMESC) in La Crosse, Wisconsin, established a CRADA with the Coating Place, Inc. (CPI) in Verona, Wisconsin, and the Great Lakes Fisheries Commission (GLFC). UMESC has a long-standing established program to provide technical assistance, lampricide formulation development, and regulatory support to the GLFC Sea Lamprey Control Program. The GLFC provides financial and directional support for the UMESC program as part of its responsibility to administer the binational Sea Lamprey Control Program. CPI is an established producer of multiple lampricide formulation used in the Sea Lamprey Control Program and has expertise in formulation and coating development.

Under the CRADA, UMESC staff are working with CPI to develop a water-based formulation of liquid Bayluscide as a replacement to the current Bayluscide 20% Emulsifiable Concentrate lampricide. Numerous issues have been noted by the control agents when applying the current formulation, including clogging of spreader tubing, erosion of pump seals, and problematic cleaning of application equipment. These problems prompted research for a replacement formulation. Preliminary analysis of the water-based formulation of Bayluscide (Bayluscide LF), developed by CPI, showed promise in eliminating application and cleanup issues. UMESC worked with the U.S. Environmental Protection Agency and Michigan's Department of Environment, Great Lakes, and Energy to obtain an Experimental Use Permit (EUP) waiver for an experimental field application. An experimental field application of the water-based formulation was conducted on the Indian River on September 24, 2019. Approximately 55 L of the experimental Bayluscide formulation was successfully applied; however, settling of the Bayluscide formulation in the containers was observed. UMESC met with CPI to discuss formulation modifications that could resolve product settling issues, and a path forward for the formulation was initiated in 2020.

In a similar effort, UMESC staff are working with CPI to develop an improved surfactant-based trifluoromethyl nitrophenol (TFM) lampricide bar formulation as a replacement to the current bar formulation to treat small feeder streams. Lampricide bars are placed in feeder streams to prevent sea lamprey from seeking refuge in untreated waters as the main treatment block passes. The current bar formulation dissolves too quickly and can require reapplication to prevent sea lamprey larvae escape. UMESC prepared and provided TFM Crystalized Extract for CPI to use in experimental bar formulations, and during FY 2019, UMESC conducted 27 dissolution trials with nine (9) experimental TFM bar prototypes. Experimental TFM bar formulations show promise for improved performance characteristics. Additional formulation development work in 2020 included evaluating increased active ingredient concentrations and carrier surfactant modifications and/or substitutions.

[40] While Sea Lamprey are not native to the great lakes, only two of the preyed upon species listed are native—Lake Sturgeon and Lake Trout. The non-native fish in this list were intentionally introduced to prey on another non-native species, Alewife. They also provide recreational fishing opportunities and are generally considered beneficial by the Great Lakes fisheries management community.

USGS: Characteristics of Dust and Risk Factors Associated with the Development of Rapidly Progressive Pneumoconiosis and Progressive Massive Fibrosis
Since the mid-1990s, research studies and surveillance reports have documented a significant increase in coal workers' pneumoconiosis (CWP)—including the most severe forms of progressive massive fibrosis (PMF) and rapidly progressive pneumoconiosis (RPP)—in U.S. coal miners, with many cases occurring in younger miners. The Appalachian coalfields appear to be particularly affected. There are several possible explanations for these observations, including excessive exposure to respirable dust and increased exposure to particulate dust constituents (e.g., freshly fractured silica and silicates or smaller particles) that may be the result of changing mining practices. To date, however, the causal links between specific exposure characteristics and the increase in cases of RPP and PMF have not been elucidated; therefore, current protections for active mine workers may not be adequate. As part of its mission, USGS studies how geologic materials influence human health. Under this CRADA, USGS will collaborate with the University of Illinois at Chicago (UIC) to explore the link between the inhalation of respirable airborne geologic particulate matter released during coal mining processes and the documented significant increase in coal workers' pneumoconiosis (CWP) and progressive massive fibrosis (PMF). The UIC seeks USGS expertise in providing field emission scanning electron microscopy analyses of particulate matter in situ of lung tissue samples and from bleach-digested lung tissue. It also requires USGS knowledge and expertise to develop a method for bulk chemical analysis of the bleach digestion solution to determine possible bleach-soluble phases within the lung tissue.

This CRADA benefits both USGS and collaborators by providing funding that will support the USGS scientists for scientifically and societally important research, enhance transdisciplinary research collaborations with the public health community, and lead to the development of new methods for the study of mineral matter in tissue that can then, in turn, be applied to future projects.

In addition, the anticipated outcomes of the collaboration could benefit the American people by providing guidance to mitigate risk factors to coal miners exposed to particulate matter.

To date, USGS has digested and acquired automated particle size and classification analysis from 30 samples. Data are currently being reviewed for consistency and accuracy. The work conducted by USGS and collaborators was summarized and presented at the American Thoracic Society Meetings.

United States Fish and Wildlife Service (FWS): National Conservation Training Center
The FWS Conservation Library at the National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, provides a searchable collection of selected documents, images, historical artifacts, audio clips, publications, and video, most of which are in the public domain. FWS also makes internal publications, reports, and other information available to the public through the FWS website. Collections of current and legacy publications (including biological and technical publications) are available online from the NCTC library catalog and websites. NCTC also maintains links to biological and technical publications, as well as additional publications regarding birds, wetlands, fish hatcheries, and National Wildlife Refuges.

NCTC also hosts publicly-accessible webinars dealing with a variety of scientific and technical issues that affect the nation's fish and wildlife resources. During FY 2018, NCTC hosted 60 online science, technology, and educational webinars; 70 e-courses; and 33 podcasts related to managing the nation's fish, wildlife, and plant resources. These are an important component of FWS's traditional technology transfer activities.

FWS: Aquatic Invasive Species

The 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 miniscule 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.

The FAC program 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 more 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 FWS's risk assessment protocol.

Office of Surface Mining Reclamation and Enforcement (OSMRE): OSMRE Unmanned Aircraft Systems (UAS) Program

In FY 2019, OSMRE continued using the UAS to enhance assessment of active and abandoned mine sites, especially on large land areas with diverse and complicated topography and over areas where dangerous conditions exist, allowing surveillance of an area without endangering people on the ground. OSMRE has new multispectral sensors that can be mounted on the aircraft to collect data that cannot be obtained through visual inspection. The data can be used, among other applications, to evaluate vegetation health before release of bond posted to ensure reclamation. As the UAS Program progresses, many States are seeking OSMRE assistance in using this technology for data collection and processing on sites that require quick action and accurate digital terrain modeling.

OSMRE drone pilots provided technical assistance to our customers to help them develop, maintain, and grow their UAS programs. OSMRE's technical assistance includes technical transfer roadshows, office visits, presentations at various conferences, and field visits, with hands-on demonstration flights over reclaimed and abandoned coal mine sites to showcase UAS applications OSMRE also conducts frequent phone calls (including bimonthly UAS tech chats), emails, and UAS workshops and shares various technical and policy documents with its customers.

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

Gulf Coast Inventory and Monitoring Network, one of 32 NPS Inventory and Monitoring Networks, has a CRADA with In-Situ, Inc., to develop and test an NPS employee's invention and evaluate its potential for commercial manufacture and sale. The device enables currently available datasondes—which are 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.

In FY 2019, the Gulf Coast Inventory and Monitoring Network continued operating two of the modified instruments at Padre Island National Seashore (PAIS). Before the deployment of the invention at PAIS, instruments needed to be cleaned and maintained every 2 weeks to maintain data quality. These same instruments can now be deployed for more than 45 days without maintenance, resulting in significant savings to the Network. The goal is to make the invention available on the open market so others can benefit from using the device.

Bureau of Reclamation (Reclamation): Patch Antennas – New Technology to Map Corona and Detect Other Partial Electrical Discharges in High Voltage Environments

Reclamation's Technical Service Center, Hydropower Diagnostics and Supervisory Control and Data Acquisition (SCADA) Group developed a detection device that uses patch antennas to measure partial electrical discharge within small spaces. Potential use cases would include mapping partial discharge activity throughout a hydropower generator from within the air gap without removing the rotor. Reclamation has filed a provisional patent for this technology and is currently seeking research partners to develop a potential commercial device.

Current methods to measure partial discharge in a rotating machine's stator winding involve removing the rotor, exciting the stator to operating voltages, and physically probing the stator winding with an iron core antenna, as illustrated in the following photograph. This typically involves using many personnel hours to remove the rotor, which increases the potential for maintenance-induced failures due to the mechanical complexity of rotor removal, exposes personnel to high-voltage safety risks, and results in lost revenue.

Despite the high risks inherent to current testing methods, the data obtained from the test procedure are extremely valuable. With this new device, a schematic of which is shown below, the downsides of the patch antenna could be significantly mitigated. This new device may allow diagnostic tests to be performed routinely, and data could be used to anticipate and forestall future machine failures and reduce unplanned machine failures and associated outages. Such savings in operational and maintenance costs would directly benefit Reclamation by continuing to advance toward a more economically competitive posture within power generation.

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: 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. This report summarizes the implementation of technology transfer authorities established by the Technology Transfer Commercialization Act of 2000 (Pub. L. 106-404) and other legislation.

U.S. DOT continues to increase coordination and collaboration efforts among its OAs and Federal laboratories, as evidenced through the collection and submission of this T2 Annual Summary Report to U.S. DOT's budget examiner in the Office of Management and Budget. This report is also provided to the Department of Commerce's (DOC's) National Institute of Standards and Technology in support of the Commerce Secretary's Annual Summary Report to the President, the Congress, and to the U.S. Trade Representative on the status of technology transfer by Federal laboratories.

The 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. The 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.

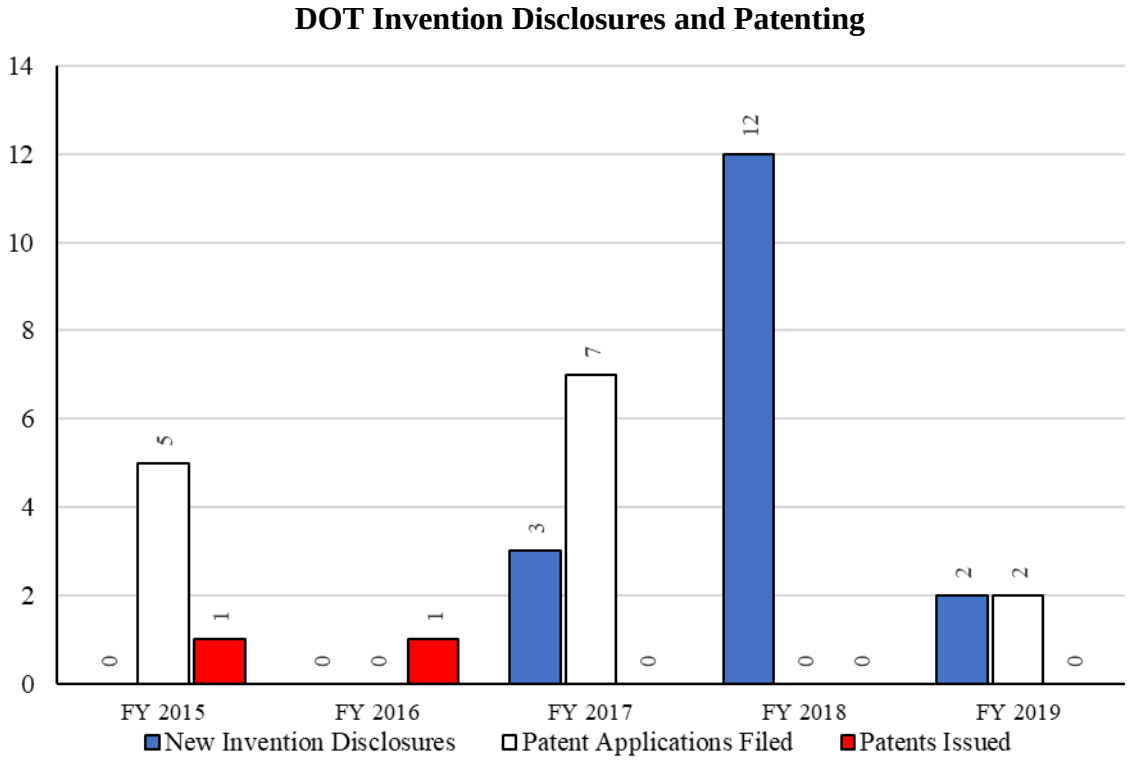
DOT's annual technology transfer report is available online.

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

FAA | FHWA | OST-R | FRA

DOT Invention Disclosures and Patenting

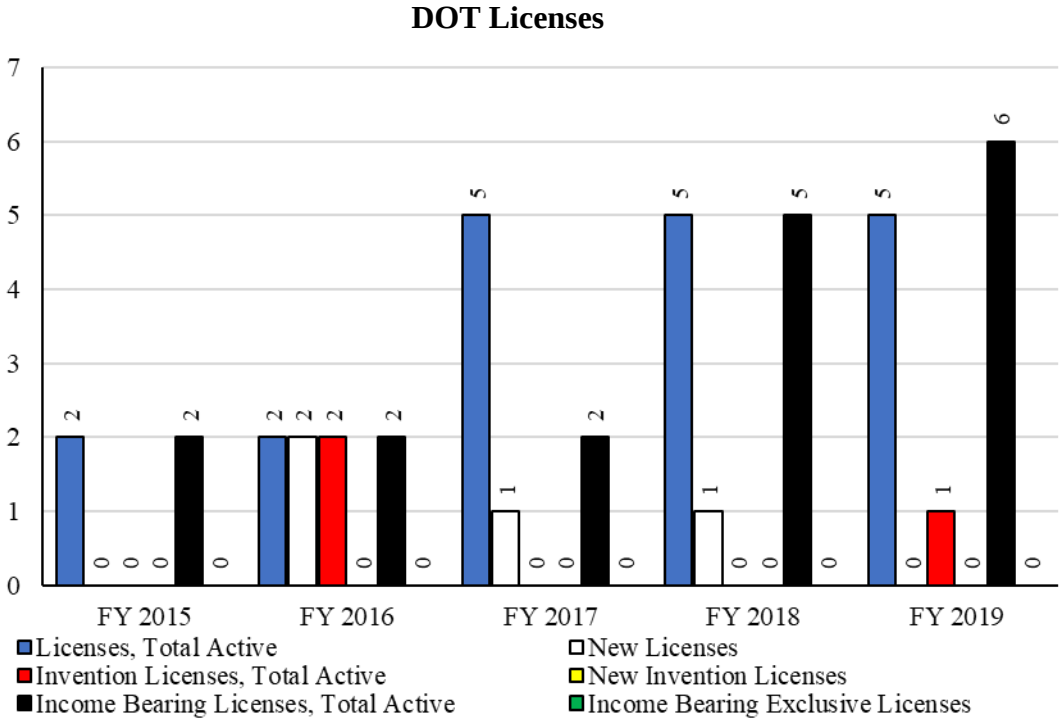
In FY 2019, DOT reported 2 invention disclosures and 2 patent applications. No new patents were awarded.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	0	0	3	12	2
Patent Applications Filed	5	0	7	0	2
Patents Issued	1	1	0	0	0

DOT Licenses

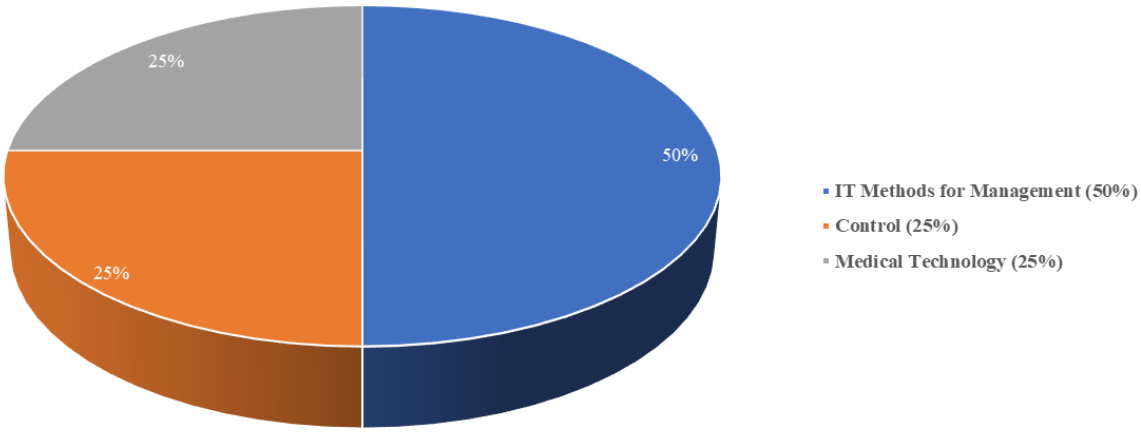
Between FY 2015 and FY 2019, active licenses increased by 150%, from 2 in FY 2015 to 5 in FY 2019. DOT reported one invention license in FY 2019. Income bearing licenses increased by 200%, from 2 in FY 2015 to 6 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	2	2	5	5	5
New Licenses	0	2	1	1	0
Invention Licenses, Total Active	0	2	0	0	1
New Invention Licenses	0	0	0	0	0
Income Bearing Licenses, Total Active	2	2	2	5	6
Income Bearing Exclusive Licenses	0	0	0	0	0

The patents issued to DOT in FY 2019 covered multiple technology areas including: IT Methods for Management (50%), Control (25%), and Medical Technology (25%).[41]

USPTO Patents Assigned to DOT by Technology Area: FY 2019

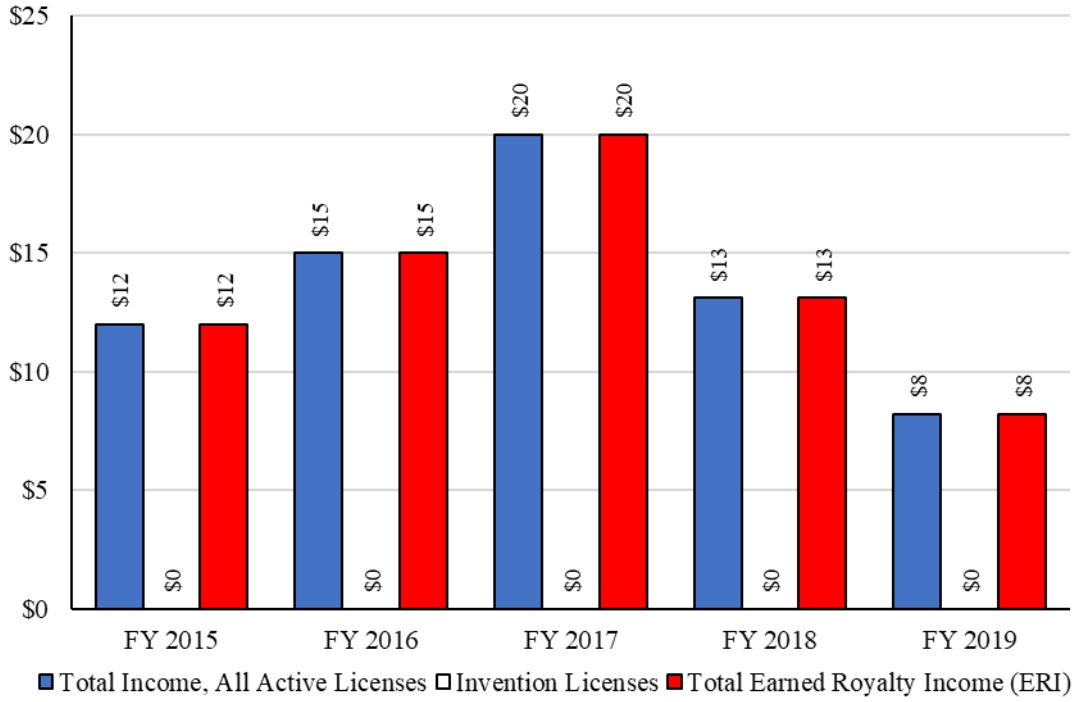


[41] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DOT Income from Licensing

Between FY 2015 and FY 2019, total income from all active licenses decreased by 32%. In FY 2019, DOT reported zero income from invention licenses. Total Earned Royalty Income was reported to be $8 thousand, a 32% decrease from FY 2015.

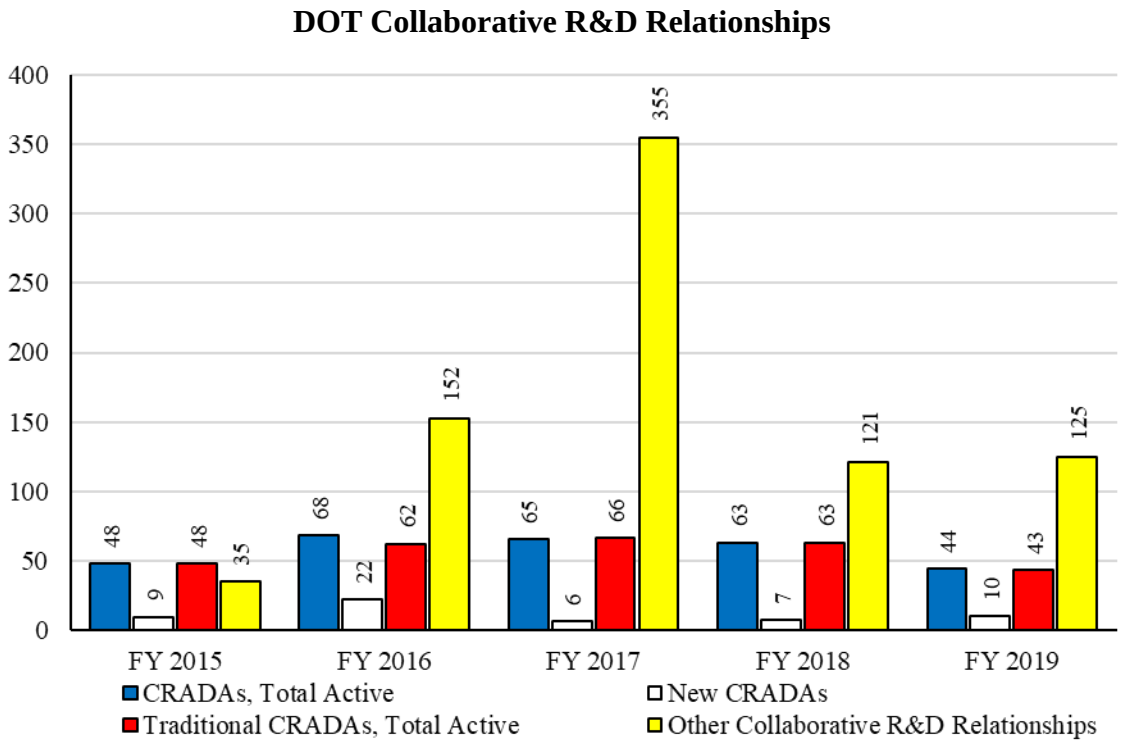
DOT Income from Licensing ($000s)



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$12	$15	$20	$13	$8
Invention Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income, (ERI)	$12	$15	$20	$13	$8

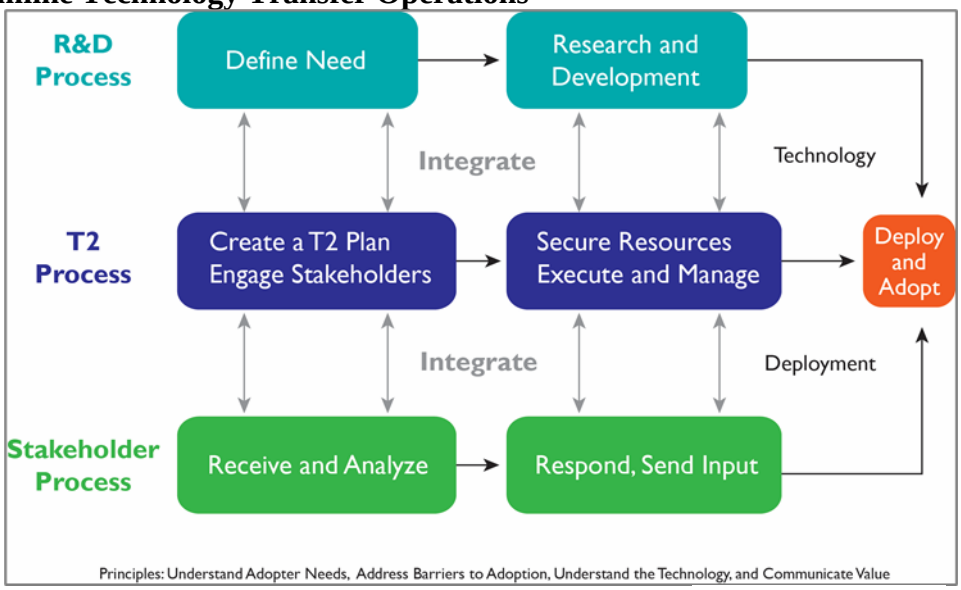
DOT Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs decreased by 8%, from 48 in FY 2015 to 44 agreements in FY 2019. New CRADAs agreements increased by 11%, from 9 in FY 2015 to 10 in FY 2019. Traditional CRADAs decreased by 10%, from 48 in FY 2015 to 43 in FY 2019. Other collaborative R&D relationships increased by 257%, from 35 in FY 2015 to 125 in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	48	68	65	63	44
New CRADAs	9	22	6	7	10
Traditional CRADAs, Total Active	48	62	66	63	43
Other Collaborative R&D Relationships	35	152	355	121	125

DOT Efforts to Streamline Technology Transfer Operations



Source: U.S. DOT.

The importance of technology transfer (T2) within U.S. DOT is reflected in its strategic plan for FY 2018 to FY 2022, which was released in February 2018. Citing innovation as one of the four main strategic goals in the plan, U.S. DOT strives to lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's transportation system. Under that strategic goal, "deployment of innovation" is a key objective and T2 is identified as one of the strategies to be used to accomplish that objective. The relationship of T2 to the department's R&D process and to stakeholder engagement is shown in the figure.

Additional information on DOT efforts to streamline technology transfer operations can be found online in the DOT Technology Transfer Annual Reports.

DOT Downstream Success Stories

Federal Highway Administration (FHWA): Unmanned Aircraft Systems Enhance Safety and Efficiency of Highway Agencies

An unmanned aircraft system (UAS) equipped with cameras can be an effective tool that reduces safety risks to inspectors working in hard-to-reach areas and lessens the burden on motorists by eliminating lane closures. It provides a high level of detail that can only be replicated using under-bridge inspection vehicles, while saving an average of 40 percent compared to traditional methods. A UAS is also useful in emergency response operations after roadway disturbances such as rockslides, avalanches, and floods and damage assessments following earthquakes, fires, and bridge hits. This relatively low-cost method enables agencies to obtain high-quality data quickly, leading to better-informed decisions.

UAS will benefit nearly all aspects of highway transportation by collecting high-quality data safely and efficiently at reduced costs. FHWA's EDC-5 team is promoting UAS technology, coupled with high-definition cameras and sensors, to improve data gathering for structural and construction inspections and to assist with emergency response.

The EDC-5 team is focused on five UAS applications for structural inspections: bridges, high-mast lighting, confined spaces, retaining walls, and tunnels. Structural inspection enhanced by

UAS improves safety for the inspection team and the traveling public by reducing the need for temporary work zones. UAS can aid construction inspection tasks such as surveying, project scoping, and monitoring traffic in work zones. UAS allows for an overhead view of a project's progress and the development of three-dimensional (3D) models to document construction processes and assist in earthwork quantity measurement.

As of 2021, 46 States have set goals to demonstrate, assess, or standardize the use of UAS in transportation applications. Minnesota DOT implemented UAS to support its bridge inspection program, particularly for bridges with difficult-to-access elements. Utah DOT (UDOT) uses UAS technology for rapid, high-quality data gathering. On its State Route 20 construction project, UDOT was the first agency to use a 3D-engineered model as the contract document. Combining UAS with 3D modeling and "e-Construction" tools (for inspection documentation) resulted in overall project savings of about $83,000, increased workforce productivity by 45 percent, and enabled UDOT to complete the project 25 days ahead of schedule.

Federal Aviation Administration (FAA): William J. Hughes Technical Center's Airframe Structural Beam Test (ABST)

Established in 2018 in collaboration with Boeing, the Airframe Beam Structural Test (ABST) fixture is one of the FAA's core capabilities for structural testing of aircraft wings and components under realistic flight conditions. Engineers use the data from ABST testing to address safety concerns and structural integrity issues.

The ABST is a national resource for research and development activities used by researchers to evaluate the design, certification, and continued airworthiness of airframe structures in current and future generation aircraft. The ABST fixture effectively leverages resources through partnerships with other government agencies, industry, and academia. It provides critical data to engineers in order to calibrate, verify, and validate methodologies used for fatigue and damage testing of aircraft structural components.

Federal Transit Administration (FTA): Mobility on Demand is a Vision for the Future

Mobility on Demand (MOD) envisions a transportation system that is multimodal, integrated, automated, accessible, and connected. Emerging solutions such as bike and car sharing and on-demand bus services are providing travelers with flexible and personalized transportation options. MOD uses on-demand information, real-time data, and predictive analysis to provide travelers with choices that best serve their transportation needs and circumstances.

In April 2019, the Intelligent Transportation Society of America, a key FTA research partner on mobility innovation, officially launched its Mobility on Demand Alliance to help determine what the future of mobility should look like, with participation from both the public and private sectors.

FTA's MOD Sandbox Demonstration Program provides a venue through which integrated concepts and solutions–supported through local partnerships–are demonstrated in real-world settings. Two of MOD Sandbox grantees—TriMet and the Vermont Agency of Transportation—launched OpenTripPlanner apps that incorporate fixed and flexible-route/MOD modes. These options draw on international best practices and create shared mobility marketplaces within their apps in which bike/scooter-sharing and ride-sourcing are operated by the same company.

While the shared mobility market has grown and local governments are taking a proactive regulatory role, expedited knowledge and information sharing are imperative as cities and transit agencies work to understand the evolving mobility marketplace. For example, the annual Shared Mobility Summit in March 2019 convened its largest gathering to date, with over 700 attendees representing shared mobility private operators; transit agencies; and Federal, State, and local governments. The MOD Learning Center website has had nearly 1,000 visitors since its launch in March 2019 at the Shared Mobility Summit. The high number of visitors to the MOD Learning Center website helps underscore the need for timely and accurate information on shared mobility so that jurisdictions and agencies can effectively plan for a shared mobility future.

Federal Railroad Administration (FRA): Railroaders' Guide to Healthy Sleep Website Project

The railroad industry involves safety-critical work and around-the-clock operations, placing demands on employees to perform during times that interrupt normal sleep-wake cycles. Railroaders who work unpredictable schedules have difficulty getting enough sleep, and when compared to the general population, are at increased risk for fatigue and sleep-related disorders. For train and engine employees in particular, the sedentary nature of their work is an additional known risk factor for sleep apnea.

The Federal Railroad Administration (FRA) launched the Railroaders' Guide to Healthy Sleep website in 2012 as a non-regulatory, educational resource for safety-critical rail employees. The website was created by the U.S. DOT Volpe Center in collaboration with experts in sleep science and health from the Harvard Medical School Division of Sleep Medicine—with railroad employees and their support networks in mind. The project team fully redesigned the website in 2015 in partnership with the railroad industry and used best practices from educational technology and web design.

The website features articles, videos, illustrations, and interactive options aimed at increasing awareness of the importance of sleep for personal health and safe performance on the job. Tailored, proven behavioral strategies are provided to help individuals improve sleep habits, increase alertness while awake, and achieve a healthy work/life balance. Additional resources are available to help railroaders assess sleep habits and health and to download alertness scales, a sleep-wake diary, and a zip-code feature to locate nearby accredited sleep disorder specialists.

The project team employed real-time demonstrations, in-person promotion, and digital communications to targeted (self-selected) subscribers, and collected website use statistics. The main focus of the website is to promote good sleep habits for railroad employees, which can improve safety and health both on and off the job.

Department of Veteran Affairs (VA)

The 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 America's veterans and by holding all employees to the core values of integrity, commitment, advocacy, respect and excellence. The 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, is the largest administration and the largest integrated health care system in the United States, providing care at 1,250 sites of care that include 172 medical centers and 1,069 outpatient sites of care. These sites serve over 9 million veterans each year;
- 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 the 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 VHA which aspires to discover knowledge, develop VA researchers and health care leaders, and create innovations that advance health care for veterans of the nation. The research program within the VA has an illustrious past in which its researchers have won three Nobel prizes in medicine, seven Lasker Awards, one Malcolm Baldrige Quality Award, and have created the largest genomic medicine sample collection program in the world (the Million Veteran Program).

ORD is headquartered in Washington, D.C., but includes an estimated 2,500 VA investigators and 10,000 research staff located at over 100 VA Medical Centers nationwide. Over 60% 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. The VA research program differs from other federal research programs in that it is completely funded with intramural dollars. The VA investigators can apply for other federal and private funds, but non-VA employees or appointees cannot receive VA research funding. The 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 that 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, evaluation and commercialization to final clinical application.

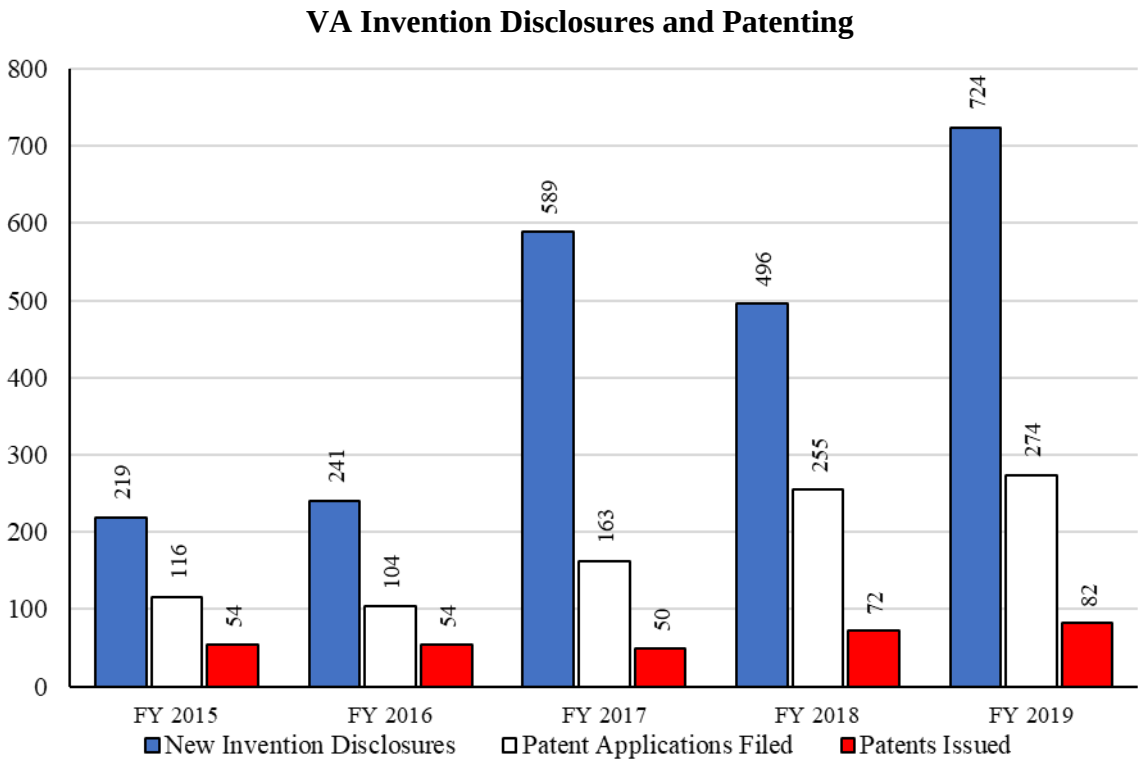
The three supportive programs housed within ORD include VA Technology Transfer, the VA Non-Profit offices, and the Program for Research Integrity Development and Education (PRIDE) which provides oversight and programmatic certification for human research compliance. Each of these supportive programs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

The ORD’s mission is focused on improving the future of healthcare for veterans. 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

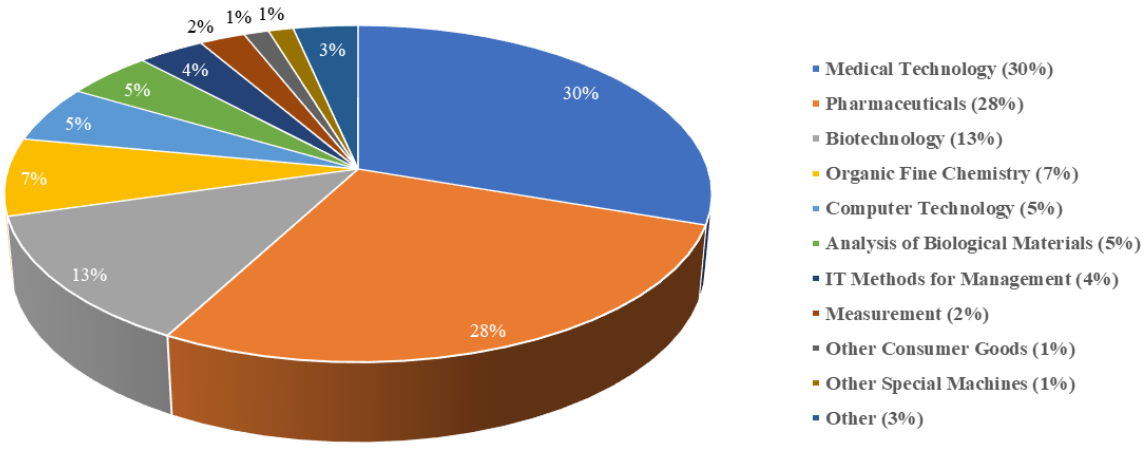
Between FY 2015 and FY 2019, new inventions disclosed increased by 231%, from 219 in FY 2015 to 724 disclosures in FY 2019. Patent applications filed increased by 136%, from 116 in FY 2015 to 274 in FY 2019. Patents issued increased by 52%, from 54 in FY 2015 to 82 patents in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	219	241	589	496	724
Patent Applications Filed	116	104	163	255	274
Patents Issued	54	54	50	72	82

Patents issued to VA in FY 2019 covered many technology areas including Medical Technology (30%), Pharmaceuticals (28%), Biotechnology (13%), Organic Fine Chemistry (7%), and Computer Technology (5%).[42]

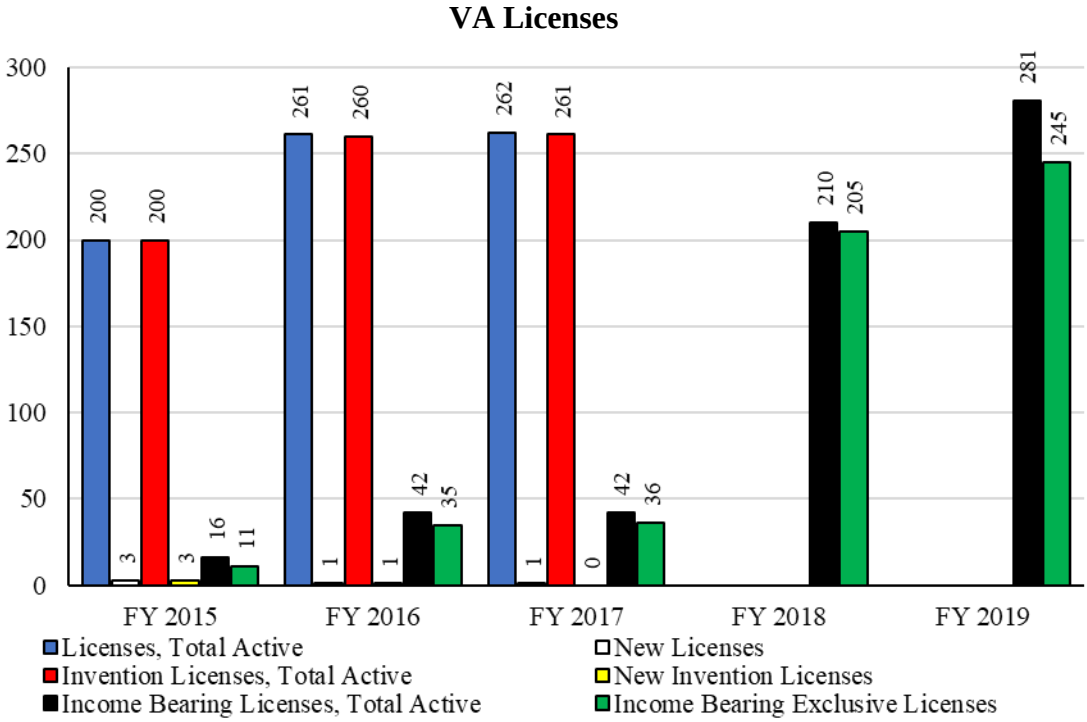
USPTO Patents Assigned to VA by Technology Area: FY 2019



[42] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

VA Licenses[43]

Between FY 2015 and FY 2019, income bearing licenses increased by 1656%, from 16 in FY 2015 to 281 in FY 2019. Exclusive income bearing licenses increased by 2127%, from 11 in FY 2015 to 245 in FY 2019.



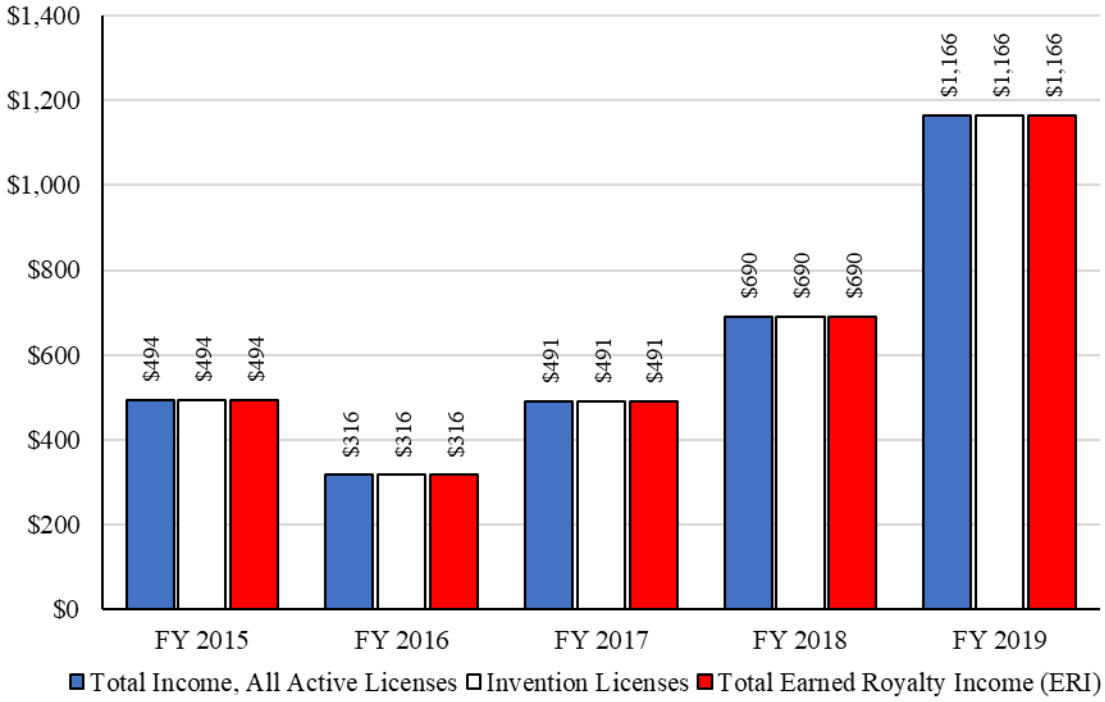
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	200	261	262	n.a.	n.a.
New Licenses	3	1	1	n.a.	n.a.
Invention Licenses, Total Active	200	260	261	n.a.	n.a.
New Invention Licenses	3	1	0	n.a.	n.a.
Income Bearing Licenses, Total Active	16	42	42	210	281
Income Bearing Exclusive Licenses	11	35	36	205	245

[43] VA was unable to report total active licenses, new licenses, total active invention licenses, and new invention licenses for FY 2018 and FY 2019.

VA Income from Licensing

Between FY 2015 and FY 2019, VA reported that total income from all active licenses increased by 136%, from $494 thousand in FY 2015 to $1.2 million in FY 2019. Income from invention licenses and earned royalty income were the same as income from all active licenses.

VA Income from Licensing ($000s)

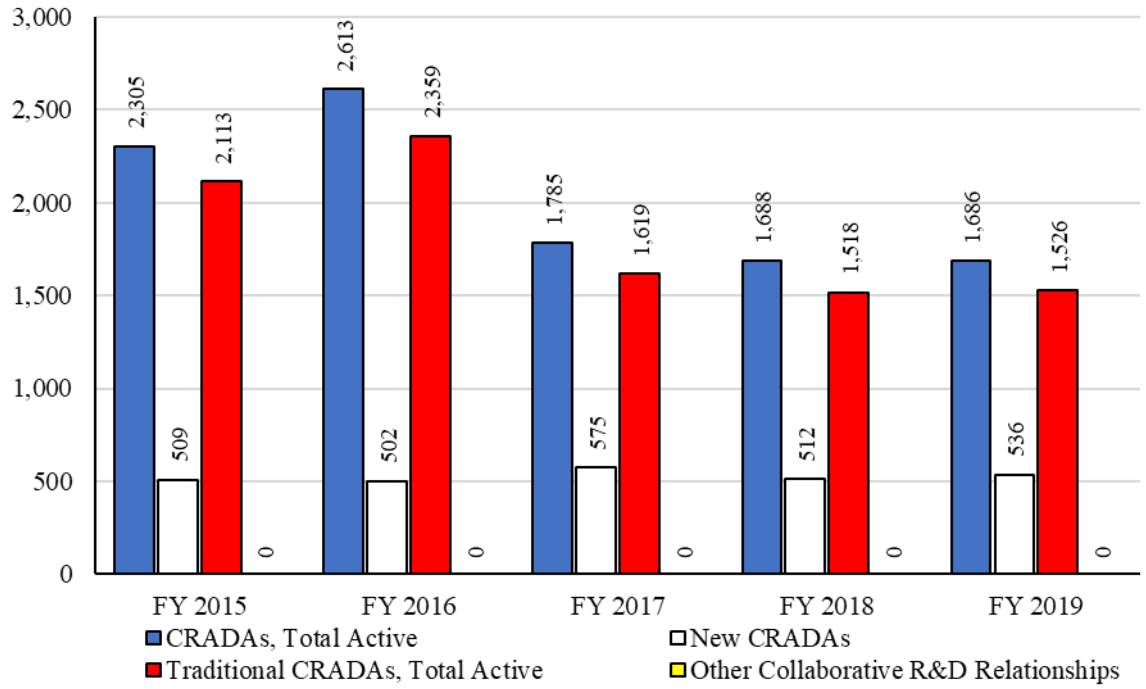


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$494	$316	$491	$690	$1,166
Invention Licenses	$494	$316	$491	$690	$1,166
Total Earned Royalty Income, (ERI)	$494	$316	$491	$690	$1,166

VA Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs decreased by 27%, from 2,305 in FY 2015 to 1,686 agreements in FY 2019. New CRADAs increased by 5%, from 509 in FY 2015 to 536 new agreements in FY 2019. Traditional CRADAs decreased by 28%, from 2,113 in FY 2015 to 1,526 in FY 2019. No other collaborative R&D relationships were reported.

VA Collaborative R&D Relationships



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	2,305	2,613	1,785	1,688	1,686
New CRADAs	509	502	575	512	536
Traditional CRADAs, Total Active	2,113	2,359	1,619	1,518	1,526
Other Collaborative R&D Relationships	0	0	0	0	0

VA Efforts to Streamline Technology Transfer Operations
The TTP conducted an assessment to determine improvements to existing infrastructure. As a result, TTP entered into a partnership with the DOC's National Technical Information Service (NTIS) to make technology improvements for efficiency in operations. Through this collaboration, the need was identified to develop an online invention disclosure portal that could intake different types of invention disclosures. In the past, TTP decided to accept the academic affiliate invention disclosure in lieu of the VA form to increase the disclosure rate. Each academic affiliate has their own unique disclosure form, thus requiring a custom intake portal that can read the forms. The new intake portal will further streamline operations, eliminate errors, and enable the use of artificial intelligence (AI) for ownership analysis, as well as a commercialization potential analysis. Progress continues in the development of this tool and it is being alpha and beta tested at select VA sites.

The assessment also identified a need for improvements to the existing IP database utilized by TTP. This database serves as a knowledge management system that is aligned with TTP's workflow to manage VA's IP portfolio. TTP entered into a partnership to have its database housed in the commercial cloud as a Software as a Service (SaaS) to enable further collaboration between VA and non-VA partners. This tool will be FedRAMP certified and expected to become operational by the end of FY 2020.

As noted, the TTP operation is centralized in Washington, D.C. TTP is piloting a decentralized initiative to promote compliance, services to the field, and to increase commercial interest by placing local tech transfer specialists at select field locations. Two sites were selected as pilot locations in FY 2019: Ann Arbor, MI and Atlanta, GA. In addition to performing technology transfer activities, the new field representatives will also support the local research office operations.

VA Downstream Success Stories

Update
In 2002, TransMedics, Inc. became one of the first firms to exclusively license a VA technology. Today, TransMedics is a publicly-traded medical device company headquartered in Andover, Massachusetts, that was founded to address the growing need for healthier organs for transplantation. The company is dedicated to transforming the standard of care for organ transplantation by increasing organ utilization, improving patient outcomes, and reducing transplant costs. In May 2019, the company completed an initial public stock offering that resulted in $91.4 million common stock net proceeds. TransMedics developed from VA associated patents the Organ Care System (OCSTM) as a revolutionary technology for preserving organs used in the treatment of end-stage heart, lung, and liver failure. The first-in-class technology platform has the potential to improve outcomes for transplant patients and to dramatically increase the number of transplantable organs worldwide.

Novel Therapeutics
Kerafast and the VA entered into a non-exclusive license for a portfolio of peptides and antibodies useful for research and therapeutic development related to urinary tract infection and

cancers of the bladder. The peptides and antibodies were developed by Dr. Susan Keavy over a lengthy research career at the VA in collaboration with the University of Maryland.

Environmental Protection Agency (EPA)

The EPA's FTTA program was established to promote collaboration between private sector and federal researchers. The 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 to the marketplace, resulting in better protection of human health and the environment.

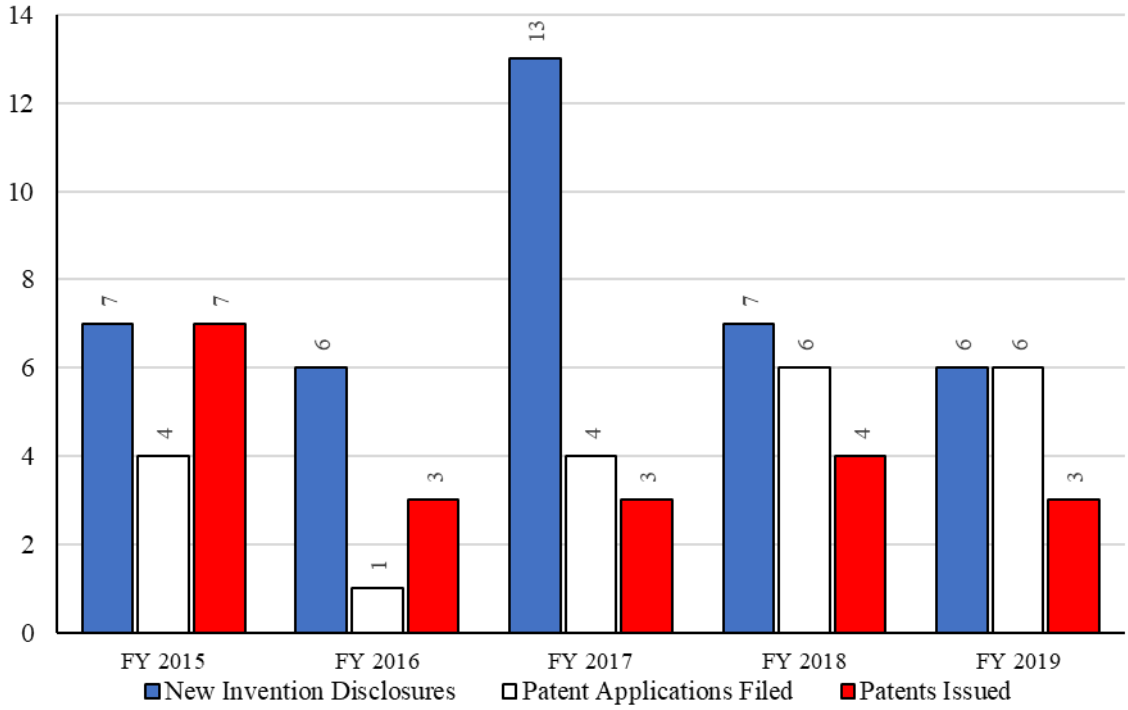
The EPA's annual technology transfer report is available online.

More information about EPA technology transfer activities is available online.

EPA Invention Disclosures and Patenting

Between FY 2015 and FY 2019, new inventions decreased by 14%, from 7 disclosures in FY 2015 to 6 in FY 2019. Patent applications filed increased by 50%, from 4 in FY 2015 to 6 in FY 2019. Patents issued decreased by 57%, from 7 in FY 2015 to 3 in FY 2019.

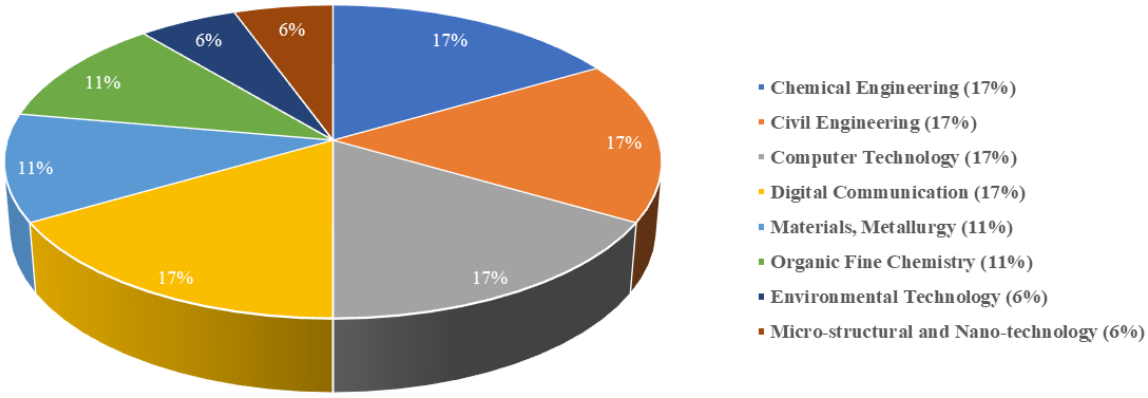
EPA Invention Disclosures and Patenting



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	7	6	13	7	6
Patent Applications Filed	4	1	4	6	6
Patents Issued	7	3	3	4	3

Patents issued to EPA in FY 2019 covered many technology areas including Chemical Engineering (17%), Civil Engineering (17%), Computer Technology (17%), Digital Communication (17%), and Materials, Metallurgy (17%).[44]

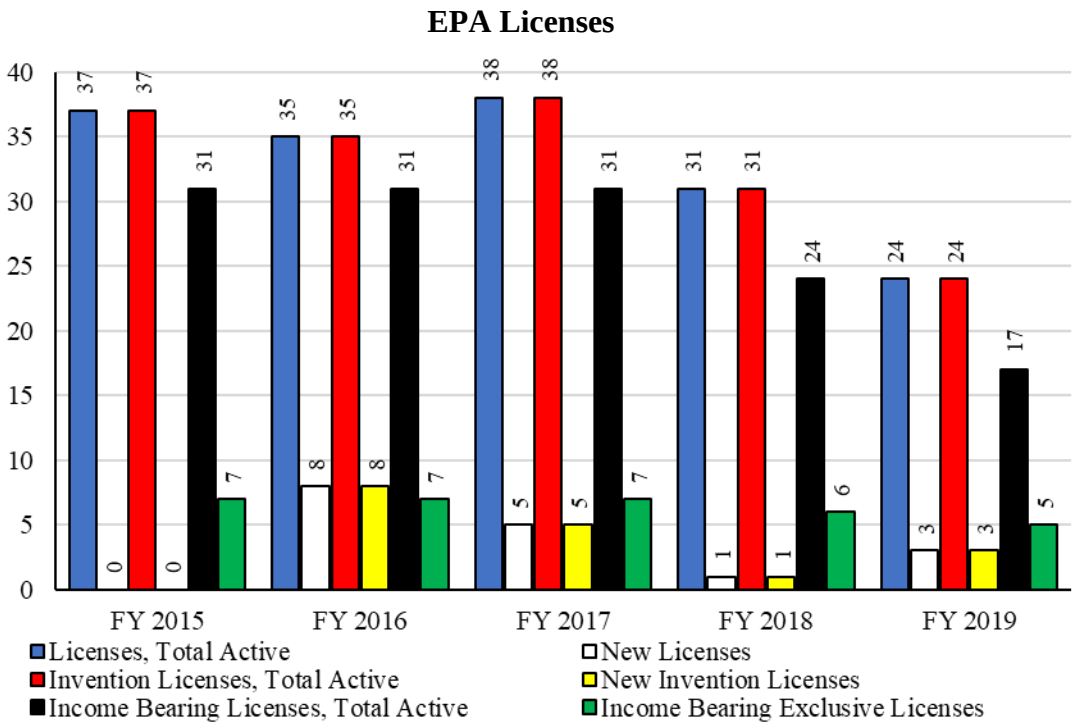
USPTO Patents Assigned to EPA by Technology Area: FY 2019



[44] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

EPA Licenses

Between FY 2015 and FY 2019, total active licenses decreased by 35% from 37 licenses in FY 2015 to 24 licenses in FY 2019. EPA reported no new licenses in FY 2019. All active licenses were invention licenses. Income-bearing licenses decreased by 45%, from 31 in FY 2015 to 17 in FY 2019. Exclusive income-bearing licenses decreased by 29%, from 7 in FY 2015 to 5 in FY 2019.

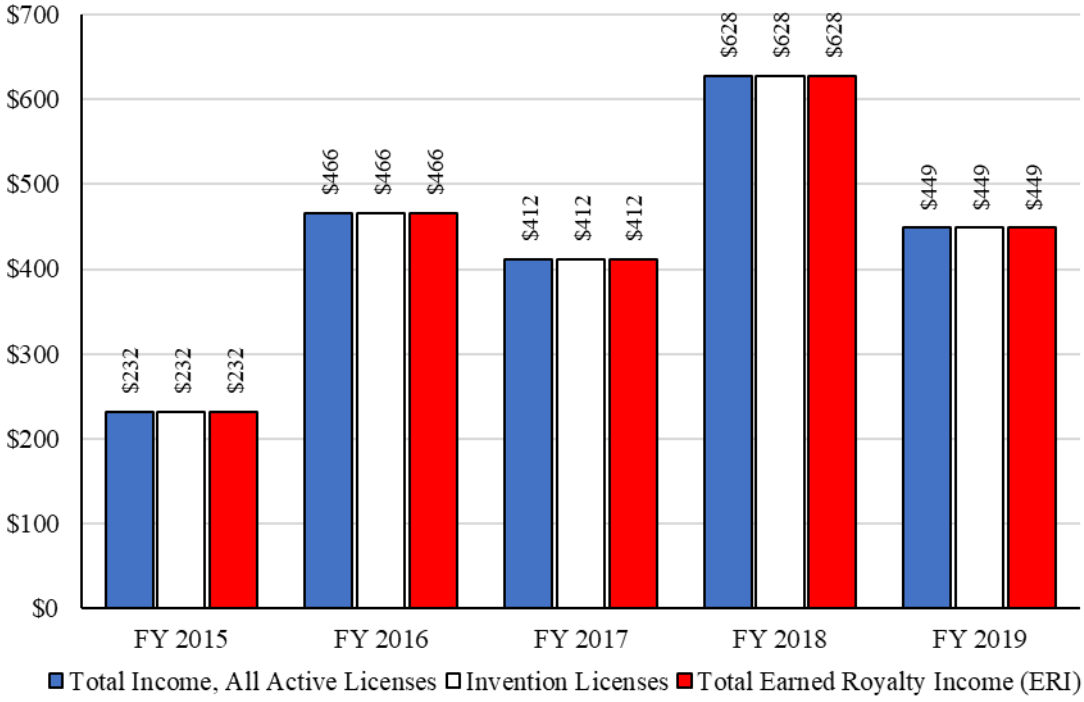


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	37	35	38	31	24
New Licenses	0	8	5	1	3
Invention Licenses, Total Active	37	35	38	31	24
New Invention Licenses	0	8	5	1	3
Income Bearing Licenses, Total Active	31	31	31	24	17
Income Bearing Exclusive Licenses	7	7	7	6	5

EPA Income from Licensing

Between FY 2015 and FY 2019, EPA reported that total income from all active licenses increased by 94% from $232 thousand to $449 thousand in FY 2019. All income from licenses came from invention licenses. Total earned royalty income increased 94% from $232 thousand in FY 2015 to $449 thousand in FY 2019.

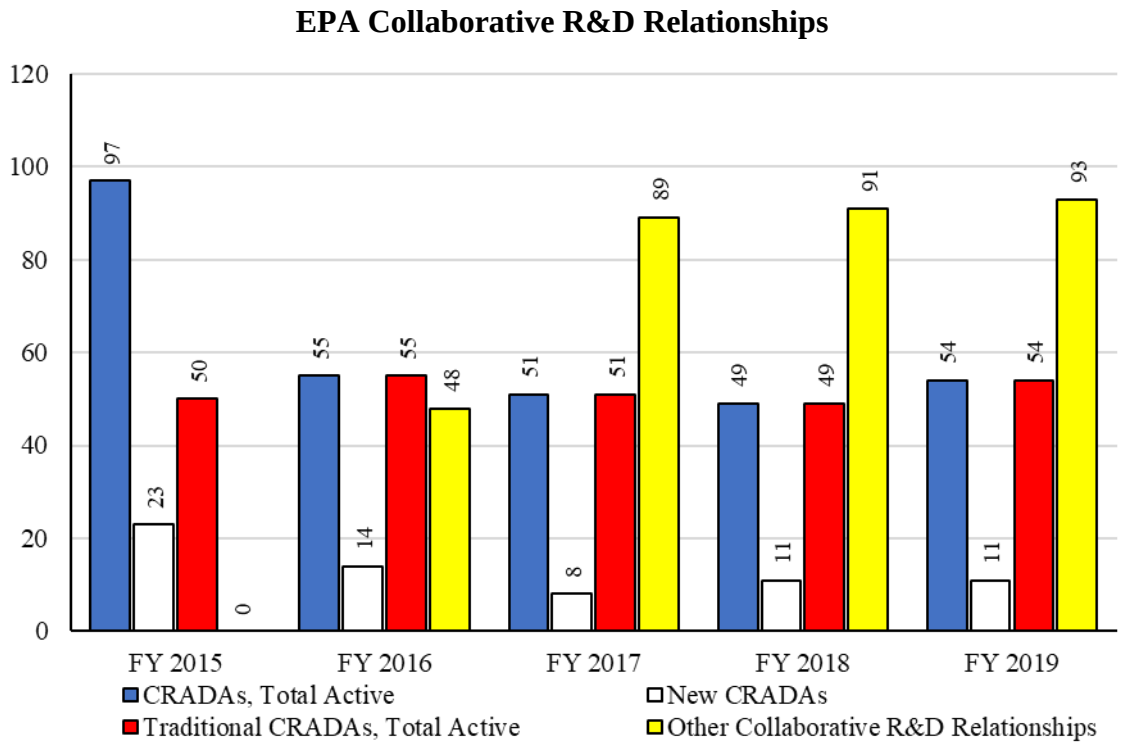
EPA Income from Licensing ($000s)



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$232	$466	$412	$628	$449
Invention Licenses	$232	$466	$412	$628	$449
Total Earned Royalty Income, (ERI)	$232	$466	$412	$628	$449

EPA Collaborative R&D Relationships

Between FY 2015 and FY 2019, total active CRADAs decreased by 44%, to from 97 agreements in FY 2015 to 54 in FY 2019.[45] New CRADAs decreased by 52%, from 23 in FY 2015 to 11 new agreements in FY 2019. Traditional CRADAs increased by 8%, from 50 in FY 2015 to 54 in FY 2019. In FY 2019, 93 other collaborative R&D were reported.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	97	55	51	49	54
New CRADAs	23	14	8	11	11
Traditional CRADAs, Total Active	50	55	51	49	54
Other Collaborative R&D Relationships	0	48	89	91	93

[45] Starting in FY 2020, EPA changed their method of calculating the values for total active CRADAs and reported revised values for FY 2016 through FY 2019. Data for the FY 2015 value of total active CRADAs combines traditional CRADAs and other collaborative agreements. These values are reported separately for FY 2016 through FY 2019.

EPA Downstream Success Stories

EPA's Microbial Source Tracking Technologies Helping Municipalities Identify Failing Infrastructure

According to the Environmental Protection Agency's (EPA's) National Water Quality Inventory Report to Congress, fecal bacteria are one of the leading causes of U.S. surface water impairment.

EPA scientists recently sought an innovative approach to monitor fecal pollution through the study of fecal bacterial communities at a molecular level. The result was the development of novel genetic-based technologies that can measure human and cattle fecal pollution levels in surface water samples. These patented Microbial Source Tracking (MST) methods are technologies aimed at identifying and, in some instances, quantifying fecal animal sources of contamination in environmental waters.

Due to nationwide fecal pollution concerns there is a growing demand by academic, state, and municipal government laboratories to implement EPA MST technologies. To accommodate interest from nonprofit entities, EPA developed non-commercial licenses for government agencies and universities.

One of the government licensees on this technology is the Hampton Roads Sanitation District (HRSD). HRSD protects water in 18 cities and counties in southeastern Virginia. In its first two years using EPA's technology, HRSD has found great success in applying the technology to monitor open water bodies and stormwater discharge.

HRSD has begun an effort to reduce bacteria contamination in local waterways by proactively identifying and repairing ailing and failing sewer infrastructure sources of human fecal contamination. HSRD has been using a variety of microbial source tracking tools to accomplish this mission, including utilization of EPA's patented technology.

HRSD is focusing efforts on identifying ailing and failing sewer infrastructure throughout its system. Its approach has been to target potential conduits of human fecal contamination using human-associated markers. Any stormwater outfalls that are found to be positive for a common human MST marker are investigated further by systematically sampling the upstream stormwater conveyance system at key access locations. Each time a branch point is encountered in the network, samples are collected upstream in each reach. In this way, the human-associated marker signal is traced through the stormwater infrastructure. When the extent of the signal has been demarcated in the stormwater conveyance system, adjacent sections of the sewer infrastructure are assessed for potential failure mechanisms. The initial effort uses one readily-available human-associated marker (HF183); however, repairs to the sewer conveyance system are confirmed with the more specific markers developed by EPA.

One case study in HRSD's jurisdiction involves Wayne Creek. HRSD personnel completed a downstream to upstream stormwater pipe network investigation, sampling every tributary stormwater outfall intersecting the stormwater network of interest. After delineating the problem area, the City of Norfolk identified a leaking sewer pipe in the Wayne Creek sub-watershed.

Sampling conducted one month after the repair confirmed that there was no remaining human fecal contamination at the sampling sites.

Through its use of EPA's licensed MST technology, in concert with its use of related MST technologies, HRSD is able to provide a healthier water system for its constituents.

EPA Collaborates with California on Tire Crumb Rubber Exposure Research

In 2016 a multi-agency research effort under the Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds was launched by EPA, the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR), and the Consumer Product Safety Commission (CPSC) to address concerns raised by the public about soccer players and the safety of recycled tire crumb used in playing fields and playgrounds. The research activities represent a collaborative federal effort to increase knowledge and available information about synthetic turf fields by developing exposure information (what is in the material and how people come in contact with the material).

Researchers at California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment (CalEPA OEHHA) are also conducting research aimed at reducing data gaps for tire crumb rubber constituents and human exposures. Federal researchers collected tire crumb rubber samples from nine tire recycling plants and 40 synthetic turf fields across the U.S. and OEHHA collected samples from California. Under a Materials Cooperative Research and Development Agreement (MCRADA), the EPA regularly consults OEHHA scientists to coordinate efforts. The federal and state researchers are identifying and implementing methods and approaches that will, where feasible, produce comparable data. This could effectively expand the overall U.S. research sample size and will provide additional insight into potential exposure variability. There are also important differences between the federal and OEHHA studies that will provide complementary data for improved exposure assessment.

EPA Collaborates on a Study to Determine Social Demands on Aquatic Resources

In June 2018, EPA executed a Cooperative Research and Development Agreement (CRADA) with Southern Methodist University, and Clayton Cox to evaluate various social values pertaining to surface water of the United States. This CRADA was initiated to support development of a cell phone application that could be used by citizen scientists to provide information on social values associated with surface water.

In the United States, information from water quality testing, tracking, and modeling is used to report comprehensive information on the condition of water bodies throughout the country. However, information regarding social demands associated with these aquatic resources (i.e., ecological and social beneficial uses) is not systematically reported or collected. Data on fisheries and recreation, as they relate to water quality, have been studied as ecosystem services. However, comprehensive national-scale data characterized by public usage and benefit (e.g., aesthetics, spiritual, wellness, or cultural) are absent.

The Clean Water Act (33 U.S.C. §§1251-1387) is a benchmark for instream value protection in the U.S., which requires water bodies to be classified for the type of beneficial water uses they are to support (e.g., fisheries, drinking water, recreation). Some beneficial uses have been studied

using the framework of ecosystem services, while other uses remain less explored. A more complete understanding of the diversity of social demands of aquatic ecosystems could better inform resource managers on the diversity and scale of social demands provided by aquatic ecosystems. This information, in turn, supports the exploration of a broader array of management options and a better understanding of how various user groups may be differentially impacted. Ideally, this process should result in the discovery of more socially acceptable management options that reduce conflict, increase public support for management decisions, and ultimately, increase protection of aquatic ecosystems.

This collaborative research effort identified environmental and social factors that have been shown to influence social demands on aquatic resources. The partners identified ancillary information that should be collected as part of these efforts given its potential to identify drivers of response data variability (e.g., age, education, income, juxtaposition to resource). They identified six main categories of factors: extent and influence of place-based knowledge; proximity to, and frequency of visitation of the resource(s) being considered; basic demographics such as age, gender, education, income; home community type; aesthetic appeal of the resource; and primary reason for engagement with the resource. The outcomes of this project highlight that the collection of data on the social demands of aquatic ecosystems would be valuable factors if integrated into existing national data collection efforts and assimilated into policy in much the same way as other aquatic ecosystem and biological data.

For more information regarding this CRADA, please refer to Factors influencing social demands of aquatic ecosystems published in Ecology and Society.

Development of Anti-Biofouling Water Tubes to Prevent the Spread of Pathogens
Water filters attach to plumbing fixtures and have been in use for many years. These filters are inserted into the waterline prior to the plumbing fixture and are generally designed to remove particulates from the water. Some water filters are designed to remove chlorine or other oxidizing agents. Carbon filters have been designed for residential applications and may be used to remove chlorine from the water, thereby improving water taste and odor. However, carbon filters have a relatively short life and by removing the chlorine or oxidizing agents, the treated water can become more susceptible to bacterial contamination. Further, carbon filters are unable to remove different forms of bacteria and/or pathogens from the water. Additionally, present point-of-use filtration systems are unable to inactivate opportunistic premise plumbing pathogens (OPPPs) such as Legionella. Legionella bacteria can multiply in all kinds of water systems. The bacterium Legionella pneumophila is responsible for most cases of legionnaires' disease.

Biofilms are the result of an aggregation of microbial cells embedded in extracellular polymeric substances and are widely present in engineered water systems including plumbing systems. OPPPs, such as Legionella pneumophila, Pseudomonas aeruginosa, and non-tuberculous mycobacteria, can infiltrate biofilms in plumbing systems, allowing them to thrive in harsh artificial environments. OPPPs are the originating source for two-thirds of all such waterborne outbreaks in the United States. However, their prevention in the plumbing system presents complex challenges due to their persistence in biofilm, resistance to disinfection, and the complex microbial ecology in pipe wall surface area.

The EPA is partnering under a Cooperative Research and Development Agreement (CRADA) with W.L. Gore & Associates to develop a device that prevents biofilm formation and further inactivates waterborne microorganisms in water plumbing systems and medical and dental equipment devices using multiple wavelength UV-LEDs. Such an apparatus has the potential for wide application, with relevant uses within hospitals, senior care facilities, and other commercial applications.

EPA researchers have been working to inactivate OPPPs in plumbing for several years. In 2018 EPA filed a non-provisional patent on filter assembly for disinfecting pathogens using multiple wavelength ultraviolet light emitting diodes. The application relates generally to the technical field of water filters, and more specifically, to the technical field of a filter assembly for a water fixture for disinfecting pathogens from the water in the water fixture using UV LEDs.

National Aeronautics and Space Administration (NASA)

NASA is changing the way it transfers technologies with the entrepreneurs, startups, and companies by instilling a "customer-first" mindset across the entire agency. This means ensuring all steps of transferring technologies to the public—from discovery to delivery—are easy to follow and quick to complete.

Since being written into law by Congress following the 1958 Space Act that established NASA, the technology transfer (T2) program's main objective is to bring NASA technology down to Earth. T2 does this by collecting and patenting new technologies made for space exploration missions and encouraging industry to license these innovations. This is done to create a new commercial product or enhance an existing product line, stimulating the economy and improving lives across the world.

Now, a new industry is emerging. With the arrival of commercial space companies, NASA technologies previously thought to have limited applications could see new life. Commercial space companies won't have to envision and develop a terrestrial application for the technology—they are ready-made for this unique and challenging environment.

With this new industry player, NASA is developing the "customer-first" approach even further. To better understand what commercial space companies need from NASA, a commercial space study was launched in early 2019. Now completed, NASA is using the study's findings to improve technology transferring tools, policies, and procedures to better serve not only commercial space, but industry players across the nation.

Program Achievements in 2019

Completion of the Commercial Space Study

The NASA's technology transfer program provides technologies developed for space exploration to the public, maximizing the benefit to the nation. Previously, these technologies were to be developed further by companies for terrestrial applications. With the emergence of the commercial space industry, transferring technologies that benefit space applications is now an option. To help meet NASA's mission to grow the commercial space industry, a study was performed to better understand what commercial space companies needed and how to engage them.

RTI and Acuity Edge's study began with a review of existing NASA policies and procedures related to IP followed by a series of interviews with internal (NASA) and external (commercial space company) stakeholders. The stakeholders provided insight, improvement ideas, and recommendations on engaging commercial space industries and any current issues that could hinder collaboration. They found the following:

1. Low awareness of NASA IP: commercial space companies have generally low awareness of, and interest in, NASA-owned patents and licensing opportunities.
2. TTP patenting and licensing decisions could be tailored to commercial space: commercial space companies do not know about NASA T2 practices; or if they do, there are often questions related to NASA's intentions, policies, and practices.

3. There is an opportunity to create innovative and streamlined processes, including flexible agreements to drive space-related commercialization: NASA researchers and commercial space companies want to have streamlined and flexible agreements to enable commercial space-related development activities.
4. IP rights associated with commercial space need clarification: IP ownership of, and rights related to, inventions and patents developed by NASA, or in partnership with NASA, are a major concern for commercial space companies.

To help address and correct the findings, RTI and Acuity Edge recommend:

1. Improve awareness, both internally and externally, about processes and opportunities related to NASA T2 and commercial space. Communicate about relevant technologies and how the TTP can license NASA IP, developed/owned by NASA, to benefit commercial space.
2. Expand options for T2 without a patent. Recognize that the investment to patent may not make sense with the timelines associated with commercial space, and as such, NASA should consider options to share technology without a patent (e.g., new agreements like NASA Kennedy Space Center's (KSC's) Technology Transfer Agreement (TTA), publications, sharing through industry consortiums). Consider metrics that reflect the value that the TTP brings through non-patent transfer.
3. Improve guidance/management of IP and relationships specific to commercial space. Build better connections to the commercial space industry to understand interests, directions, needs, and timelines, as well as parallel connections to NASA missions. In effect, clarify contact points and roles specific to T2 as it relates to commercial space companies and NASA missions.
4. Tweak the current TTP flow to intentionally consider commercial space. Recognize that, legally, commercial space must be treated like any other industry. The TTP can clarify the process flow for considering commercial space, making strategic decisions for commercial space, and the handling of IP. This includes when the TTP chooses to patent (or not) and whether to negotiate exclusivity and consideration of deal terms (e.g., royalties, milestones, triggers/timing, services, sharing hardware). Recommended default positions include:

- For New Technology Reports (NTRs) with only commercial space value/applications, share without a patent.
- For NTRs with value/application in both commercial space and other applications, patent and share a non-exclusive field-of-use license for commercial space applications.

In response to these findings (specifically item 3), NASA has created the position of "Licensing Concierge." The concierge will serve as the single point of guidance for all potential licensees. The concierge is knowledgeable about the patent portfolio and the automated systems used by licensees to apply for technologies and software programs. The concierge will also track and monitor the licensees progress to ensure the license is executed at the field center within a reasonable timeframe.

In response to the other recommendations, NASA initiatives begun in FY 2021 and FY 2022 are ongoing.

Significant Program Metrics

Despite several months of program disturbance due to the government furlough, significant metrics stayed healthy, and in many areas, continued a positive, upward trend.

New Technology Reports.

New Technology Reports saw a 4 percent increase from the previous year. Agency leaders ramped up monthly in-reach events at each NASA field center, educating approximately 2,900 inventors in 2019. The field centers provided training on reporting new technologies using the electronic New Technology Reporting system (e-NTR) and provided inventor notebooks and posters, a popular and cost-effective incentive.

U.S. Patent Applications Filed.

NASA has implemented a more strategic approach to patenting technologies. Using a centralized contract to provide the program with detailed screenings and assessments, NASA only patents and maintains technologies the agency believes have commercial potential. Because of this more consistent and thorough strategy, patent application numbers saw a decline in applications filed. This approach keeps taxpayer dollars from being wasted on maintenance fees on technologies that are unlikely to produce a license.

Patent Licenses.

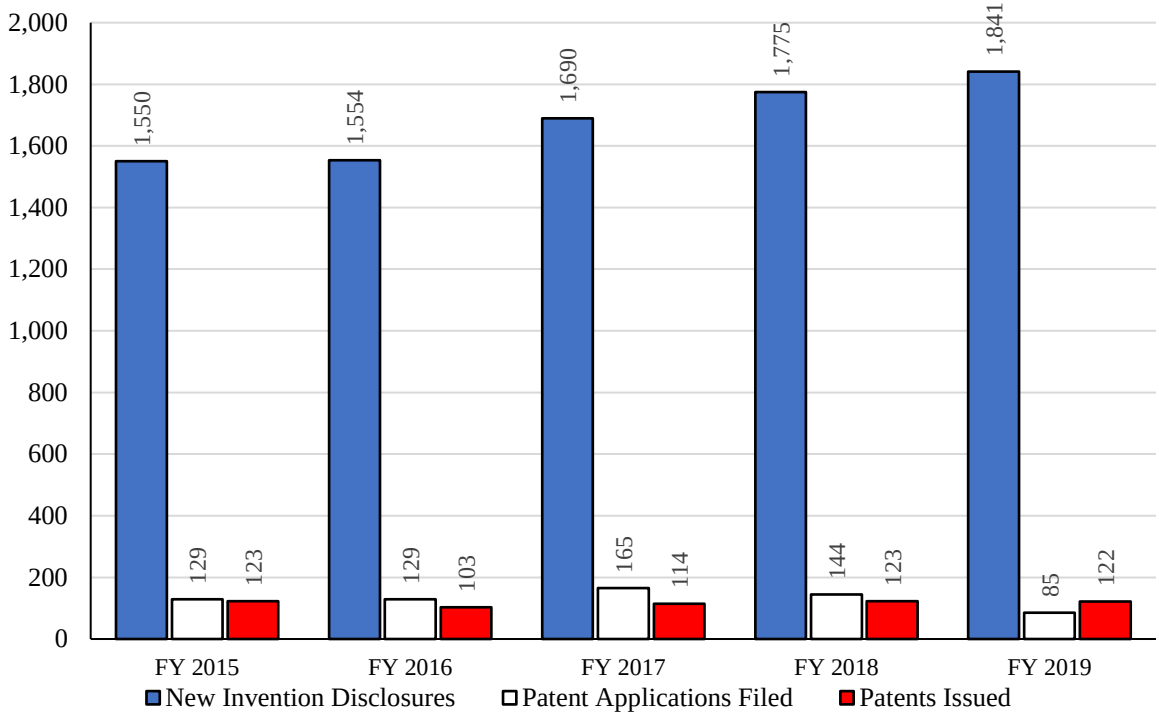
While not exceeding the licensing numbers from the previous year because of the furlough, 2019's numbers are still considered successful. Prior to NASA's concentrated efforts to increase licensing, the agency averaged 22 licenses executed per year (as of fiscal years 2010–2012). As of fiscal years 2016-2019, the agency has averaged 107 licenses per year. Significant improvements to the program to increase licensing include the implementation of streamlined systems, such as the Automated Technology Licensing Application System (ATLAS), which guides potential licensees through the process of filling out and submitting an application.

Software Usage Agreements.

Software Usage Agreements (SUAs) continued a historically positive trend. From 2016–2019, NASA saw an average of 3,339 SUAs, a 200% increase from an average of 1,111 SUAs during 2010–2012. A new Software Catalog containing previously unreleased and updated software program codes available for download was launched on software.nasa.gov. Users are able to search, request, and acquire NASA software from this website.

NASA Invention Disclosures and Patenting

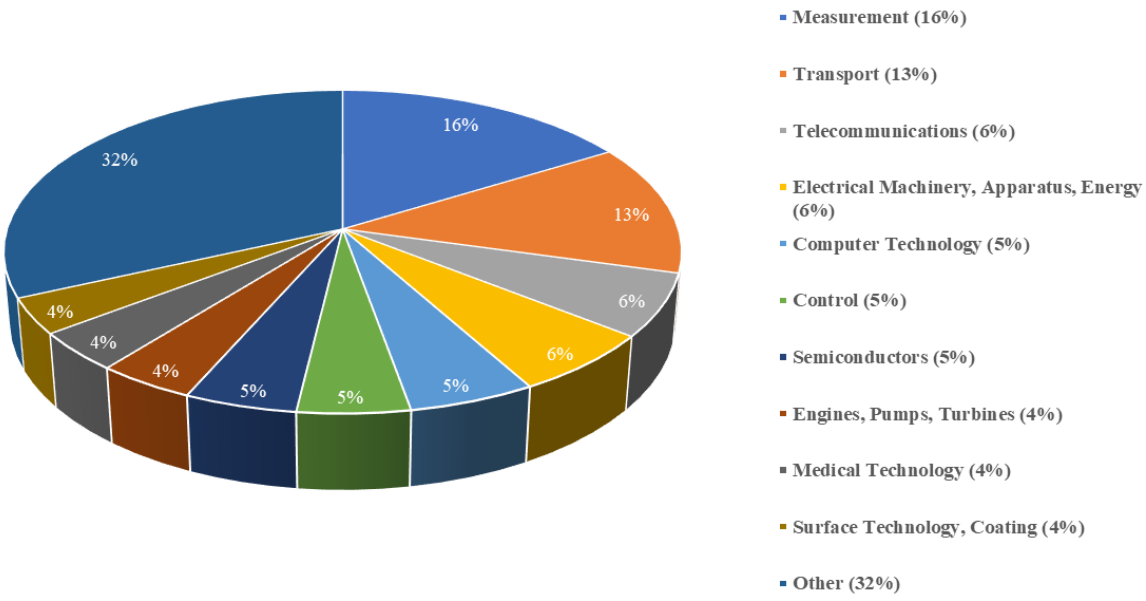
Between FY 2015 and FY 2019, new inventions disclosed increased by 19% from 1,550 in FY 2015 to 1,841 disclosures in FY 2019. Patent applications filed decreased by 34%, from 129 in FY 2015 to 85 in FY 2019. Patents issued decreased by 1%, from 123 in FY 2015 to 122 patents in FY 2019.



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
New Invention Disclosures	1,550	1,554	1,690	1,775	1,841
Patent Applications Filed	129	129	165	144	85
Patents Issued	123	103	114	123	122

Patents issued to NASA in FY 2019 covered many technology areas including Measurement (16%), Transport (13%), Telecommunications (6%), Electrical Machinery, Apparatus, Energy (6%), and Computer Technology (6%).[46]

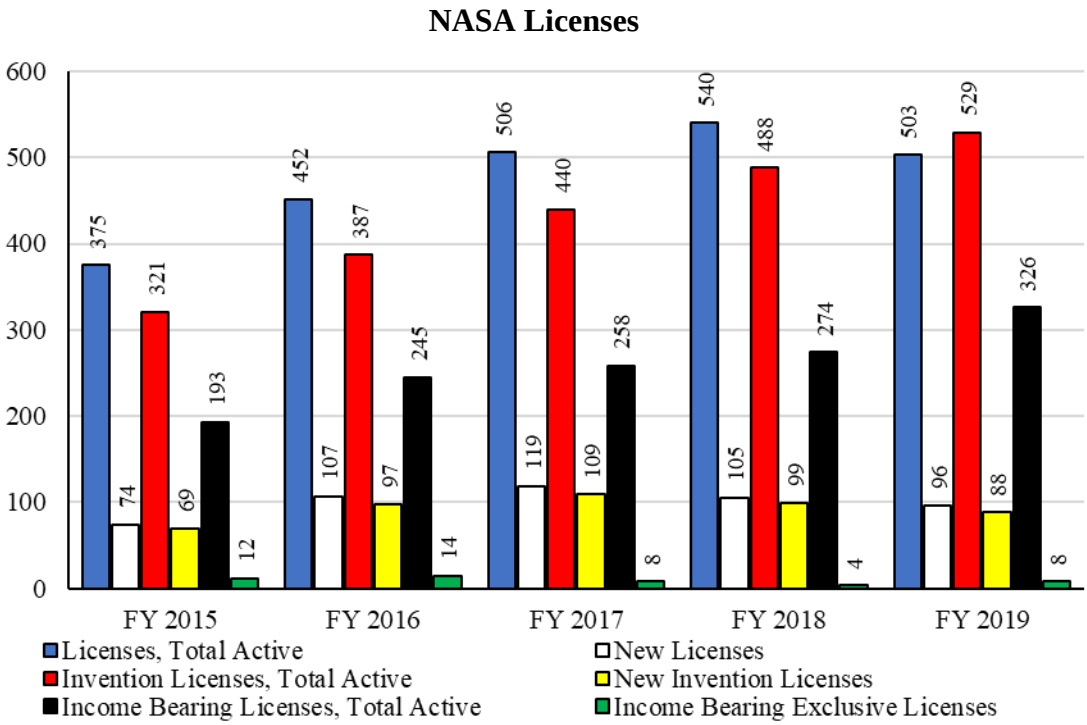
USPTO Patents Assigned to NASA by Technology Area: FY 2019



[46] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

NASA Licenses

Between FY 2015 and FY 2019, total active licenses increased by 34%, from 375 in FY 2015 to 503 licenses in FY 2019. New licenses increased by 30%, from 74 in FY 2015 to 96 in FY 2019. Total active invention licenses increased by 65%, from 321 in FY 2015 to 529 in FY 2019. New invention licenses increased by 28%, from 69 in FY 2015 to 88 in FY 2019. Total active income bearing licenses increased by 69% to 326, while income-bearing exclusive licenses decreased by 33%, from 12 to 8.

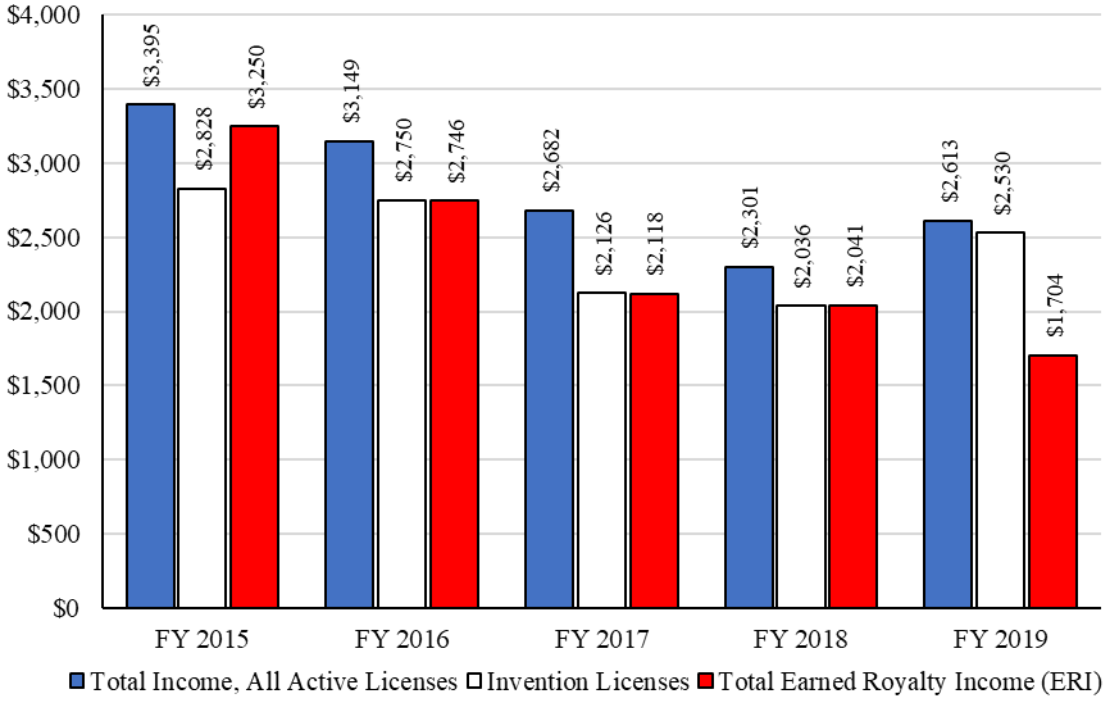


	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Licenses, Total Active	375	452	506	540	503
New Licenses	74	107	119	105	96
Invention Licenses, Total Active	321	387	440	488	529
New Invention Licenses	69	97	109	99	88
Income Bearing Licenses, Total Active	193	245	258	274	326
Income Bearing Exclusive Licenses	12	14	8	4	8

NASA Income from Licensing

Between FY 2015 and FY 2019, NASA reported that the total income from all active licenses decreased by 23%, from $3.4 million in FY 2015 to $2.6 million in FY 2019. The income from invention licenses decreased by 11%, from $2.8 million in FY 2015 to $2.5 million in FY 2019. Total earned royalty income decreased by 48%, from $3.3 million to $1.7 million in FY 2019.

NASA Income from Licensing ($000s)



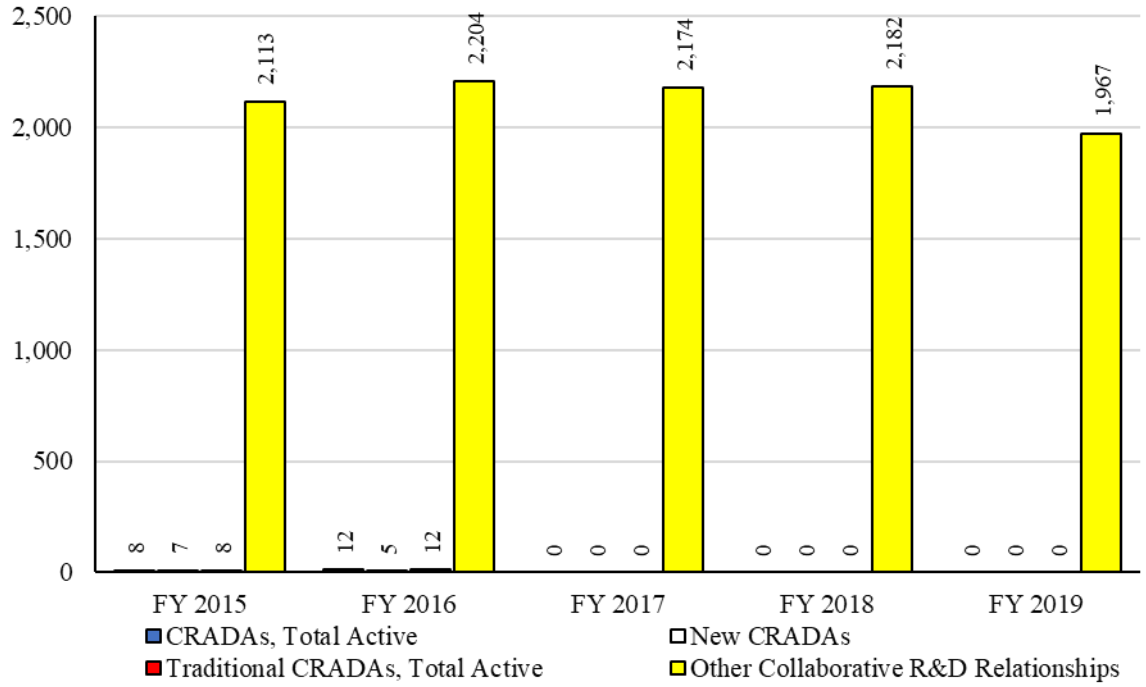
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total Income, All Active Licenses	$3,395	$3,149	$2,682	$2,301	$2,613
Invention Licenses	$2,828	$2,750	$2,126	$2,036	$2,530
Total Earned Royalty Income, (ERI)	$3,250	$2,746	$2,118	$2,041	$1,704

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. The 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 CRADAs, and therefore in this report, Space Act Agreements are included under the category "Other Collaborative R&D Relationships."

Between FY 2015 and FY 2019, Space Act Agreements decreased 7% from 2,113 agreements in FY 2015 to 1,967 in FY 2019.

NASA Collaborative R&D Relationships



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
CRADAs, Total Active	8	12	0	0	0
New CRADAs	7	5	0	0	0
Traditional CRADAs, Total Active	8	12	0	0	0
Other Collaborative R&D Relationships	2,113	2,204	2,174	2,182	1,967

NASA Downstream Success Stories
In 2019, Spinoff told the stories of 49 companies across 19 U.S. states that are selling products derived from NASA technology. Fresh content is published regularly on Spinoff's website, which receives 2–3 million unique visitors per month, and is also routinely featured on NASA's homepage. Spinoff also maintains a robust social media presence.

Free print copies of the publication are distributed to the White House, each member of Congress, the United Nations, other government agencies and laboratories, universities, as well as members of the public who request the book. The entire publication is available in multiple formats online at https://spinoff.nasa.gov.

Examples of successful technology transfer stories featured in Spinoff 2019 include:

Unique Polymer Finds Widespread Use in Heart Devices
A material that a Langley Research Center scientist stumbled on in the early 1990s has helped to keep hundreds of thousands of patients' hearts beating properly all over the world. Since 2009, medical technology giant Medtronic, based in Minneapolis, has been using the substance now known as LaRC-SI to get a relatively new type of pacemaker implanted into more patients more easily. As a result, many patients who might otherwise have continued to suffer symptoms of congestive heart failure were able to be treated.

Battery Innovations Power All-Electric Aircraft
One major challenge to developing all-electric aircraft— safely delivering enough power to the motors—got a boost from industry, California-based Electric Power Systems. The company used funding from Armstrong Flight Research Center to develop a new technique to safely package thousands of off-the-shelf lithium-ion cells into one lightweight, powerful battery. The company is now supplying similar batteries to power an all-electric training airplane and has contracts with companies interested in designing electric vehicles for travel between small airports and within urban areas.

Wrapped Tanks Cut Weight on Everything from Buses to Paintball Guns
What do infant incubators, a Mars lander, and paintball guns have in common? All employ an invention developed at Glenn Research Center to cut weight from the Space Shuttles. Composite overwrapped pressure vessels, made of a liner tightly wrapped in high-strength filament, weigh half as much as all-metal pressure tanks by safely storing gases and liquids at higher pressures than was previously possible. Today, Worthington Industries, with production facilities in Pomona, California, sells them for, among many applications, fuel tanks for buses and breathing systems for firefighters.

NASA Brings Accuracy to World's Global Positioning Systems
GPS is an Air Force program, but NASA algorithms are largely to thank for the system being useful for secure, precision applications like airplane guidance, self-driving farm equipment, and directing first responders. Raw GPS data can be off by 30 feet or more, so the Jet Propulsion Laboratory developed software to correct for these errors, enabling real-time precision GPS. An early adopter, Long Island-based Comtech Telecommunications Corporation, remains a major

provider of location-based services, including for cell phone companies, helping 911 operators pinpoint the location of a caller.

Bowflex System Spurs Revolution in Home Fitness

The Bowflex Revolution home gym was a phenomenon of the 2000s and to this day sells well—but it might not exist without NASA. Inventor Paul Francis took his idea for a weightless weight-trainer, using elastic resistance, to Johnson Space Center, which was looking for ways to help astronauts retain muscle mass and bone density in microgravity. The end product launched to the space station in 2000, and Francis began approaching fitness companies. Nautilus Group, now based in Vancouver, Washington, licensed the technology and released the Bowflex Revolution in 2005.

Software Helps Design Artery Stents, Lawn Mowers, Airplanes

Lockheed Martin developed the Structural Analysis of General Shells (STAGS) code under contract to Langley Research Center in the 1980s. It was a finite element analysis (FEA) program, meaning it broke down models of structures into tiny elements to model a structure's behavior as a whole. In 2005, French company Dassault Systèmes acquired Abaqus Inc. of Johnston, Rhode Island, which had developed the Abaqus FEA program. The company regularly consulted with users, including Langley's STAGS developers, and many of STAGS' capabilities were added to the program.

Chapter 3
Conclusion

Technology transfer is an active and essential mission of federal R&D laboratories. By leveraging the nation's innovative nature and investing in science and technology, the U.S. economy and competitiveness can be strengthened in world markets. In recent years, agencies have engaged in efforts to increase the rate and efficacy of technology transfer activities, thereby improving 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 2015 and FY 2019, there has been a 23% increase in invention disclosures, a 4% increase in patent applications, and a 19% increase in patents issued. In FY 2019, the largest number of federal patents issued involved the technical areas of Measurement (12%) followed by Electrical Machinery, Apparatus, Energy (8%), Computer Technology (6%), Biotechnology (6%), Other Special Machines (6%), Pharmaceuticals (6%), and Telecommunications (5%).

Between FY 2015 and FY 2019, for agencies for which data were available, total active licenses decreased by 13%, new licenses increased by 12%, invention licenses decreased by 3%, and new invention licenses increased by 1%. Income-bearing licenses decreased by 17%, and exclusive income-bearing licenses increased by 58%.

Between FY 2015 and FY 2019, income from all licensing decreased by 44%, income from invention licenses decreased by 46%, and total earned royalty income decreased by 31%.

Between FY 2015 and FY 2019, CRADAs increased by 22%, and new CRADAs decreased by 16%. Traditional CRADAs increased by 21% and other collaborative R&D relationships decreased by 5%.

In CY 2019, federal researchers published 70,0108 papers. More than half of these papers were in the fields of Health Sciences (26%), Biological and Biomedical Sciences (19%), Engineering (14%), and Physics (12%). In FY 2019, 20,334 papers cited in U.S. patents were authored or coauthored by federal researchers. Of these papers, 90% involved research in the fields of Biological and Biomedical Sciences (35%), Health Sciences (23%), Engineering (12%), Physics (12%), and Chemistry (8%).

In summary, this report shows that agencies have made steady progress in their efforts to improve the transfer of technologies from federal laboratories. 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 2015	FY 2016	FY 2017	FY 2018	FY 2019
USDA	New Inventions Disclosed	222	244	166	320	243
	Patent Applications Filed	125	109	111	120	97
	Patents Issued	94	60	68	67	71
DOC	New Inventions Disclosed	61	64	43	77	60
	Patent Applications Filed	32	25	46	56	65
	Patents Issued	20	16	34	28	33
DoD	New Inventions Disclosed	743	782	978	839	839
	Patent Applications Filed	875	858	869	1,060	955
	Patents Issued	620	624	630	600	653
DOE	New Inventions Disclosed	1,645	1,760	1,794	1,748	1,891
	Patent Applications Filed	949	999	937	868	837
	Patents Issued	755	856	817	854	919
HHS	New Inventions Disclosed	321	320	354	322	268
	Patent Applications Filed	222	269	289	253	207
	Patents Issued	501	579	554	624	708
DHS	New Inventions Disclosed	12	15	20	22	14
	Patent Applications Filed	12	15	0	17	38
	Patents Issued	5	3	2	8	8
DOI	New Inventions Disclosed	7	8	12	9	8
	Patent Applications Filed	8	4	5	7	3
	Patents Issued	3	1	3	6	1
DOT	New Inventions Disclosed	0	0	3	12	2
	Patent Applications Filed	5	0	7	0	2
	Patents Issued	1	1	0	0	0
VA	New Inventions Disclosed	219	241	589	496	724
	Patent Applications Filed	116	104	163	255	274
	Patents Issued	54	54	50	72	82
EPA	New Inventions Disclosed	7	6	13	7	6
	Patent Applications Filed	4	1	4	6	6
	Patents Issued	7	3	3	4	3
NASA	New Inventions Disclosed	1,550	1,554	1,690	1,775	1,841
	Patent Applications Filed	129	129	165	144	85
	Patents Issued	123	103	114	123	122

Total	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
	New Inventions Disclosed	4,787	4,994	5,662	5,627	5,896
	Patent Applications Filed	2,477	2,513	2,596	2,786	2,569
	Patents Issued	2,183	2,300	2,275	2,386	2,600

Federal Licenses

Agency	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
USDA	Licenses, Total Active	427	441	448	472	512
	New Licenses	37	31	40	40	51
	Invention Licenses, Total Active	362	370	373	386	392
	New Invention Licenses	22	25	31	27	17
	Income Bearing Licenses, Total Active	421	439	437	471	522
	Income Bearing Exclusive Licenses	292	307	302	324	334
DOC	Licenses, Total Active	46	57	68	67	74
	New Licenses	13	15	19	11	15
	Invention Licenses, Total Active	46	57	68	67	74
	New Invention Licenses	13	15	19	11	15
	Income Bearing Licenses, Total Active	29	31	35	37	33
	Income Bearing Exclusive Licenses	16	20	19	22	20
DoD	Licenses, Total Active	560	515	552	480	575
	New Licenses	69	35	162	168	58
	Invention Licenses, Total Active	431	286	514	n.a.	470
	New Invention Licenses	69	57	24	n.a.	58
	Income Bearing Licenses, Total Active	203	185	396	306	283
	Income Bearing Exclusive Licenses	n.a.	209	196	151	179
DOE	Licenses, Total Active	6,310	5,410	4,045	4,742	4,640
	New Licenses	648	621	567	662	686
	Invention Licenses, Total Active	1,336	943	916	844	822
	New Invention Licenses	155	145	128	100	98
	Income Bearing Licenses, Total Active	4,577	3,963	3,057	3,323	2,749
	Income Bearing Exclusive Licenses	98	231	190	181	113
HHS	Licenses, Total Active	1,767	1,750	1,806	1,867	1,933
	New Licenses	279	278	334	335	346
	Invention Licenses, Total Active	1,354	1,721	1,354	1,411	1,472
	New Invention Licenses	232	221	282	292	291
	Income Bearing Licenses, Total Active	843	837	907	978	1,001
	Income Bearing Exclusive Licenses	119	145	130	143	158
DHS	Licenses, Total Active	4	5	5	5	5
	New Licenses	3	1	0	0	0
	Invention Licenses, Total Active	4	5	5	5	5
	New Invention Licenses	3	1	0	0	0
	Income Bearing Licenses, Total Active	4	1	1	1	1
	Income Bearing Exclusive Licenses	0	0	0	0	0

Federal Licenses (continued)

Agency	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
DOI	Licenses, Total Active	20	22	15	17	18
	New Licenses	3	0	0	2	2
	Invention Licenses, Total Active	18	20	13	n.a.	16
	New Invention Licenses	3	0	0	n.a.	2
	Income Bearing Licenses, Total Active	18	17	13	13	16
	Income Bearing Exclusive Licenses	7	8	7	n.a.	7
DOT	Licenses, Total Active	2	2	5	5	5
	New Licenses	0	2	1	1	0
	Invention Licenses, Total Active	0	2	0	0	1
	New Invention Licenses	0	0	0	0	0
	Income Bearing Licenses, Total Active	2	2	2	5	6
	Income Bearing Exclusive Licenses	0	0	0	0	0
VA	Licenses, Total Active	200	261	262	n.a.	n.a.
	New Licenses	3	1	1	n.a.	n.a.
	Invention Licenses, Total Active	200	260	261	n.a.	n.a.
	New Invention Licenses	3	1	0	n.a.	n.a.
	Income Bearing Licenses, Total Active	16	42	42	210	281
	Income Bearing Exclusive Licenses	11	35	36	205	245
EPA	Licenses, Total Active	37	35	38	31	24
	New Licenses	0	8	5	1	3
	Invention Licenses, Total Active	37	35	38	31	24
	New Invention Licenses	0	8	5	1	3
	Income Bearing Licenses, Total Active	31	31	31	24	17
	Income Bearing Exclusive Licenses	7	7	7	6	5
NASA	Licenses, Total Active	375	452	506	540	503
	New Licenses	74	107	119	105	96
	Invention Licenses, Total Active	321	387	440	488	529
	New Invention Licenses	69	97	109	99	88
	Income Bearing Licenses, Total Active	193	245	258	274	326
	Income Bearing Exclusive Licenses	12	14	8	4	8

Total	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
	Licenses, Total Active	9,748	8,950	7,750	8,226	8,289
	New Licenses	1,129	1,099	1,248	1,325	1,257
	Invention Licenses, Total Active	4,109	4,086	3,982	3,232	3,805
	New Invention Licenses	569	570	598	530	572
	Income Bearing Licenses, Total Active	6,337	5,793	5,179	5,642	5,235
	Income Bearing Exclusive Licenses	562	976	895	1,036	1,069

Federal Income from Licensing ($000s)

Agency	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
USDA	Total Income, All Active Licenses	$5,067	$4,784	$5,703	$3,835	$3,562
	Invention Licenses	$4,842	$4,456	$5,378	$3,495	$3,275
	Total Earned Royalty Income, (ERI)	$3,510	$3,633	$3,504	$2,716	$3,172
DOC	Total Income, All Active Licenses	$164	$149	$141	$147	$136
	Invention Licenses	$164	$149	$141	$147	$136
	Total Earned Royalty Income, (ERI)	$164	$149	$141	$147	$136
DoD	Total Income, All Active Licenses	$9,169	n.a.	n.a.	n.a.	$5,601
	Invention Licenses	$8,203	$554	n.a.	n.a.	$2,977
	Total Earned Royalty Income, (ERI)	$7,621	$5,823	$7,415	$6,802	$7,279
DOE	Total Income, All Active Licenses	$33,137	$31,149	$36,567	$21,085	$21,974
	Invention Licenses	$28,966	$27,364	$33,436	$17,237	$18,220
	Total Earned Royalty Income, (ERI)	$21,245	$16,273	$13,216	$10,239	$10,466
HHS	Total Income, All Active Licenses	$151,727	$132,833	$134,567	$110,709	$78,540
	Invention Licenses	$147,512	$130,701	$132,536	$108,276	$76,468
	Total Earned Royalty Income, (ERI)	$114,102	$110,193	$135,963	$111,628	$79,000
DHS	Total Income, All Active Licenses	$5	$12	$20	$36	$38
	Invention Licenses	$0	$12	$20	$36	$38
	Total Earned Royalty Income, (ERI)	$5	$12	$20	$36	$38
DOI	Total Income, All Active Licenses	$106	$83	$50	$51	$42
	Invention Licenses	$106	$83	$50	$51	$42
	Total Earned Royalty Income, (ERI)	$106	$83	$50	$51	$42
DOT	Total Income, All Active Licenses	$12	$15	$20	$13	$8
	Invention Licenses	$0	$0	$0	$0	$0
	Total Earned Royalty Income, (ERI)	$12	$15	$20	$13	$8
VA	Total Income, All Active Licenses	$494	$316	$491	$690	$1,166
	Invention Licenses	$494	$316	$491	$690	$1,166
	Total Earned Royalty Income, (ERI)	$494	$316	$491	$690	$1,166
EPA	Total Income, All Active Licenses	$232	$466	$412	$628	$449
	Invention Licenses	$232	$466	$412	$628	$449
	Total Earned Royalty Income, (ERI)	$232	$466	$412	$628	$449
NASA	Total Income, All Active Licenses	$3,395	$3,149	$2,682	$2,301	$2,613
	Invention Licenses	$2,828	$2,750	$2,126	$2,036	$2,530
	Total Earned Royalty Income, (ERI)	$3,250	$2,746	$2,118	$2,041	$1,704

Total	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
	Total Income, All Active Licenses	$203,508	$172,956	$180,653	$139,495	$114,130
	Invention Licenses	$193,347	$166,851	$174,590	$132,596	$105,301
	Total Earned Royalty Income, (ERI)	$150,741	$139,709	$163,350	$134,991	$103,460

Federal Collaborative R&D Relationships

Agency	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
USDA	CRADAs, Total Active	301	238	330	212	260
	New CRADAs	80	79	91	61	95
	Traditional CRADAs, Total Active	301	238	330	182	260
	Other Collaborative R&D Relationships	4,730	5,628	6,125	3,369	1,888
DOC	CRADAs, Total Active	2,752	2,940	2,932	3,363	2,564
	New CRADAs	2,548	2,608	2,443	2,770	1,893
	Traditional CRADAs, Total Active	365	335	413	534	493
	Other Collaborative R&D Relationships	3,125	3,273	3,181	3,497	3,431
DoD	CRADAs, Total Active	2,377	2,603	2,995	4,976	6,090
	New CRADAs	786	774	813	949	936
	Traditional CRADAs, Total Active	2,130	2,273	2,424	3,010	3,768
	Other Collaborative R&D Relationships	247	330	571	1,966	2,322
DOE	CRADAs, Total Active	747	784	936	1,030	1,072
	New CRADAs	186	264	330	312	287
	Traditional CRADAs, Total Active	747	784	936	1,030	1,072
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	400	590	588	577	575
	New CRADAs	112	134	112	87	93
	Traditional CRADAs, Total Active	202	391	462	465	476
	Other Collaborative R&D Relationships	150	147	126	112	99
DHS	CRADAs, Total Active	230	343	412	164	212
	New CRADAs	98	114	107	104	60
	Traditional CRADAs, Total Active	200	272	326	164	212
	Other Collaborative R&D Relationships	30	71	71	n.a.	n.a.
DOI	CRADAs, Total Active	826	873	841	740	470
	New CRADAs	586	511	477	422	352
	Traditional CRADAs, Total Active	38	37	58	53	43
	Other Collaborative R&D Relationships	318	319	247	249	269
DOT	CRADAs, Total Active	48	68	65	63	44
	New CRADAs	9	22	6	7	10
	Traditional CRADAs, Total Active	48	62	66	63	43
	Other Collaborative R&D Relationships	35	152	355	121	125
VA	CRADAs, Total Active	2,305	2,613	1,785	1,688	1,686
	New CRADAs	509	502	575	512	536
	Traditional CRADAs, Total Active	2,113	2,359	1,619	1,518	1,526
	Other Collaborative R&D Relationships	0	0	0	0	0
EPA	CRADAs, Total Active	97	55	51	49	54
	New CRADAs	23	14	8	11	11
	Traditional CRADAs, Total Active	50	55	51	49	54
	Other Collaborative R&D Relationships	0	48	89	91	93
NASA	CRADAs, Total Active	8	12	0	0	0
	New CRADAs	7	5	0	0	0
	Traditional CRADAs, Total Active	8	12	0	0	0
	Other Collaborative R&D Relationships	2,113	2,204	2,174	2,182	1,967

Total	Metric	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
	CRADAs, Total Active	10,091	11,119	10,935	12,862	13,027
	New CRADAs	4,944	5,027	4,962	5,235	4,273
	Traditional CRADAs, Total Active	6,202	6,818	6,685	7,068	7,947
	Other Collaborative R&D Relationships	10,748	12,172	12,939	11,587	10,194

Appendix B

Technology Area Classification
Mapping of International Patent Classifications to Technology Area[47]

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 materials.

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 liquids, 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, spreading 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.

[47] 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 infra-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 but is not limited to data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory, or forecasting purposes.

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

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

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

Measurement – Includes but is not limited to measuring linear dimensions, measuring distances, surveying, navigation, gyroscopic instruments, measuring volume, weighing, measurement of mechanical vibrations, measurement of intensity or velocity, measuring temperature or quantity

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

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

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

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

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

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

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

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

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

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

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

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

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

Thermal Processes and Apparatus – Includes but is not limited to methods of steam generation, superheating of steam, methods or apparatus for combustion using fluid or solid fuel, burners, grates, feeding fuel to combustion apparatus, regulating or controlling combustion, ignition, domestic stoves or ranges, air-conditioning, fluid heaters, ice production, steam or

vapor condensers, other heat exchange apparatus, and cleaning of internal or external surfaces of heat-exchange or heat-transfer conduits.

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

Appendix C

Fields and Subfields of S&E Publications Data[48]

Agricultural Sciences – dairy animal sciences, agricultural and food sciences

Astronomy – 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 – 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

[48] 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.

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

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

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