Federal Laboratory Technology Transfer

Fiscal Year 2020

Summary Report to the President and 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 2020 Technology Transfer Summary Report to the President and 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, operate at the forefront of scientific discovery, invention, and technological innovation. Technology transfer benefits the public by facilitating the practical application of Federal 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 and services have been offered, and the formation of new companies has occurred, through technology transfer initiatives.

Cross-agency efforts focus on the important role that innovation plays in accelerating the development of new industries, products, and services that lead to improvements in economic prosperity, national security, public health, public safety, quality of life, and more. Agencies continued to engage in efforts to streamline technology transfer activities, collect technology transfer metrics, establish performance goals, and evaluate programs to enhance the efficiency and impact of their technology transfer activities.

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, significantly impacted the United States starting in Fiscal Year 2020. Federal agencies initiated a wide range of responses to this pandemic—adapting their day-to-day operations, adopting new procedures and processes, and shifting their resources to address this novel virus. This report includes highlights of agency responses to the COVID-19 pandemic and offers insight into the role that Federal technology transfer played in addressing this extraordinary challenge.

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, national security, public health, and more.

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 may 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 technology transfer occurs.[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 is in many ways 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 improve the overall customer experience. These include efforts to streamline internal operations that increase efficiency and improvements to increase accessibility to the Federal technology transfer system for external customers.

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

[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 2020, total Federal obligations for R&D were $167,403 million. Of this, $101,781 million (61%) 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, $64,622 million (39%), supported R&D activities that occurred inside Federal laboratories. This includes $51,472 million to support intramural activities and $13,150 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 2020 ($ million)[4]

	Total R&D	Intramural[(a)]	FFRDCs	Intramural and FFRDCs	Percent of Total R&D Budget
All Agencies	$167,403	$51,472	$13,150	$64,622	39%
DoD	$66,695	$22,667	$1,822	$24,489	37%
HHS	$60,006	$19,300	$931	$20,231	34%
DOE	$13,453	$872	$7,566	$8,438	63%
NASA	$10,538	$2,552	$2,266	$4,818	46%
USDA	$2,644	$1,690	$0	$1,690	64%
DOC	$1,622	$1,193	$24	$1,217	75%
VA	$1,565	$1,495	$70	$1,565	100%
DOT	$1,184	$222	$70	$292	25%
DOI	$837	$720	$1	$721	86%
DHS	$508	$133	$92	$225	44%
EPA	$489	$244	$2	$246	50%
Other Agencies	$7,863	$384	$307	$691	9%

(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 2020-21, Federal Obligations for Research and Development, by Agency and Performer, FY 2020, Table 7. https://ncses.nsf.gov/pubs/nsf22323

In FY 2020, DoD spent the largest amount of funding on intramural activities and FFRDCs with $24,489 million (37% of its R&D budget). HHS was second with $20,231 million (34% of its R&D budget), and DOE was third with $8,438 million (63% 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 2016 through FY 2020.[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 2020 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 2020 if the agencies have updated those data after the agency report was submitted.

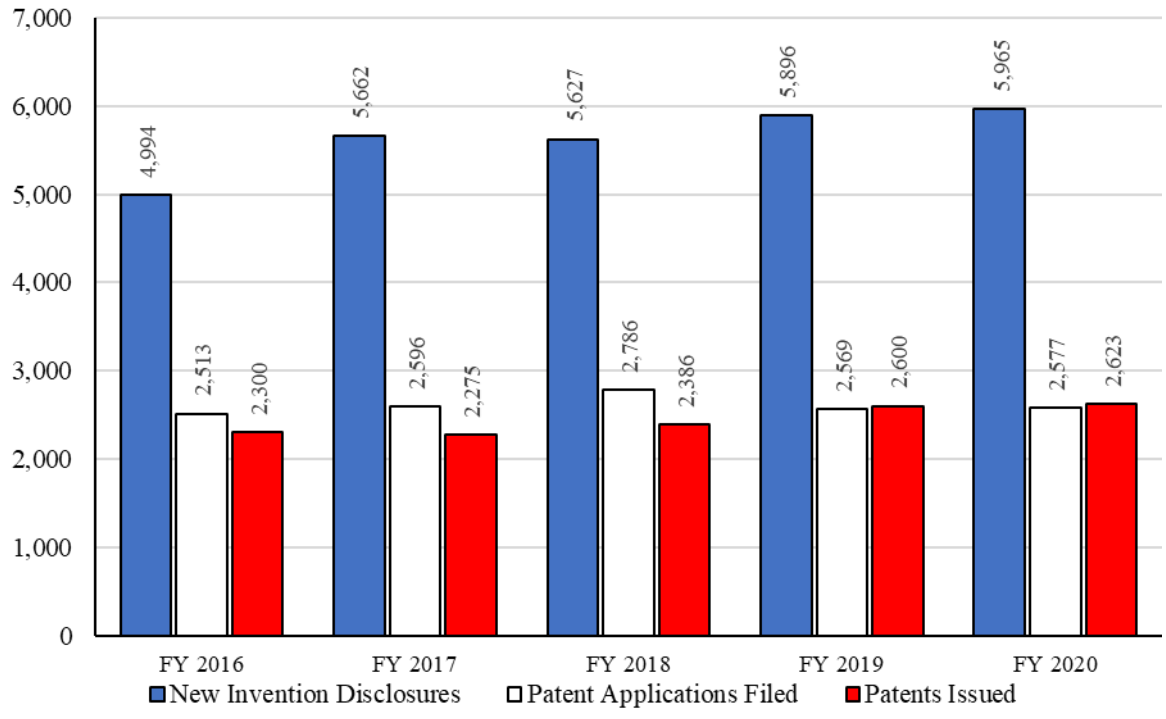
Federal Invention Disclosures and Patenting

The protection of intellectual property (IP) can be vital to attracting additional investment and product development resources necessary for early-stage technologies 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 2016 and FY 2020, invention disclosures reported by Federal agencies increased by 19%, from 4,994 in FY 2016 to 5,965 in FY 2020. Patent applications filed increased by 3%, from 2,513 in FY 2016 to 2,577 in FY 2020. Patents issued increased by 14%, from 2,300 in FY 2016 to 2,623 in FY 2020. DOE reported the largest number of invention disclosures with 2,021 in FY 2020, followed by NASA with 1,882, and DoD with 804. These three agencies accounted for 78% of all invention disclosures reported in FY 2020.

In FY 2020, DOE reported the largest number of patent applications with 956, followed by DoD with 881, and VA with 248. These three agencies accounted for 81% of patent applications in FY 2020. DOE reported the largest number of patents issued in FY 2020 with 929, followed by HHS with 738, and DoD with 655. These three agencies accounted for 89% of reported patents issued in FY 2020.

Federal Invention Disclosures and Patenting

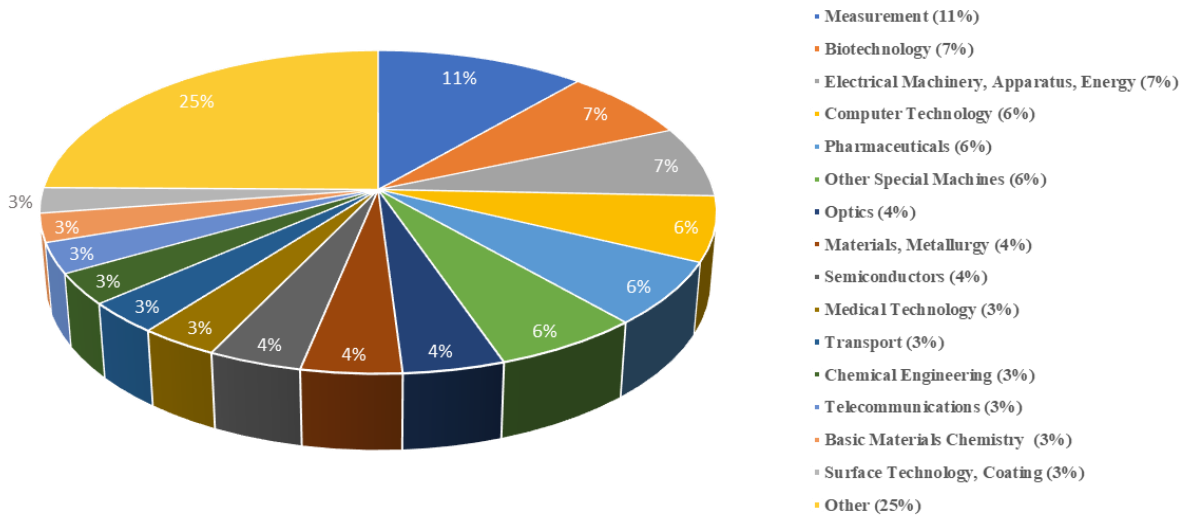


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	4,994	5,662	5,627	5,896	5,965
Patent Applications Filed	2,513	2,596	2,786	2,569	2,577
Patents Issued	2,300	2,275	2,386	2,600	2,623

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 2020. The chart shows the percentage of patents issued to Federal agencies by technology area based on fractional count patents.[7] In FY 2020, the largest number of Federal patents issued involved Measurement (11%) followed by Biotechnology (7%); Electrical Machinery, Apparatus, Energy (7%); Computer Technology (6%); Pharmaceuticals (6%); Other Special Machines (6%); Optics (4%); Materials, Metallurgy (4%); Semiconductors (4%); Medical Technology (3%); Transport (3%); Chemical Engineering (3%); Telecommunications (3%); Basic Materials Chemistry (3%); Surface Technology, Coating (3%); and Other (25%).[8]

USPTO Patents Assigned to Selected U.S. Federal Agencies by Technology Area: FY 2020



[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 January 2022. Used with permission.

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

Federal Licenses[9]

Licensing 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 benefits the public and contributes to overall competitiveness and domestic economic growth. Without the ability to grant licenses and accompanying incentives to the non-Federal sector, federally developed innovations might be doomed to an idle future rather than developed into commercial products or services. The terms and conditions under which Federal IP 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, and projected market impact.

Between FY 2016 and FY 2020, total active licenses reported by agencies for which data were available increased by 2%, from 8,689 in FY 2016 to 8,865 in FY 2020.[10] New licenses reported by agencies for which data were available increased by 31%, from 1,098 in FY 2016 to 1,434 in FY 2020.[11] Total active invention licenses reported by agencies for which data were available increased by 7%, from 3,826 in FY 2016 to 4,087 in FY 2020.[12] New invention licenses reported by agencies for which data were available increased by 22%, from 569 in FY 2016 to 697 in FY 2020.[13] Invention licenses refers to inventions that are patented or could be patented. Income-bearing licenses decreased by 5%, from 5,793 in FY 2016 to 5,496 in FY 2020. Exclusive income-bearing licenses increased by 4%, from 976 in FY 2016 to 1,012 in FY 2020.

In FY 2020, DOE reported the largest number of total active licenses with 4,862 licenses. HHS was second with 2,028 licenses, and DoD was third with 627 licenses. These three agencies accounted for 85% of all licenses reported in FY 2020.

In FY 2020, HHS reported the largest number of invention licenses with 1,546, followed by DOE 816, and NASA with 582. Together these three agencies accounted for 72% of invention licenses in FY 2020.

In FY 2020, DOE reported the largest number of income-bearing licenses, 2,772. HHS was second with 1,059, followed by USDA with 594. Together these three agencies accounted for 81% of income-bearing licenses in FY 2020.

[9] Data for some agencies were not available for this report. Data for FY 2018, FY 2019, and FY 2020 values for total active licenses, new licenses, 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 invention licenses, total active, new invention licenses, and income bearing exclusive licenses were not available for DOI.

[10] Total active licenses for all agencies, including those for which data were not available, decreased by 1%, from 8,950 in FY 2016 to 8,865 in FY 2020.

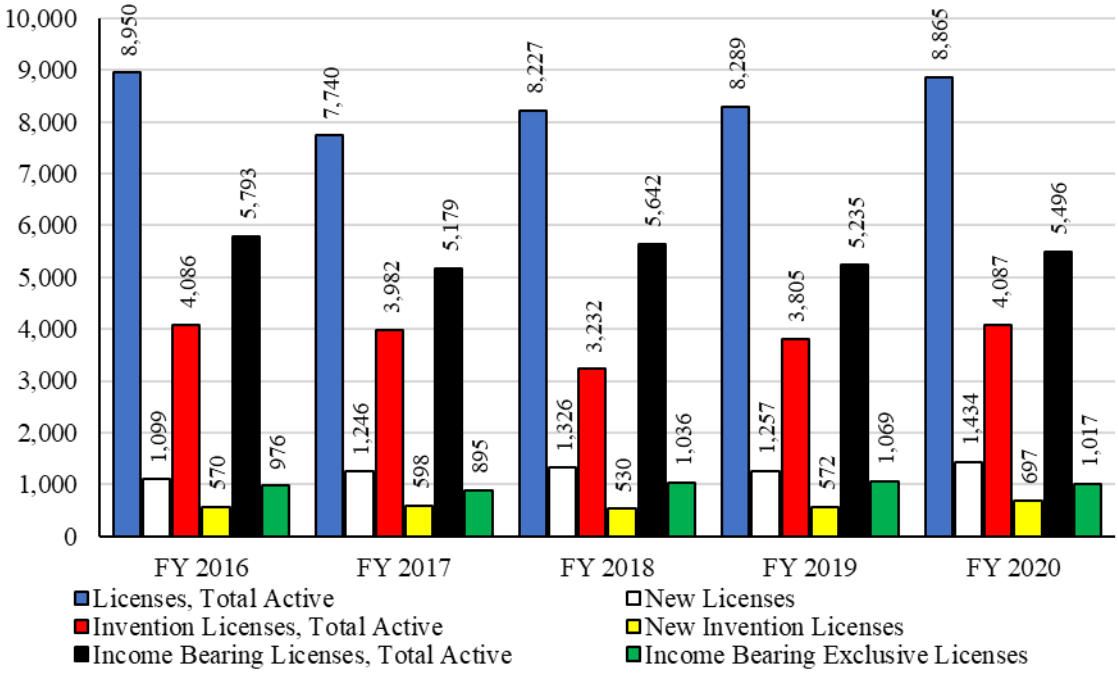
[11] New licenses for all agencies, including those for which data were not available, decreased by 30%, from 1,098 in FY 2016 to 1,434 in FY 2020.

[12] Total active invention licenses for all agencies, including agencies for which data were not available, increased by 0.02%, from 4,086 in FY 2016 to 4,087 in FY 2020.

[13] New invention licenses for all agencies, including agencies for which data were not available, increased by 22% from 570 in FY 2016 to 697 in FY 2020.

In FY 2020, USDA reported the largest number of income-bearing exclusive licenses with 342, followed by VA with 211, and DoD with 144. Together these three agencies accounted for 69% of income-bearing exclusive licenses in FY 2020.

Federal Licenses[14]



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	8,950	7,750	8,226	8,289	8,865
New Licenses	1,099	1,248	1,325	1,257	1,434
Invention Licenses, Total Active	4,086	3,982	3,232	3,805	4,087
New Invention Licenses	570	598	530	572	697
Income Bearing Licenses, Total Active	5,793	5,179	5,642	5,235	5,496
Income Bearing Exclusive Licenses	976	895	1,036	1,069	1,017

Federal Income from Licenses[15]

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 2016 and FY 2020, income from all licensing for agencies for which data were available decreased by 50%, from $173 million in FY 2016 to $86 million in FY 2020.[16] Income from invention licenses for agencies for which data were available decreased by 49%, from $167 million in FY 2016 to

[14] This figure shows data for all reporting agencies, including agencies for which some data were not available.
[15] Data for some agencies was not available for this report. DoD was unable to provide values for total income for all active licenses for FY 2017, FY 2018, and FY 2019. DoD was also unable to provide values for invention license income for FY 2017 and FY 2018.
[16] Total income for all reporting agencies, including those for which data were not available, decreased by 45%, from $173 million in FY 2016 to $95 million in FY 2020.

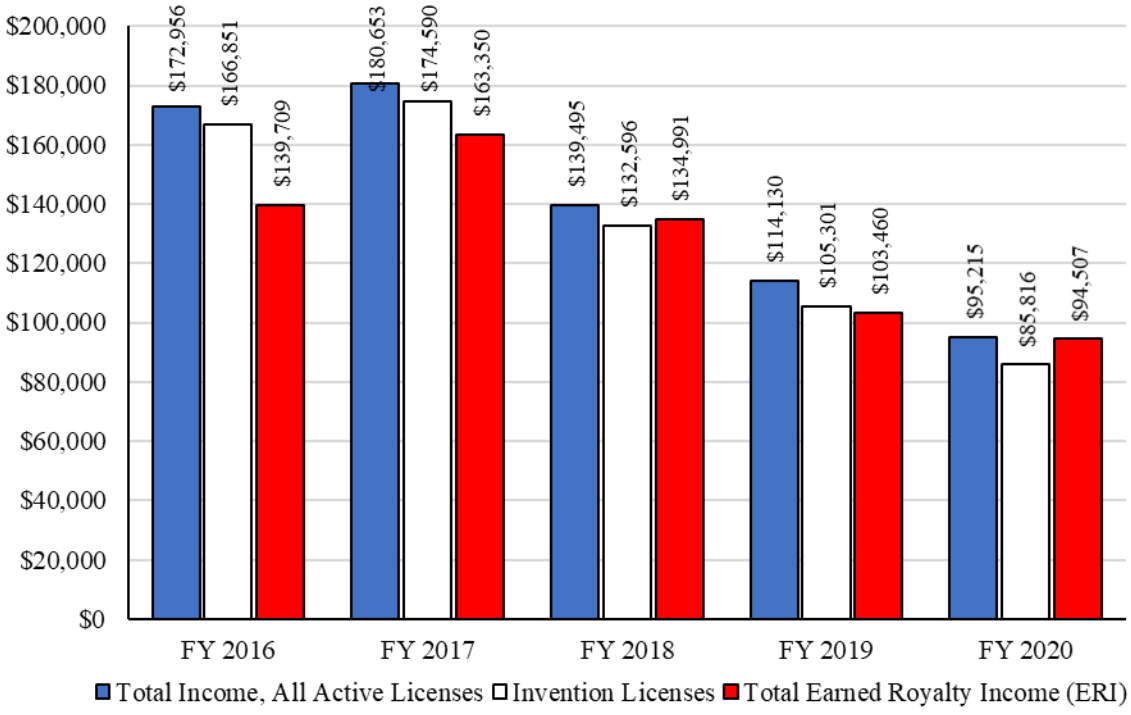
$86 million in FY 2020. Total earned royalty income decreased by 32%, from $140 million in FY 2016 to $95 million in FY 2020.

HHS accounted for the most licensing income with $54 million, followed by DOE with $25 million, and DoD with $9 million. Together these three agencies accounted for 93% of reported licensing income.

HHS accounted for the most invention license income with $52 million, followed by DOE with $21 million, and DoD with $6 million. Together these three agencies accounted for 92% of reported invention license income.

HHS accounted for the most Earned Royalty Income with $64 million, followed by DOE with $16 million, and DoD with $9 million. Together these three agencies accounted for 94% of reported earned royalty income.

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



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$172,956	$180,653	$139,495	$114,130	$95,215
Invention Licenses	$166,851	$174,590	$132,596	$105,301	$85,816
Total Earned Royalty Income, (ERI)	$139,709	$163,350	$134,991	$103,460	$94,507

[17] This figure shows data for all reporting 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 and knowledge 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 CRADA, 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 non-Federal partners. Other special CRADA arrangements are used by Federal agencies to address special purpose applications such as material transfer agreements or agreements that facilitate technical assistance activities.

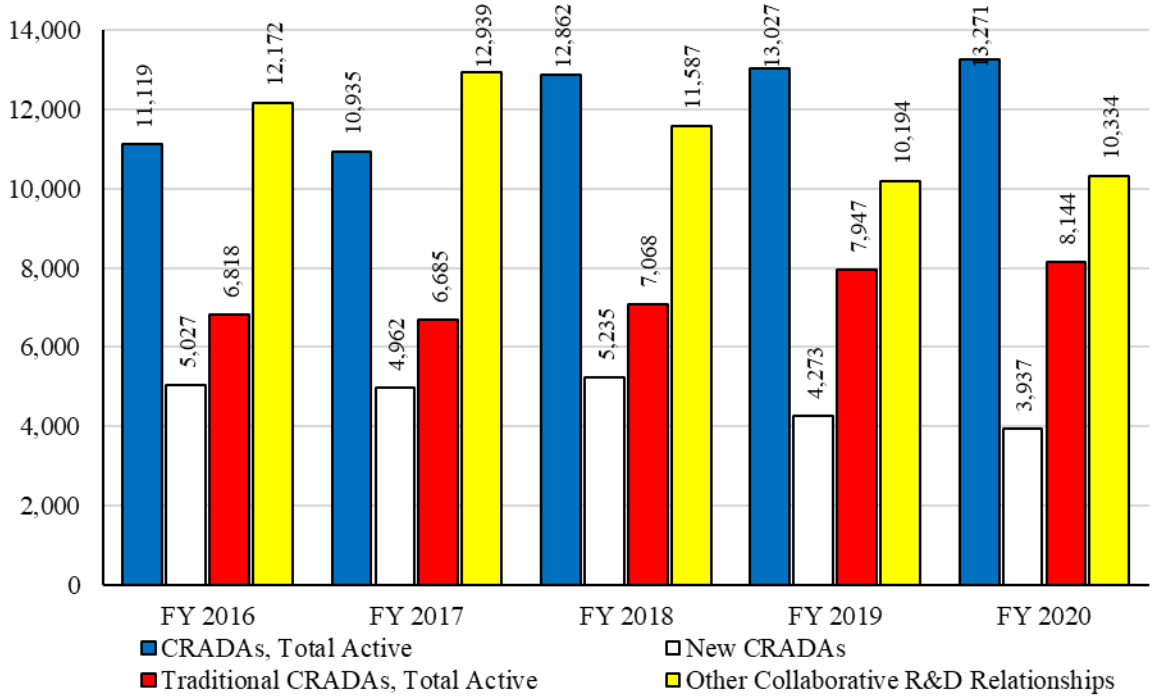
In addition to CRADAs, agencies may have other specific authorities that also facilitate cooperative R&D relationships, such as Space Act Agreements from NASA or other transaction authorities.

Between FY 2016 and FY 2020, active CRADAs increased by 19%, from 11,119 in FY 2016 to 13,271 in FY 2020. New CRADA agreements decreased by 22%, from 5,027 in FY 2016 to 3,937 in FY 2020. Other collaborative R&D relationships for agencies for which data were available decreased by 15%, from 12,172 in FY 2017 to 10,334 in FY 2020.[19]

In FY 2020, DoD reported the largest number of active CRADAs with 6,962, followed by DOC with 2,014, and VA with 1,587. DOC reported the largest number of other collaborative R&D relationships with 2,952, followed by DoD reporting 2,755, and NASA reporting 2,004 (Space Act Agreements).

[18] DHS was unable to provide values for other collaborative agreements for FY 2018, FY2019, and FY 2020.
[19] Other collaborative R&D relationships for all agencies, including those for which some data were not available, decreased by 15% from 12,172 in FY 2016 to 10,334 in FY 2020.

Federal Collaborative R&D Relationships[20]



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	11,119	10,935	12,862	13,027	13,271
New CRADAs	5,027	4,962	5,235	4,273	3,937
Traditional CRADAs, Total Active	6,818	6,685	7,068	7,947	8,144
Other Collaborative R&D Relationships	12,172	12,939	11,587	10,194	10,334

Science and Engineering (S&E) Articles

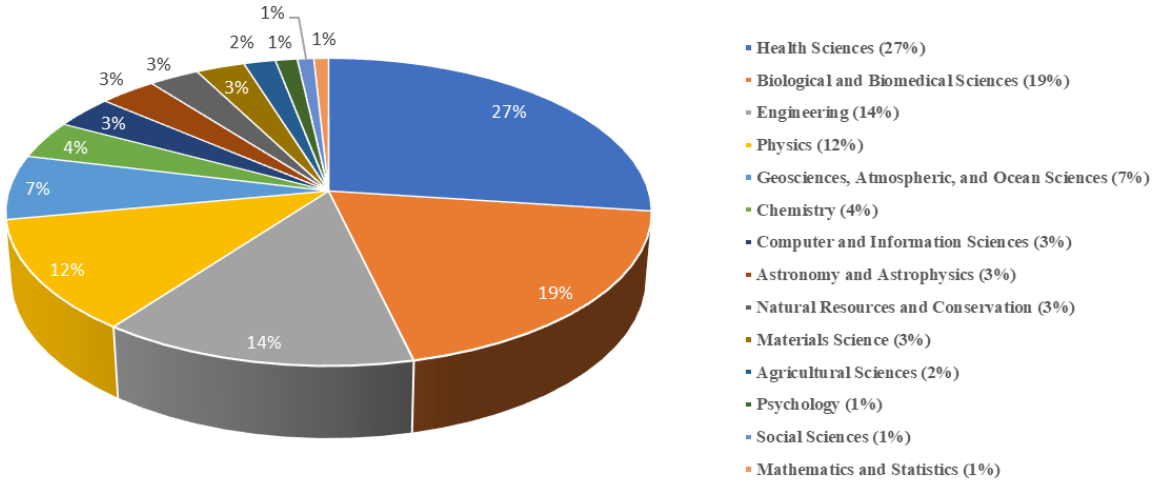
Although IP has traditionally been tracked in terms of patents, licenses, and collaborative efforts, most Federal research results are transferred through publication of S&E articles. Unfortunately, a uniform tracking system for S&E articles across all Federal agencies does not exist. However, data from 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 calendar year (CY) 2020, Elsevier reported that Federal researchers authored or coauthored 73,196 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).[21]

[20] This figure shows data for all reporting agencies, including agencies for which some data were unavailable.

[21] Data prepared by Science-Metrix. Taxonomy of Discipline (TOD) fields are used to classify articles. The TOD is a classification scheme developed by the National Science Foundation to suit its need for a unified scheme. Science-Metrix developed an alignment of its own classification scheme with the TOD and this alignment replaces the WebCaspar classification which was used in the past to produce bibliometric data for the Science & Engineering Indicators (SEI) reports. Journals are assigned to a unique TOD except for generalist journals, such as Science and Nature, for which articles are instead reclassified individually in TOD fields using an automated procedure based on machine-learning techniques. 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 (27%); Biological and Biomedical Sciences (19%); Engineering (14%); Physics (12%); and Geosciences, Atmospheric, and Ocean Sciences (7%).[22]

S&E Articles Authored by Selected U.S. Federal Agencies, by S&E Fields: CY 2020



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 2020, more than 20,309 articles authored or coauthored by Federal researchers were cited in U.S. patents.[23] Of these, the greatest number of articles addressed research in Biological and Biomedical Sciences (38%), Health Sciences (22%), Engineering (12%), Physics (11%), and Chemistry (8%).[24]

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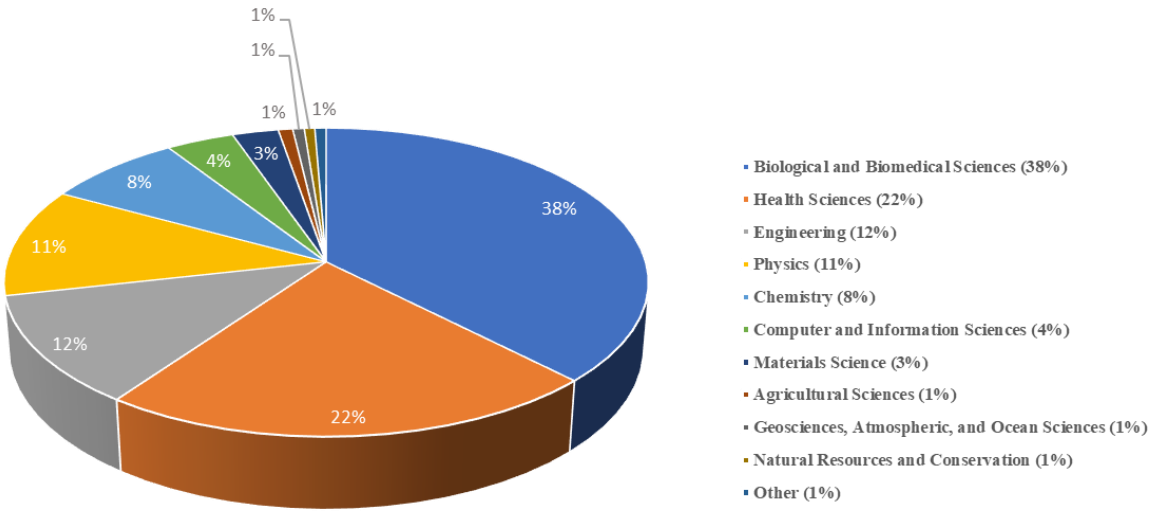
[22] Articles are credited on a whole-count basis. Source: Data prepared by Science-Metrix using Scopus (Elsevier) accessed in February 2022. Used with permission.

[23] Data prepared by Science Metrix. Taxonomy of Discipline (TOD) fields are used to classify articles. The TOD is a classification scheme developed by the National Science Foundation to suit its need for a unified scheme. Science-Metrix developed an alignment of its own classification scheme with the TOD and this alignment replaces the WebCaspar classification which was used in the past to produce bibliometric data for the Science & Engineering Indicators (SEI) reports. Journals are assigned to a unique TOD except for generalist journals, such as Science and Nature, for which articles are instead reclassified individually in TOD fields using an automated procedure based on machine-learning techniques. Used with permission.

[24] 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 January 2022.

Citation of U.S. S&E Articles Authored by Selected U.S. Federal Agencies, in USPTO Patents, by S&E Field: FY 2020



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) 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.[25] 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.[26]

The American Innovation and Competitiveness Act (AICA) (14 USC §1862s–8) provides a legislative mandate for the I-Corps program. Furthermore, it states, "I-Corps should continue to promote a strong innovation system by investing in and supporting female entrepreneurs through mentorship, education, and training because they are historically underrepresented in entrepreneurial fields." NSF has extended this mandate to include individuals from underrepresented groups to align with its ongoing mission of creating an inclusive entrepreneurial community that reflects the nation as a whole.

[25] See https://beta.nsf.gov/funding/initiatives/i-corps/about-i-corps

[26] Descriptions of agency-specific I-Corps programs are taken from the 2021 Biennial Report issued by NSF: https://nsf-gov-resources.nsf.gov/2022-06/NSFI-Corps2021BiennialReport.pdf

NSF

NSF I-Corps improves the realization of the potential benefits of inventions by increasing the likelihood of successful commercialization through an immersive seven-week experiential training course led by experts in technology translation. NSF takes all areas of science and engineering into consideration for inclusion in I-Corps. The curriculum integrates scientific inquiry and customer discovery in an inclusive, data-driven culture impelled by rigor, relevance, and evidence. Through I-Corps training, academic researchers can reduce the time to translate a promising idea from the laboratory to the marketplace or relevant societal setting.

NSF seeks to strengthen a national innovation ecosystem that fosters innovation among scientific faculty and students; promotes regional coordination, linkages, and sharing of promising practices; and encourages networks to address pressing societal needs and economic opportunities for the nation.

Specifically, I-Corps has four primary objectives:

- Prepare scientists and engineers to extend their focus beyond the research laboratory
- Translate laboratory discoveries into solutions with benefits for the economy and society
- Leverage Federal research investments by advancing commercialization of research outcomes
- Increase the economic impact of federally funded research

In FY 2019 and FY 2020, NSF piloted giving SBIR/STTR awardees the opportunity to participate in I-Corps cohorts. The pilot program provided the SBIR/STTR awardees with the I-Corps curriculum and access to I-Corps instructors, and it required 100+ industry interviews. Sixty-one (61) teams participated in I-Corps cohorts for which the final decision was to identify next steps toward success. It is anticipated that this pilot will continue.

NIH

I-Corps at NIH empowers entrepreneurs to develop and validate a strategic business model through diverse customer discovery to address unmet clinical needs. The I-Corps at NIH teams participate in an 8-week entrepreneurial immersion course based on NSF I-Corps to generate insights into challenges associated with the commercialization of biomedical and life sciences technologies.

In contrast to the NSF I-Corps program, which traditionally engages university researchers, the I-Corps at NIH program is designed with small businesses in mind: NIH SBIR/STTR Phase I awardees. In SBIR/STTR Phase I, awardees work on early-stage technologies to establish their technical merit, feasibility, and commercial potential. In this early stage, projects and teams benefit from the I-Corps curriculum. The program impacts the future direction of participants' careers, research, and teaching, and it improves the commercial outcomes of NIH-funded small businesses.

By design, the I-Corps at NIH program's team structure incorporates the titles and roles of individuals with decision-making authority within the small business. Participating companies enter the program with three-person teams:

- C-Level Corporate Officer (e.g., CEO)
- Principal Investigator/Technical Lead (e.g., assigned program director (PD) or principal investor (PI) listed on the Phase I award)
- Industry Expert (e.g., internal or external professional possessing business development background in the target industry)

DOE

The DOE's Energy I-Corps aims to accelerate the deployment of energy technologies by granting DOE laboratory staff access to direct market feedback on their technology offerings. Inspired by the NSF I-Corps model, the Energy I-Corps program empowers teams with the tools, resources, and relationships necessary to discover potential market pathways for their innovations. The DOE ARPA-E program also uses I-Corps to train researchers funded by ARPA-E.

The DOE's Energy I-Corps program encourages company formation but also defines metrics of success to include other outcomes such as external licenses, market insight into research, and improved external engagement. DOE sees great value in changing the problem-solving approach for researchers who return to the bench better equipped to ask and frame research questions through a customer lens based on their customer outreach. This promotes culture change and a new approach to problem solving that reverberates across the lab system for years to come.

Established in CY 2015 and formerly known as DOE's Lab-Corps, Energy I-Corps became part of the OTT portfolio in CY 2018 and is managed by the 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	National Energy Technology 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
Los Alamos National Laboratory	SLAC National Accelerator Laboratory

Other Agencies

Other agencies have incorporated I-Corps into their programs. DHS, DoD, and NASA have partnered with NSF to send their awardees through the NSF I-Corps programs.

DoD

The goals of I-Corps @ DoD are: to spur the translation of fundamental research with potential defense relevance to the marketplace; to encourage collaboration between academia and industry; and to train students, faculty, and other researchers to understand innovation and entrepreneurship. DoD sends teams to NSF I-Corps cohorts.

DHS

The DHS Science and Technology Directorate SBIR program offers select awardees an opportunity to participate in NSF I-Corps. The participant companies evaluate the market

opportunity of their DHS-funded innovations to improve preparation for commercialization and increase the odds of successful commercialization.

NASA

The NASA I-Corps program enables small businesses, including startups, to improve the likelihood of success by introducing their SBIR and STTR awardees to business model development. NASA teams participate in NSF I-Corps cohorts. In addition to sending teams to NSF cohorts, NASA teams also participate in the NSF Beat-the-Odds Boot Camp.

Chapter 2
Agency Performance in FY 2020

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 IP licensing) for FY 2020 and several prior years (FY 2016-2019);
- 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 "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; 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 IP 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.

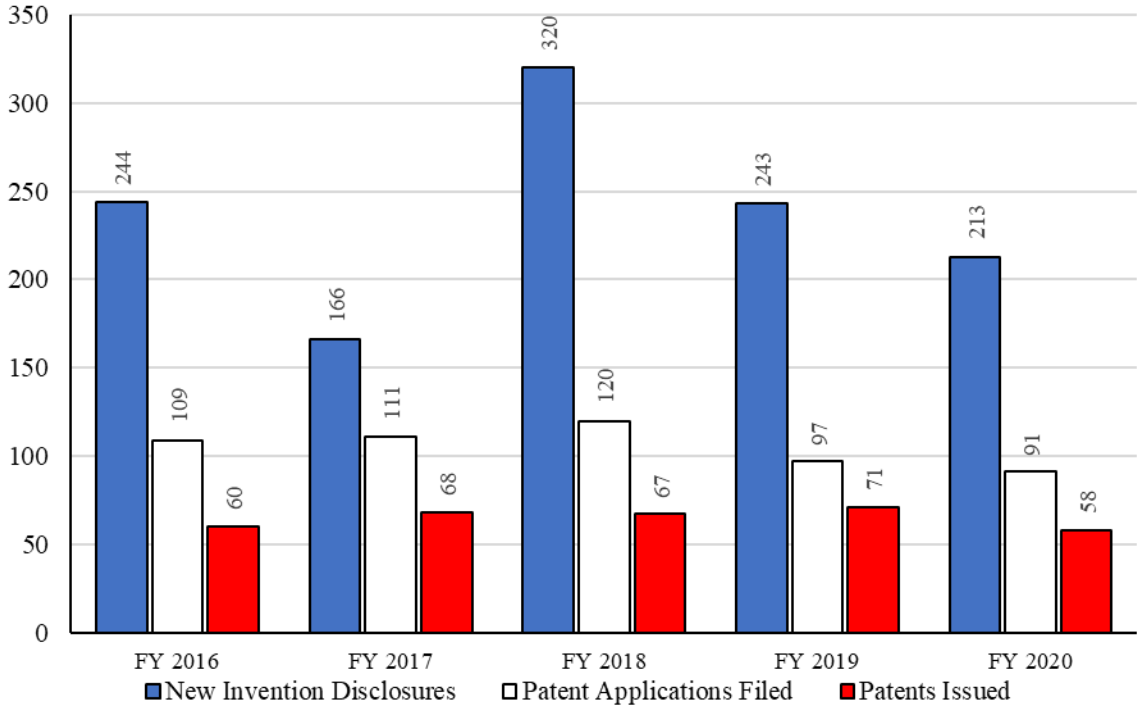
The USDA's FY 2020 annual report is available online and covers technology-transfer activities and metrics for the USDA Agricultural Marketing Service (AMS), Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), Economic Research Service (ERS), Foreign Agricultural 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 2016 and FY 2020, invention disclosures received decreased by 13%, from 244 to 213. Patent applications filed decreased 17%, from 109 in FY 2016 to 91 in FY 2020. Patents issued decreased by 3% from 60 in 2016 to 58 in FY 2020.

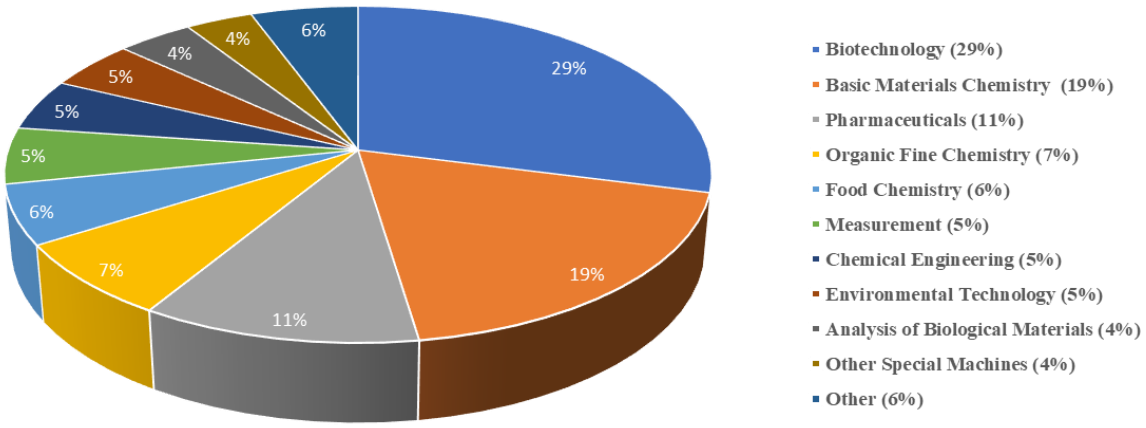
USDA Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	244	166	320	243	213
Patent Applications Filed	109	111	120	97	91
Patents Issued	60	68	67	71	58

Patents issued to USDA in FY 2020 covered many technology areas including Biotechnology (29%), Basic Materials Chemistry (19%), Pharmaceuticals (11%), Organic Fine Chemistry (7%), and Food Chemistry (6%).[27]

USPTO Patents Assigned to USDA by Technology Area: FY 2020

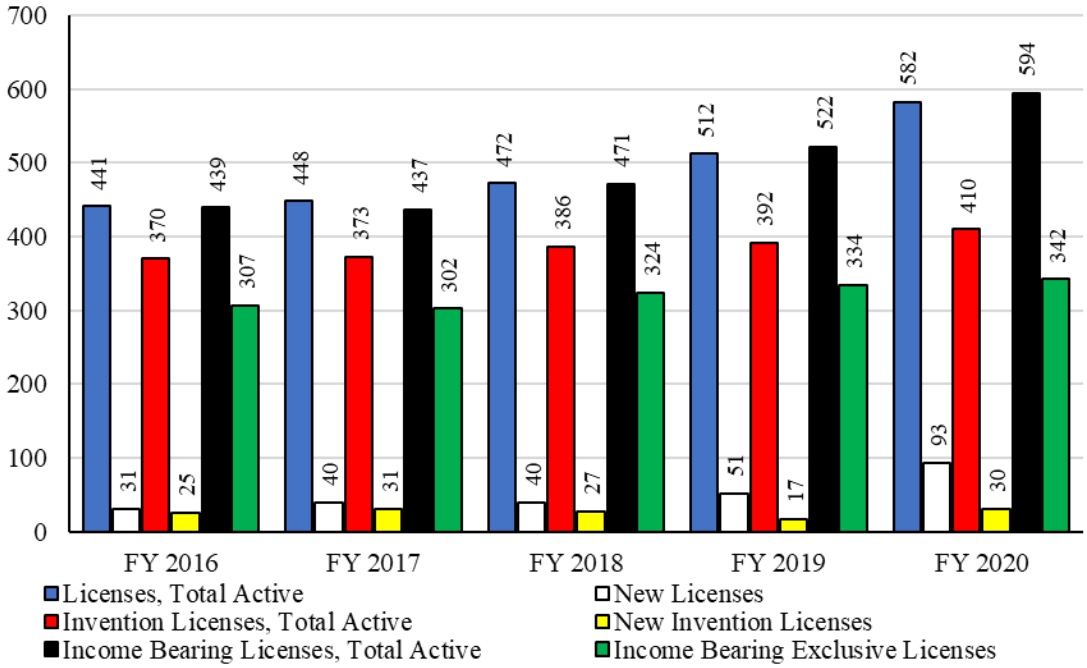


[27] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView accessed in January 2022. Used with permission.

USDA Licenses

Between FY 2016 and FY 2020, total active licenses increased by 32% to 582 licenses in FY 2020. Total active invention licenses increased by 11% to 410 licenses. Total active income bearing licenses increased 35%, from 439 in FY 2016 to 594 in FY 2020, while income-bearing exclusive licenses increased by 11% to 342.

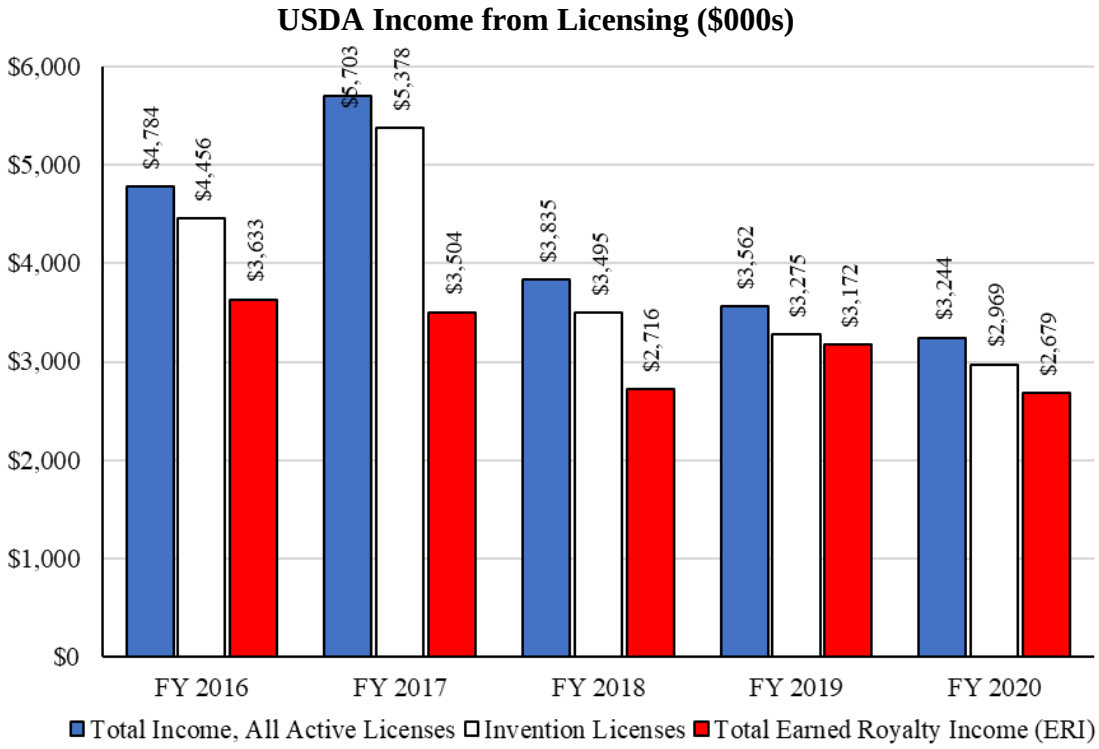
USDA Licenses



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	441	448	472	512	582
New Licenses	31	40	40	51	93
Invention Licenses, Total Active	370	373	386	392	410
New Invention Licenses	25	31	27	17	30
Income Bearing Licenses, Total Active	439	437	471	522	594
Income Bearing Exclusive Licenses	307	302	324	334	342

USDA Income from Licensing

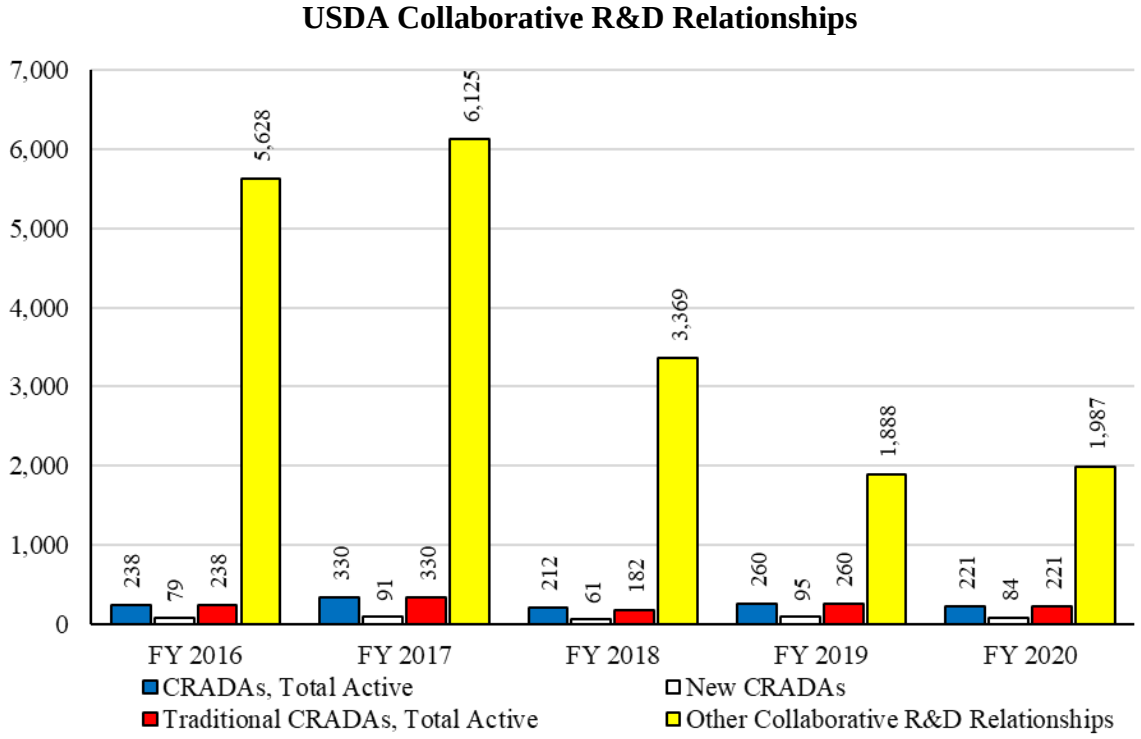
Between FY 2016 and FY 2020, total income from all active licenses decreased by 32% to $3.6 million in FY 2020. The income from invention licenses decreased by 33% to $3.0 million. Total earned royalty income decreased by 26%, from $3.6 million in FY 2016 to $2.7 million in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$4,784	$5,703	$3,835	$3,562	$3,244
Invention Licenses	$4,456	$5,378	$3,495	$3,275	$2,969
Total Earned Royalty Income, (ERI)	$3,633	$3,504	$2,716	$3,172	$2,679

USDA Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs decreased by 7% to 221 agreements while new CRADAs increased by 6% to 84. Traditional CRADAs decreased by 7% to 221. Other collaborative R&D relationships decreased by 65% to 1,987 in FY 2020.[28]



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	238	330	212	260	221
New CRADAs	79	91	61	95	84
Traditional CRADAs, Total Active	238	330	182	260	221
Other Collaborative R&D Relationships	5,628	6,125	3,369	1,888	1,987

[28] 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 Downstream Success Stories

Agricultural Marketing Service (AMS): Harmonizing Biotech Reference Methods

There is a need for highly specific and accurate tests for the various GE crops grown in the United States. The Federal Grain Inspection Service (FGIS) has developed intra-laboratory validated, real-time polymerase chain reaction (PCR) methods and has evaluated the accuracy, reliability, and proficiency of publicly available methods used to detect and identify GE grains and oilseeds. These PCR reference methods are used in a Corn and Soy Biotech Proficiency Program, wherein FGIS seeks to improve the overall performance of testing for GE grains and oilseeds. The FGIS proficiency program report contains inter-laboratory comparisons to determine the performance of individual laboratories' ability to detect and/or quantify transgenic traits in corn or soy as well as to monitor laboratories' continuing performance. The program does not assess the effectiveness of different detection methods for GE traits, nor does it determine the characteristics of fortified samples to a particular degree of accuracy. However, the FGIS Proficiency Program helps organizations identify areas of concern and take corrective actions to improve testing precision, capability, and reliability.

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 700 different pesticide residues. In FY 2020, PDP tested nearly 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 inform its targeted surveillance activities. 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 are also considered by the Codex Alimentarius Committee on Pesticide Residues to assist in benchmarking international Maximum Residue Levels (MRLs), as PDP is one of the largest sources for food pesticide residue data available.

Animal and Plant Health Inspection Service (APHIS): Feral Swine Management Tool Development

Invasive feral swine have been reported in at least 35 states in the United States, causing major damage to property, agriculture (crops and livestock), native species and ecosystems, and cultural and historic resources. The National Wildlife Research Center (NWRC) Feral Swine Research Project (FSRP) is participating in multiple partnerships that are leading to significant advances in toxicant and toxicant delivery systems and machine learning for use in feral swine damage management. In addition, scientists in this group have received national recognition for authoring seminal publications on feral swine damage management issues.

In FY 2020, the FSRP partnered with private business in two separate CRADAs aimed at developing new tools for feral swine management. The first CRADA, which began several years ago, is with an Australian vertebrate pesticide manufacturing company. It focuses on the

development and registration of a toxicant for use in feral swine management. The 9-year effort has resulted in two toxicant formulations. The first formulation is registered for use in Australia and is seeing promising results and sales. The second formulation is for use in the United States. The Australian company is looking to establish U.S.-based manufacturing capabilities by either constructing a new manufacturing facility or contracting with an existing U.S. pesticide manufacturer. This collaboration also resulted in a patent-pending, swine-specific feeding station that prevents most other wildlife from accessing bait.

The second FSRP CRADA is with a U.S. company and focuses on the development of a recognition system to identify feral swine as they approach a feeding station. This CRADA uses two unique recognition systems, acoustic and visual, to distinguish feral swine from other species, such as deer, bear, or raccoon. When a positive identification is made, a mechanism on the feeding station is unlocked allowing the pig to access the bait. The combination of the toxicant, feral swine feeder and feral swine recognition system will yield valuable new tools for feral swine management.

In another collaboration, FSRP worked with computer scientists from a western university to develop software that analyzes images from motion-activated cameras (also known as camera traps or trail cameras) which remotely observe wildlife, including feral swine. Trail cameras can produce thousands of images which must be individually inspected to determine if the species of interest is in a photo. Machine learning was used to quickly and accurately review and classify images. NWRC and APHIS' Veterinary Services, as well as State, non-profit, and university partners, used more than 3 million known wildlife images to train and test a deep-learning model to classify species of wildlife captured on camera traps. The trained model classified approximately 2,000 images per minute and achieved 98-percent accuracy in identifying U.S. wildlife species, the highest accuracy of such a model to date. The free tool, available as an R package (Machine Learning for Wildlife Image Classification), allows users to either use the existing trained model, or train their own model using images of wildlife from their studies. This system speeds up the analysis and evaluation of the types of wildlife attracted to and accessing the bait stations, which aids in the bait station design.

In recognition of their expertise and leadership in the field of feral swine damage management, FSRP scientists were finalists for the FY 2020 APHIS Scientist of the Year Award. They were acknowledged for their contributions to the development of "Invasive Wild Pigs: Ecology, Impacts and Management," a comprehensive, 480-page reference book on invasive feral swine. Nominees were judged on the following criteria: scientific impact, scientific collaborative spirit, fostering an exceptional scientific work environment, supporting science in APHIS' mission, and external scientific recognition. The book was also named The Wildlife Society's 2020 Wildlife Publication of the Year in the Edited Book Category.

Agricultural Research Service (ARS): Non-inherited changes in DNA due to diet are associated with cardiovascular disease risk factors and all-cause mortality

Although genetics is known to play a role in heart disease and expected lifespan, there are also changes to genetic material that are not inherited. Such changes include binding of methyl groups to DNA, which changes the expression, or activity, of various genes. ARS-supported scientists in both Boston, MA, and Houston, TX, took part in a consortium that analyzed blood

samples from 6,662 individuals with European ancestry, 2,702 with African ancestry, and 360 with Hispanic ancestry. In individuals with European ancestry, habitual diet quality was associated with differential methylation levels in sites on DNA of white blood cells, most of which were also associated with multiple health outcomes. These findings demonstrate that integration of genomic analysis with dietary information may reveal molecular targets for disease prevention and treatment that are amenable to improved dietary choices.

Economic Research Service (ERS): Atlas of Rural and Small-Town America
Policymakers and the public are provided with easily accessible data on rural areas and issues through the ERS Atlas of Rural and Small-Town America (https://www.ers.usda.gov/data-products/atlas-of-rural-and-small-town-america). The online mapping tool provides county-level information on over 110 statistical indicators on the people, jobs, agriculture, and county characteristics of rural (nonmetropolitan) America. The Atlas helps State and local decision makers pinpoint the needs of particular areas, recognize their diversity, and develop strategies to build on their assets by using location-based data on population, age structure, race and ethnicity, income, employment, indicators of well-being, and other measures. In FY 2018, the Atlas was updated with the most recent information on veterans, education, migration, and income from the American Community Survey. In FY 2019, the Atlas was updated with the most recent county-level information on population, employment, poverty, veterans, education, migration, and income from the Census Bureau and the Bureau of Labor Statistics. In FY 2020, ERS continued to update the Atlas to include annual unemployment and employment data for 2019. New features were added to improve functionality and users' ability to delineate rural and urban data for reporting and analysis.

Forest Service (FS): Approval of cross laminated timber shear wall system in U.S. codes
Cross laminated timber (CLT) is an innovative mass timber product that has now been commonly accepted as a new-generation engineered wood product with great potential to expand the wood building market. With the introduction of CLT to the U.S. construction market and the current modern urbanization trend, many believe that it can serve as a very effective solution for commercial and mixed-use building markets in seismic regions. The purpose of this study was to facilitate recognition of CLT seismic system in the U.S. building codes for the first time in 50 years.

CLT offers many advantages such as the potential for mass production, prefabrication, speed of construction, and sustainability as an environmentally friendly and renewable construction product. Good thermal insulation, acoustic performance, and fire ratings are some additional benefits of the system. Despite these advantages, the lack of a current design approach is one of the challenges inhibiting widespread adoption of CLT in North America.

One area that requires attention is the development of seismic performance factors for CLT lateral systems so designers in the U.S. can begin to utilize CLT shear walls in seismic regions. CLT-based Seismic Force Resisting Systems (SFRS) are not recognized in current U.S. design codes. The study follows a systematic approach that integrates design method, experimental results, nonlinear static and dynamic analyses, and incorporates uncertainties. The research consists of various development phases that encompass archetypes, design methodology, component and system testing, nonlinear structural modeling, and incremental time history

analyses. All phases of development resulted in both the structural design procedure and associated seismic design parameters for the first approved wood-based lateral force resisting system in over 50 years.

The design procedure and seismic design parameters were approved by the Building Seismic Safety Council of the National Institute of Building Sciences in the spring of 2020. While the CLT shear wall design procedure was approved in July 2020 for the next version of the Special Design Provisions for Wind and Seismic, approval of the seismic design parameters for inclusion in the next version of ASCE 7 Minimum Design Loads and Associated Criteria for Buildings is ongoing. This final approval will result in the CLT shear wall lateral restrain systems to be in all U.S. building codes (such as the International Building Code). It will also eliminate the highest priority structural need as identified on the first Mass Timber needs assessment.

National Agricultural Statistics Service (NASS): Geospatial Products
NASS completed its 48-state Cropland Data Layer (CDL) in 2020 for the 2019 crop year, making 12 years of national CDLs available. This layer provides information on the crops planted and is useful in land cover, animal habitat, and watershed monitoring; soils utilization analysis and agribusiness planning; addressing biodiversity, crop intensity, and agricultural sustainability concerns; environmental research; and the remote sensing and Geographical Information System (GIS) value-added industry. The 48-state Crop Frequency Layers for corn, soybeans, wheat, and cotton were released in 2020 for the 2019 crop season. These layers identify crop-specific planting frequency and are based on land cover information derived from the 2008 through 2019 CDLs. NASS has been working collaboratively with the USDA Agricultural Research Service (ARS) to modernize the publicly available end-of-year CDL, which is published on a web portal as CropScape, as it is moved to the USDA cloud.

NASS, in collaboration with NASA and the ARS, developed a new geospatial portal, Crop Condition and Soil Moisture Application (Crop-CASMA), which is hosted at George Mason University (https://cloud.csiss.gmu.edu/Crop-CASMA). Crop-CASMA provides daily and weekly top and sub soil volumetric measurements; the measurements have been calibrated to the categorical moisture assessments presented in the weekly NASS Crop Progress and Condition Report. This product facilitates early determination of drought stress and excessive water or inundation. NASS continues to provide its 48-State VegScape portal, which is a geospatial data service offering automated updates of vegetative condition at daily, weekly, and biweekly intervals. The VegScape and Crop-CASMA portals are in the process of integrating soil moisture and vegetation condition quantitative observations to inform on crop change dynamics.

Geospatial decision support products were derived and provided for rapid response to assess flooded areas and identify potential crop losses caused by the 12 named storms to make landfall in the contiguous U.S. during 2020. 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 has been posted

on the NASS website for public dissemination at https://www.nass.usda.gov/Research_and_Science/Disaster-Analysis/index.php. 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): Large Scale Conditioning and Transport of Maize Pollen

Accelerated Ag Technologies (AAT, dba PowerPollen®) developed protocols for large scale conditioning and transport of maize pollen suitable for field applications. The company collaborated with agricultural manufacturing firms to construct and deploy commercial-scale pollen collectors and PowerPollen applicators for parent seed fields and commercial hybrid seed fields. New technology developed enabled the conditioning, preservation, and storage of massive amounts of maize pollen. This novel technology generated new IP now listed under patents US20170238535A1 and US20190008144A1. From 2018 to 2020, AAT deployed PowerPollen across several commercial customers. The company entered into a long-term commercial license agreement in 2021, driven by the technology innovation.

Natural Resources Conservation Service (NRCS): Addressing Priority Pandemic Response Issues: Animal Mortalities Management

In early April 2020, COVID-19 diagnoses among workers at multiple large meat packing plants caused major concern for the livestock industry, particularly for pork producers. Due to the just-in-time nature of modern livestock production, closure of slaughter facilities could easily leave producers with animals that were too large to keep on farm and could not be sold for meat.

Producer organizations warned that growers could be faced with no other option but to euthanize large numbers of animals, primarily hogs. These carcasses would need to be disposed of in an environmentally responsible manner. Dairy producers were facing a similar issue with surplus milk that could not be marketed due to closures of major customers, including schools. The USDA Animal and Plant Health Inspection Service (APHIS) requested assistance from NRCS to help develop guidance for these livestock producers. The NRCS National Animal Manure and Nutrient Management Team was assigned to coordinate the agency response and requested assistance from agency soil scientists. They quickly identified two existing soil interpretations directly related to livestock carcass disposal, which were included in the initial guidelines presented and provided to NRCS staff within a week.

Within a few days of this initial response, APHIS asked NRCS for additional assistance to support a new carcass disposal method called shallow burial. This method, which combined aspects of traditional burial and composting, was believed to be more acceptable to farmers, since it required less time and did not require special equipment. APHIS also requested information from NRCS to inform disposal of excess milk that was accumulated on farm in response to market disruptions. NRCS national and regional soil scientists incorporated APHIS-provided criteria for shallow burial into a new soil interpretation based on the format of existing related interpretations. Working collaboratively with the Connecticut State soils staff, they also developed a national milk disposal interpretation based on their existing State-specific prototype. Soil and Plant Science Division (SPSD) spatial analysis staff then developed maps and tabular information for both interpretations and made it available to all State soil scientists through an

easily accessible web portal. In addition, this new information, along with the types and scope of assistance soil scientists should provide to agency field, area, and State staff was presented on a national webinar accompanied by written guidelines.

Fortunately, livestock producers proved to be very innovative and meat packing plants reopened in short order. This prevented the need for widespread carcass disposal. However, these materials will remain available to speed agency response to future emergencies.

Department of Commerce (DOC)

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

DOC conducts research and development (R&D) in areas of science and technology at the laboratory facilities of NIST, NOAA, and 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.

DOC is also responsible for organizing technology transfer activities across Federal agencies. Through NIST, DOC supports the interagency technology transfer community by serving as Co-Chair of the National Science and Technology Council's Lab-to-Market Subcommittee (L2M), host agency for the Federal Laboratory Consortium (FLC), and convener of the Interagency Working Group for Technology Transfer (IAWGTT) and the Interagency Working Group on Bayh-Dole (IAWGBD), and it issues implementing regulations for the Bayh-Dole Act.

As a Co-Chair and the Executive Secretariat for L2M, DOC, through NIST, sets the high-level strategies for increasing the efficiency at which federally funded technologies move out of the laboratories and into the market. Current strategies include identifying administrative and regulatory impediments, increasing engagement with innovation ecosystems, sponsoring innovative technology transfer tools and services, and finding gaps in the R&D continuum. Implementing these strategies is accomplished through the work of several subgroups such as the FLC, the IAWGTT, and the IAWGBD.

DOC coordinates the IAWGTT, a NIST-hosted interagency discussion group that focuses on policy, new approaches to technology transfer, and lessons learned from agency technology transfer programs.[29] The IAWGTT was established in 1987 by Executive Order 12591, Section 7, to "convene an interagency task force comprised of the heads of representative agencies and the directors of representative Federal laboratories, or their designees, in order to identify and disseminate creative approaches to technology transfer from Federal laboratories."

NIST also serves as the host agency for the FLC, which provides a forum for Federal labs to develop strategies and opportunities for linking technologies and expertise with the marketplace.

[29] 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.

The FLC operates as a quasi-governmental body, founded in statute (15 U.S. Code § 3710), that shares technology transfer best practices, develops promotional materials, facilitates partnerships, and organizes networking events. The mission of the FLC is "To increase the impact of Federal laboratories' technology transfer for the benefit of the U.S. economy, society, and national security."[30] Through the various resources, education and training, tools, and services the FLC creates and provides its members, Federal labs are better able to create partnerships, navigate the commercialization process, and achieve market success.

As the agency tasked with promulgating the Bayh-Dole regulations, DOC through NIST also coordinates the IAWGBD.[31] The IAWGBD reviews and discusses issues related to Bayh-Dole, including potential amendments to the Bayh-Dole regulations, and the alignment and coordination of Bayh-Dole policies across agencies. Recently, the IAWGBD has been reviewing the implementation of changes to the iEdison reporting system to ensure the system adheres to regulatory requirements as well as agency needs. iEdison is an interagency system used by over 30 agencies and bureaus to facilitate the reporting of inventions and patents that were conceived or first actually reduced to practice using extramural Federal research funding. NIST redesigned and modernized the iEdison system prior to the transfer of the management and maintenance of the system from NIH to NIST in 2022. NIST's improvements to iEdison are expected to bring increased reporting compliance and improved tracking of the utilization of these federally funded inventions including information on where resulting products are being manufactured.

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

NIST | NOAA | ITS

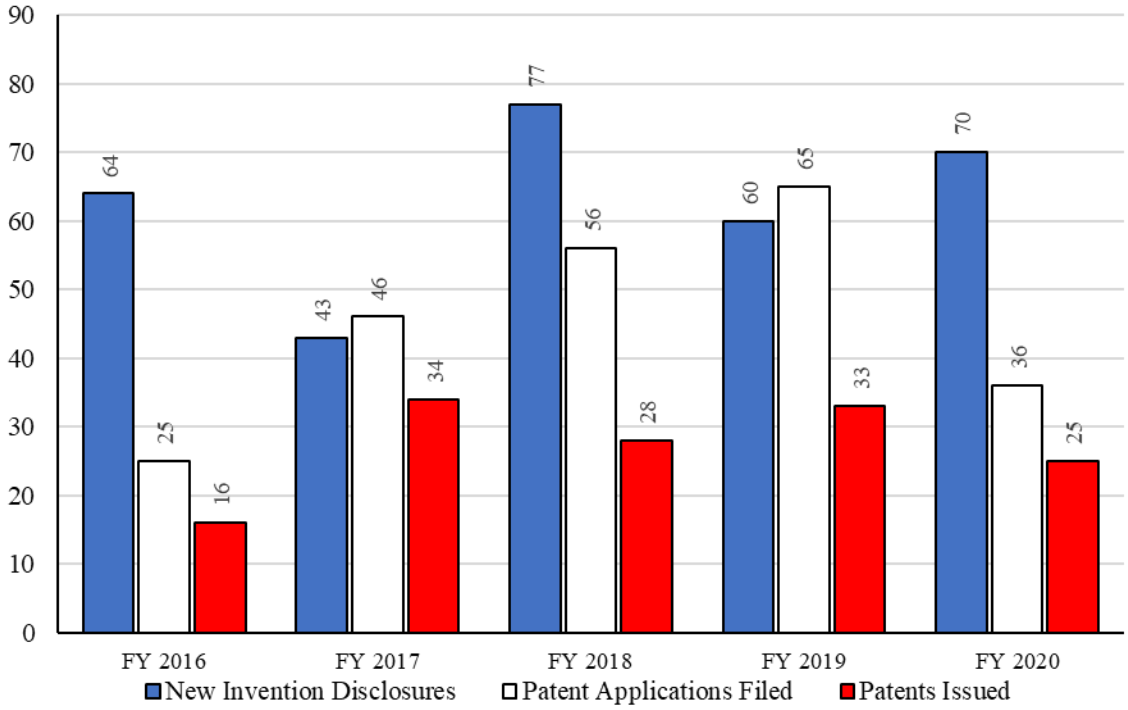
[30] https://federallabs.org/about/who-we-are/mission-vision

[31] The IAWGBD was formed to facilitate a response to 35 U.SC. 206 and included representatives from across the federal government including individuals from 14 federal agencies, the Executive Office of the President, and the White House Office of Science and Technology Policy.

DOC Invention Disclosures and Patenting

Between FY 2016 and FY 2020, new inventions disclosed increased by 9%, from 64 in FY 2016 to 70 in FY 2020. Patent applications filed increased by 44%, from 25 in FY 2016 to 36 in FY 2020. Patents issued increased by 56%, from 16 in FY 2016 to 25 in FY 2020.

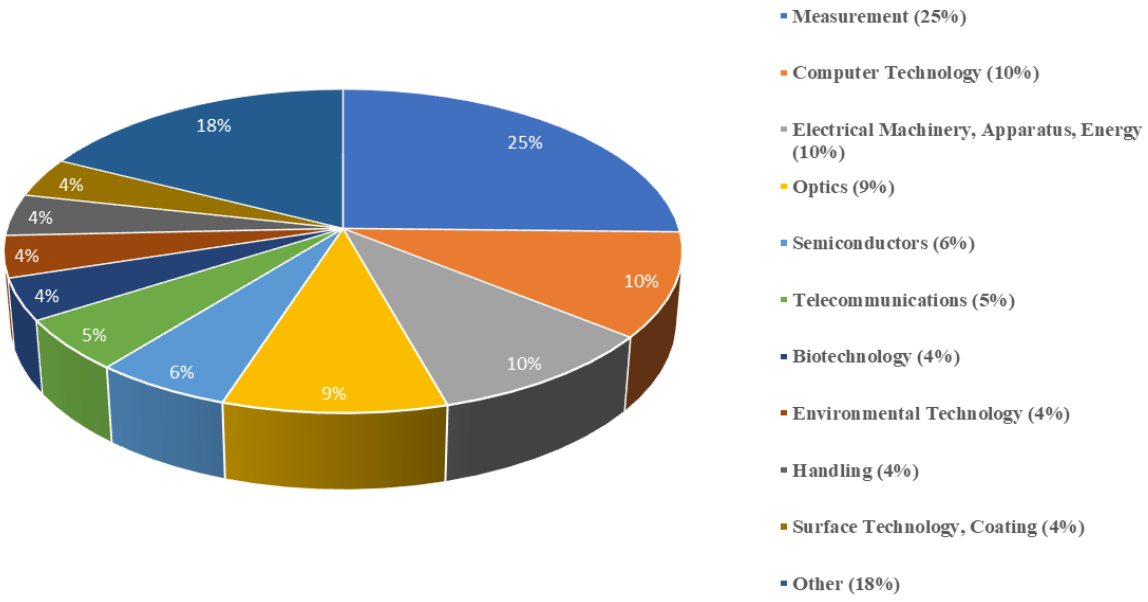
DOC Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	64	43	77	60	70
Patent Applications Filed	25	46	56	65	36
Patents Issued	16	34	28	33	25

Patents issued to DOC in FY 2020 covered many technology areas including Measurement (25%); Computer Technology (10%); Electrical Machinery, Apparatus, Energy (10%); Optics (9%); and Semiconductors (6%).[32]

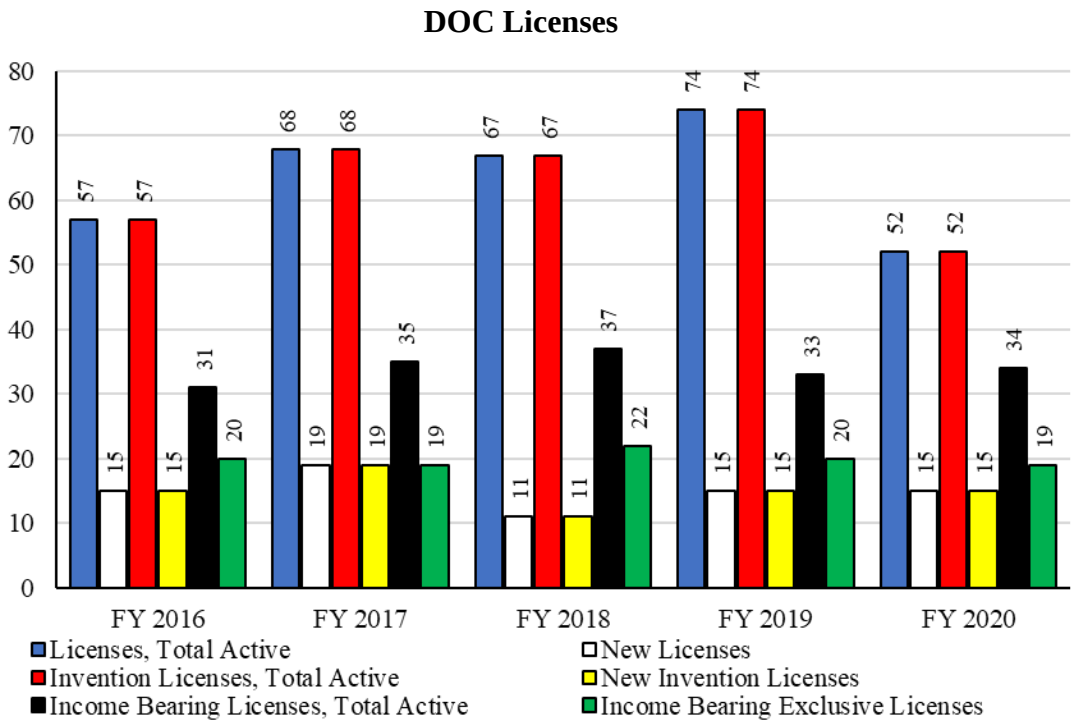
USPTO Patents Assigned to DOC by Technology Area: FY 2020



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

DOC Licenses

Total active licenses decreased by 9%, from 57 in FY 2016 to 52 in FY 2020. New licenses did not increase or decrease, with 15 in FY 2016 and 15 in FY 2020. All licenses were invention licenses. Total active income bearing licenses increased by 10% to 34, while income bearing exclusive licenses decreased by 5% to 19.

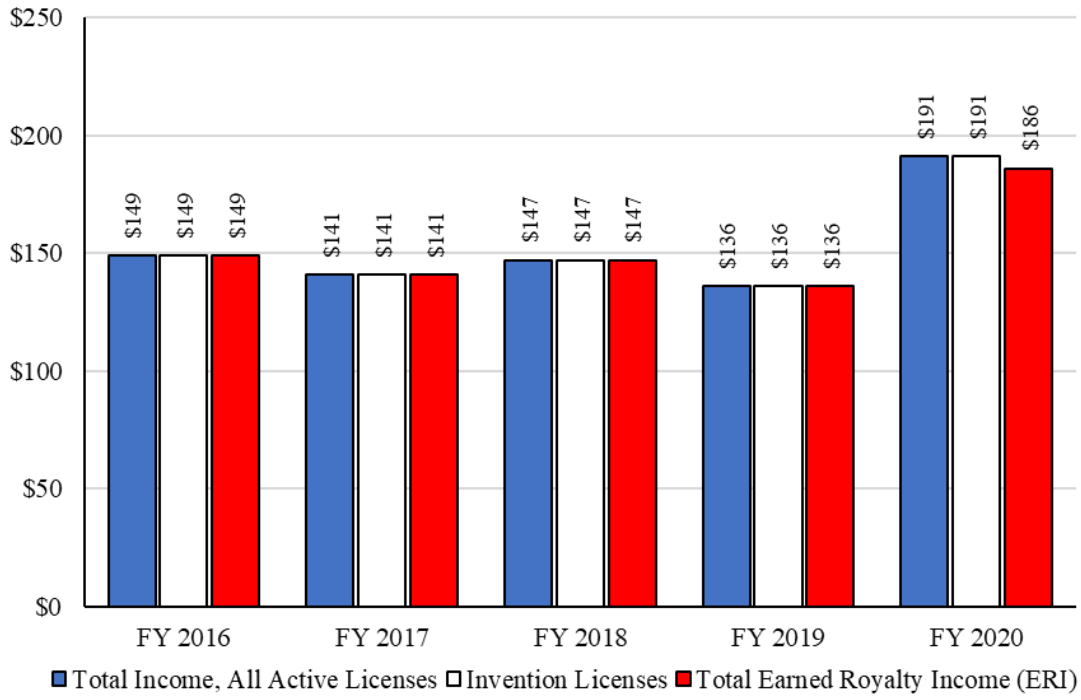


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	57	68	67	74	52
New Licenses	15	19	11	15	15
Invention Licenses, Total Active	57	68	67	74	52
New Invention Licenses	15	19	11	15	15
Income Bearing Licenses, Total Active	31	35	37	33	34
Income Bearing Exclusive Licenses	20	19	22	20	19

DOC Income from Licensing

DOC reported that all income from licensing comes from invention licenses. During the five-year period from FY 2016 to FY 2020, there was a 28% increase in total income from all active licenses, from $149 thousand in FY 2016 to $191 thousand in FY 2020. There was a 25% increase in earned royalty income, from $149 thousand in FY 2016 to $186 thousand in FY 2020.

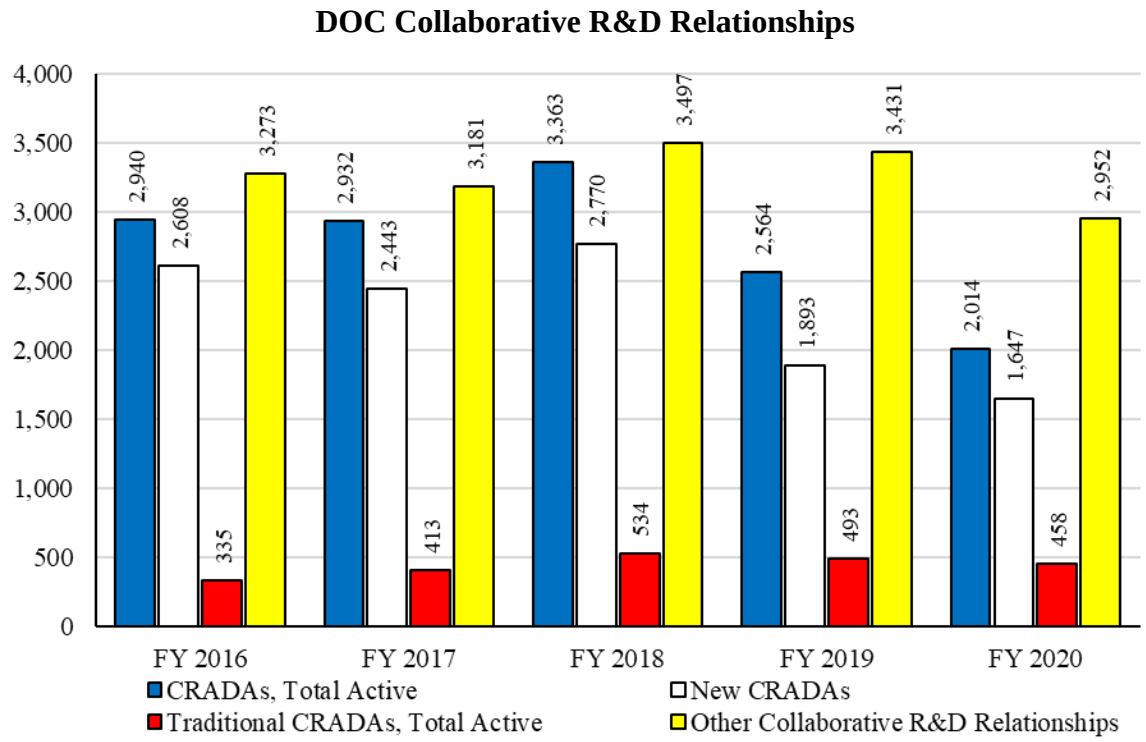
DOC Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$149	$141	$147	$136	$191
Invention Licenses	$149	$141	$147	$136	$191
Total Earned Royalty Income, (ERI)	$149	$141	$147	$136	$186

DOC Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs decreased by 31% to 2,014 agreements, while new CRADAs decreased by 37% to 1,647. Traditional CRADAs increased 37%, from 335 in FY 2016 to 458 in FY 2020. Other collaborative R&D relationships decreased by 10%, from 3,275 in FY 2016 to 2,952 in FY 2020.

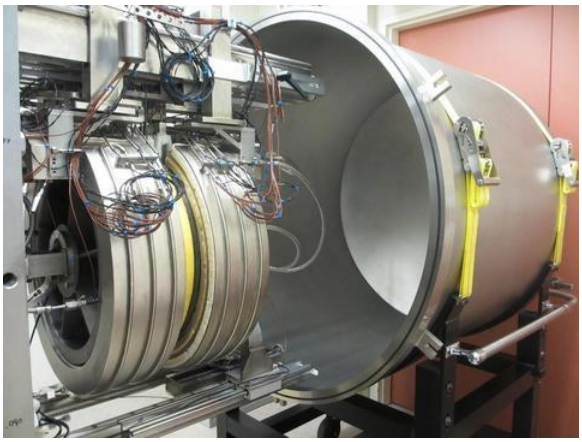


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	2,940	2,932	3,363	2,564	2,014
New CRADAs	2,608	2,443	2,770	1,893	1,647
Traditional CRADAs, Total Active	335	413	534	493	458
Other Collaborative R&D Relationships	3,273	3,181	3,497	3,431	2,952

DOC Downstream Success Stories

NIST: SRM in Space

NIST's thermal insulation standard reference materials (SRMs) are used to evaluate commonly used insulation materials such as cellular plastics, fiberglass, or mineral wool for buildings. But NIST's thermal insulation SRM played a role in helping the European Space Agency and Japanese Aerospace Exploration Agency test their BepiColombo probe that is headed to Mercury. To keep cool around all the radiation in space, the craft needs to collect heat with solar panels, transfer it through the panel's supporting structures, and push it back out into the stellar beyond.



How it works: Researchers check the SRM and our printout of its properties against their own guarded hotplate (like the NIST one shown here). Source: NIST.

The NIST SRM allowed the agencies to determine if their probe's materials were up to the task of cooling the craft. The researchers used NIST's SRMs to make sure their own test methods were accurate. This helped the agencies' scientists ensure that the supporting structures were doing what they were designed to do.

NIST: NIST and OSTP Launch Effort to Improve Search Engines for COVID-19 Research

In the first months of the COIVD-19 pandemic, researchers, clinicians, and policy makers involved with the response to COVID-19 needed reliable information on the virus and its impact. NIST and the White House Office of Science and Technology Policy (OSTP) launched a joint effort to support the development of search engines for research to help in the fight against COVID-19.[33] This project was launched on April 15, 2020, in response to the March 16, 2020 White House call to action for a new machine readable COVID-19 Dataset.[34] The result of this effort was the TREC-COVID Challenge, a collaboration among the Allen Institute for Artificial Intelligence (AI2), the National Institute of Standards and Technology (NIST), the National Library of Medicine (NLM), Oregon Health & Science University (OHSU), and the University of Texas Health Science Center at Houston (UTHealth).

TREC-COVID was based on the Text Retrieval Conference (TREC) model. In the TREC model, NIST provides a test set of documents and questions. Research organizations that choose to participate run their own retrieval systems on the data and return to NIST a list of the retrieved top-ranked documents. NIST pools the individual results, judges the retrieved documents for correctness, and evaluates the results. The TREC cycle ends with a workshop that is a forum for participants to share their experiences.

[33] https://www.nist.gov/news-events/news/2020/04/nist-and-ostp-launch-effort-improve-search-engines-covid-19-research

[34] https://trumpwhitehouse.archives.gov/briefings-statements/call-action-tech-community-new-machine-readable-covid-19-dataset/

TREC-COVID built a set of Information Retrieval (IR) test collections based on the COVID-19 document sets. The document set used in the TREC-COVID Challenge was the COIVD-19 Open Research Dataset (CORD-19). TREC-COVID consisted of a series of five rounds, with each round using a later version of the document set and a larger set of COVID-related topics. Participants in a round created ranked lists of documents for each topic ("runs") and submitted their runs to NIST. The fifth, and final round of data releases was on July 16, 2020, four months after the original call to action.

The final document and topic sets, together with the cumulative relevance judgments, comprise a COVID test collection called TREC-COVID Complete. The incremental nature of the collection as viewed through the successive rounds supports research on search systems for dynamic environments. The results of the TREC-COVID Challenge helped researchers find answers for critical questions about COVID-19 and created infrastructure to improve tomorrow's search systems.

NOAA: Mayday.ai Applies Artificial Intelligence to NOAA Satellite Imagery to Detect Natural Disasters, Starting with Wildfires

NOAA's Big Data Program, which was launched in 2016, provided the general public with the ability to access and analyze near real-time data feeds from NOAA satellites and other NOAA data sources via the major U.S. Cloud Service Platforms. This access eliminated the need for a satellite dish and a supercomputer to analyze and develop products and services from these data. This low-cost access to near real-time data, together with the powerful computing resources and advanced AI technology available on the Cloud Service Providers' platforms, has opened the door for small startups and innovators, such as California-based startup Mayday.ai.

Mayday.ai was founded in May 2018 with the mission to help save lives, reduce costs and impacts of disasters, and protect the environment. Using multiple resources, including satellites, traffic cameras, and social media, Mayday.ai has developed a cloud-based platform which can provide centralized early warning and dispatch for first responders and emergency managers combating high-impact events, such as wildfires.

The 2020 fire season was unprecedented in California, Oregon, and beyond, which put Mayday.ai's concept quickly to the test and provided multiple opportunities to evaluate and fine tune this early-warning technology. Mayday.ai has been training its analysis engine using Machine Learning to see through partial clouds, which has enabled Mayday.ai to detect a high proportion of wildfire events up to 15 minutes after starting and well in advance of 911 calls reporting the incidents.

NTIA ITS: Innovative Commercial Services

NTIA's ITS research, technology transfer, and testing was critical to the successful commercial deployments of the new Citizens Broadband Radio Service (CBRS) and $4.6 billion auction of licenses within CBRS in FY2020. Under CRADAs with industry partners, ITS conducted certification testing on environmental sensing capability sensors (ESC) and spectrum access systems (SAS). These test reports paved the way for the FCC, after consultation with the DoD and NTIA's Office of Spectrum Management (OSM), to authorize initial commercial operations at 3.5 GHz on September 16, 2019. Subsequent real-world deployments proved the ITS testing

regime successful, enabling the FCC to authorize full commercial service in 2020, and to conduct a $4.6 billion auction of priority access licenses within the CBRS band.

When the FCC, in consultation with NTIA, created the innovative three-tiered access and authorization framework to accommodate shared Federal and non-Federal use of the 3.5 GHz band, no roadmap existed for creating and authorizing the new sharing system between high power Federal radars and commercial mobile services. Broadly and openly disseminated ITS research and publications on electromagnetic compatibility between LTE and radars, LTE hotspot emission measurements, on-shore detections of off-shore radars, and effects of high-power radars on low noise amplifiers informed the development of technical requirements and commercial solutions.

Initial estimates indicated that geographically very large exclusion zones would be needed to protect Federal maritime radars from harmful interference from commercial wireless networks, precluding access to new services for nearly 60% of the U.S. population. ITS, working with NTIA's OSM, conducted analyses to decrease the initial exclusion zones by 77%. ITS worked closely with WInnForum to analyze the methodology they proposed to further facilitate dynamic protection and sharing, opening up more population-dense coastal geographic areas where commercial services could co-exist with Federal radars and making a commercial service in the band economically viable.

ITS worked with the industry-led standards organization on applying those analyses in the development of technical standards for a technology-neutral commercial broadband service, including providing critical propagation software through publication of the C++ implementation of the eHata propagation model. At the request of the FCC, ITS developed a certification testing system for ESCs critical for protection of Federal radar systems, and conformance tests for the SAS that leveraged the WInnForum SAS certification system. ITS published a technical memorandum detailing procedures and processes for ESC testing and published a SAS test software-based study guide via GitHub.

Department of Defense (DoD)

The U.S. Department of Defense (DoD) is the largest employer of scientists and engineers in the United States, with over 50,000 of these professionals working in over 60 defense laboratories, warfare centers, and engineering centers. As these technology hubs pursue next-generation capabilities to give the U.S. military a decisive technical edge, they tackle an immense diversity of research, development, and engineering projects. Activities range from research in basic biology, chemistry, engineering, and materials, to development of preventative and therapeutic medications for humans and animals, to projects aimed directly at meeting DoD's near- and long-term challenges, such as the development and testing of advanced weapons systems.

While all of the defense laboratory activities can be distilled to one essential mission—"support the Warfighter"—the work of DoD scientists and engineers finds many uses that extend beyond strictly military applications. Numerous technologies that have become indispensable for daily life, such as the internet, smartphones, and the Global Positioning System (GPS), were initially developed in DoD laboratories and made their way into the public sphere through technology transfer (T2) processes and activities. Offices facilitating T2 exist throughout DoD and the Military Departments, providing support to DoD scientists and engineers. The T2 professionals in these offices use the full spectrum of authorities available to them to move innovation out of Government labs and bring innovation in from academia, industry, and the private sector.

Policy for and oversight of T2 is managed through the Laboratories and Personnel Office (L&PO) within the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)). This office is responsible for the collection and reporting of the metrics found in this chapter. Additionally, this office convenes and chairs the Laboratory Quality Enhancement Program panel on Tech Transfer (LQEP-T2) established by Congress in the National Defense Authorization Act for Fiscal Year 2017 (Public Law 114-328). The panel is comprised of representatives from all of the Components actively engaged in T2.[35] This forum gives the participants the opportunity to convey best practices, discuss challenges, and provide support to one another, while allowing L&PO to develop policy, as well as solicit comments on proposed policy changes originating from interagency working groups. The cooperative partnership between L&PO and the LQEP-T2 panel members help to shape the future of technology transfer and transition for the Department.

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.

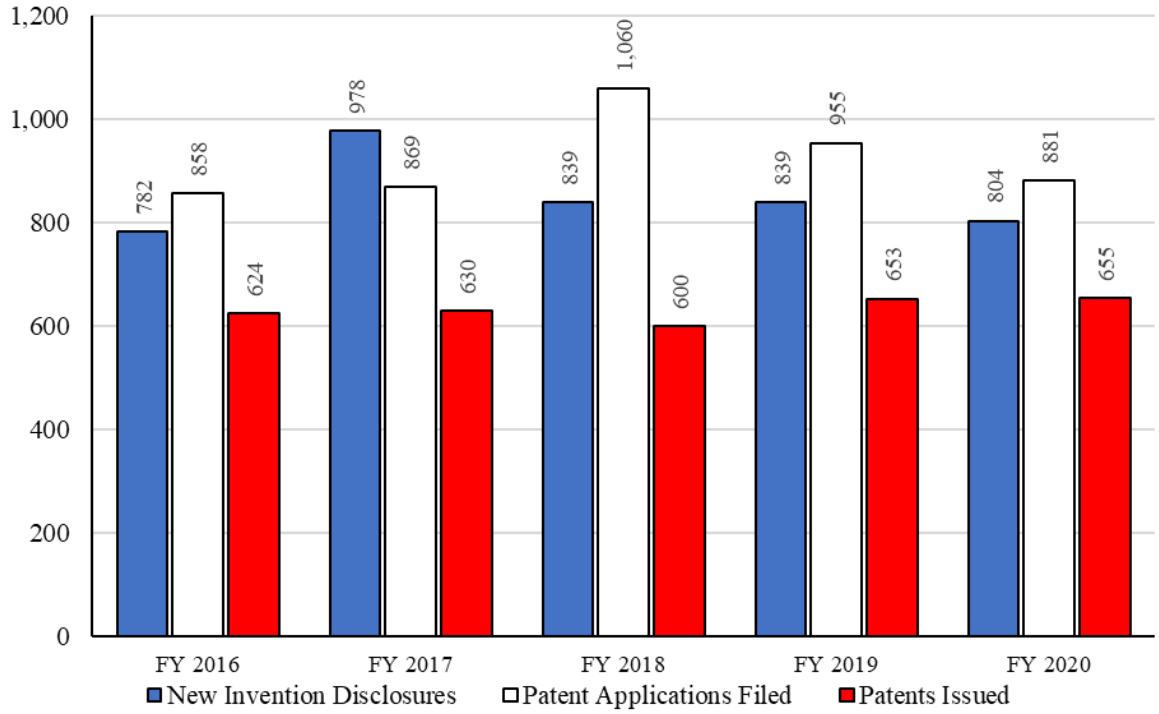
DoD Research & Engineering Enterprise
U.S. Army Research Laboratory
Office of Naval Research

[35] DoD components are defined as: The Office of the Secretary of Defense (OSD); the military departments; the Joint Chiefs of Staff (JCS or Joint Staff); the combatant commands; the Office of the Inspector General, Department of Defense (DoDIG); the Defense agencies; and DoD field activities. https://samm.dsca.mil/glossary/dod-components

DoD Invention Disclosures and Patenting

Between FY 2016 and FY 2020, new inventions disclosed increased by 3%, from 782 disclosures in FY 2016 to 804 disclosures in FY 2020. Patent applications filed increased by 3%, from 858 in FY 2016 to 881 in FY 2020. Patents issued increased by 3%, from 624 patents in FY 2016 to 655 patents in FY 2020.

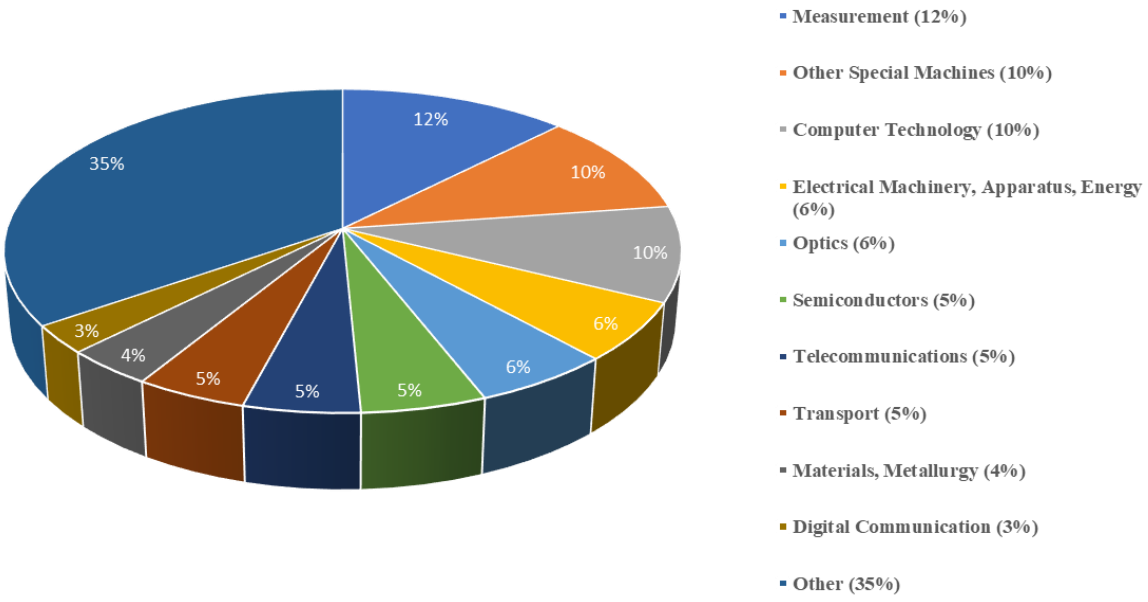
DoD Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	782	978	839	839	804
Patent Applications Filed	858	869	1,060	955	881
Patents Issued	624	630	600	653	655

Patents issued to DoD in FY 2020 covered many technology areas including the top categories of Measurement (12%); Other Special Machines (10%); Computer Technology (10%); Electrical Machinery, Apparatus, Energy (6%); and Optics (6%).[36]

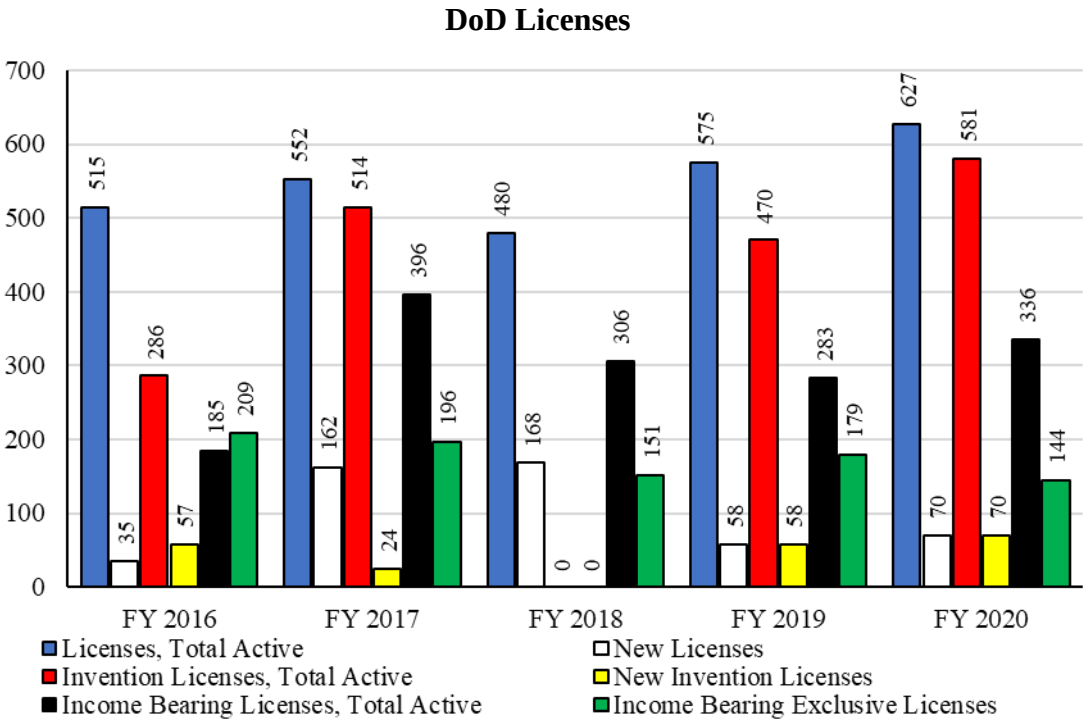
USPTO Patents Assigned to DoD by Technology Area: FY 2020



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

DoD Licenses[37]

Total active licenses increased by 22%, from 515 licenses in FY 2016 to 627 licenses in FY 2020, while new licenses increased by 100%, from 35 in FY 2016 to 70 in FY 2020. From FY 2016 to FY 2020, total active invention licenses increased by 103% to 581 and new invention licenses increased by 23% to 70. From FY 2016 to FY 2020, total active income bearing licenses increased by 82% to 336.

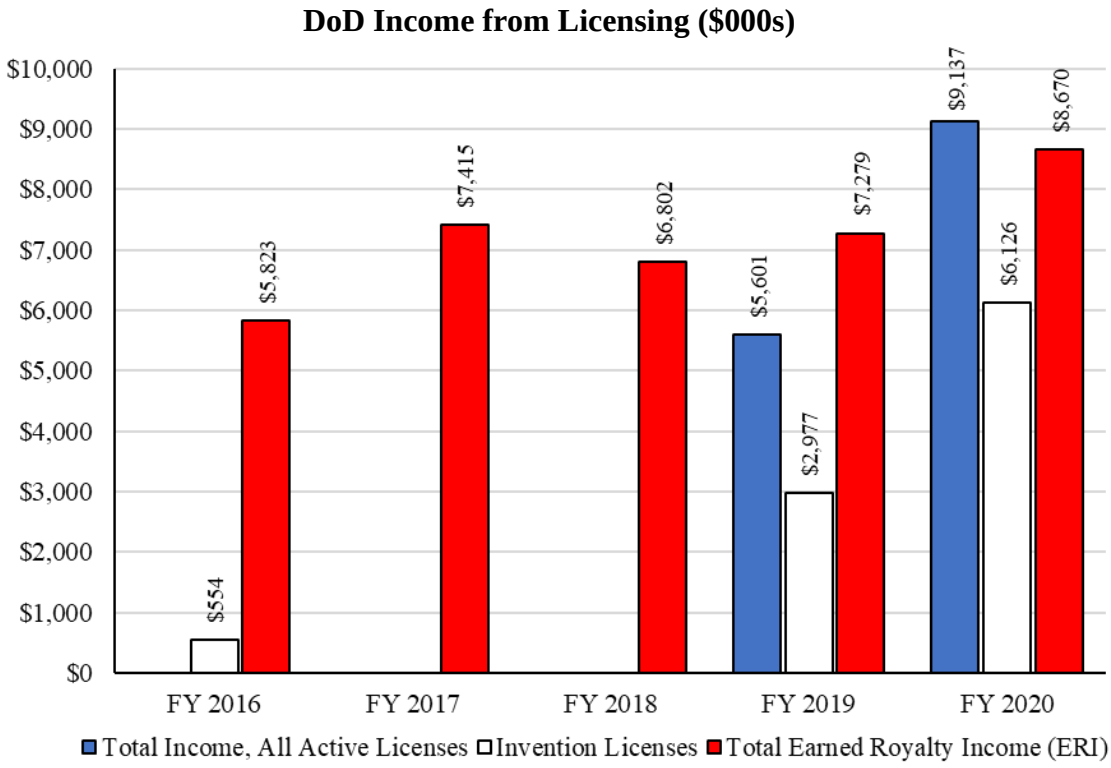


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	515	552	480	575	627
New Licenses	35	162	168	58	70
Invention Licenses, Total Active	286	514	n.a.	470	581
New Invention Licenses	57	24	n.a.	58	70
Income Bearing Licenses, Total Active	185	396	306	283	336
Income Bearing Exclusive Licenses	209	196	151	179	144

[37] 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[38]

In FY 2020, total income from all active licenses was $9.1 million. Income from invention licenses was $6.1 million in FY 2020. Total earned royalty income increased by 49%, from $5.8 million in FY 2016 to $8.6 million in FY 2020.

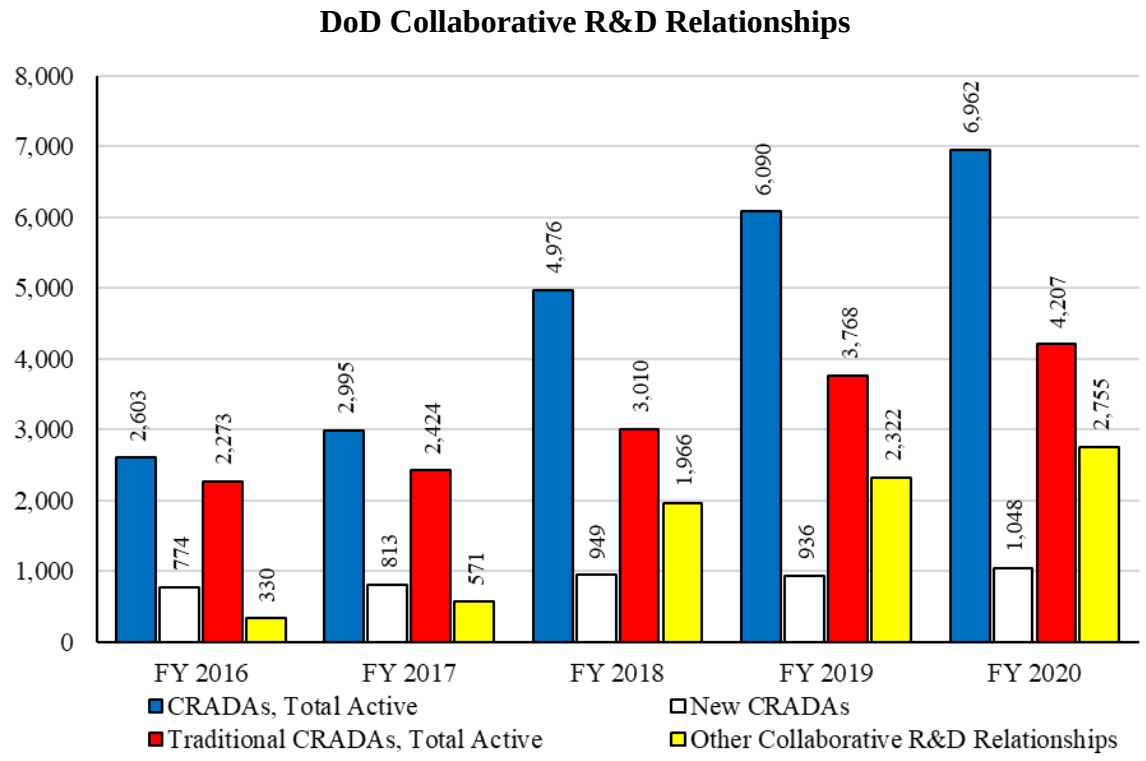


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	n.a.	n.a.	n.a.	$5,601	$9,137
Invention Licenses	$554	n.a.	n.a.	$2,977	$6,126
Total Earned Royalty Income, (ERI)	$5,823	$7,415	$6,802	$7,279	$8,670

[38] 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 2016 and FY 2020, total active CRADAs increased by 167%, from 2,603 in FY 2016 to 6,962 in FY 2020, while new CRADAs increased by 35%, from 774 in FY 2016 to 1,048 in FY 2020. Traditional CRADAs increased by 85%, from 2,273 in FY 2016 to 4,207 in FY 2020. Other collaborative relationships increased by 735%, from 330 in FY 2016 to 2,755 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	2,603	2,995	4,976	6,090	6,962
New CRADAs	774	813	949	936	1,048
Traditional CRADAs, Total Active	2,273	2,424	3,010	3,768	4,207
Other Collaborative R&D Relationships	330	571	1,966	2,322	2,755

DoD Downstream Success Stories

Air Force: Multi-Modal Communication

A sensory psychologist and technology transfer specialist in the Air Force Research Laboratory's 711th Human Performance Wing were selected for a 2020 Excellence in Technology Transfer Award by the Federal Laboratory Consortium (FLC) for Technology Transfer for Multi-Modal Communication (MMC). Drs. Brian Simpson and James Kearns were selected for the successful technology transfer of MMC, which is a system invented to manage complex communication environments.

"This award is very meaningful to our team," said Simpson, a sensory psychologist with 711 HPW and one of the inventors of MMC. "We've always believed in this technology as it clearly has the potential to not only enhance effectiveness for Air Force operations, but also for the civilian world. It can truly support life-saving capabilities across multiple military and civilian domains."

The transferred technology, which is Air Force-patented, enables operators to accurately monitor multiple channels of high-traffic communication and respond to distributed personnel across multiple locations, such as military ground operations or flight missions.

"In typical command and control environments, an operator may need to monitor multiple channels of information from sources such as radios, intercoms, and telephones, among others," explained Simpson. "This information is typically analog and therefore does not afford reliable or timely forensic capabilities for the operator. If the communications are actually being recorded, they are typically available for after-action review only and not accessible in real-time for use during the mission." In other words, once a message is spoken, it is lost. If the operator realizes she/he missed a call, that operator must discover not only what was said, but often who said it, as well. We thought there might be a more effective way for the C2 operator to work with today's technologies in order to enhance user performance and decision making.

GlobalFlyte, Inc., a startup in Dayton, Ohio, was the recipient of the transferred MMC technology. According to the company's website, its mission is "to continually improve emergency response operations by providing unparalleled communications, imaging and data technologies on an integrated platform for the purpose of saving lives, protecting property and managing catastrophic incidents to minimize loss."

"The company's committed belief in MMC and its potential value to military and civilian users underlies the excellence and innovation of this technology transfer," said Dr. James Kearns, 711 HPW program manager in AFRL's Office of Research and Technology Applications. Kearns developed the Patent License Agreement and supportive CRADA for this effort.

GlobalFlyte's founders were inspired to find preventive solutions to the deadly radio-traffic confusion during the 9/11 response that tragically impacted New York City fire departments. The company employees leading the integration of MMC into their new product line include former firefighters, law enforcement, and military members—all first responders aware of the need for a communication system that helps clear the verbal/audio chaos subverting emergency responses

or military operations. Now commercially available, GlobalFlyte's solution is a TRL9-secure, cloud-based Software as a Service integrated situational awareness platform.

"In crisis situations, minutes or even seconds can make a difference," explained Simpson. "Through its transfer to private industry, 711 HPW's MMC technology is now able to save lives, reduce property loss, and prevent miscalculated operations that could prove tragic."

Uniformed Services University of Health Science: Public Health Impact: Countermeasures for Highly Pathogenic Emerging Henipaviruses

Research at the Uniformed Services University of the Health Sciences (USU), analyzing two potentially fatal viruses that can be transmitted from livestock to humans, has resulted in a vaccine to prevent infection in horses and a treatment for humans who have been exposed. Hendra and Nipah viruses are new disease-causing agents that emerged in the 1990s, causing serious outbreaks in humans and livestock in Australia, Malaysia, Singapore, Bangladesh and India. The fatality rate for infected humans is 40–100%.

More than 700,000 doses of the USU-originated equine vaccine have been administered to nearly 170,000 horses since 2015, and no vaccinated horse has been infected with Hendra virus. Since 2010, 14 people have received USU-developed, high-dose antibody therapy on an emergency use basis because of high-risk exposure to Hendra or Nipah, and all have remained well. A human vaccine is also in development.

In 2012, the HeV-sG vaccine was licensed to Zoetis, an animal health products company in Florham Park, NJ, through the USU–HJF (Henry M. Jackson Foundation for the Advancement of Military Medicine) Joint Office of Technology Transfer (USU-HJF JOTT). This partnership led to the approval of the Equivac®HeV equine vaccine in Australia in 2015. This vaccine, the only antiviral approach for Hendra virus infection, a One-Health measure that breaks the cycle of virus transmission from horses to humans.

The m102.4 antibody, also developed at USU, is the only known treatment for humans exposed to or infected with Nipah or Hendra virus. An antibody is a protein that binds to a specific target; m102.4 specifically targets and neutralizes Hendra and Nipah viruses.

Technology transfer from USU, first with the government of Queensland, Australia, and then India, provides access to m102.4 antibody for people exposed to the Nipah or Hendra viruses. This T2 story started in 2010, when a mother and daughter were exposed to Hendra virus in Australia, and USU provided the antibody under a compassionate use agreement. Subsequent agreements with the Queensland government allowed them to conduct a clinical study and to produce the antibody for future use in Australia or in other locations. When a Nipah outbreak occurred in Kerala, India, in May 2018, the USU-HJF JOTT coordinated a transfer of the antibody from the Queensland stockpile to the Indian Council for Medical Research (ICMR) for compassionate-use purposes.

Another USU license was issued in 2018 to Baltimore, MD-based Profectus Biosciences Inc., for the development of a Nipah/Hendra human vaccine. The Coalition for Epidemic Preparedness Innovations (CEPI) has awarded up to $25 million to Profectus for clinical development and

evaluation; the U.S. National Institute of Allergy and Infectious Diseases and global health organization PATH have also provided support.

Army: Maryland Defense Technology Commercialization Center (DefTec Center)
An Army-led pilot network of Federal laboratories, government entities, and private-sector partners has diversified income streams in Maryland and established a model for promoting and supporting technology transfer at state and local levels.

The Maryland Department of Commerce Office of Military and Federal Affairs and the U.S. Army Combat Capabilities Development Command (CCDC) jointly created the Maryland Defense Technology Commercialization Center (DefTech Center) to support transferring technology out of Federal labs and helping local companies commercialize viable products. The Harford County Office of Community & Economic Development provides in-kind facility and utilities support for the DefTech Headquarters housed within the Harford Business Innovation Center and co-located with other aligned small-business resources.

Within the network, CCDC's role is to develop technologies for potential commercialization and engage prospective DefTech clients. Within CCDC, the Army Research Laboratory (ARL); the Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR, formerly CERDEC) Center; and the Chemical Biological Center (CBC, formerly ECBC) all play key roles in the DefTech partnership.

Funding from the DoD Office of Economic Adjustment helped launch a 12-month pilot program. A competitive bidding process led to the selection of Axcel Innovation LLC of Charlottesville, Virginia, as the third-party contracted vendor to deliver the program. The Army Alliance (supporting Aberdeen Proving Ground) joined with partners Early Charm Ventures of Baltimore and Altus Engineering of Darlington, Maryland, and the Maryland Technology Development Corp. (TEDCO).

In a year and a half, DefTech created a state-specific database of defense-related patents, and to date has matched more than 150 patents to the needs of its client businesses. In addition, the DefTech team provides training, support, and mentoring to more than 40 client companies. DefTech has signed five patent licenses or CRADAs with the DoD labs, and five more companies have patent license agreements (PLAs) or CRADAs in the works.

Because of the pilot program's success, additional Federal funding of $750,000 was awarded through the Federal Economic Development Administration under its i6 Challenge grant program in December 2018 to continue geographical expansion. Additional network partners will increase accessibility for businesses and further enhance commercialization outcomes.

DefTech has created new opportunities for dialogue among government, industry, and innovators by reducing the barriers to meaningful interactions. By simplifying access to senior subject matter experts, the network demonstrates to entrepreneurs that Federal IP can be a viable part of creating and growing a business. DefTech and CCDC's partnership includes conducting workshops and teaching lab scientists and engineers how to pitch their ideas and inventions to commercial businesses and investors.

Plans are underway to provide seed funding for companies commercializing lab IP, a customized pitch program to connect lab scientists and local entrepreneurs, and new entrepreneurship resources at local community colleges.

Navy: Northwest Tech Bridge Rapid Prototypes Protective Gear for First Responders
To equip those on the front lines of coronavirus response, the Naval Undersea Warfare Center (NUWC) Division Keyport—in partnership with the U.S. Navy's Tech Bridges program—manufactured over 500 face shields and personal protection equipment for first responders at two hospitals and naval commands in the state of Washington.

Johannes Schonberg, director of the Northwest Tech Bridge at NUWC Division Keyport, teamed with engineers in the rapid-prototyping shop at NUWC Division Keyport's Maintenance, Engineering and Industrial Operations Department, where they refurbished the protective equipment using traditional manufacturing methods as well as 3D printing.

The project was so successful that ONR is sponsoring a similar collaboration among the Northwest Tech Bridge, NUWC Division Keyport and the University of Alaska Fairbanks (a Tech Bridge academic partner). NUWC Division Keyport and the Northwest Tech Bridge are sharing best practices and successful manufacturing models with the university—providing it with a playbook to work with local industry to produce protective equipment for first responders at Fairbanks Memorial Hospital.

Air Force: New Invention Projects to Make Splash in Commercial Market
The concept of getting high-tech results for a significant discount has always been attractive to the military. For physicist and innovator Joshua Lentz, currently working with the Airforce Research Laboratory (AFRL), it all comes down to something as simple as a child's toy.

"I view the idea generation process as Legos," Lentz said. "I'll take a product or technology and consider it like a single Lego shape. I spend time trying to come up with ways to build products out of that one type of Lego."

Brick by brick, that process has led to his invention and patent for a Low-Cost Wide Field of View (FOV) Projector. Lentz, who began his career earning BAs in Math and Physics from East Stroudsburg University in Pennsylvania, before moving on to add a Masters and PhD in Optics from the University of Central Florida – and currently has 16 inventions to his name – placed the first Lego while studying Digital Micromirror Display (DMD).

DMD works very similar to a Digital Light Projector; creating a picture element being projected to a screen. Lentz noted that the most expensive DMDs operate at incredibly high speeds, but could still produce the desired results if slowed down.

"[My] invention takes advantage of that extra time by steering the output to an adjacent spot [a tiled image location] and changing the image," Lentz explained. "For a sensor like the eye, there is no recognition— if done fast enough—that [if] the DMD projected an image, pointed to

another spot and projected a different image, so the result looks like a continuous picture of twice the size."

FOV uses a spatial light modulator (SLM) and a fast steering mirror (FSM) cooperatively managed by a projection sequence controller. The computer-implemented process determines projection regions within the FOV, creates subimages of an input target image for each of the regions, and operates the SLM and FSM to time-division multiplex sequential projections of each of the sub-images and to direct each projection to a respective region in the FOV within an observer frame rate.

Though FOV exists merely on paper at this stage, Lentz sees enormous potential commercially in terms of marketing and advertising. "Projection onto buildings, walls, structural posts, etc. is expanding. In some cases, this bypasses the need to obtain permits since permanent signs are not installed," Lentz said. "If an advertisement of five times the size can be accomplished (at a fraction of) the cost, the return on investment will get attention."

Lentz says FOV could be beneficial in the field of additive manufacturing, commonly referred to as 3D printing. The Air Force Rapid Sustainability Office is using this technology to create engine parts for fighter aircraft. 3D printing involves depositing layers of a specified material to create an object from a computer graphic. Utilizing FOV in this process has the potential to create larger scale components rather than just individual parts requiring massive post-print assembly.

This application is a bit less direct and would require some adaptations. "Using the same DMD and covering far more print area has advantages," Lentz added. As the Legos click together, Lentz says he now has the necessary hardware to start developing and demonstrating this invention soon.

"Hopefully, I can get some demonstrations accomplished in the next year and publish them. Alternatively, finding a commercial or industrial -- or even academic -- partner to license the technology would increase exposure," he said.

Department of Energy (DOE)

The Department of Energy (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 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 undertaken by the National Laboratories:

- 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 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 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)

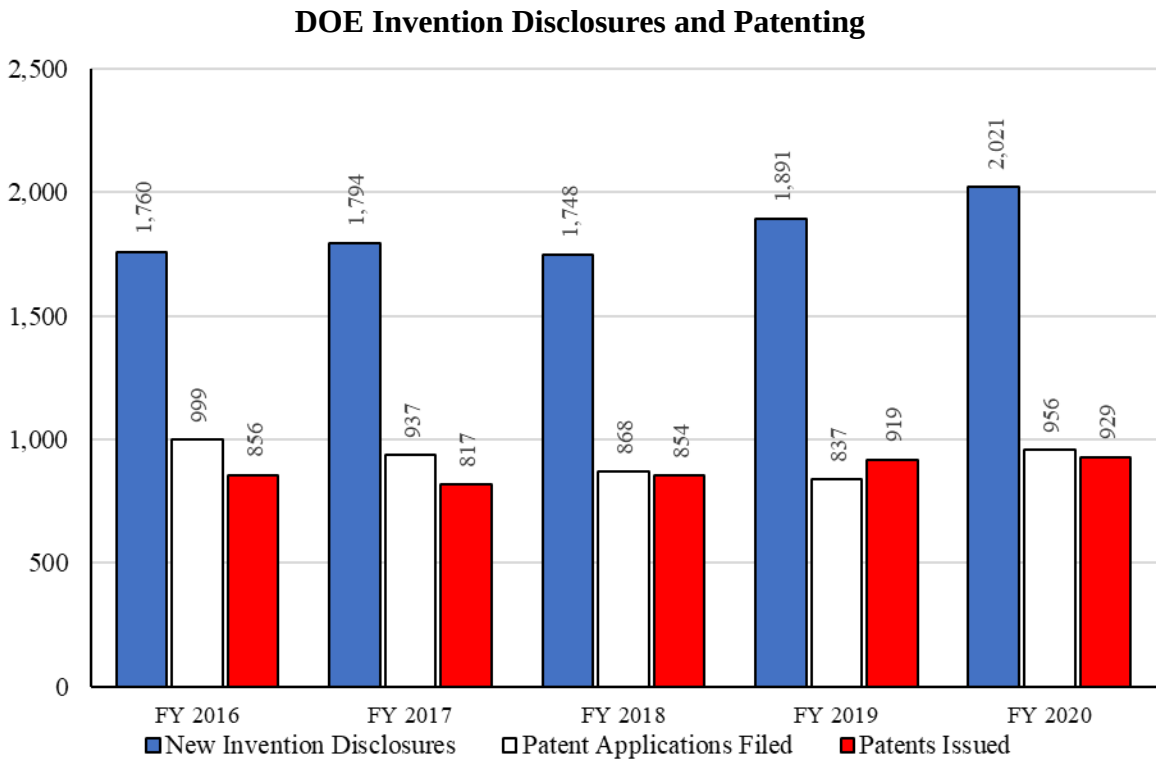
Science and engineering are not linear. DOE's system of National Laboratories, user facilities, research centers, and shared research facilities, makes the pursuit of discovery—and the many solutions that result—both a collaborative enterprise and a shared national resource. Collaboration with industry, 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 mission of the Office of Technology Transitions (OTT) 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

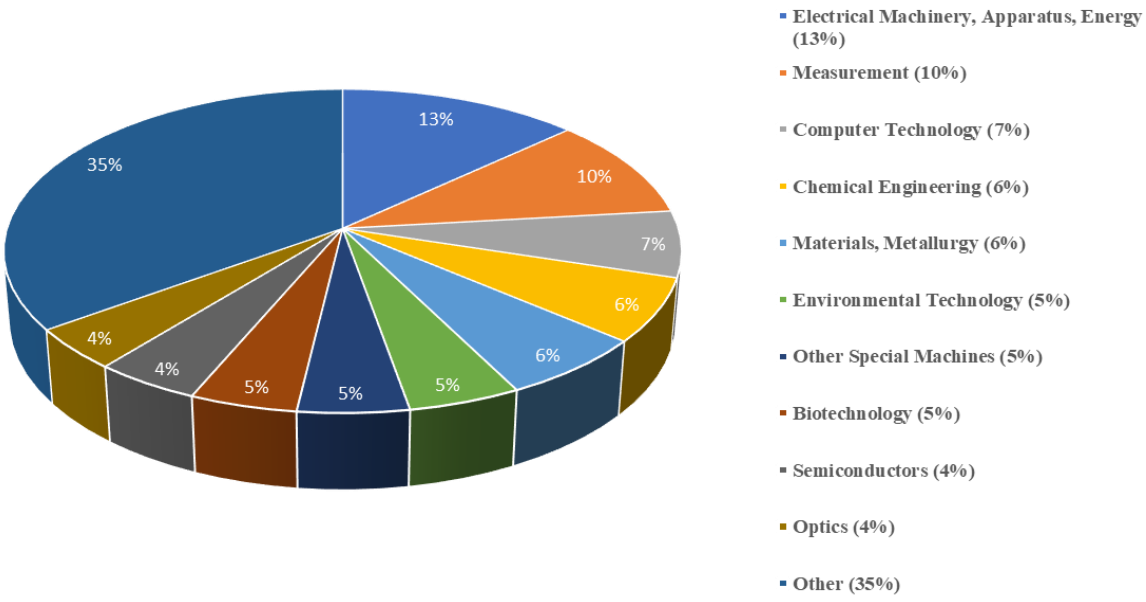
Between FY 2016 and FY 2020, new inventions disclosed increased by 15%, from 1,760 in FY 2016 to 2,021 disclosures in FY 2020. Patent applications filed decreased by 4%, from 999 in FY 2016 to 956 in FY 2020, while patents issued increased by 9%, from 856 in FY 2016 to 929 patents in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	1,760	1,794	1,748	1,891	2,021
Patent Applications Filed	999	937	868	837	956
Patents Issued	856	817	854	919	929

Patents issued to DOE in FY 2020 covered many technology areas including Electrical Machinery, Apparatus, Energy (13%); Measurement (10%); Computer Technology (7%); Chemical Engineering (6%); and Materials, Metallurgy (6%).[39]

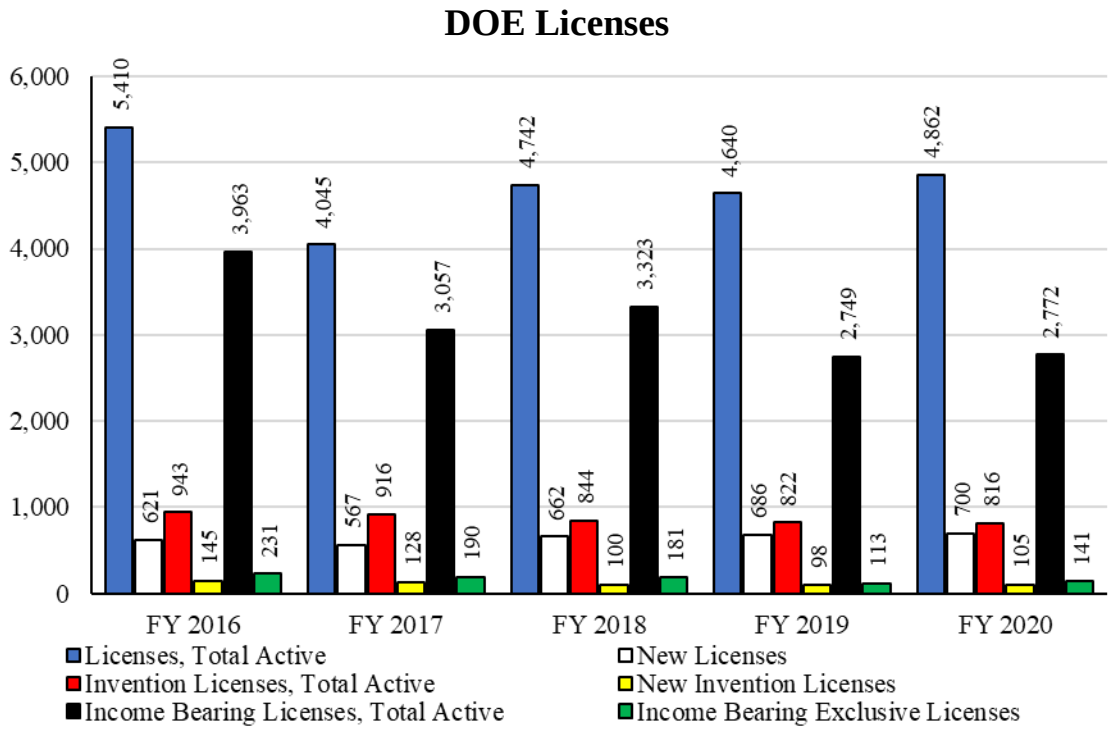
USPTO Patents Assigned to DOE by Technology Area: FY 2020



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

DOE Licenses

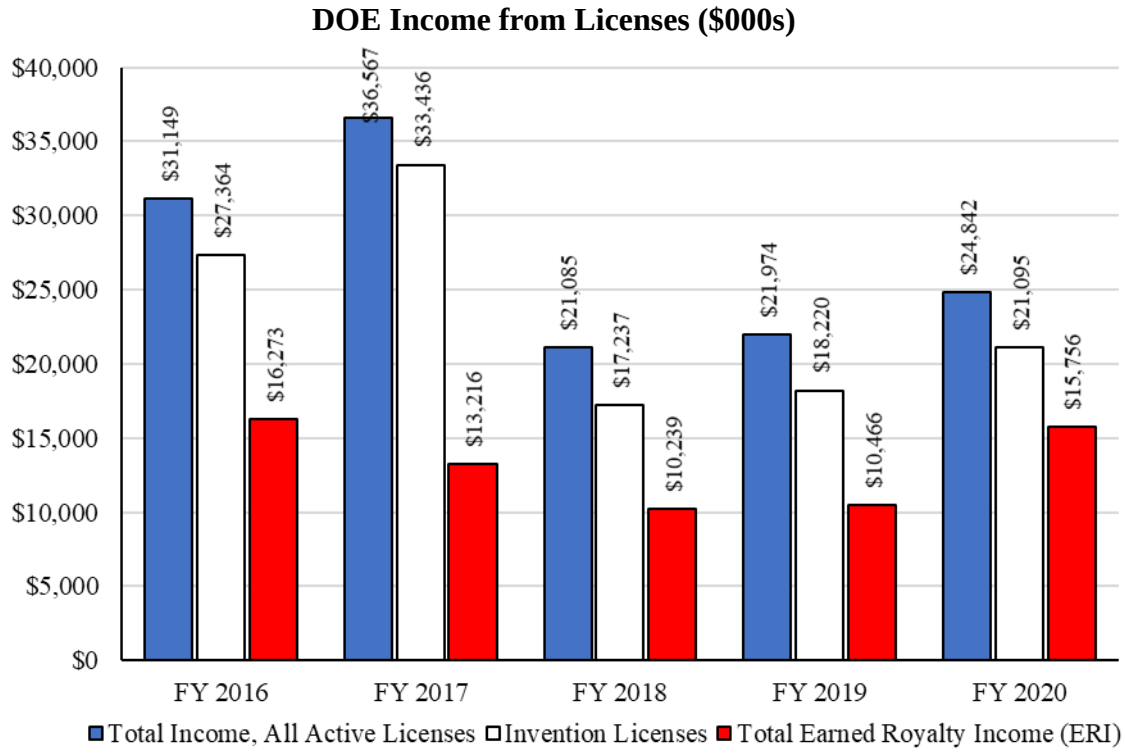
Between FY 2016 and FY 2020, DOE reported a 10% decrease in total active licenses, from 5,410 in FY 2016 to 4,862 in FY 2020. New active licenses increased by 13%, from 621 in FY 2016 to 700 in FY 2020. Total active invention licenses decreased by 13%, from 943 in FY 2016 to 816 in FY 2020. New invention licenses decreased by 28%, from 145 in FY 2016 to 105 in FY 2020. Income bearing licenses decreased by 30%, from 3,963 in FY 2016 to 2,772 in FY 2020 and income bearing exclusive licenses decreased by 39%, from 231 in FY 2016 to 141 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	5,410	4,045	4,742	4,640	4,862
New Licenses	621	567	662	686	700
Invention Licenses, Total Active	943	916	844	822	816
New Invention Licenses	145	128	100	98	105
Income Bearing Licenses, Total Active	3,963	3,057	3,323	2,749	2,772
Income Bearing Exclusive Licenses	231	190	181	113	141

DOE Income from Licensing

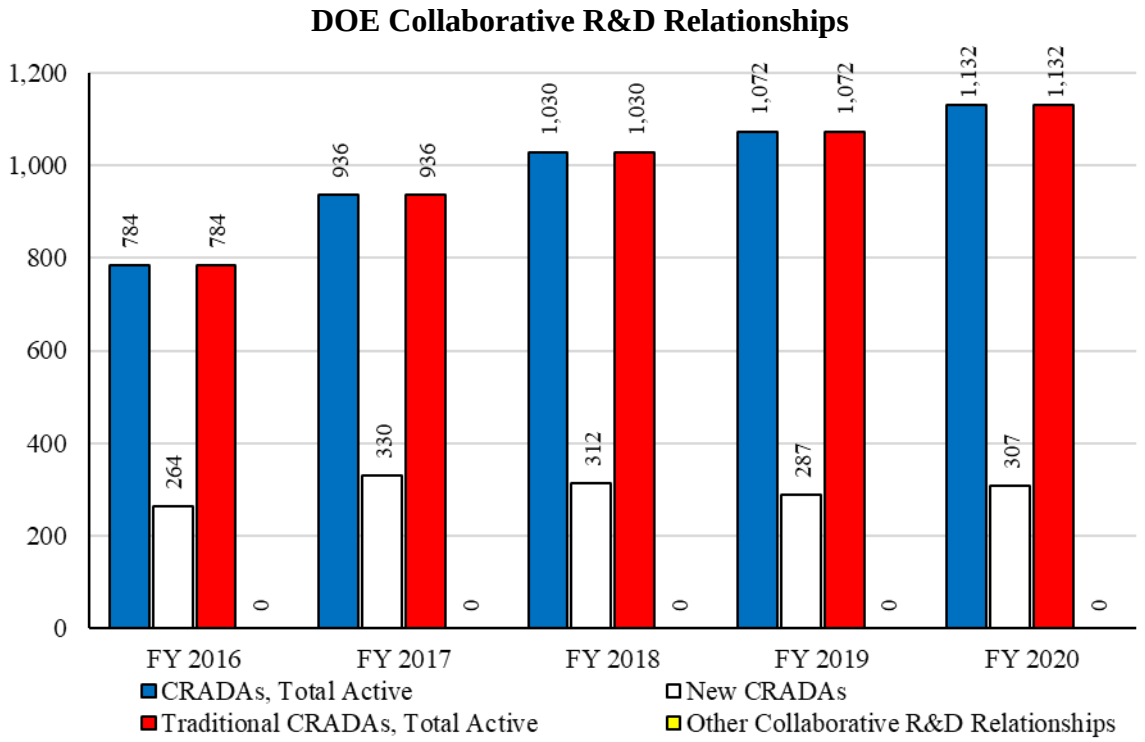
Between FY 2016 and FY 2020, DOE reported that total income from all active licenses decreased by 20%, from $31.1 million in FY 2016 to $24.8 million in FY 2020. Income from invention licensees decreased by 23%, from $27.4 million in FY 2016 to $21.1 million in FY 2020. Total earned royalty income decreased 3%, from $16.3 million in FY 2016 to $15.8 million in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$31,149	$36,567	$21,085	$21,974	$24,842
Invention Licenses	$27,364	$33,436	$17,237	$18,220	$21,095
Total Earned Royalty Income, (ERI)	$16,273	$13,216	$10,239	$10,466	$15,756

DOE Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs increased by 44%, from 784 in FY 2016 to 1,132 in FY 2020. New CRADAs increased by 16%, from 264 in FY 2016 to 307 in FY 2020. Total active traditional CRADAs increased by 44%, from 783 in FY 2016 to 1,132 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	784	936	1,030	1,072	1,132
New CRADAs	264	330	312	287	307
Traditional CRADAs, Total Active	784	936	1,030	1,072	1,132
Other Collaborative R&D Relationships	0	0	0	0	0

DOE Downstream Success Stories

Lawrence Livermore National Laboratory (LLNL): Novel Ventilator Design for COVID-19 Use
While hospitals across the U.S. faced a possible shortage of mechanical ventilators due to COVID-19, a self-assembled skunk works team at Lawrence Livermore National Laboratory (LLNL) worked tirelessly to prototype a simple ventilator design for quick and easy assembly from available parts.

Dubbed the "Novel Emergency Response Ventilator" (NERVe), the design is derived from proven concepts and contains parts that are not being used by commercial ventilator manufacturers, to avoid disrupting already thin supply chains. It is designed to meet the functional requirements of COVID-19 patients requiring mechanical ventilation, including a simple user interface, air flow circuits for inhalation and exhalation, and alarms to notify physicians if air pressures get too low. It can operate in a continuous ventilation mode — common for late-stage COVID-19 patients — but can adapt to patients who spontaneously breathe on their own.

Determined to contribute to the fight against COVID-19, the LLNL team set about developing a prototype ventilator system that could potentially serve as a stopgap solution until ventilator manufacturers could catch up to the anticipated demand. The design would have to be adequately functional and suitable for medical use, but simple enough that it could be mass produced from off-the-shelf parts to make the greatest impact on the global health crisis.

They first looked at CPAP machines — breathing aids commonly used to treat sleep apnea — as a potential viable option for sourcing components. When that proved unfeasible, the team started from scratch, studying ventilator design and manufacturing as well as talking to medical professionals. The team includes 20 scientists and engineers from the Lab's Computing, Engineering and Physical and Life Sciences directorates.

Building something fast that can get through FDA approval, is easy to operate, and doesn't interfere with the supply chain is a key to helping people with COVID-19.

Currently there are several companies interested in working with LLNL to help mass produce and commercialize the prototype ventilator.

For additional information see: NERVe info.

Sandia National Laboratory (SNL): Sandia Researchers Work with New Mexico Small Businesses to Test New Respirator Materials
A media comprised of a sandwich of materials tested by Sandia is being manufactured into N95-like respirators that could be used in local medical facilities. The project originated from the urgent need for personal protective equipment when the COVID-19 outbreak began.

"I can almost assure you that no one else in the country is making respirators the way we're making them," said Dave Mayberry, technical lead for Marpac, Sierra Peaks, and Sew-EZ, the

companies that worked with Sandia on materials testing. “We didn’t want to research the same materials already used in the typical N95 supply chain due to availability issues, so we looked into other materials we could get ahold of that seemed most likely to meet the filtration requirements.”

Marpac, Sierra Peaks, and Sew-EZ were matched with Sandia scientists through the New Mexico Small Business Assistance (NMSBA) program that pairs Sandia and Los Alamos National Laboratories with companies seeking help to solve technical problems. Sandia worked on a project with each company.

“It’s been very satisfying to see NMSBA, a state program, help New Mexico businesses address COVID-19 issues,” said Jackie Kerby Moore, manager of technology and economic development at Sandia. “It was also rewarding to see the Sandia team jump on the opportunity to help these three businesses with their respirators.”

Marpac specializes in manufacturing medical tube securement devices and works closely with engineering and manufacturing companies Sierra Peaks and Sew-EZ.

Mayberry reached out to Sandia after receiving an inquiry from a local hospital to see if the company could help address the potential shortage of N95 respirators. Certified N95 respirators are worn like masks and protect users from 95% of airborne particles and liquid contamination.

Sandia has the equipment and expertise to help, and within a few days after Marpac reached out, a team of scientists began working on the challenging task of modifying systems to make sure samples were tested properly.

Sandia principal investigator Michael Omana said the team modified aerosol and filtration systems typically used for nuclear nonproliferation work. They had to reduce the systems’ airflow significantly to mimic the rate that humans breathe. They also modified existing test boxes to quickly mount and seal the samples inside prior to running them through the testbed.

“We were tapped about the first project with Marpac on a Thursday and drafted the scope of work and contract by Friday,” Michael said. “By Monday or Tuesday, we had finished all system modifications. Initial testing of the first set of materials was completed by the end of the week, and data was provided to Marpac.”

Initial test materials underperformed, with the best sample coming within 10% of the desired filtration levels. Within a couple of weeks, the researchers started seeing promising results from new material compositions. Creativity in combining materials resulted in samples with protection levels comparable to N95 respirators.

Marpac manufactured 500 N95-like respirators using the materials Sandia tested, and Mayberry said they passed fit tests at a local hospital. They are also looking into additional medical facilities that could use the product.

"Working quickly was critical for the projects," Sandia distinguished technologist Dora Wiemann said, "and the team put in long hours — including on weekends."

The projects with each company built upon each other. For the first project with Marpac, researchers tested sheets of composite materials provided by the company in the large, modified filtration system.

For the second project with Sierra Peaks, additional test-box modifications enabled the scientists to mount and seal samples cut in respirator geometries, and to complete comparison studies against certified N95 respirators.

The third project with Sew-EZ, which is ongoing, involves further sample testing using the filtration system and an additional commercial-off-the-shelf system, which is typically used by industry to certify products like N95 respirators.

"Sandia is not a certification lab, but the joint use of the systems enabled us to provide data that may be compared against products which have been certified through traditional avenues," Michael said. "This data will help the company if it chooses to seek certification of its product through the proper organizations."

Michael and a couple of other researchers test the materials in the lab, then forward data to be processed into quantitative results. The timeline on all projects has been tight, but the researchers said promising tests have been rewarding, especially because the result has the potential to help people during a time of crisis.

"I'm glad to be in the position I am so that I can help with this really big issue with characterizing materials that can be used for N95 replacements," Dora said. "By the end of the initial modifications and testing, we were a very close-knit team, solving an important problem. It was exhausting and exhilarating."

National Energy Technology Laboratory (NETL): NETL-led Collaboration Develops New Rare Earth Element Extraction Sorbent
In an NETL-supported collaboration with Wayne State University (WSU), WSU researchers used a newly developed sorbent and a process previously developed for nuclear applications to produce an economically viable concentration of rare earth elements (REEs) from domestic coal fly ash.[40]

The new sorbent media developed by WSU researchers, in collaboration with the University of California, Los Angeles (UCLA) and Los Alamos National Laboratory (LANL), successfully concentrated the REEs in a coal fly ash sample taken from a coal-fired power plant near Detroit, resulting in a rare earth oxide (REO) powder of more than 13 percent weight, which demonstrates potential for economic viability.

[40] Coal fly ash is byproduct of coal combustion that coal-fired boilers release along with other flue gasses.

Using custom-built reactors at LANL, researchers used hydrothermal leaching to extract the REE content from the fly ash. A new sorbent developed at WSU was used in a solid-liquid recovery process, which eliminated the use of potentially hazardous organic solvents. The process combined multiple techniques previously developed to process spent nuclear fuel and other nuclear materials.

This development came as part of an NETL-funded cooperative agreement intended to develop a domestic supply chain for REEs, which are vital to the manufacturing of personal electronics, energy infrastructure, and defense technologies, among many other high-tech applications.

The project successfully identified a commercially viable fly ash supply. With Wayne State's hydrothermal process, more than 76% of the REEs in the coal fly ash can be extracted, which represents a 20 percent increase over conventional acid-based methods.

The newly developed sorbent media that was used to concentrate REEs also demonstrated a selectivity for mid and heavy REEs and the potential for use in separating individual rare earth elements. With ease and efficient recovery of these elements, consideration for inclusion and use on a larger industrial-scale separations facility may be an opportunity in the future.

An invention disclosure for the sorbent media has been filed with WSU and a patent application will be submitted soon.

NETL is a U.S. Department of Energy National Laboratory that produces technological solutions for America's energy challenges. From developing creative innovations and efficient energy systems that make coal more competitive, to advancing technologies that enhance oil and natural gas extraction and transmission processes, NETL research is providing breakthroughs and discoveries that support domestic energy initiatives, stimulate a growing economy, and improve the health, safety, and security of all Americans. Highly skilled men and women at NETL's sites in Albany, Oregon; Anchorage, Alaska; Houston, Texas; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, conduct a broad range of research activities that support DOE's mission to advance the national, economic, and energy security of the United States.

Argonne National Laboratory (ANL): Shaping Nanoparticles for Improved Quantum Information Technology

Particles that are mere nanometers in size are at the forefront of scientific research today. They come in many different shapes: rods, spheres, cubes, vesicles, S-shaped worms, and even donut-like rings. What makes them worthy of scientific study is that, being so tiny, they exhibit quantum mechanical properties not possible with larger objects.

Researchers at the Center for Nanoscale Materials (CNM), a DOE Office of Science User Facility located at DOE's Argonne National Laboratory, have contributed to a recently published Nature Communications paper that reports the cause behind a key quantum property of donut-like nanoparticles called "semiconductor quantum rings." This property may find application in quantum information storage, communication, and computing in future technologies.

In this project, the CNM researchers collaborated with colleagues from the University of Chicago, Ludwig Maximilian University of Munich, University of Ottawa, and National Research Council in Canada.

The team assembled circular rings made out of cadmium selenide, a semiconductor that lends itself to growing donut-shaped nanoparticles. These quantum rings are two-dimensional structures — crystalline materials composed of a few layers of atoms. The advantage of semiconductors is that when researchers excite them with a laser, they emit photons.

“If you illuminate a two-dimensional photon emitter with a laser, you expect them to emit light along two axes,” said Xuedan Ma, assistant scientist at CNM. “But what you expect is not necessarily what you get. To our surprise, these two-dimensional rings can emit light along one axis.”

The team observed this effect when breaking the perfect rotational symmetry of the donut shape, causing them to be slightly elongated. “By this symmetry breaking,” says Ma, “we can change the direction of light emission. We can thus control how photons come out of the donut and achieve coherent directional control.”

Because the photons in the light emits from these rings along a single direction, rather than spreading out in all directions, researchers can tune this emission to effectively collect single photons. With this control, researchers can integrate topology information into the photons, which can then be used as messengers for carrying quantum information. It may even be possible to exploit these encoded photons for quantum networking and computation.

“If we can gain even greater control over the fabrication process, we could make nanoparticles with different shapes such as a clover with multiple holes or a rectangle with a hole in the center,” noted Matthew Otten, a Maria Goeppert Mayer Fellow at Argonne’s CNM. “Then, we might be able to encode more types of quantum information or more information into the nanoparticles.”

“I should add that geometry is not the only factor in causing this quantum effect. The atomistic structure of the material also counts, as is often the case in nanoscale materials,” said Ma.

A paper based on the study, “Uniaxial transition dipole moments in semiconductor quantum rings caused by broken rotational symmetry,” appeared in Nature Communications. In addition to Ma and Otten, authors include Nicolai F. Hartmann, Igor Fedin, Dmitri Talapin, Moritz Cygorek, Pawel Hawrylak, Marek Korkusinski, Stephen Gray, and Achim Hartschuh.

This work was supported by the DOE Office of Science.

Department of Health and Human Services (HHS)

Research at the Department of Health and Human Services (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:

- Protects U.S. IP 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.

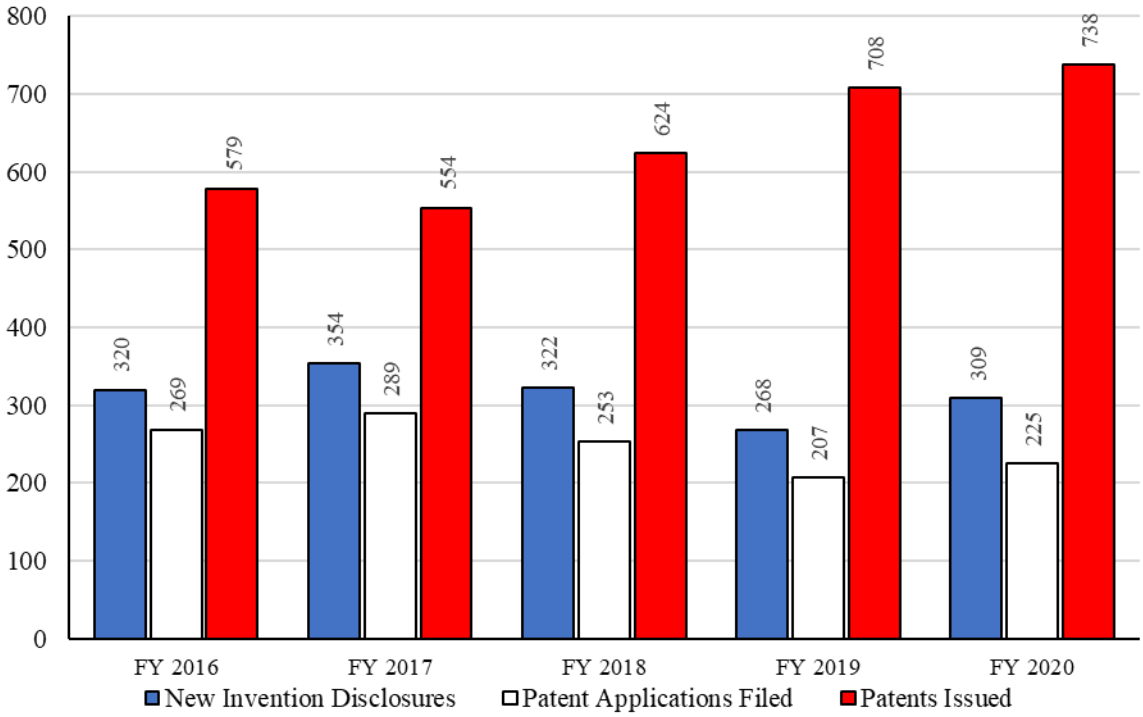
More information about HHS technology transfer activities is available on the following websites:

CDC | NIH | FDA

HHS Invention Disclosures and Patenting

Between FY 2016 and FY 2020, new invention disclosures decreased by 3%, from 320 in FY 2016 to 309 disclosures in FY 2020. Patent applications filed decreased by 16%, from 269 in FY 2016 to 225 in FY 2020, while patents issued increased by 27%, from 579 in FY 2016 to 738 patents in FY 2020.

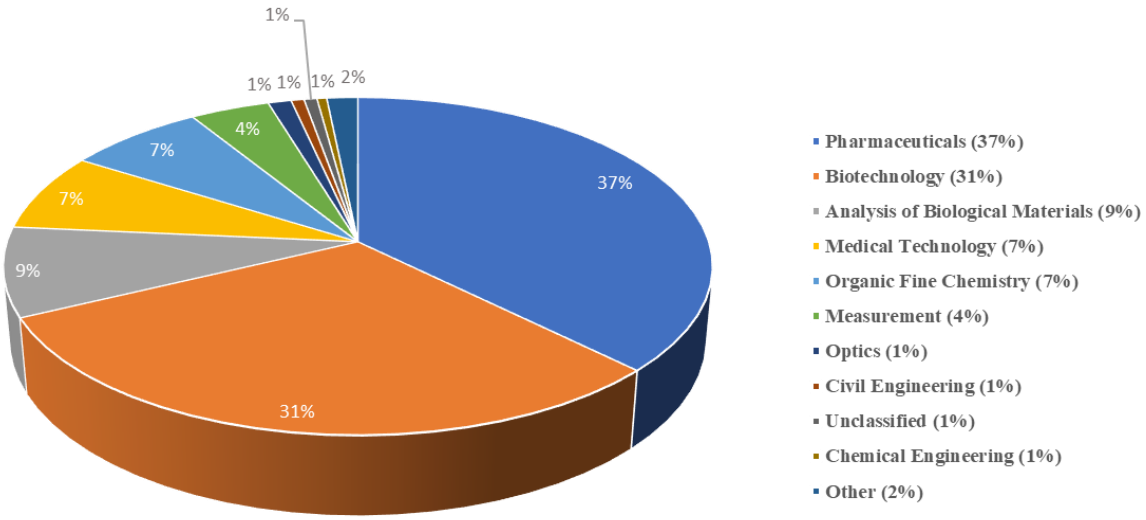
HHS Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	320	354	322	268	309
Patent Applications Filed	269	289	253	207	225
Patents Issued	579	554	624	708	738

Patents issued to HHS in FY 2020 covered many technology areas including Pharmaceuticals (37%), Biotechnology (31%), Analysis of Biological Materials (9%), Medical Technology (7%), and Organic Fine Chemistry (7%).[41]

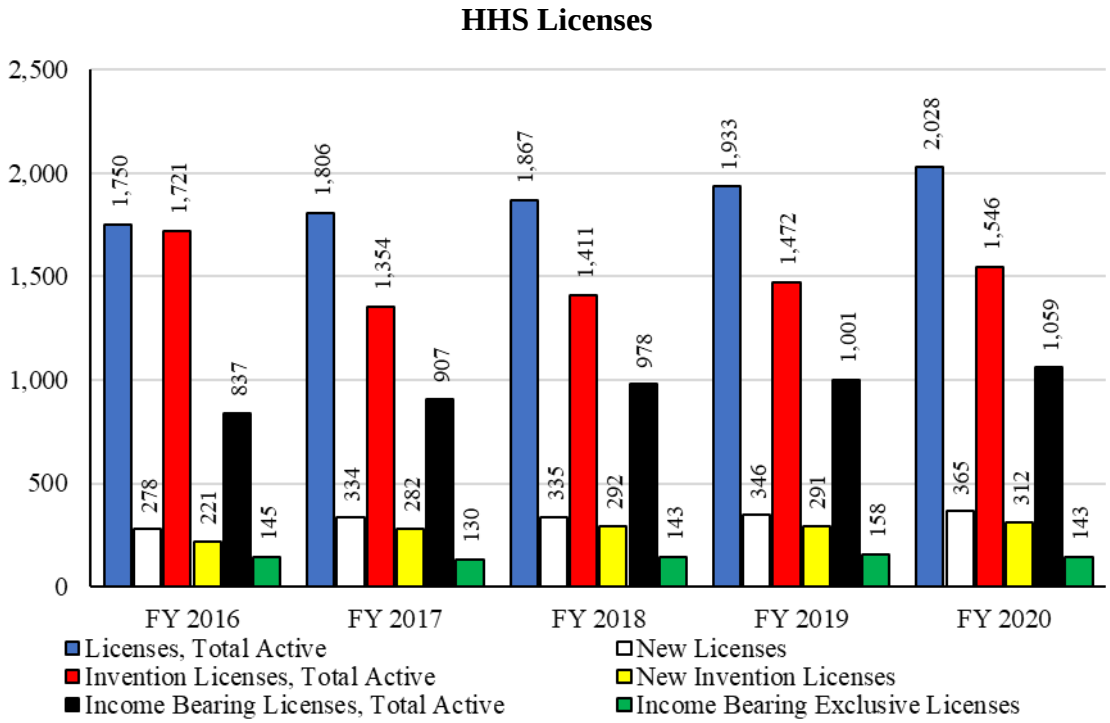
USPTO Patents Assigned to HHS by Technology Area: FY 2020



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

HHS Licenses

Between FY 2016 and FY 2020, total active licenses increased by 16%, from 1,750 in FY 2016 to 2,028 licenses in FY 2020. New licenses increased by 31%, from 278 in FY 2016 to 365 in FY 2020. Total active invention licenses decreased by 10%, from 1,721 in FY 2016 to 1,546 licenses in FY 2020. New invention licenses increased by 41%, from 221 in FY 2016 to 312 in FY 2020. Total active income bearing licenses increased by 27%, from 837 in FY 2016 to 1,059 in FY 2020. Income bearing exclusive licenses decreased by 1%, from 145 in FY 2016 to 143 licenses in FY 2020.

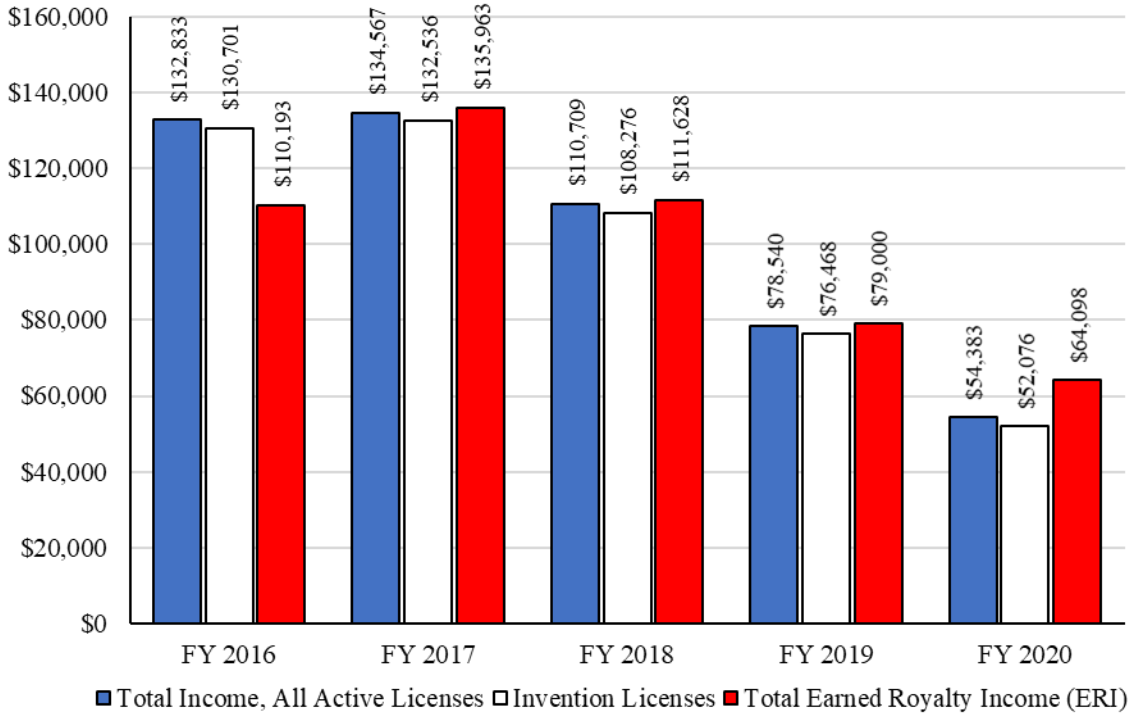


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	1,750	1,806	1,867	1,933	2,028
New Licenses	278	334	335	346	365
Invention Licenses, Total Active	1,721	1,354	1,411	1,472	1,546
New Invention Licenses	221	282	292	291	312
Income Bearing Licenses, Total Active	837	907	978	1,001	1,059
Income Bearing Exclusive Licenses	145	130	143	158	143

HHS Income from Licensing

Between FY 2016 and FY 2020, total income from all active licenses decreased by 59%, from $132.8 million in FY 2016 to $54.3 million in FY 2020. The income from invention licenses decreased by 60%, from $130.7 million in FY 2016 to $52.1 million in FY 2020. Total earned royalty income decreased by 42%, from $110.2 million in FY 2016 to $64.1 million in FY 2020.

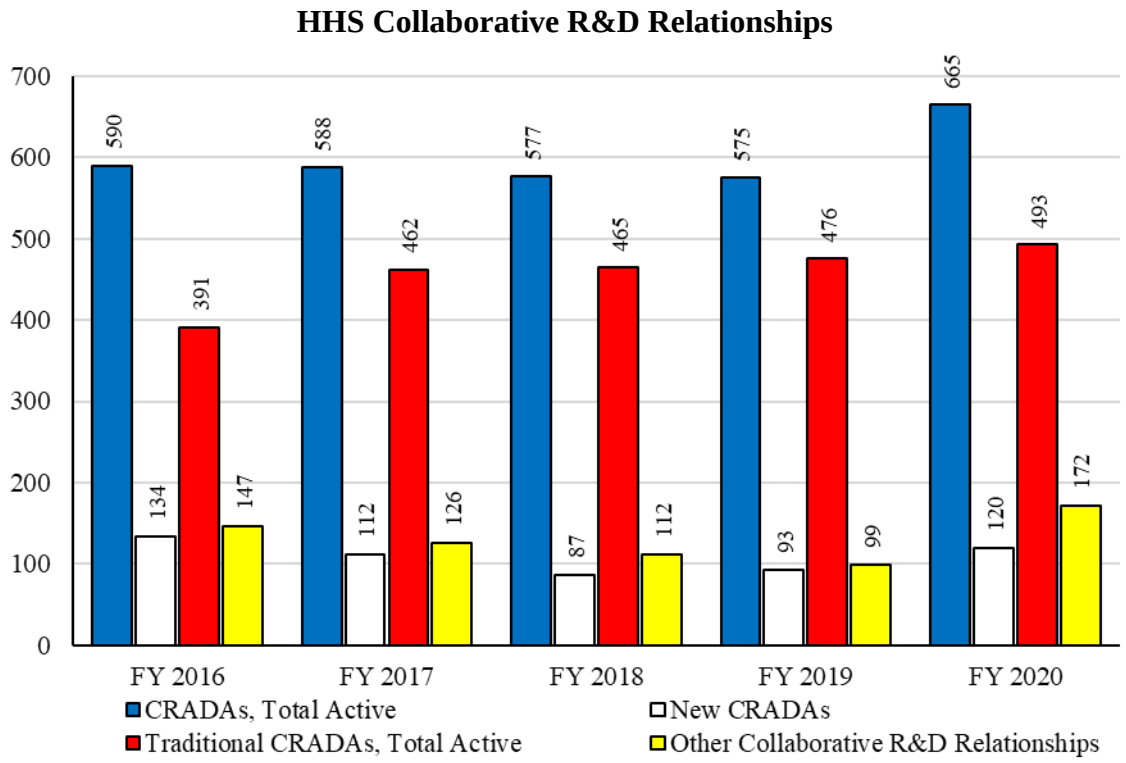
HHS Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$132,833	$134,567	$110,709	$78,540	$54,383
Invention Licenses	$130,701	$132,536	$108,276	$76,468	$52,076
Total Earned Royalty Income, (ERI)	$110,193	$135,963	$111,628	$79,000	$64,098

HHS Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs increased by 13%, from 590 in FY 2016 to 665 in FY 2020. New CRADA agreements decreased by 10%, from 134 in FY 2016 to 120 in FY 2020. Traditional CRADAs increased by 26%, from 391 in FY 2016 to 493 in FY 2020. Other collaborative R&D relationships increased by 17%, from 147 in FY 2016 to 172 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	590	588	577	575	665
New CRADAs	134	112	87	93	120
Traditional CRADAs, Total Active	391	462	465	476	493
Other Collaborative R&D Relationships	147	126	112	99	172

HHS Downstream Success Stories

NIH: Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) Program (ACTIV-1)

NIH's Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) program is an ongoing public-private partnership to speed development of the most promising treatments and vaccine candidates. The first master protocol—a structure that allows coordinated and efficient evaluation of multiple investigational agents as they become available, but within the same clinical trial structure, across multiple study sites—was ACTIV-1. ACTIV-1 was an adaptive Phase 3 clinical trial to evaluate the safety and efficacy of three immune modulator drugs in hospitalized adults with COVID-19.

Three agents were selected based on several factors including their relevance to COVID-19, strong evidence for use against inflammatory reaction, and availability for large-scale clinical studies. The initial agents were infliximab (REMICADE), developed by Janssen Research & Development, LLC, one of the Janssen Pharmaceutical Companies of Johnson & Johnson (Janssen); abatacept (ORENCIA), developed by Bristol Myers Squibb (BMS); and Cenicriviroc (CVC), an investigational late-stage agent developed by AbbVie—Janssen, BMS, and AbbVie will be collectively referred to as Pharma partners. COVID-19 would be a new use for these drugs (i.e., this is a drug repurposing effort). Gilead supplied the Remdesivir.

The National Center for Advancing Translational Sciences (NCATS) coordinated and oversaw the trial with funding support from the Biomedical Advanced Research and Development Authority (BARDA) of the U.S. Department of Health and Human Services Office of the Assistant Secretary for Preparedness and Response, in support of the Trump administration's Operation Warp Speed (OWS) goals.

NCATS OSA launched into negotiations with the Pharma partners quickly. The NIAID Technology Transfer and Intellectual Property Office collaborated and shared their ACTIV clinical templates, which provided helpful background as NCATS customized their own trial-related agreements. NCATS OSA and BARDA negotiated and executed a Memorandum of Understanding (MOU) to define the roles and responsibilities between the two parties. OSA quickly negotiated and executed the Confidential Disclosure Agreements (CDAs) with each Pharma Partner. The CDAs covered the scope of project and acknowledge that the information might be shared with others who were part of the ACTIV-1 program. CDAs were put in place with each pharma partner to begin Investigational New Drug (IND) discussions. NCATS OSA also drafted and negotiated three Clinical Trial Agreements (CTAs) and a Clinical Supply Agreement (CSA), all in parallel and with input from the entire ACTIV-1 scientific team.

More information on ACTIV, including all ACTIV master protocols, are available online.

NCATS and NCI: Advancing Innovations through Mentorship (AIM)

Advancing Innovations through Mentorship (AIM) is a new short-course program that has been crafted to advance translational discovery and development arising from the NIH Intramural Research Program (IRP) and to empower NIH investigators in evaluating their technologies in the context of the commercial and healthcare landscape. AIM is based on the NIH Innovation

Corps (I-Corps) program that has been further developed and fine-tuned for the NIH intramural program. Since 2018, leaders across the NCI Small Business in Research (SBIR) Development Center, the NCI Technology Transfer Center, and NCATS Office of Strategic Alliances (OSA) have been discussing expansion of the already successful NCI-led SBIR I-Corps program for the NIH IRP. In its current form, I-Corps at NIH is an entrepreneurial training program designed to help small business innovators - Phase I SBIR/STTR awardees - assess their technologies, recognize commercial opportunities, and build a scalable business model. This program has enormously increased the commercial awareness of SBIR/STTR awardees and has helped them to identify funding sources and finesse their commercialization plans.

The value of an I-Corps-like program for intramural scientists was soon recognized and led to the development of the pilot AIM program. Through this pilot program intramural investigators at NCI and NCATS would be able to translate their ideas from the bench to the bedside using the customer discovery process. In April 2020, the leadership at NCI and NCATS approved the pilot cohort of the AIM program. AIM's goal is to increase the likelihood that discoveries arising from NIH intramural research program are translated into products that can benefit patients and positively impact world health. Through structured mentorship, the AIM program can help advance NIH-conceived inventions to the marketplace by leading the course participants to perform customer discovery and incorporate methodologies for agile development into their research. In May 2020, NCI and NCATS sponsored a total of seven teams for the initial pilot.

From August to September 2020, the first pilot cohort of teams completed the course. Through AIM, NCATS and NCI intramural scientists who applied and participated in the course worked in teams with their respective Technology Transfer Managers and an I-Corp entrepreneurial expert to advance their focus beyond the laboratory and to focus on the economic and societal benefits of public-funded basic-research projects. The results of the pilot program have more than exceeded initial expectations. The course's exit questionnaire captured some striking data - see highlights of these statistics below. Many of the teams conducted close to 40 interviews, and these resulted in uncovering multiple new development paths. One team initiated two new collaborations, and another hired an outside instrument development group to make improvements to their prototype, to address customer preferences, as told to them during the interviews:

- 95% of respondents said they would rate the course as good or very good
- 85% of respondents said the course met or exceeded their expectations
- 95% of respondents said all aspects of the course were valuable (Pre-course assignments got the lowest response)
- 75% of respondents said the course would change their approach to doing research.
- ~95% or respondents said the course would, even a little, impact their development pathway

NIAID, CDC, and HHS: Cooperation to Rapidly Share SARS-CoV-2 Virus Specimens and Materials

SARS-CoV-2, the virus responsible for coronavirus disease (COVID-19), has wreaked havoc around the globe and caused substantial illness and death. As of January 28, 2021, more than 101

million COVID-19 cases were reported across 192 countries and territories, resulting in more than 2.1 million deaths, including more than 430,000 deaths in the United States.

As a novel virus, at first, little was known about the biology of, and medical countermeasures for SARS-CoV-2. Rapid sharing of SARS-CoV-2 materials, especially SARS-CoV-2 virus strains, was and remains an essential requirement for improving understanding of the virus and the development of effective diagnostics, vaccines, and therapeutics. Academic centers, U.S. government agencies, private companies, and the public health community requested specimens from NIAID to support SARS-CoV-2 research and development of medical countermeasures. Private companies were particularly eager to access SARS-CoV-2 materials with ease in coordinating shipments and without protracted legal negotiations or other constraints.

Technology transfer offices at NIAID, CDC, and the staff in the HHS Office of the Assistant Secretary for Preparedness and Response first tested a new approach to sharing materials during the Zika virus epidemic in 2016. Since that time, Federal cross-agency partners including NIAID, CDC, and HHS Office of Global Affairs developed a more efficient and collaborative approach for sharing critical virus materials. The CDC reached out to its extensive global network of partner laboratories and sentinel surveillance sites to access SARS-CoV-2 specimens in early February 2020. Similarly, NIAID was able to access specimens from around the world by communicating through the Institute's grantee and contractor network.

As of late 2020, the repository supported by NIAID received deposits of SARS-CoV-2 materials from 22 organizations, including CDC, NIAID, and three other U.S. Federal agencies, and has fulfilled 8,441 requests for SARS-CoV-2 materials, all under emergency use simple letter agreements (EUSLA). Unlike traditional material transfer agreements, the EUSLA does not have a restriction on commercial use and does not prohibit subsequent transfer of the materials by a recipient. The team executed 4,108 agreements that allowed shipments of SARS-CoV-2 materials to 319 universities, hospitals, and research institutes; 509 biotech and pharmaceutical companies; 39 Federal agencies and state public health departments; as well as 5 foreign governments. Materials have been distributed geographically to 49 U.S. states, Puerto Rico, and 43 countries.

The World Health Organization (WHO) in its Research and Development (R&D) Blueprint highlights the critical importance of transferring biological samples from one place to another during an outbreak. Progress in scientific methods, medical research, and the development and distribution of effective medical and behavioral measures are often tied to the availability of these biological samples and the willingness of governments and other partners to share samples. Movement of samples must be as simple, efficient, and transparent as possible. Efforts by WHO and its international partners to fully implement timely global specimen sharing of Zika virus, SARS-CoV-2, and other new and emerging infectious diseases continue to face significant challenges.

NCI: NCI Guides Fast-moving Collaboration with Immunotherapy Startup
In December 2019, Dr. James Yang, NCI CCR Surgery Branch, met with the vice president of research for Elicio Therapeutics, a start-up company formed to develop a technology licensed from MIT. Elicio is planning to use a novel approach to immunotherapy by harnessing its

"Amphiphile Platform" to target a wide range of immunogens to the lymphatic system, the "brain center" of the immune response. Their Amphiphile platform is engineered to target immune-modulatory therapeutics and vaccines directly to the lymph nodes. By delivering these immunogens directly to immune cells in the lymph nodes, Amphiphiles can control immune signaling to stimulate and orchestrate the development of the immune response against cancer. The company's goal: develop vaccines to "super-charge" CAR-Ts at the lymph nodes and improve immune responses to cancer. One of the company's lead compounds, ELI-002, is an "AMP KRAS-vaccine" containing seven Amphiphile mKRAS peptides and a proprietary Amphiphile adjuvant.

A week after the initial meeting at a scientific conference, NCI initiated a Confidential Disclosure Agreement (CDA) that was executed by January 2020. Preliminary discussions between Dr. Yang and Elicio led to NCI and Elicio entering into a Collaboration Agreement (CA) for non-human materials in April 2020.[42] The research goal was to discover and evaluate mutant murine KRAS specific T cell Receptors (TCRs) for their potential to be used in engineered TCR-T cells for therapy of patients with KRAS-mutated tumors. This study would help monitor patient responses in the planned clinical study of ELI-002 and would set the stage for future clinical trials combining ELI-002 with KRAS-targeting T cells.

The results of the initial CA were positive. In July, NCI and Elicio executed a second CA for human materials. In this CA, NCI and Elicio set out to collaborate on the development of a new biomarker assay. In addition, Elicio and NCI are developing an amphiphile vaccine to boost mEGFR specific T cell responses. In the meantime, Elicio completed preclinical validation, IND-enabling GLP toxicology studies, and a pre-IND meeting with the U.S. FDA for its lead candidate, ELI-002. As part of a plan to conduct multi-site Phase 1/2 trials, Elicio hired a Contract Research Organization, Icon. Icon reached out to NCI with a request to execute a CDA to allow them to share the clinical trial protocol with Dr. Yang in order to discuss next steps and a clinical trial agreement with NCI. Instead of a new CDA, TTC amended the existing CDA (with Elicio) to specifically add the clinical protocol. This enabled Icon to share the protocol with Dr. Yang who indicated interest in participating in Elicio's multi-site clinical trial as one of the trial sites. TTC's Dr. Aida Cremesti, TTM, supported these efforts.

[42] A CDA is a "formal collaborative agreement with industry, academia, and non-profits to facilitate co-development through the exchange and development of research materials, knowledge, and technologies." A CA is a specific type of CDA that "permits a two-way exchange of materials and information, and assumes exchange of results and/or conclusions will occur between NIH and companies, universities, state/local governments, Federal labs, and non-profits." More information on NIH CDAs can be found online.

Department of Homeland Security (DHS)

The Department of Homeland Security (DHS) protects the nation and its critical infrastructure from security threats and responds to natural and man-made disasters. DHS secures land, air, and sea borders; protects cyberspace; and secures critical infrastructure as diverse as energy infrastructure and dams, financial services, and agriculture. DHS provides direction to the broader homeland security community, including state, local, regional, tribal, and territorial government organizations; first responders; and private organizations involved in critical infrastructure sectors. DHS also collaborates with international partners, working to protect similar and, sometimes, common critical infrastructure.

The breadth of homeland security responsibilities and operations requires DHS staff and other members of the homeland security community to use diverse and often specialized technologies and methods. The DHS Science and Technology Directorate (S&T) applies scientific, engineering, and analytic innovations to advance mission-critical technologies and methods. End users of these technologies are often members of the broader homeland security community (e.g., local firefighters and police will use Next Generation 911 systems). DHS works with user communities to understand their needs and limitations, seeks out promising candidate technologies, invests in technology development, collaborates with community members to evaluate candidate technologies, and shares the results through a variety of mechanisms.

DHS uses various technology transfer mechanisms to address the breadth of needs within the homeland security community. Traditional patenting and licensing activities enable businesses to commercialize DHS technologies and make products available in the market. CRADAs support specialized laboratory testing and evaluation, operational tests, and/or field assessments by members of the user community. The results help innovators refine their technologies and expose the user community to new solutions to ongoing challenges. Because the technology needs of many homeland security organizations and activities are very specialized and not well supported by the general commercial marketplace, DHS funds early-stage prototyping by new companies through the Small Business Innovation Research (SBIR) program and the Commercialization Accelerator Program.

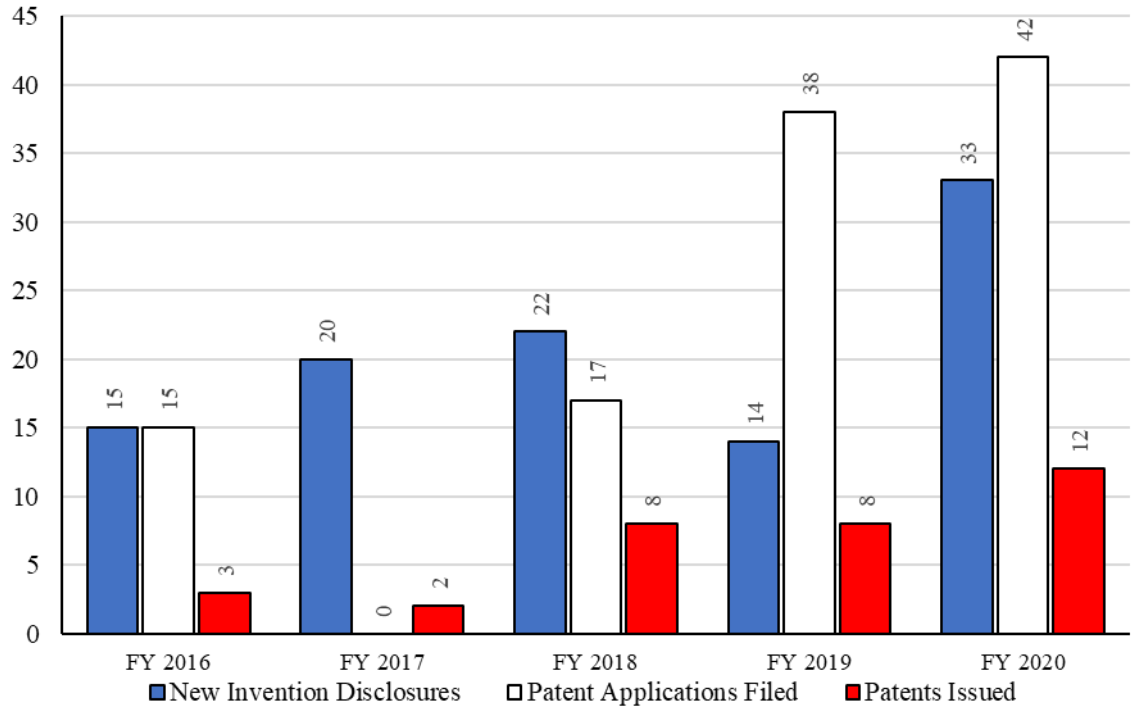
As the designated DHS Office of Research and Technology Applications (ORTA; 15 USC §3710(b)), the Technology Transfer and Commercialization Program (T2C) manages technology transfer and commercialization activities for the Department, including DHS components and the DHS laboratory network. T2C works directly with the DHS Office of General Counsel Technology Programs Law Division to protect, manage, and license DHS IP. T2C has also delegated responsibility for establishing research collaborations and partnerships through CRADAs and provides 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: https://www.dhs.gov/science-and-technology/technology-transfer-program

DHS Invention Disclosures and Patenting

Between FY 2016 and FY 2020, inventions disclosures increased by 120%, from 15 in FY 2016 to 33 in FY 2020. From FY 2015 to FY 2019, DHS reported a 180% increase in patent applications filed with 15 in FY 2016 and 42 in FY 2020. Patents issued increased by 300%, with 3 in FY 2016 and 12 in FY 2020.

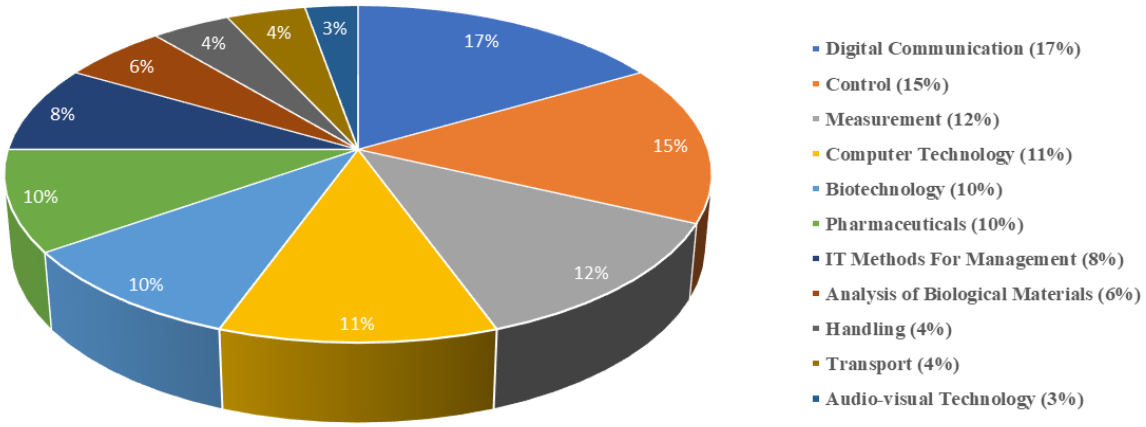
DHS Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	15	20	22	14	33
Patent Applications Filed	15	0	17	38	42
Patents Issued	3	2	8	8	12

Patents issued to DHS in FY 2020 covered multiple technology areas including Digital Communication (17%), Control (15%), Measurement (12%), Computer Technology (11%), and Biotechnology (10%).[43]

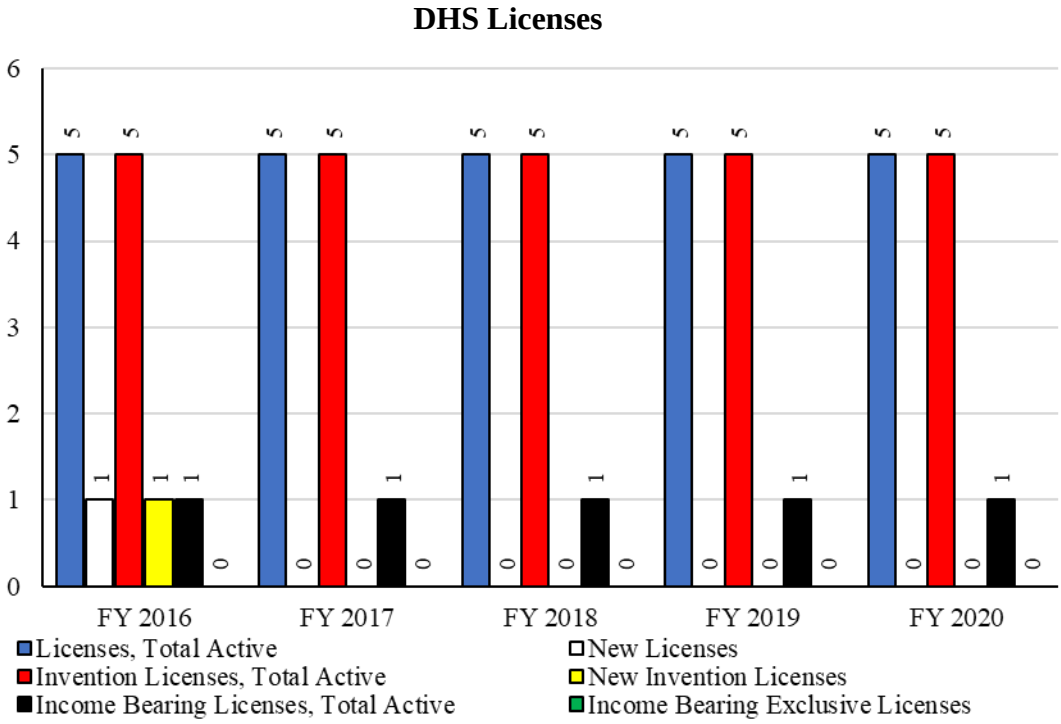
USPTO Patents Assigned to DHS by Technology Area: FY 2020



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

DHS Licenses

In FY 2020, DHS managed 5 active license agreements. Out of the 5 active agreements, one was income bearing.

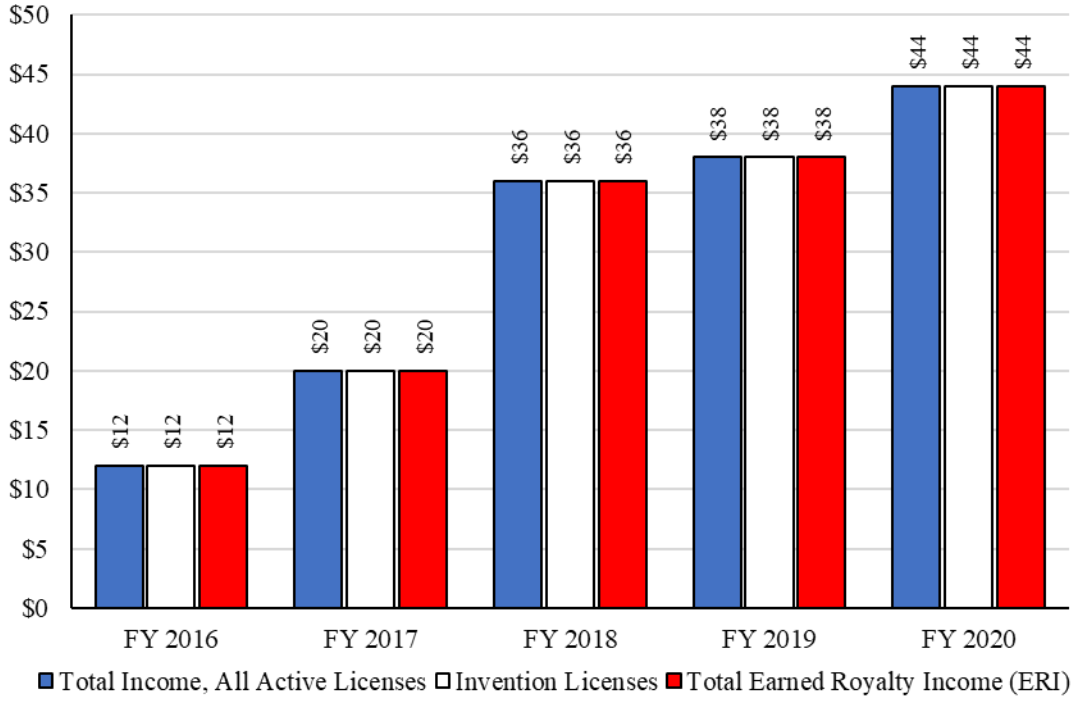


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	5	5	5	5	5
New Licenses	1	0	0	0	0
Invention Licenses, Total Active	5	5	5	5	5
New Invention Licenses	1	0	0	0	0
Income Bearing Licenses, Total Active	1	1	1	1	1
Income Bearing Exclusive Licenses	0	0	0	0	0

DHS Income from Licensing

From FY 2016 to FY 2020, DHS reported a 267% increase in total income, from $12 thousand in FY 2016 to $44 thousand in FY 2020. All income was reported as invention licensing income. Total earned royalty income increased by 267%, from $12 thousand in FY 2016 to $44 thousand in FY 2020.

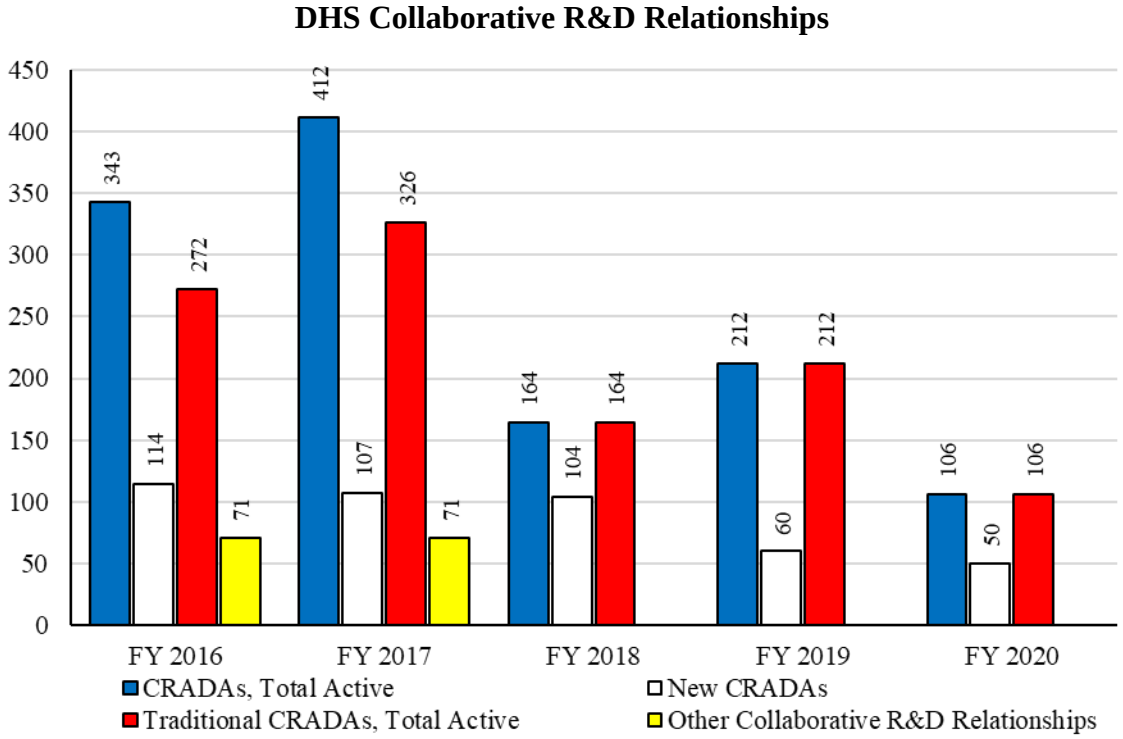
DHS Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$12	$20	$36	$38	$44
Invention Licenses	$12	$20	$36	$38	$44
Total Earned Royalty Income, (ERI)	$12	$20	$36	$38	$44

DHS Collaborative R&D Relationships[44]

Total active CRADAs decreased by 69%, from 343 in FY 2016 to 106 in FY 2020. New CRADAs decreased by 56%, from 114 in FY 2016 to 50 in FY 2020. Total active traditional CRADAs decreased by 61%, from 272 in FY 2016 to 106 in FY 2020.

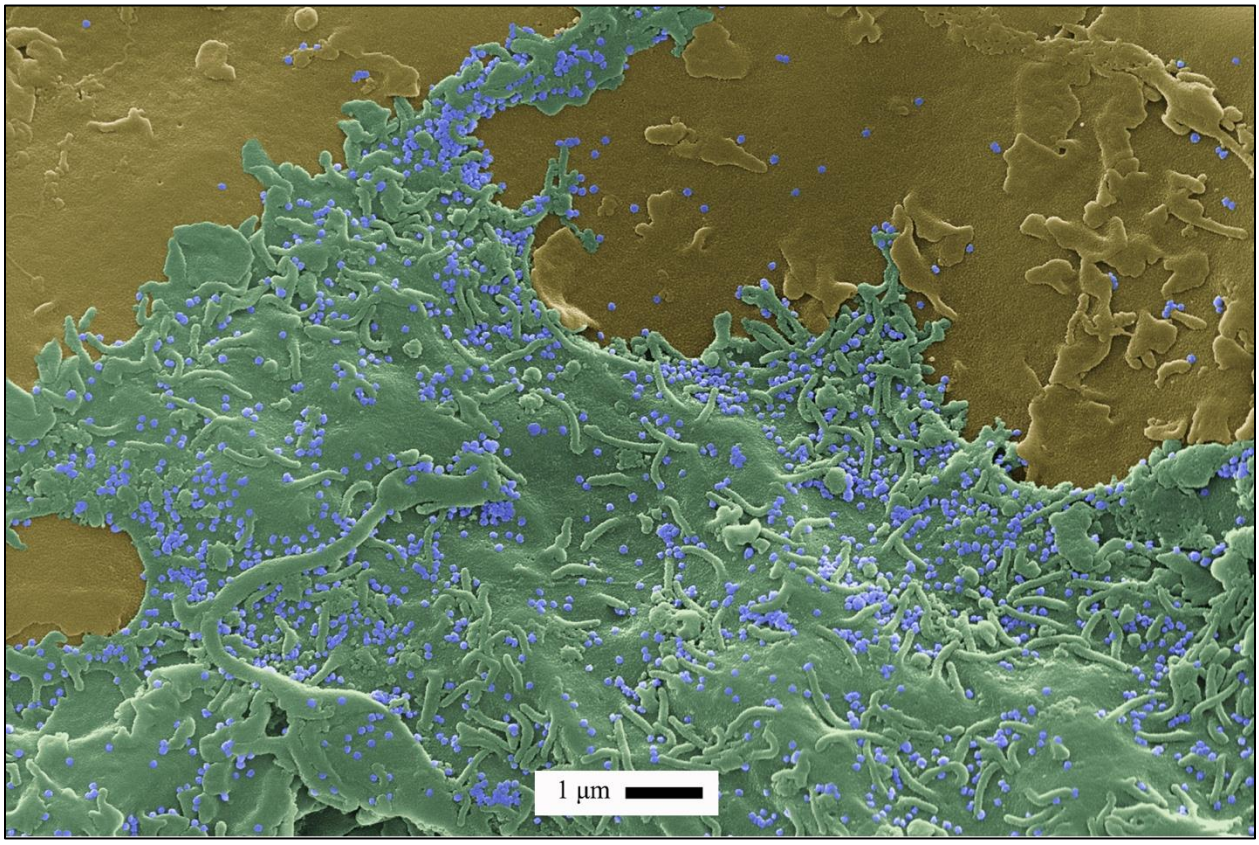


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	343	412	164	212	106
New CRADAs	114	107	104	60	50
Traditional CRADAs, Total Active	272	326	164	212	106
Other Collaborative R&D Relationships	71	71	n.a.	n.a.	n.a.

[44] DHS was unable to report values for other collaborative R&D agreements for FY 2018, FY 2019, and FY 2020.

DHS Downstream Success Stories

Responding to the Coronavirus (COVID-19) Pandemic



Scanning electron micrograph of the surface of a SARS-CoV-2 infected Vero cell (green), surrounded by less infected Vero cells (tan). SARS-CoV-2 can be seen budding from the surface and bound to the surface (blue). Magnification: 16,750X. Source: U.S. DHS

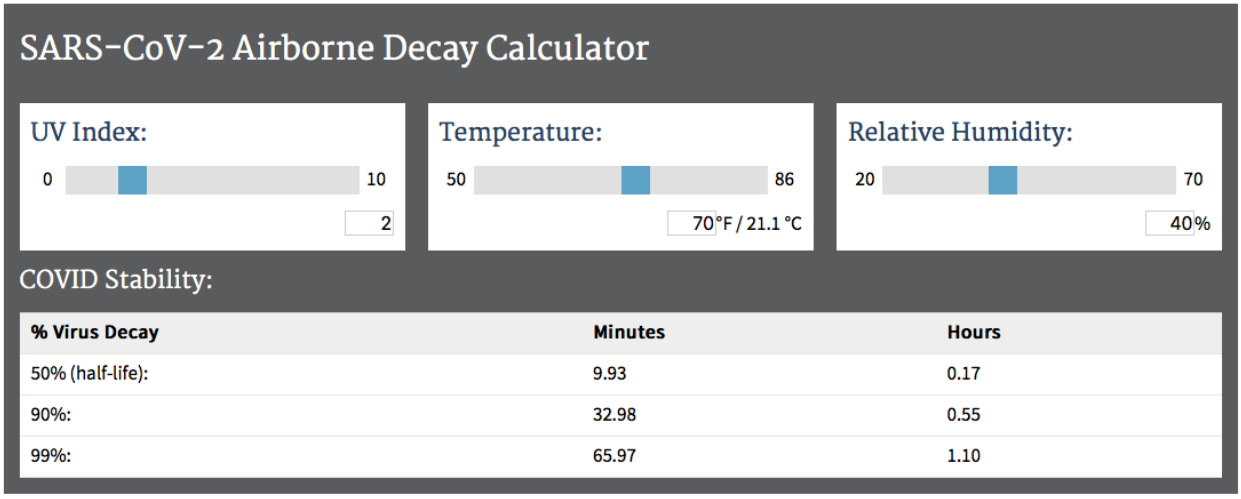
In 2020, DHS moved quickly to address the COVID-19 pandemic on multiple fronts, using the capabilities of its established laboratories, technologies that enable biological threat characterization, and research scientists. The following COVID-19 projects made important impacts.

Web-Accessible Calculators to Estimate Airborne and Surface Decay of SARS-CoV-2
To realistically assess risk and develop effective policy, health and safety professionals need access to scientific research findings. In early 2020, as the SARS-CoV-2 virus spread worldwide, few, if any, research results were available, so health and safety professionals lacked the knowledge to provide scientific guidance to the public. Health officials could not answer the most basic questions: Is it safe to touch a postal package? Could I become infected if another commuter on my bus is sick with COVID-19?

Scientists at DHS's National Biodefense Analysis and Countermeasures Center (NBACC) regularly conduct experiments to better understand biological vulnerabilities and hazards, and NBACC was quickly pulled in to support DHS's agency-wide COVID-19 response efforts.

NBACC researchers performed experiments with SARS-CoV-2 in their biosafety facility to determine how long the virus remained stable in either aerosols (airborne) or on surfaces, given various environmental conditions such as temperature and relative humidity. Their research findings provided the necessary scientific models to address these basic questions.

However, health and safety professionals needed a tool to help use the research models. DHS S&T's Probabilistic Analysis for National Threats Hazards and Risks (PANTHR) program develops tools to assist risk-informed decision making. PANTHR scientists and engineers developed easy-to-use, web-based calculators that allow health and safety professionals and members of the general public worldwide to input environmental conditions to determine how long the virus would remain viable. These calculators enabled the development of scientifically based public policy (e.g., requirements for face mask-wearing on public transit) and public safety guidance (e.g., it's safe to touch packages, but wash your hands after you open them). The figure shows the airborne stability calculator.



Coronavirus airborne stability calculator. Source: U.S. DHS

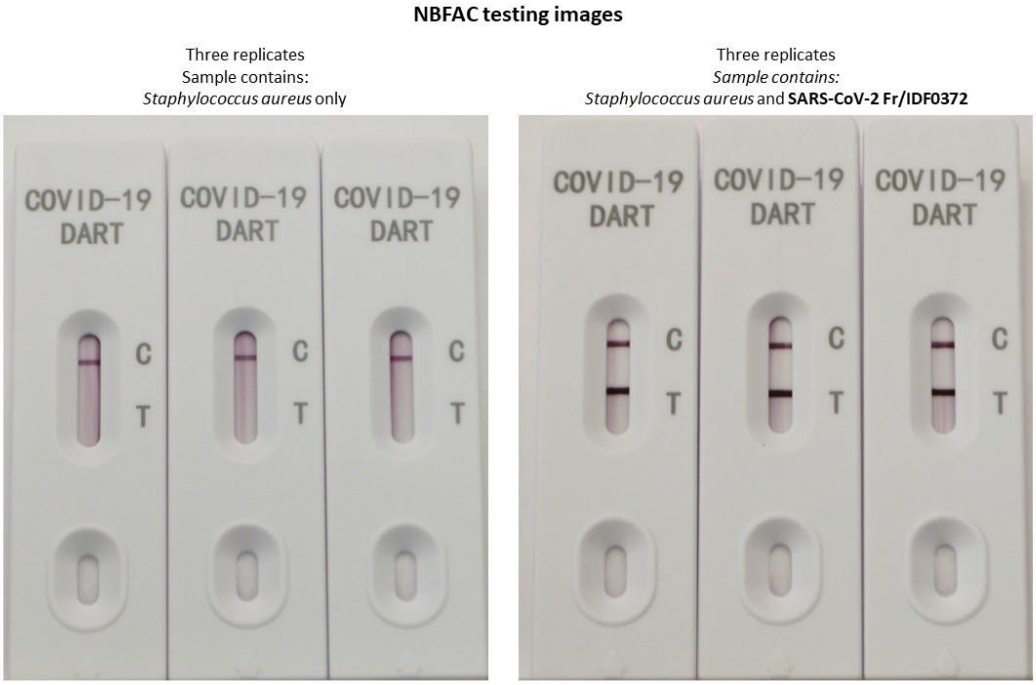
More information about the Coronavirus Stability Calculator is available at https://www.dhs.gov/science-and-technology/sars-airborne-calculator

Evaluation of a SARS-CoV-2 Direct Antigen Rapid Test (DART)

The need for a fast, accurate, inexpensive test to determine if an individual has been infected with SARS-CoV-2 was evident in early 2020 and will remain essential due to the ease with which the virus spreads and the potential disease severity. Fast test results enable clinical triage and allow doctors to make immediate decisions about treatment and patient isolation. Unfortunately, the majority of tests available in 2020 were polymerase chain reaction (PCR) tests, which accurately detect active SARS-CoV-2 infection in the individual but are labor intensive and time consuming.

S&T identified E25Bio, a small biotech company with a promising fast and inexpensive testing method based on a lateral flow immunoassay, the E25Bio Direct Antigen Rapid Test (DART). In their straightforward approach, the individual or a health professional 1) takes a sample using a nasal swab, 2) places the swab into a tube with test fluid, 3) squeezes a few drops of the fluid

onto a DART test cartridge, 4) waits 15 minutes, and 5) interprets colored markers that appear on the cartridge (similar to a home pregnancy test). E25Bio needed to generate data to confirm that the device was effective and accurate enough in detecting SARS-CoV-2 for making medical decisions.



E25Bio Direct Antigen Rapid Test (DART) result cartridge. Source: U.S. DHS

DHS entered into a CRADA with E25Bio to enable NBACC scientists to perform the necessary experiments with the E25Bio DART and collect data to demonstrate its effectiveness. E25Bio used the data generated by NBACC to support its applications to the U.S. Food and Drug Administration for home use and to the European Union for a Conformité Européenne (CE) mark. The CE mark was granted, enabling E25Bio to establish a global distribution agreement with PerkinElmer. The test is now sold as the PerkinElmer COVID-19 Antigen Test and is available in any region that accepts the CE mark for medical devices.

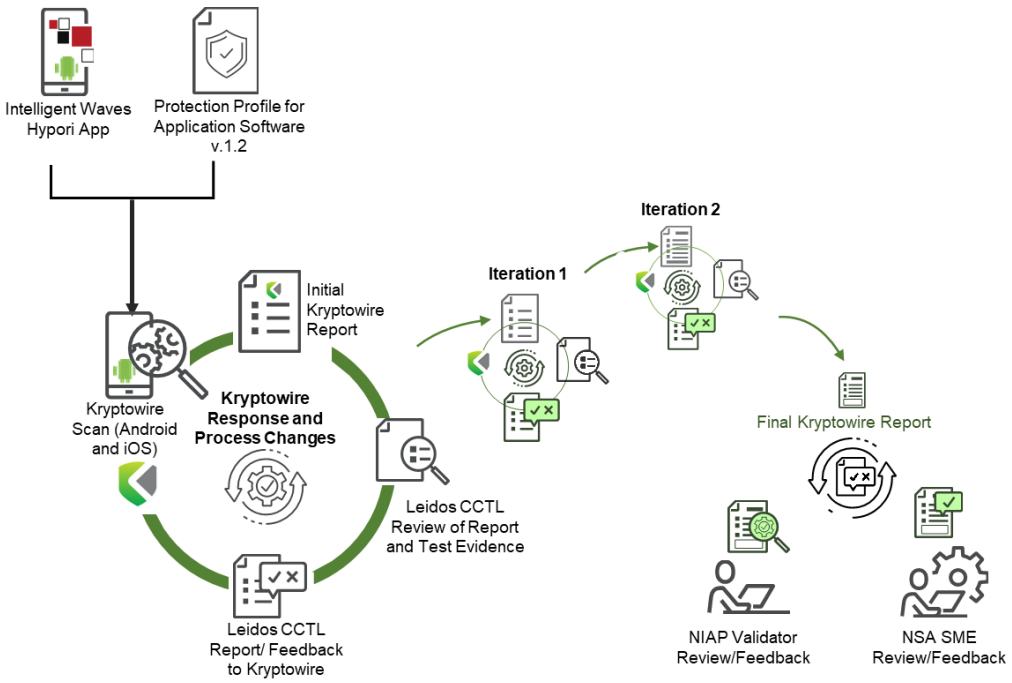
Automating NIAP Requirements Testing for Mobile Apps

Determining if application software meets the security requirements of an organization is essential and challenging. The National Security Agency-funded National Information Assurance Partnership (NIAP) oversees a program that evaluates the security characteristics of commercial products and certifies them for use in U.S. national security systems. The NIAP independent testing and evaluation process is internationally recognized for its thorough security assessment, and many government and commercial organizations adopt NIAP standards and use the results of its product evaluations for their most critical software procurement decisions.

Unfortunately, the NIAP evaluation process can be time consuming and costly. Timeliness and cost effectiveness are especially important for mobile apps (software applications that run on

mobile devices), as this software is updated frequently. Vetting just one mobile app through the NIAP process can consume as many as 60 hours of work by cybersecurity and technology experts, costing a Federal agency from $40,000 to $80,000. The timeframe for completing the NIAP process can be three to six months.

S&T partnered with NIAP on a pilot study to determine if a technology solution can be used to improve the timeliness and cost effectiveness of mobile app evaluations, without compromising the integrity of the evaluation. The pilot study used Kryptowire's software assurance tool, funded by S&T, to automate mobile app testing (i.e., mobile app vetting) as shown. During the study, Kryptowire engineers used their tool to test the iOS and Android versions of a mobile app that was recently certified to be compliant with NIAP's application software assurance standard as determined by NIAP's standard assessment process.



NIAP Automation Pilot Process. Source: U.S. DHS

The pilot showed that up to 90% of the NIAP testing for a mobile app can be automated and completed in just two hours. This significantly improves the efficiency of the evaluation process, shortens assessment timelines, and reduces costs, all of which are essential for frequently updated mobile apps. These results are good news for government and commercial organizations that want an effective, efficient tool to reduce security risks from commercially available apps.

The pilot project was also valuable for Kryptowire. Feedback from NIAP evaluation experts led Kryptowire engineers to augment the tool's testing capabilities, adjust result reporting to better align with the evidentiary needs of the certification process, and make the product easier to use. Publication of the study results helped Kryptowire distinguish its app-vetting product from those of its competitors. New customers have adopted the Kryptowire product, including some U.S. civilian government agencies, commercial companies, and international government agencies.

Some international government agencies, previously unaware of the NIAP app security standards, are now considering adopting those standards for their own environments.

The study report, "Automating NIAP Requirements Testing for Mobile Apps," June 29, 2020, authored by S&T and the NSA is available at:
https://www.dhs.gov/sites/default/files/publications/niap_report_508c_062620.pdf

Low-Cost Flood Inundation Sensors
Flooding is the nation's leading natural disaster, resulting in catastrophic loss of life, property damage, and economic impact. Over the past 30 years, flooding is estimated to have cost more than $8.2 billion in damages and averaged more than 105 fatalities per year. Some of this devastation could be prevented by using flood inundation sensors. Unfortunately, the high cost (close to $20,000 for a single unit, plus more than $10,000 in annual maintenance) of many permanent flood sensors available today significantly limits their use.

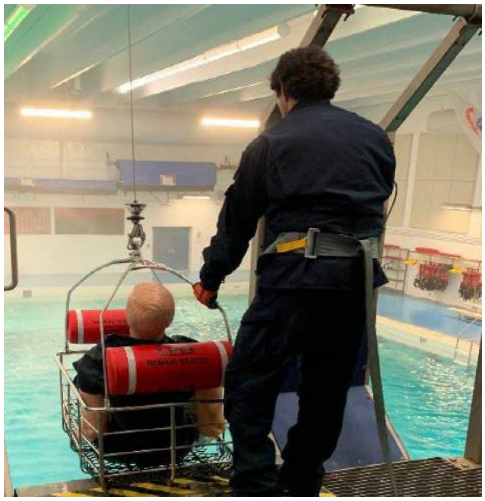
Intellisense Systems, an S&T SBIR awardee, designed and developed a rugged, but inexpensive (under $4000 per unit) flood inundation sensor that can be incorporated into a scalable, wireless network to rapidly measure rising water and report flood conditions back to operations centers, first responders, and citizens.

The Intellisense Systems' AWARE flood sensor, while commercially available, is now part of several multi-party CRADAs with state and local governments to obtain additional data to improve the design and operation of the flood sensor. The ultimate goal of the CRADAs is to improve the technology and offer it to the public at a lower cost. The lower cost of the sensors will enable affected communities to distribute them more widely, establishing a more comprehensive flood monitoring platform.

More information about the low-cost flood inundation sensors can be found at:
https://www.dhs.gov/sites/default/files/publications/floodsensor_factsheet.pdf

Developing a Hoist Rescue Glove
Helicopter search and rescue operations aid people who are in distress or imminent danger, often in emergency situations such as floods, wildland fires, or challenging wilderness conditions. To lift people aboard a helicopter, rescue personnel must often manually guide a steel hoist cable. Other hoist missions, such as cave, white water, or dive rescues, tend to involve rope-based trail lines, rather than steel cables.

S&T's First Responder Research Group identified a high priority need for durable hoist rescue gloves that support good dexterity. Abrasion from hoist cables can damage or destroy the gloves after only one or two rescues, and abraded glove material can become dangerously



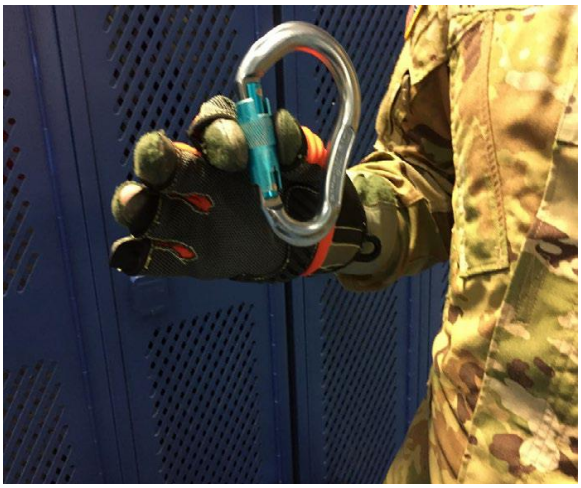
Evaluator performing a hoist test.
Source: U.S. DHS

entangled in the rescue cable. Hand dexterity is essential for successful rescue operations, as the safety of both victims and rescue personnel depend on it.

Under a CRADA, S&T worked with Higher Dimension Materials, Inc. (HDM) and the North Carolina State University Textile Protection and Comfort Center (TPACC) to conduct research and development of advanced, abrasion-resistant glove materials and alternative glove designs. HDM and TPACC worked with commercial glove manufacturers to design and produce three glove prototypes using high-performance materials.

S&T's National Urban Security Technology Laboratory (NUSTL) conducted an operational field assessment at the U.S. Coast Guard's (USCG) Aviation Technical Training Center to evaluate the suitability of the gloves for use by emergency responders. Rescue personnel from the North Carolina National Guard, the San Diego (California) Fire and Rescue, and USCG evaluated the prototype gloves in tests with cables and ropes in calm air and mechanically generated wind and rain.

Testers performed intricate manual tasks, such as attaching and detaching carabiners, adjusting buckles, and operating helicopter controls and keyboards. They tried various combinations of wet and dry hands with wet and dry gloves. Evaluators began with new gloves, and durability characteristics were checked after each activity, culminating in a test of guiding a weighted hoist cable continuously for one minute.



Evaluator performing a dexterity test. Source: U.S. DHS

Feedback from the evaluators on the location and thickness of padding, color of wear evidenced by fabric layers (which might be difficult to distinguish after paint from hoist-cable markings transfers to the gloves), seam placement, and other features enabled HDM to combine the preferred characteristics from the different prototypes and design a single glove to best meet operator needs.

HDM identified a manufacturer for the new hoist rescue gloves and the initial production run of 500 rescue hoist gloves were provided primarily to search and rescue helicopter units in the United States. American Security Today awarded S&T's NUSTL a 2020 Platinum ASTORS award for Excellence in Public Safety for their work in the development of the hoist rescue gloves.

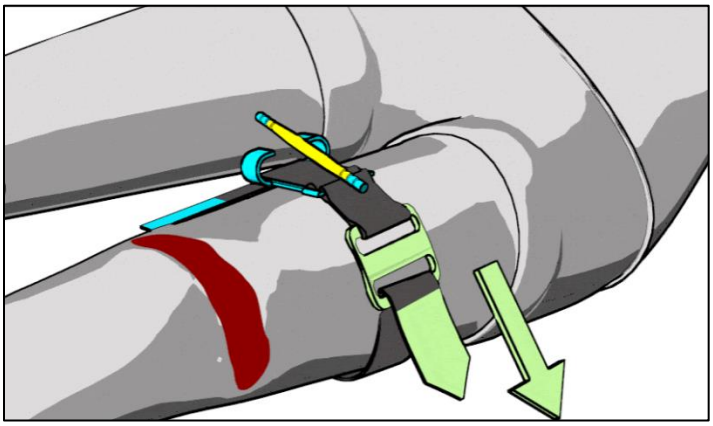
More information about the hoist rescue gloves is available at: https://www.dhs.gov/science-and-technology/news/2020/03/31/snapshot-enhancing-hoist-rescue-gloves-aerial-rescue and https://www.dhs.gov/science-and-technology/news/2021/05/24/news-release-enhanced-rescue-hoist-glove-available-responders

Training High School Students to Stop Severe Bleeding

FAST teaches to high school students proper use of tourniquet techniques with readily available items Source: U.S. DHS

Severe bleeding from traumatic injuries during disasters or accidents can lead to death in as little as five minutes. If properly trained, bystanders can save lives if they act quickly to stop the bleeding until medical help arrives. When high school students across the nation are provided with first aid training focused on these lifesaving skills, they will be better prepared to respond to traumatic injuries and potentially save the lives of their friends, family, or the public.

S&T, in collaboration with the Federal Emergency Management Agency, funded the Uniformed Services University's National Center for Disaster Medicine and Public Health (NCDMPH) to develop age-appropriate trauma training for high school students. The First Aid for Severe Trauma (FAST) training was developed by NCDMPH and the American Red Cross in partnership with teachers and medical experts.



FAST training research project with HOSA – Future Health Professionals. Source: U.S. DHS

The FAST curriculum was designed to teach students how to respond effectively to a bleeding emergency, regardless of the cause of the injury. The course covers a variety of injury scenarios and teaches students how to assess the safety of the scene, determine whether bleeding is life-threatening or not, communicate effectively with emergency medical personnel and others at the scene, apply direct pressure, and place a tourniquet correctly.

More than 250 high school teachers have participated in certification training to become provisional FAST instructors, and virtual focus groups have examined challenges and potential solutions for FAST implementation at state and local levels and in school districts and classrooms. A study published in May 2020 in the journal *Academic Pediatrics* found that high

school students can learn effective hemorrhage control via the mixed-mode training methods (i.e., web-based training, followed by in-person skills practice) developed by the program.[45]

FAST has been transferred to the American Red Cross as a formal addition to their training opportunities and will not depend on future federal money. The American Red Cross is currently accepting pre-orders for the FAST education program. The in-classroom and blended learning (online plus in-classroom) classes are expected to be available in August 2021.
The FAST course will be offered to high school students at no charge, and the digital materials (e.g., online training videos, instructor manuals, reference cards, and student manuals) will be available to schools for free. For schools that do not already have supplies (e.g., limb models and tourniquets) for classroom training, the American Red Cross is developing classroom training kits for purchase.

More information about the FAST training can be found at https://www.redcross.org/take-a-class/first-aid/first-aid-training/first-aid-classes/fast-training.

[45] Craig Goolsby, Luis E. Rojas, Raphaelle H. Rodzik, Marianne Gausche-Hill, Matthew D. Neal, Matthew J. Levy, High-School Students Can Stop the Bleed: A Randomized, Controlled Educational Trial, Academic Pediatrics, Volume 21, Issue 2, 2021, Pages 321-328. https://doi.org/10.1016/j.acap.2020.05.012

Department of the Interior (DOI)

Technology transfer for the Department of the Interior (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 2020 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.

DOI's bureaus have varying levels of involvement with scientific and technical research and innovation and technology transfer. In FY 2020, as in previous years, the majority of technology transfer activities reported by DOI under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS), which is DOI's largest R&D organization, both in terms of budget and personnel. Typically, USGS accounts for about two-thirds of DOI's R&D budget.

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 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 2020, Bureau of Reclamation (Reclamation or BOR), Bureau of Ocean Energy Management (BOEM), Fish and Wildlife Service (FWS) and National Park Service (NPS) personnel authored or co-authored at least 720 reports, books, fact sheets and other publications disseminating mission-relevant scientific and other technical information to the public and peers in and out of government—other bureaus do not collect this information in a readily accessible manner.

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, seven DOI bureaus are active participants in the network of 17 Cooperative Ecosystem Studies Units (CESUs), a collaboration among 16 Federal agencies and more than 470 non-Federal partners (including universities, Tribes and Tribal organizations, State agencies, museums, aquariums, arboretums, and conservation organizations). The CESU Network extends across biogeographic regions in all 50 states, the District of Columbia, and U.S. insular areas. 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 Reclamation's Prize Competitions Program. From FY 2019-2020, DOI bureaus completed, had underway, or launched 14 prize competitions, which included competitions led by Reclamation, BOEM, and FWS; an additional competition was led by the National Invasive Species Council and included contributions from NPS, FWS, and USGS.

Bureaus that are active in R&D 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 DOI's bureaus and the non-governmental sector (including private entities) to pool their expertise and resources to jointly create and advance technologies that support agency missions while helping U.S. industries innovate and commercialize technologies that strengthen the 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 2020 Accomplishments

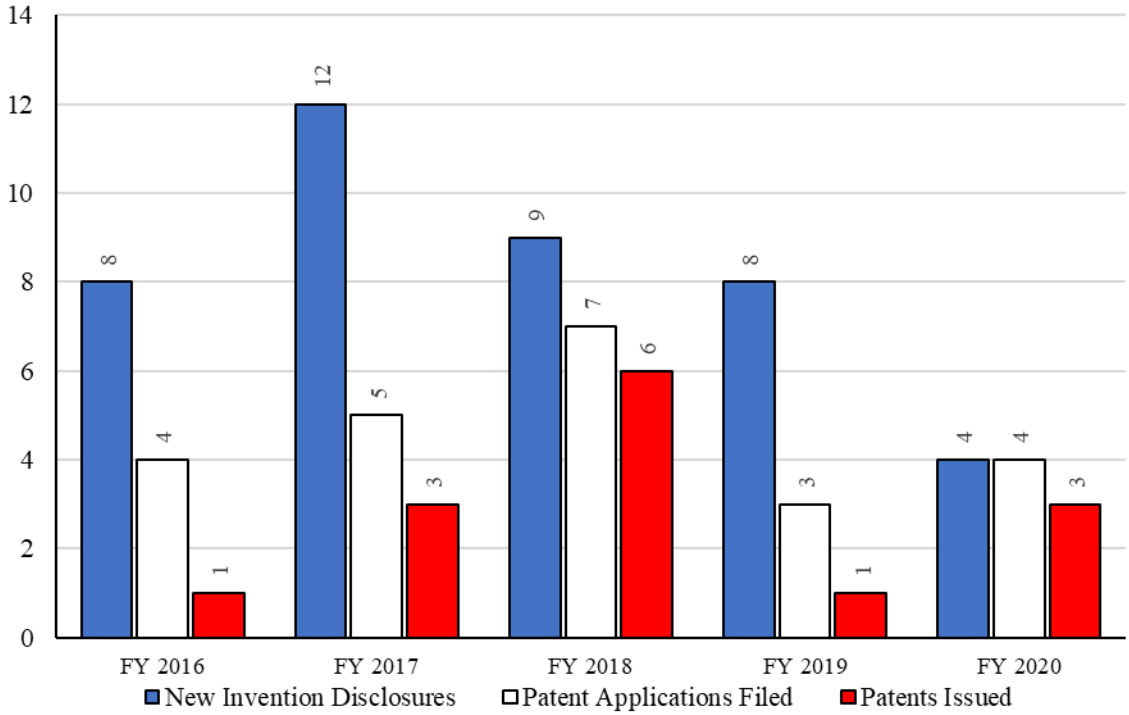
During FY 2020, DOI's scientific, technical, and engineering personnel continued to engage in a broad range of cooperative activities to develop and disseminate innovative technologies, including:

- Collaborating on 489 CRADAs, of which 237 were initiated in FY 2020. In addition, DOI engaged in at least 457 other collaborative R&D relationships.
- Engaging in 353 nontraditional CRADAs, such as material use and facility use agreements, under the FTTA.
- Four (4) new inventions were disclosed; four (4) new patent applications were filed; three (3) new patents were awarded.
- Managing seventy-one (71) active patent licenses for inventions and other IP, earning about $123,000 collectively. The large increase in licensing activity from 18 to 71 from FY 2019 to FY 2020 is mainly due to the demand from various authorities for pilot agreements and licenses to use and operate USGS's ShakeAlert systems.
- Reclamation, BOEM, FWS, and NPS personnel authored or co-authored at least 720 reports, books, fact sheets, and other publications disseminating mission-relevant scientific and other technical information to the public and peers in and out of government.

DOI Invention Disclosures and Patenting

From FY 2016 to FY 2020, new inventions disclosed decreased by 50%, from 8 in FY 2016 to 4 in FY 2020. Patent applications filed did not change, with 4 in FY 2016 to 4 in FY 2020. Patents issued increased by 200%, from 1 in FY 2016 to 3 in FY 2020.

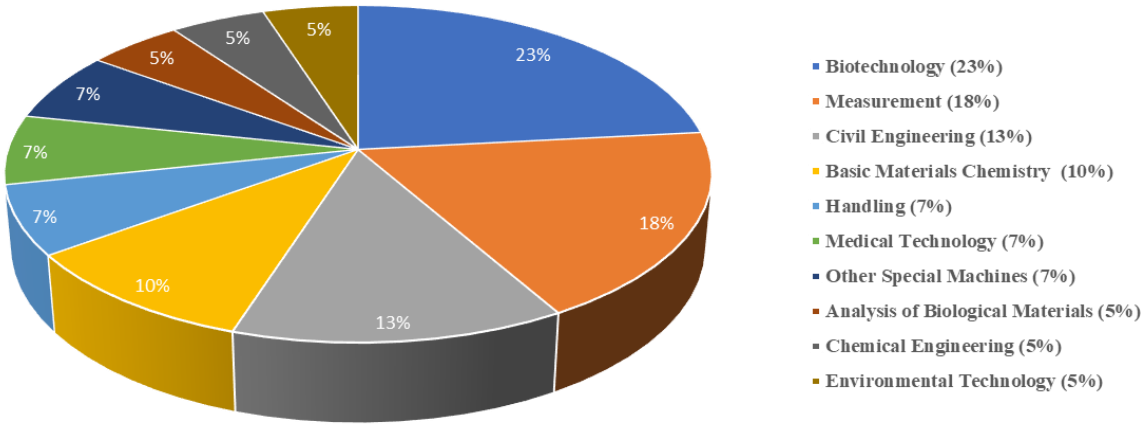
DOI Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	8	12	9	8	4
Patent Applications Filed	4	5	7	3	4
Patents Issued	1	3	6	1	3

The patents issued to DOI in FY 2020 covered multiple technology areas including Biotechnology (23%), Measurement (18%), Civil Engineering (13%), Basic Materials Chemistry (10%), and Handling (7%).[46]

USPTO Patents Assigned to DOI by Technology Area: FY 2020

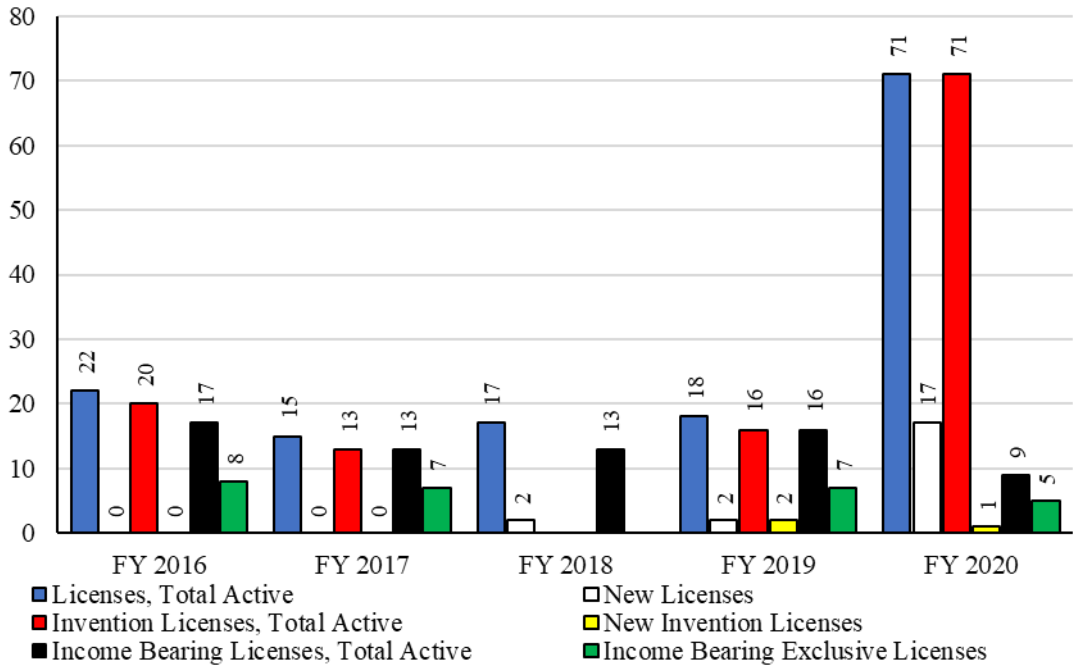


[46] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DOI Licenses[47]

From FY 2016 to FY 2020, total active licenses increased by 223%, from 22 in FY 2016 to 71 licenses in FY 2020. DOI reported 17 new invention licenses in FY 2020. Total active invention licenses increased by 255%, from 20 in FY 2016 to 71 in FY 2020. DOI reported 1 new invention license in FY 2020. Total active income bearing licenses decreased by 47%, from 17 in FY 2016 to 9 in FY 2020. Income bearing exclusive licenses decreased by 38%, from 8 in FY 2016 to 5 in FY 2020.

DOI Licenses



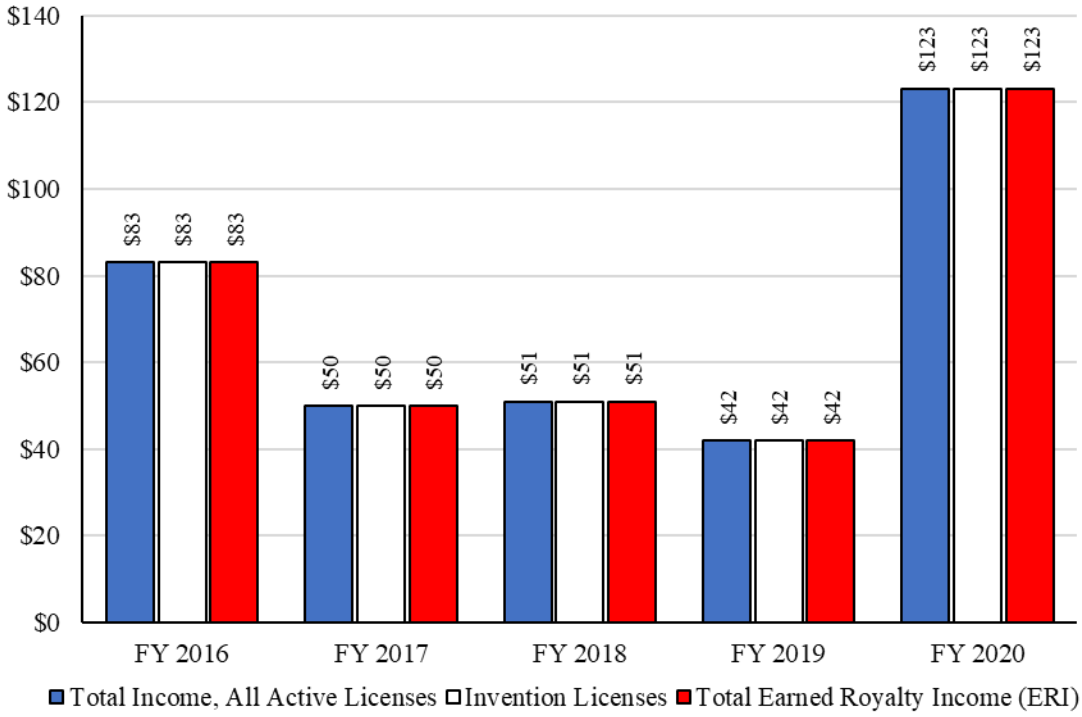
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	22	15	17	18	71
New Licenses	0	0	2	2	17
Invention Licenses, Total Active	20	13	n.a.	16	71
New Invention Licenses	0	0	n.a.	2	1
Income Bearing Licenses, Total Active	17	13	13	16	9
Income Bearing Exclusive Licenses	8	7	n.a.	7	5

[47] 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 2016 and FY 2020, total income from all active licenses increased by 48%, from $83 thousand in FY 2016 to $123 thousand in FY 2020. The income from invention licenses increased by the same amount, as all income received came from invention licenses. Total earned royalty income also increased by 48%, from $83 in FY 2016 to $123 thousand in FY 2020.

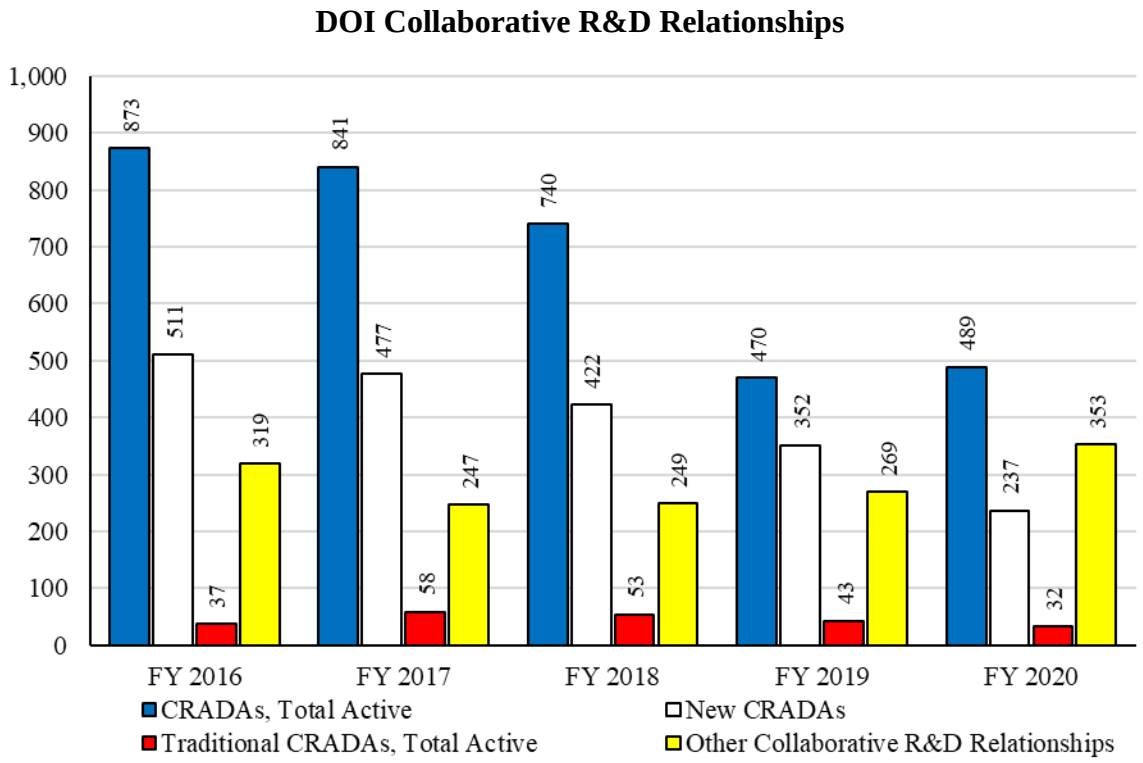
DOI Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$83	$50	$51	$42	$123
Invention Licenses	$83	$50	$51	$42	$123
Total Earned Royalty Income, (ERI)	$83	$50	$51	$42	$123

DOI Collaborative R&D Relationships

From FY 2016 to FY 2020, total active CRADAs decreased by 44%, from 873 in FY 2016 to 489 agreements in FY 2020. The number of new CRADAs decreased by 54%, from 511 in FY 2016 to 237 in FY 2020. Traditional CRADAs decreased by 14%, from 37 in FY 2016 to 32 agreements in FY 2020. Other collaborative R&D relationships increased by 11%, from 319 in FY 2016 to 353 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	873	841	740	470	489
New CRADAs	511	477	422	352	237
Traditional CRADAs, Total Active	37	58	53	43	32
Other Collaborative R&D Relationships	319	247	249	269	353

DOI Downstream Success Stories

United States Geological Survey: Gazelle™ COVID-19 Screening Test
On April 17, 2020, the U.S. Geological Survey entered into a cooperative research and development agreement with Hemex Health and PAI Life Sciences to develop a rapid COVID-19 screening test. The test will use an assay based on antibodies produced from COVID-19-vaccinated juvenile sea lamprey to detect the virus in human saliva samples. This test could be an invaluable resource for healthcare professionals in the fight against the ongoing global pandemic.

The new screening tool differs from other diagnostic coronavirus tests in that it detects the shed protein of COVID-19 rather than the virus's nucleic acids. Because the lamprey antibodies, or "lampribodies," used in the development of the tool are stable at a wide range of temperatures, the actual test would not require continuous refrigeration. Removing this step would make the test invaluable in low-resourced areas around the world.

As of January 2021, USGS scientists have successfully produced a lampribody positive control to an irrelevant protein as part of the screening process. To date, the laboratory has processed thousands of lampribody samples from vaccinated lamprey. The lead scientist has created genetic libraries encompassing the lampribody response post-vaccination with SARS-CoV-2 proteins and continues to screen these libraries for virus-specific lampribodies to use in the test. This work continues to provide strong partnership between biotech companies and government scientists.

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.

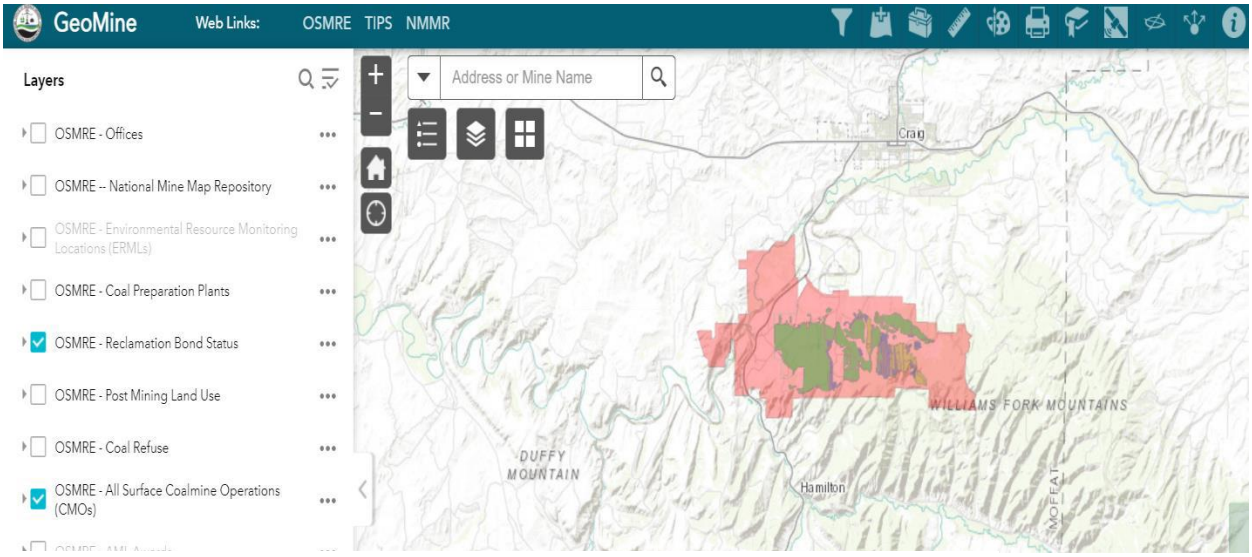
NCTC also hosts publicly accessible webinars dealing with a variety of scientific and technical issues that affect the nation's fish and wildlife resources. During FY 2020, NCTC hosted 111 online science, technology, and educational webinars and 84 e-courses related to managing the Nation's fish, wildlife, and plant resources. These are important components of FWS's traditional technology transfer activities.

Office of Surface Mining Reclamation and Enforcement (OSMRE): GeoMine Web Application
The OSMRE Technical Innovation and Professional Services (TIPS) continues to develop and enhance the GeoMine Web Application, an interactive web-based mapping application for coal mining and reclamation activities within the United States. The TIPS program also trains State, Tribal, and Federal personnel to ensure that all agencies with responsibilities under the Surface

Mining Control and Reclamation Act of 1977 (SMCRA or the Act) are using the same advanced software and hardware tools to conduct the business required by the Act.

GeoMine is designed to provide authoritative data for surface coal mining and reclamation operations across the country, merging data from numerous sources to create standardized, seamless layers that cross State and Tribal boundaries. OSMRE updated the GeoMine Web Application in 2020 to add two new layers and improve functionality, especially for mobile device optimization. The first new layer displays the DOI Unified Regional Boundaries which were finalized on August 22, 2018, and reflect DOI's recent reorganization from 49 regions across 8 bureaus to 12 Interior Regions, based on watersheds, but generally drawn along state lines to simplify coordination with external partners. The second new layer is the 2020 abandoned mine lands (AML) reclamation layer which displays the locations of abandoned mines. All layers for GeoMine are publicly available on the GEOMine website and consist of data from State, Tribal and Federal Partners. Satellite imagery is updated through a live feed.

The GeoMine data, which are updated as they are made available to OSMRE, are also linked to the national GeoPlatform.gov, making data easily searchable and integrated with data published by other agencies. This transparency allows the public to better understand the impacts of coal mining and reclamation activities.



An example of GeoMine mining-related feature classes. Source: U.S. DOI, OSMRE.

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 2020, the COVID-19 pandemic impacted In-Situ's operations, delaying existing projects and reducing the overall market demand for water monitoring instruments. 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): Developing Monitoring Technologies to Measure Online Cavitation Impacts and Residual Stress of Installed Materials in Hydropower Turbines

In 2017, Reclamation and General Electric (GE) entered a three-year CRADA to conduct research at Grand Coulee Powerplant. The first objective of this research was to develop technologies for online measurement and analysis of damaging cavitation occurring within a Reclamation generator turbine. The second objective was to measure residual stress in machine materials to determine remaining useful life of welded hydropower components. In both areas, great progress was made that will improve powerplant operation and extend component life, thereby reducing future costs to consumers.

To assess damaging cavitation, several tests and inspections were performed, focusing on generator turbine runners. Model test data depicting different cavitation types, regions, and operational zones were examined and analyzed. A cavitation monitoring system was designed and installed on a test unit and an initial cavitation damage algorithm based on model and test data was developed and integrated into the detection system. Future work will focus on comparing results of data acquired from the monitoring system to actual cavitation damage measured during maintenance inspections of the generator turbine runner. Such results will be used to improve the algorithm and predict the amount of damage incurred over a given time and operation regime.

During this cavitation research, the team focused additional attention on one cavitation case associated with the violent collapse of cavitating "rope vortices" within the turbine unit. These are helical vortices composed of spinning fluid particles which are created when turbines operate in conditions away from their design point. This creates violent pressure fluctuations caused by a helical vortex within the turbine, which can damage the turbine. When these vortices collapse, loud and violent shocks are produced that stress the turbine unit and plant structure. Operators constrain the range of turbine operation to avoid operating zones where these vortices occur. In response, the research team developed and evaluated schemes to inject air at various turbine locations to reduce their occurrence. It was determined that a small amount of injected air at specific locations could effectively mitigate these cavitating rope vortex risks and provide the benefit of expanding the turbine's range of suitable operation, thereby helping increase the amount of electricity generated at minimal cost. Based on these results, an automated air injection system was developed and installed on the test unit.

Lastly, methods for measuring residual stress of installed hydropower welded components were investigated. Residual stress provides a sense about a material's remaining service life. Different non-destructive test (NDT) measurement techniques included Magnetic Barkhausen Noise (MBN), X-ray diffraction, and hole-drilling techniques were performed on a runner in the GE shop as well as on a Francis turbine runner, pump-turbine runner, and rotor spider at Grand Coulee.

X-ray diffraction is a direct measurement technique that is relatively accurate but more costly and complex to implement whereas MBN is a new, indirect residual stress measurement technique but needs calibration against X-ray diffraction measurements to allow the conversion of magnetic parameter readings into stress readings. MBN measurements would need to be taken on a regular basis and compared to the prior one. The MBN technique was found to offer reasonable accuracy and favorable ease of implementation relative to the X-ray diffraction technique and could be well-suited for monitoring installed hydropower welded components. These CRADA successes have led Reclamation and GE to enter a successor CRADA to continue research into cavitation detection and monitoring.

Bureau of Safety and Environmental Enforcement (BSEE): Joint Industry Projects (JIPs) to Advance Remote Visual Inspection and Oil Spill Cleanup

Significant technological advances, commercialization, and increased use of Autonomous Unmanned Vehicles (AUVs) over the past 20 years are yielding greater opportunities for DOI to augment the manned safety inspection and cleanup programs undertaken by or on behalf of BSEE. Given the successes by the U.S. DOI's Office of Aviation Services which has an extensive Unmanned Aircraft Systems (UAS) Program utilizing aerial drones to fly missions for DOI agencies to combat wildfires and provide insight for the nation's natural resources, wildlife and cultural heritage, BSEE is researching opportunities to utilize similar technologies for use offshore. AUVs (robotic vehicles that travel without or with only minimal real-time input from an operator) are self-propelled vehicles that can be manually operated and/or pre-programmed to navigate 3-dimensional missions for an extended period. AUVs are deployed from a surface vessel (or from shore) to operate independently in performing surface and underwater missions from a few hours to several months in duration over distances of 1000 miles and depths to 15,000 ft. Following are two example JIPs that BSEE is involved in.

Remote Inspection of Oil and Gas Infrastructure.

BSEE is exploring the use of AUVs to inspect oil and gas infrastructure (including pipelines) along the seafloor as well as fixed and floating facilities located hundreds of miles offshore and in water depths of 8000+ feet (e.g., offshore oil platforms and ancillary facilities). AUVs have the ability to operate 24/7, 365 days a year, including bad weather days (fog, rain, high winds) that often hamper and/or prevent manual inspections, without endangering BSEE staff. AUV technology can be applied to maintain future wind turbines and associated infrastructure installed on the Outer Continental Shelf (OCS) as part of BSEE's wind-energy program. They can augment BSEE's existing inspection program by enabling inspection of submerged, damaged, poorly maintained or other problematic attributes (e.g., platforms without functioning helidecks that would otherwise require inspectors to enter by a boat and swing rope). They can also free up personnel to focus on higher consequence facilities.

Remote Oil Spill Collection Systems.
BSEE has also entered into a JIP to develop a new Remotely Operated Unmanned Surface Vehicle (ROUSV) for airborne deployment for oil spill herding agents (i.e., spill collecting agents) and igniters that will burn off the collected oil. The Oil Spill Recovery Institute (OSRI) is administering the JIP and Tactical Electronics (Tulsa, OK) has been subcontracted to develop an operational prototype of the technology. In addition to BSEE, JIP partners include ExxonMobil, Shell, Oil Spill Response Limited (OSRL), and the North Caspian Operating Company.

The ROUSV will allow more time on station with the potential to carry larger loads of herders and igniters to conduct a minimum of five in situ burn operations simultaneously. The ROUSV will be capable of being deployed from the shore, a boat, a fixed-wing airplane, or helicopter. This JIP builds upon previous efforts to develop an aerial herder ignition system and will include flight trials and testing of the full system.

Bureau of Ocean Energy Management (BOEM): Wind Tunnel Experiments for Oil and Gas Platforms and Drilling Rig Downwash
BOEM is responsible for regulating certain air emissions from oil and gas activities (exploration, development, and production) on the OCS in the Western and Central Gulf of Mexico to prevent these activities from significantly impacting any State's air quality. Dispersion models are critical to understanding how pollutants released from oil production platforms and different types of drilling rigs can be carried through the air to nearby onshore areas and possibly impact air quality and human health. This study will employ laboratory wind tunnel testing to better parameterize BOEM's dispersion models and help fill this important information need in BOEM's air quality management approach.

Bureau of Land Management (BLM): BLM's National Conservation Lands
BLM's National Conservation Lands collectively comprise a natural scientific "laboratory," attracting scientists from around the world to investigate topics ranging from geology, paleontology, archaeology and history to biology, botany and ecosystem studies. Much of the research on the National Conservation Lands is conducted through partnerships with scientists and scientific organizations including universities, government agencies, American Indian tribes, Alaska Native organizations, special-focus groups and non-governmental organizations. Scientific projects inform the decision-making process of BLM managers and public outreach is emphasized.

In FY 2020, nationwide efforts included improvements to systems for tracking research efforts and updating standardized resource condition monitoring systems and datasets in areas such as Wild & Scenic Rivers and National Scenic and Historic Trails. These improvements build upon BLM systems identified in previous DOI Technology Transfer Reports. Two volumes of guidance (methods and field guide) were released in 2020 to help assess projects on the tens-of-thousands of miles of trails. The methodology is interdisciplinary to help inform management decisions by measuring the health of the overall landscape while ensuring the protection, conservation, and opportunities for enjoyment of the cultural, historic, scenic and natural resources along these Trails.

Research and development efforts on National Conservation Lands frequently have broad landscape-level application. Highlights from FY 2020 include research informing post-fire restoration of sagebrush/sage grouse habitat; pollinator habitat studies providing cross-cutting insight into the relation between flora, fauna, and land use; night-sky research informing the impacts of land use change on dark-skies; paleontological and archaeological resource inventories that increase our knowledge of the Nation's shared heritage; wetland condition assessments; and rare species assessments.

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, the primary goal being safety. DOT's technology transfer program, which is housed in the Office of the Assistant Secretary for Research and Technology (OST-R), is responsible for coordinating, documenting, and supporting technology transfer activities across the department.

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

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

- Federal Aviation Administration (FAA):
  - Civil Aerospace Medical Institute, Oklahoma City, OK
  - The William J. Hughes Technical Center (WJHTC), Atlantic City, NJ
- 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
- Federal Railroad Administration (FRA): Transportation Technology Center, Pueblo, CO

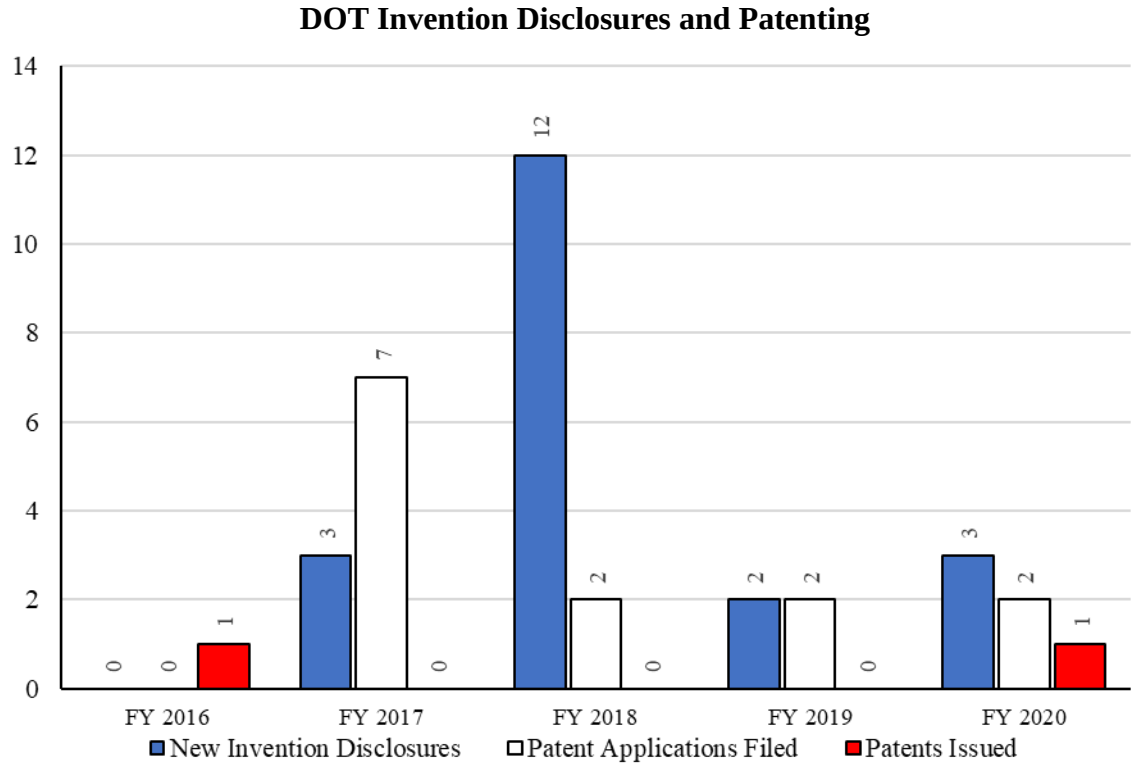
DOT also cooperates with the United States Office of Management and Budget to implement Cross-Agency Priority (CAP) goals to tackle critical government-wide challenges that cut across agencies. One of these CAP Goals is to "Improve Transfer of Federally Funded Technologies from Lab to Market." Within DOT, OST-R leads cross-modal efforts to collaborate with the White House's Office of Science and Technology Policy, in support of the Lab-to-Market (L2M) CAP Goal. As part of this effort, OST-R has created a T2 Evaluation Working Group composed of representatives from the Department's OAs. The Working Group is assessing the effectiveness of past T2 efforts and developing recommendations for future T2 efforts.

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 2020, DOT reported 3 invention disclosures, 2 patent applications, and 1 new patent was issued.

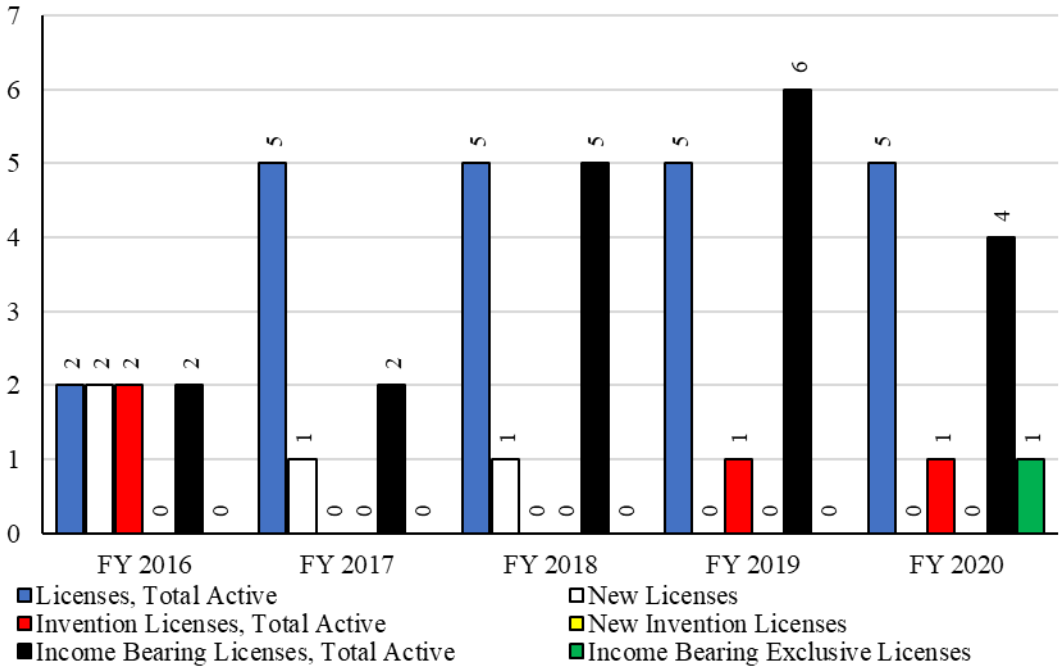


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	0	3	12	2	3
Patent Applications Filed	0	7	2	2	2
Patents Issued	1	0	0	0	1

DOT Licenses

In FY 2020, DOT reported 5 active licenses and 1 invention license. Income bearing licenses increased by 100%, from 2 in FY 2016 to 4 in FY 2020. DOT reported one income bearing exclusive license in FY 2020.

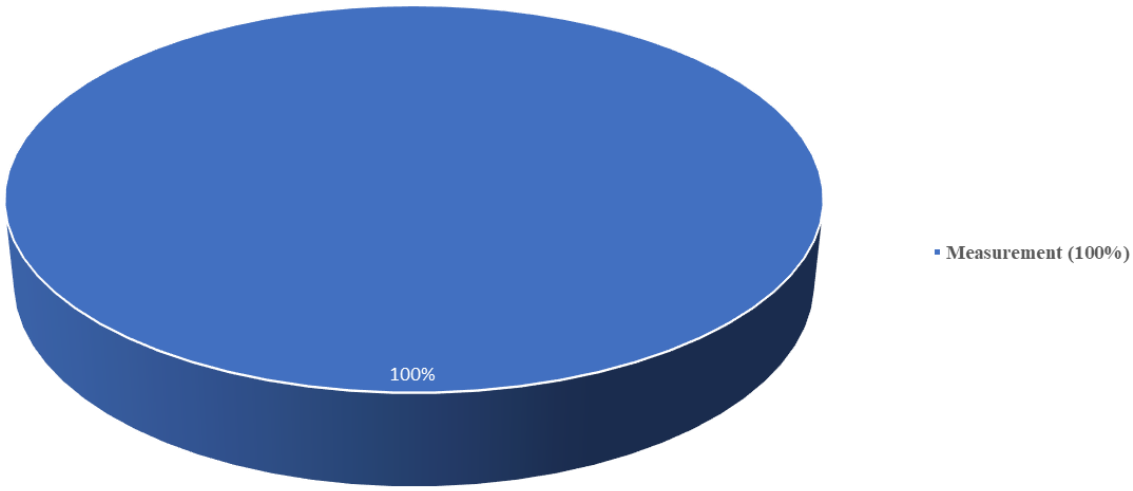
DOT Licenses



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	2	5	5	5	5
New Licenses	2	1	1	0	0
Invention Licenses, Total Active	2	0	0	1	1
New Invention Licenses	0	0	0	0	0
Income Bearing Licenses, Total Active	2	2	5	6	4
Income Bearing Exclusive Licenses	0	0	0	0	1

The patents issued to DOT in FY 2020 covered the technology area of Measurement (100%).[48]

USPTO Patents Assigned to DOT by Technology Area: FY 2020

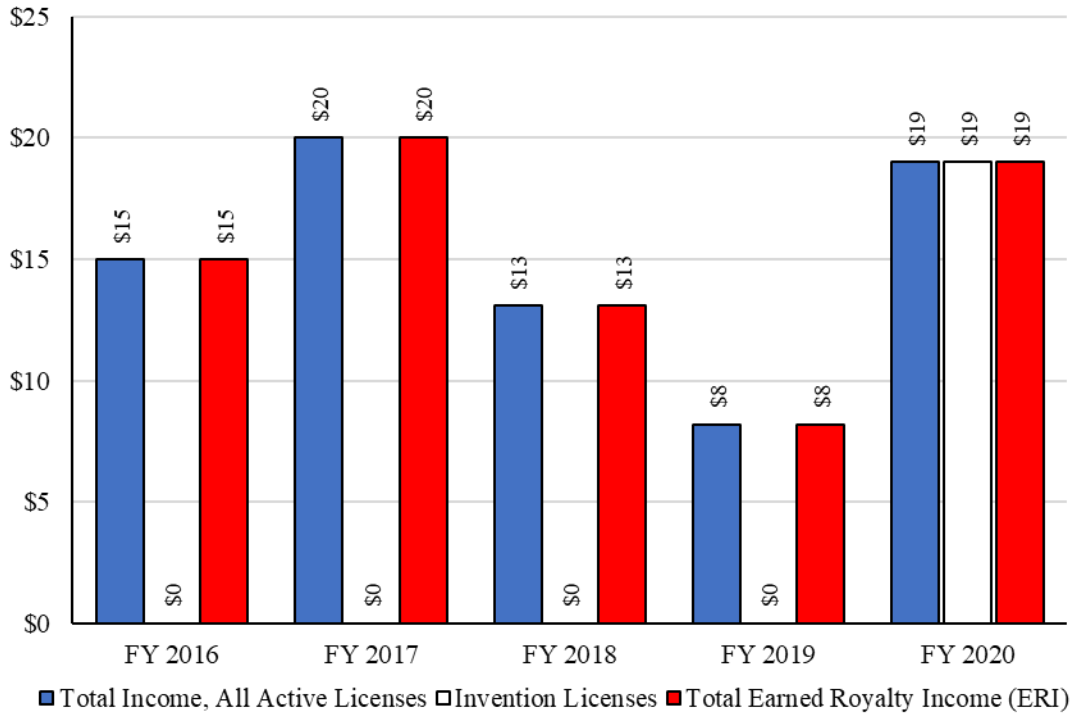


[48] Source: Prepared by Science-Metrix using USPTO data indexed in PatentsView in January 2022. Used with permission.

DOT Income from Licensing

Between FY 2016 and FY 2020, total income from all active licenses increased by 27%. All income was reported as income from invention licenses. Total earned royalty income increased by 27% from $19 thousand in FY 2016 to $19 in FY 2020.

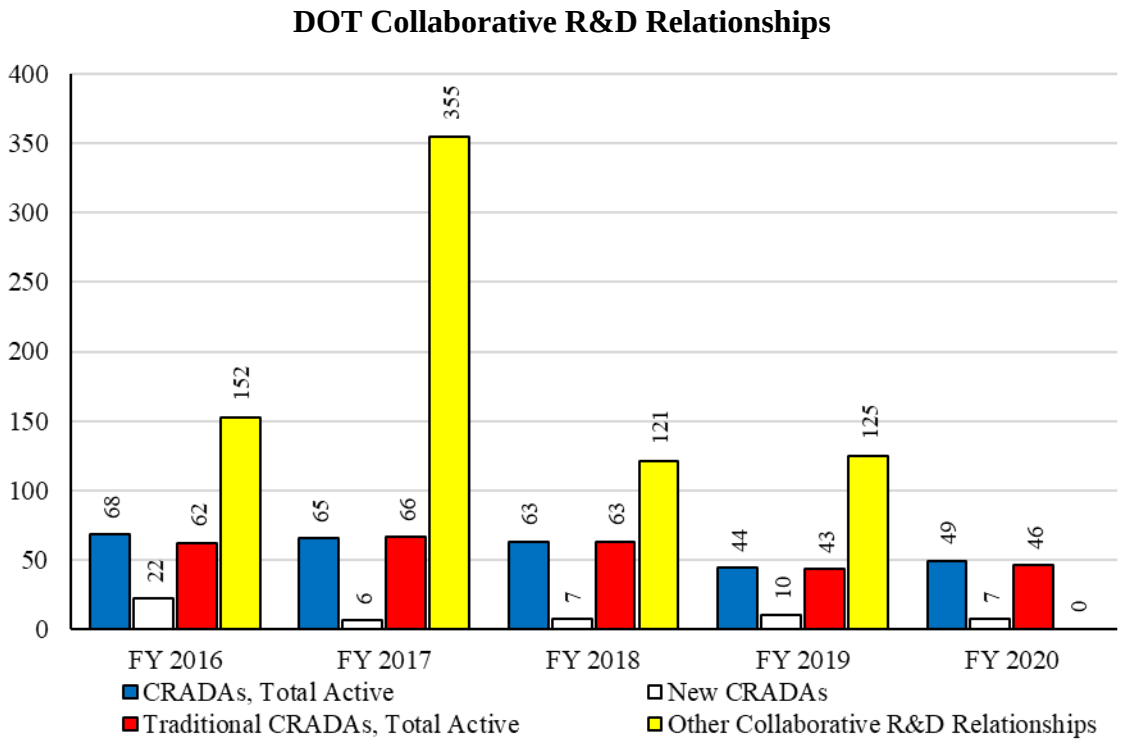
DOT Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$15	$20	$13	$8	$19
Invention Licenses	$0	$0	$0	$0	$19
Total Earned Royalty Income, (ERI)	$15	$20	$13	$8	$19

DOT Collaborative R&D Relationships

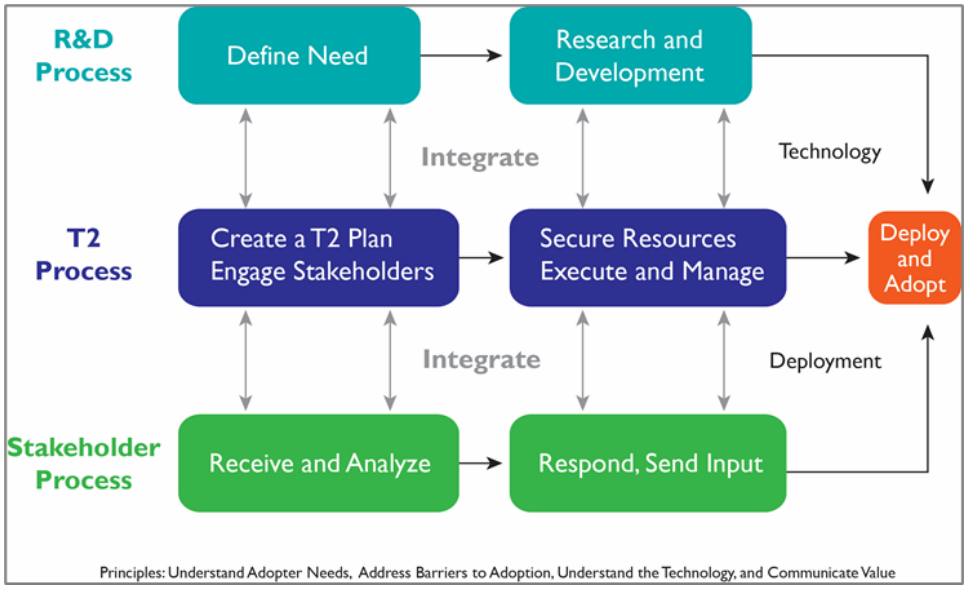
Between FY 2016 and FY 2020, total active CRADAs decreased by 28%, from 68 in FY 2016 to 49 agreements in FY 2020. New CRADAs agreements decreased by 68%, from 22 in FY 2016 to 7 in FY 2020. Traditional CRADAs decreased by 26%, from 62 in FY 2016 to 46 in FY 2020. DOT reported no other collaborative R&D relationships in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	68	65	63	44	49
New CRADAs	22	6	7	10	7
Traditional CRADAs, Total Active	62	66	63	43	46
Other Collaborative R&D Relationships	152	355	121	125	0

DOT Efforts to Streamline Technology Transfer Operations
The importance of technology transfer within DOT is reflected in its Strategic Plan for FY 2018 to FY 2022, which was released in February 2018.[49] Technology transfer aims to facilitate adoption and commercialization of market-ready transportation technologies.

During FY 2020, within DOT, OST-R led cross-modal efforts to collaborate with the White House's Office of Science and Technology Policy, in support of the Lab-to-Market (L2M) CAP Goal.



Source: U.S. DOT.

Citing *Innovation* as one of the four main strategic goals in the Strategic Plan for FY 2018 to FY 2022, 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 the Strategic Plan identifies T2 as one of the strategies to be used to accomplish that objective. The figure shows the relationship of T2 to the Department's research and development (R&D) process and to stakeholder engagement. The T2 activities of OST-R and the different OAs within the Department are described in more detail below.

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

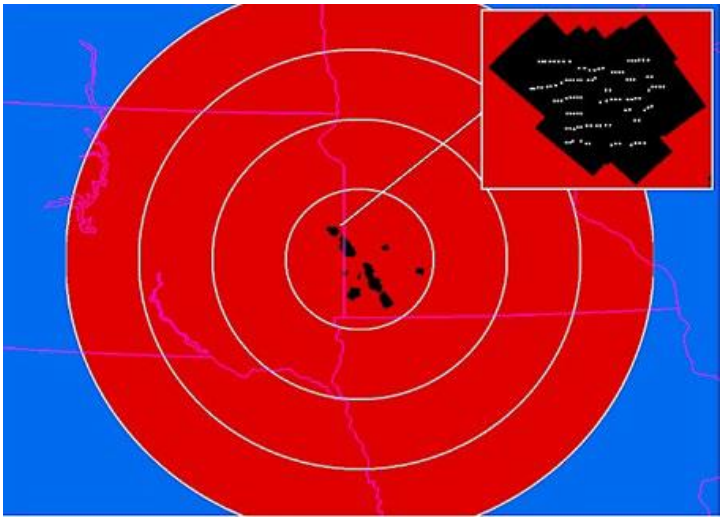
Federal Highway Administration (FHWA): Collaborative Hydraulics: Advancing to the Next Generation of Engineering
The Collaborative Hydraulics: Advancing to the Next Generation of Engineering (CHANGE) Initiative, part of the Federal Highway Administration's Everyday Counts Initiative, has encouraged transportation agencies to adopt two-dimensional (2D) hydraulic modeling, which provide a more accurate representation of real-world hydraulic conditions and better illustrate hydraulic concepts, compared to one-dimensional (1D) modeling. These advantages are outlined

[49] The importance of technology transfer to meeting DOT goals is further emphasized in the *FY 2022-26 U.S. DOT Strategic Plan*, at https://www.transportation.gov/dot-strategic-plan.

in FHWA's reference document *Two-Dimensional Hydraulic Modeling for Highways in the River Environment*. The number of States at the demonstration, assessment, or institutionalized stage of CHANGE deployment has nearly tripled from 17 at the beginning of 2017 to 46 today. Arizona and Washington State are frequent users of 2D hydraulic modeling and are recipients of State Transportation Innovation Council (STIC) Incentive Program funds to support projects that implement 2D hydraulic modeling. Compared to 1D hydraulic modeling, 2D hydraulic modeling better helps agencies understand site conditions, resulting in more reliable, resilient, and safer structures.

FHWA's CHANGE team is collaborating with the National Highway Institute to offer the training course *2D Hydraulic Modeling of Rivers at Highway Encroachments.* Additionally, the 2D Hydraulic Modeling Users' Forum drew 1,500 participants to its webinars and technical assistance offerings.

Federal Aviation Administration (FAA): Stationary Doppler Target Suppressor Patent
The FAA was awarded United States Patent Number 10,514,454 for the Stationary Doppler Target Suppressor (SDTS) Software Tool on December 24, 2019, for a critical improvement to the detection of airborne targets over and around wind farms and turbines.



Source: U.S. DOT.

Deployment of large-scale wind farms using utility grade wind turbines severely impacts the current radar systems used by the FAA for air traffic control, the Department of Homeland Security (DHS) for air domain awareness, and the Department of Defense (DoD) for air defense. The FAA's patented SDTS software tool provides a critical improvement to mitigate the impacts of wind farms on radar and improve the detection of airborne targets over and around wind farms. The SDTS software tool includes a novel algorithm for dynamically adjusting radar detection threshold in a manner that strikes a balance between providing improved sensitivity in identifying a real target in a wind farm area while still eliminating clutter that would trigger false alarms. The SDTS software tool functions so well that it was deemed by North American Aerospace Defense Command (NORAD)/Northern Command as a mitigation approach for the deployment of new wind farms. The figure shows a radar screen capture, showing the designated area where the FAA's patented SDTS detector will be applied, including a wind farm installation in Tyler, Minnesota. The upper right box in this image is a magnified section, showing the individual wind turbines within the wind farm.

By roughly doubling the performance of radar systems in wind farm areas and halving the incidences of false target detections of the turbines, this FAA invention results in a significantly improved air picture to all FAA, DHS, and DoD operators, leading to greater mission success.

Federal Transit Administration (FTA): Mobility on Demand (MOD) Sandbox Demonstration

FTA published the final report on its Mobility on Demand (MOD) Sandbox Demonstration: DART First and Last Mile Solution (Report 0164) with the Dallas Area Rapid Transit (DART). DART collaborated with a microtransit provider to give more transit trip choices for riders in a low-density area that was difficult to serve. DART achieved most of the established goals for the project, to increase ridership and replace less-productive fixed-route systems. As a result, in areas in which the service was implemented, ridership increased with less cost, more coverage, and less travel time. An overview of the MOD Sandbox Demonstration can be found online at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.

Federal Railroad Administration (FRA): Automated Track Change Detection Technology

Roughly 140,000 miles of railroad track cover the U.S. Hundreds of FRA and railroad inspectors regularly inspect every mile of track to ensure the tracks are in safe working order. Most of these inspections are completed manually, relying on human vision to detect any irregularities in the complex track structure that may impact the safety of rail operations. This is a time-consuming and labor-intensive process, required by Federal regulations.

FRA has recently sponsored research and development of a new technology to improve the quality and efficiency of visual track inspection required by 49 CFR § 213.233 – Track Inspections. The objective of this new technology, Automated Track Change Detection (ATCD), is to identify changes in the track structure that may affect the safe operation of rail traffic and automatically report these changes to decision makers for action. The technology uses invisible, laser line projectors and synchronized cameras to capture millions of high-resolution, three dimensional (3-D) images of the track. The images are compared to previous images of the same track to identify changes. The process employs cutting-edge deep neural networks and artificial intelligence techniques to isolate changes in tie spikes, rail anchors, rail fasteners, ties, rail joints, ballasts, and other critical aspects of the track system.

FRA is excited to report that its early research and development efforts on the ATCD system have been promising. This new technology is a candidate for field trials. One Class I railroad recently ordered two ATCD systems from FRA's contractor, Railmetrics. The FRA R&D Team looks forward to working with this railroad and others, to continue to evaluate the ATCD technology and its proper role in the overall track inspection process.

Intelligent Transportation Systems Joint Program Office (ITS JPO): 2020 Consumer Electronics Show

The Intelligent Transportation Systems Joint Program Office (ITS JPO) organized the DOT presence at the 2020 Consumer Electronics Show (CES), an annual trade show organized by the Consumer Technology Association. Held in multiple venues across the Las Vegas area, CES offers presentations of new products and technologies in the consumer electronics industry. The ITS JPO established an internal, multimodal CES task force that included staff from the FAA, OST-R, NHTSA, FHWA, the Pipeline and Hazardous Materials Safety Administration (PHMSA), and the TFHRC.

DOT's participation included the following:

- The Secretary of Transportation delivered a keynote address on the current state of innovation at DOT and joined the former chief technology officer of the United States, in releasing *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0* (AV 4.0). The government-wide report outlines how 38 Federal agencies are working to deploy automated vehicle technology.
- The ITS JPO organized a 90-minute super session titled *What's Next for Vehicle Automation?* The session was moderated by Finch Fulton, Deputy Assistant Secretary for Transportation Policy, and included several panelists including Sterling Anderson, Co-Founder and Chief Product Officer, Aurora; Steve Boyd, Chief Executive Officer, Peloton Technology; Debbie Hersman, Chief Safety Officer, Waymo; and Ralph Lauxmann, Senior Vice President Systems and Technology, Continental Automotive.
- DOT hosted a 30-foot-by-30-foot exhibit in the Smart Cities Pavilion. There were dedicated areas for both CARMASM and the ITS Data program. Literature racks included overviews of DOT programs, the Inclusive Design Challenge, the Data for Automated Vehicles Initiative, CARMA, and AV 4.0. Videos of connected vehicle technology and key messaging were displayed on two monitors.
- Eight UTCs provided demonstrations of technology areas such as cybersecurity, traffic prediction, driver assistance solutions simulations, and robot deployment systems.
- DOT also participated in supplemental meetings with related companies and other government organizations (primarily organized by NHTSA), which yielded positive results.

Department of Veteran Affairs (VA)

The Department of Veteran Affairs (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), the mission of which 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, the mission of which is to provide benefits and services to veterans and their families in a responsive, timely and compassionate manner in recognition of their service to the nation.
- National Cemetery Administration, the mission of which 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 focused on the five-cross cutting clinical priorities: 1) Gulf War Illness, 2) Opioids, 3) Post Traumatic Stress Disorder, 4) Suicide Prevention, and 5) Traumatic Brain Injury. 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.

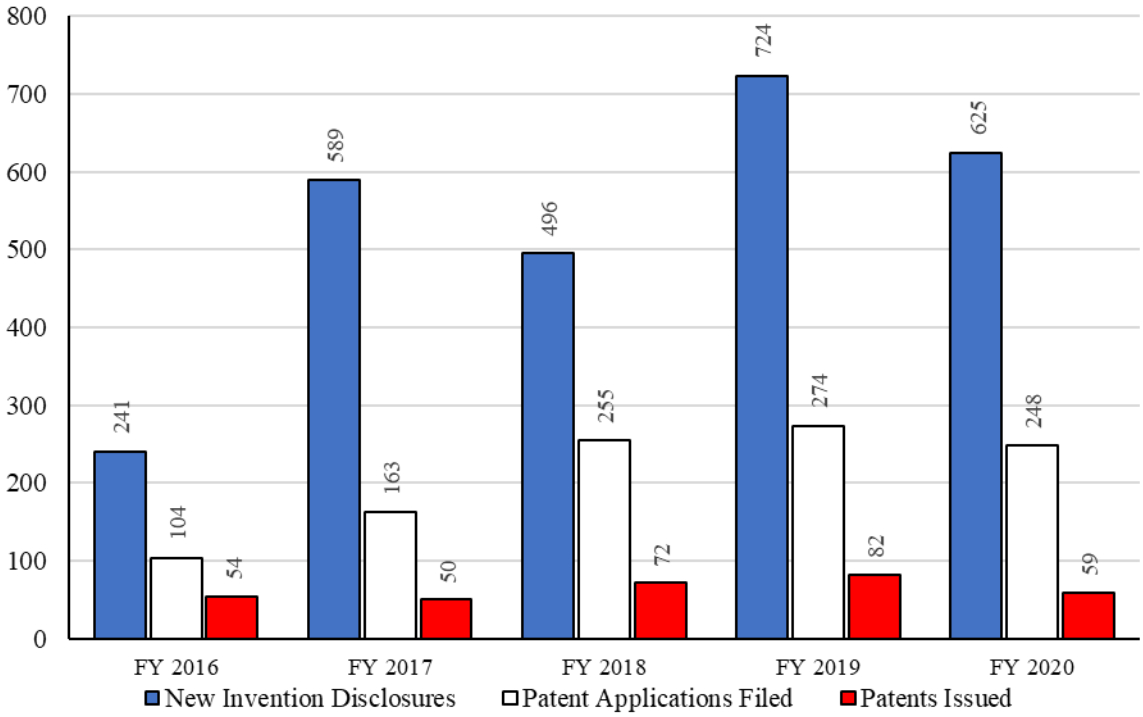
The ORD’s mission is focused on improving the future of healthcare for veterans. Technology Transfer provides a pathway within VA to move research or employee innovations and inventions from concept to benefitting the veteran, fulfilling Technology Transfer’s mission motto of “Bringing Research Advancements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

More information about VA technology transfer activities is available online.

VA Invention Disclosures and Patenting

Between FY 2016 and FY 2020, new inventions disclosed increased by 159%, from 241 in FY 2016 to 625 disclosures in FY 2020. Patent applications filed increased by 138%, from 104 in FY 2016 to 248 in FY 2020. Patents issued increased by 9%, from 54 in FY 2016 to 59 patents in FY 2020.

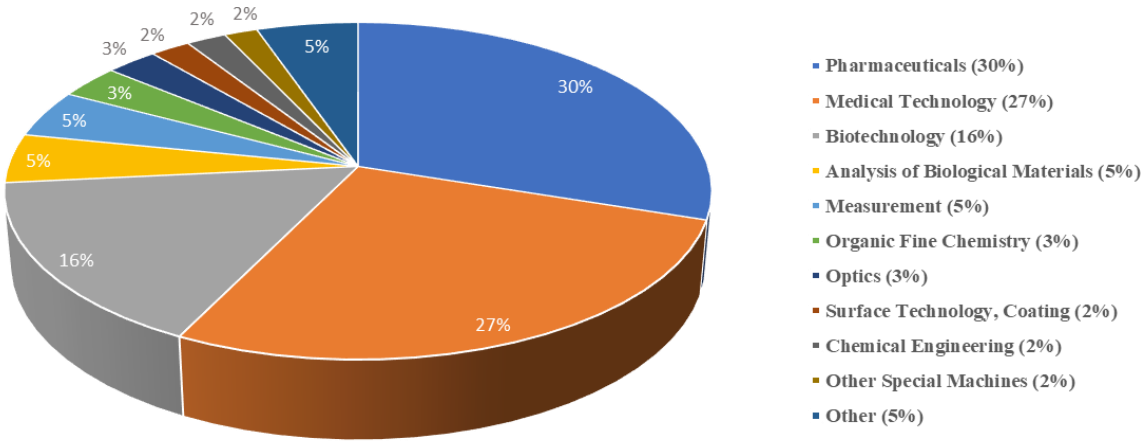
VA Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	241	589	496	724	625
Patent Applications Filed	104	163	255	274	248
Patents Issued	54	50	72	82	59

Patents issued to VA in FY 2020 covered many technology areas including Pharmaceuticals (30%), Medical Technology (27%), Biotechnology (16%), Analysis of Biological Materials (5%), and Measurement (5%).[50]

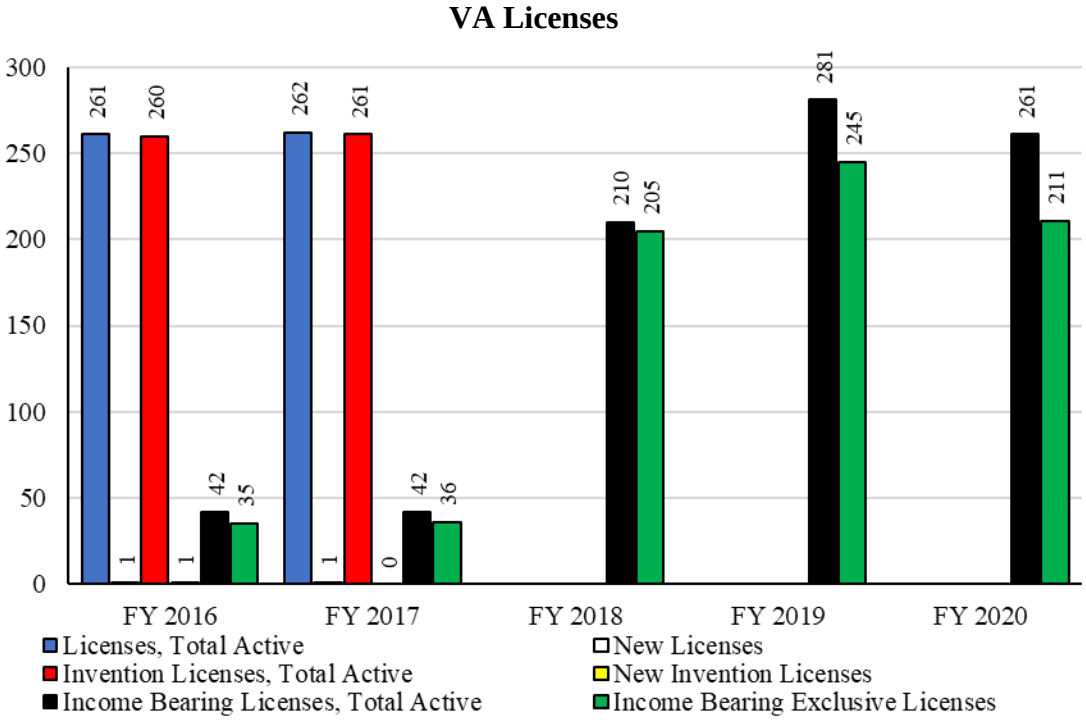
USPTO Patents Assigned to VA by Technology Area: FY 2020



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

VA Licenses[51]

Between FY 2016 and FY 2020, income bearing licenses increased by 521%, from 42 in FY 2016 to 261 in FY 2020. Exclusive income bearing licenses increased by 503%, from 36 in FY 2016 to 211 in FY 2020.



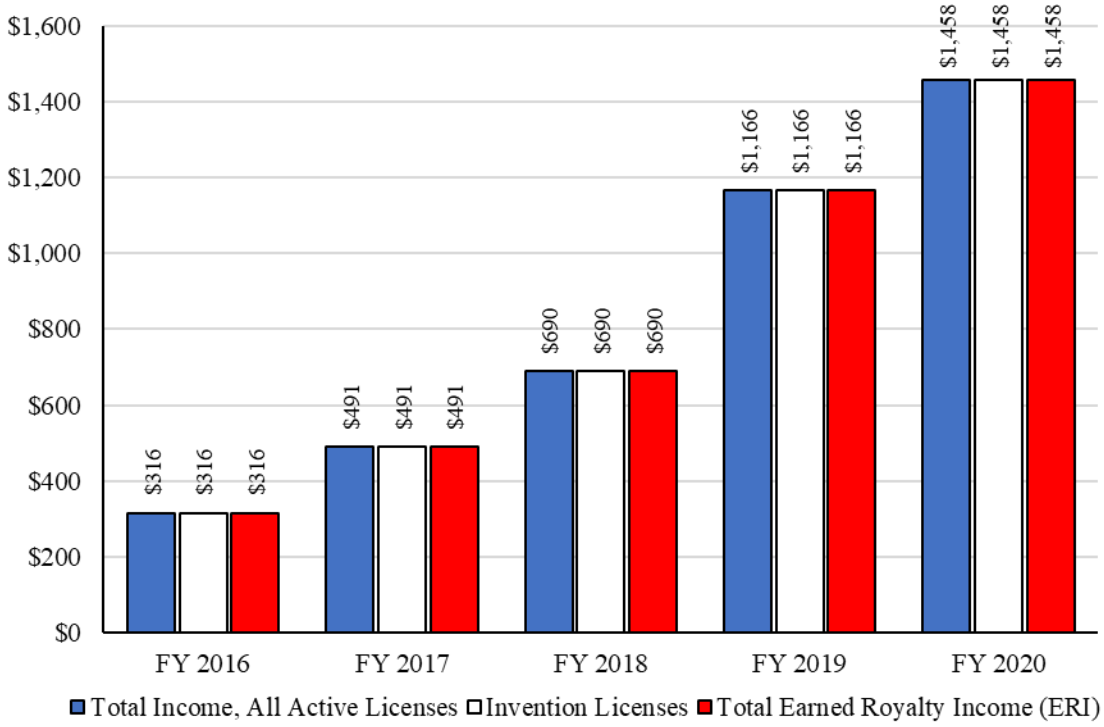
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	261	262	n.a.	n.a.	n.a.
New Licenses	1	1	n.a.	n.a.	n.a.
Invention Licenses, Total Active	260	261	n.a.	n.a.	n.a.
New Invention Licenses	1	0	n.a.	n.a.	n.a.
Income Bearing Licenses, Total Active	42	42	210	281	261
Income Bearing Exclusive Licenses	35	36	205	245	211

[51] VA was unable to report total active licenses, new licenses, total active invention licenses, and new invention licenses for FY 2018, FY 2019, and FY 2020.

VA Income from Licensing

Between FY 2016 and FY 2020, VA reported that total income from all active licenses increased by 361%, from $316 thousand in FY 2016 to $1.5 million in FY 2020. Income from invention licenses and earned royalty income were the same as income from all active licenses.

VA Income from Licensing ($000s)

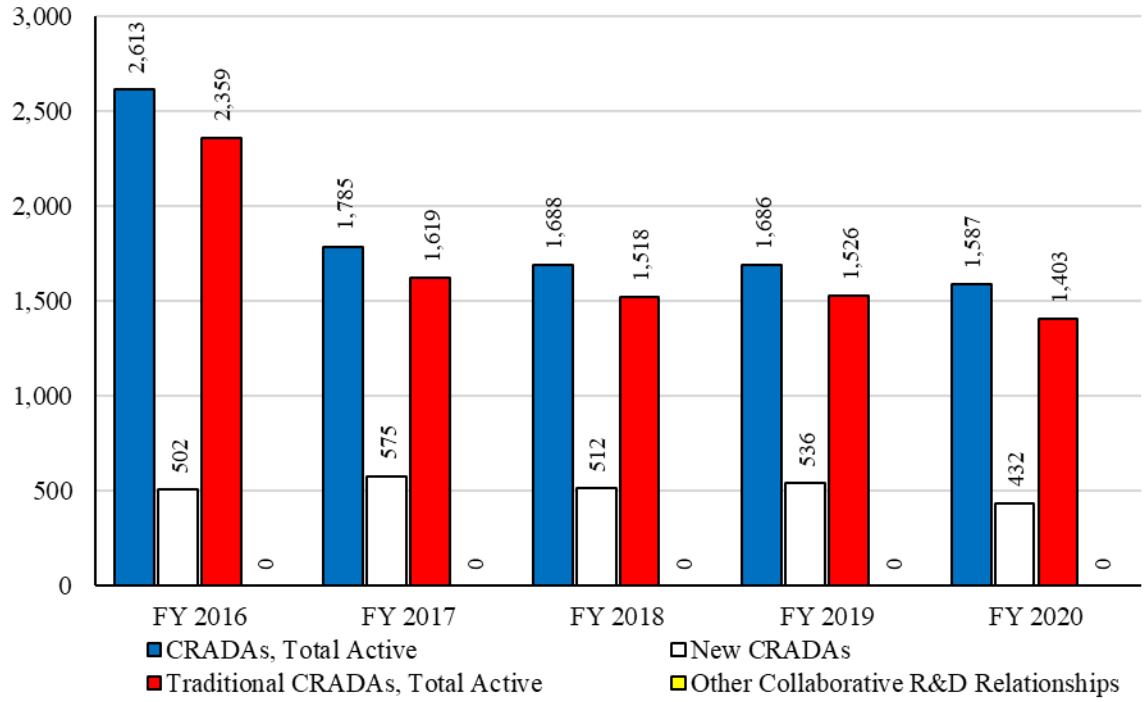


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$316	$491	$690	$1,166	$1,458
Invention Licenses	$316	$491	$690	$1,166	$1,458
Total Earned Royalty Income, (ERI)	$316	$491	$690	$1,166	$1,458

VA Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs decreased by 39%, from 2,613 in FY 2016 to 1,587 agreements in FY 2020. New CRADAs decreased by 14%, from 502 in FY 2016 to 432 new agreements in FY 2020. Traditional CRADAs decreased by 41%, from 2,359 in FY 2016 to 1,403 in FY 2020. No other collaborative R&D relationships were reported.

VA Collaborative R&D Relationships



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	2,613	1,785	1,688	1,686	1,587
New CRADAs	502	575	512	536	432
Traditional CRADAs, Total Active	2,359	1,619	1,518	1,526	1,403
Other Collaborative R&D Relationships	0	0	0	0	0

VA Efforts to Streamline Technology Transfer Operations
The VA Technology Transfer Program (TTP) operation is centralized in Washington, D.C. TTP is piloting a staff increase initiative in an effort to promote compliance, services to the field, and to increase commercial interest by placing local tech transfer specialists at select field locations. Two field sites were selected as pilot locations in FY 2020: Tampa, FL, and Atlanta, GA. In addition to performing technology transfer activities, the new local field Technology Transfer Specialists will also support the local research office operations and work with the corresponding academic affiliate under the direction of the Regional TTS.

TTP partnered with the VA's Office of Business Oversight (OBO) to conduct financial reviews of its academic affiliates and licensees. These audits were a pilot program in FY 2019 utilized to obtain reasonable assurance that terms within agreements between VA and its partners were being met. During FY 2020, TTP and OBO conducted two audits, one academic affiliate and one licensee as auditing was curtailed due to COVID-19 as the audits were on-site operations. The audits consisted of record reviews of invention disclosure reporting, patent applications, patent expenses, and license revenue. The success of the audits in FY 2019 validated the need for a more robust compliance system. TTP has now incorporated this practice into its business operations and will increase the number of reviews in FY 2021. Additionally, in FY 2020, OBO conducted a mission needs assessment of TTP and provided a detailed plan for improving office operations to help meet mission needs.

VA Downstream Success Stories

Disinfection Tracking System
Portable medical equipment has been implicated in outbreaks of Healthcare Associated Infections and the importance of their systematic disinfection has been recognized and included in infection control guidelines. To help track disinfection, the Department of Veterans Affairs-originated Disinfection Tracking System (DTS), licensed to Xenex Disinfection Services, which can be mounted to any piece of portable equipment (mobile workstations, wheelchairs, vital sign machines, IV pumps/poles, etc.), serves to record and display disinfection events. The DTS was available on the market as of 2022.

VA Tech Transfer Program in the National COVID Response
The VA Technology Transfer Program received and reviewed at least 22 new invention disclosures having the potential of impacting the care and treatment of Veterans impacted by COVID-19. These inventions also comprised innovations directed to creating a safer environment for front-line responders. The list included inventions entitled "Targeting the major protease of SARS-CoV-2 through drug repurposing," "Systems and Components for Multi-Person Mechanical Ventilation Treatment," and "Mobile Isolation Enclosure (MIE)." TTP has fast tracked the analysis and review of Covid-19 invention disclosures. In a number of instances involving devices, safety, and patient care implements, prototypes have been made using TTP's Technology Transfer Assistance Projects (TTAP) and are now being tested at local VA Medical Centers. Some of the prototypes were created solely using VA resources and others in collaboration with affiliate universities and private sector companies. One invention jointly created with the University of Michigan has received Emergency Use Authorization from the FDA and has been licensed for production. This novel device allows two patients with differing

oxygen flow needs to safely use the same ventilator. The partner company, MakeMedical, LLC, has agreed to sell the device at cost to interested medical institutions during the pandemic.

VA TTP Assisting Veterans with Patentable Ideas
As part of VA's commitment to helping Veteran's, TTP has worked with its external patent counsel to provide legal advice, in certain circumstances, to Veteran's with potentially patentable subject matter and a feasible plan for commercializing an invention. This year, the VA TTP together with Ballard Spahr, LLP took on prosecuting one Veteran's patent application that had hit headwinds at the United States Patent and Trademark Office. Through TTP's efforts and donated, Pro Bono time of Ballard, the Veteran's patent application issued this year.

Translational Research Mentoring and Educational Center (TaRMEC)
This year, TTP partnered with ORD's Biomedical Laboratory Research and Development (BLRD) Service on a new program intended to establish a VA-based core mentoring and education facility supporting VA investigators in developing discoveries, so that the discoveries can be tested in clinical studies, receive regulatory approval and be used by Veterans. The Translational Research Mentoring and Educational Center (TaRMEC) will serve VA researchers by providing highly critical research resources addressing translational programmatic needs. The intent of TaRMEC is to provide centralized resources to enhance investigators knowledge and resources for propelling research from discovery into products that will impact the clinical care of Veterans. TaRMEC will benefit the VA research community through educating VAMC staff and researchers on how to move biomedical laboratory research results towards regulatory approval and use in Veterans health care.

Environmental Protection Agency (EPA)

Implementation of the Federal Technology Transfer Act of 1986 (FTTA) and Executive Order 12591 is managed within the Environmental Protection Agency (EPA) by the Office of Research and Development's Office of Resource Management. The goals of the program are to support EPA's research mission through the use of technology transfer mechanisms, by leveraging expertise and sharing of research materials with external partners, and commercializing EPA's groundbreaking inventions.

EPA's leading-edge research informs Agency decisions and supports the emerging needs of EPA stakeholders, including the Agency's state, tribal, and community partners. EPA's current strategic plan has three over-arching goals: (1) Deliver a cleaner, safer, and healthier environment for all Americans and future generations by carrying out the Agency's core mission; (2) Provide certainty to states, localities, tribal nations, and the regulated community in carrying out shared responsibilities and communicating results to all Americans; and (3) Increase certainty, compliance, and effectiveness by applying the rule of law to achieve more efficient and effective agency operations, service delivery, and regulatory relief. To conduct science of the highest quality and relevance, EPA promotes collaborative partnerships, including use of CRADAs.

Science is the foundation for EPA's credible decision-making to safeguard human health and ecosystems from pollutants. The Office of Research and Development (ORD) provides the data, tools, and information that form the sound scientific foundation the Agency relies on to fulfill its mission to protect the environment and safeguard public health. Within ORD, EPA research is divided into six major areas of environmental concern: Air and energy, chemical safety for sustainability, safe and sustainable water resources, sustainable and healthy communities, health and environmental risk assessment, and homeland security.

For FY 2020, EPA's technology transfer program focused on facilitating collaborative research with external partners, supporting researchers' exchange of data and research materials, and licensing EPA's patented technologies. Priority attention was given to FTTA agreements involving research in the areas of COVID-19, and Per- and poly-fluoroalkyl substances (PFAS). These are particularly relevant and high priority items due to the pandemic, in the case of COVID-19, and due to the very persistent nature of these chemicals in the environment and the human body, in the case of PFAS.

EPA staff are required to submit Employee Reports of Invention (EROIs) to the FTTA team when new inventions are developed. These are evaluated by EPA's Office of General Counsel to determine the strength and viability of a potential patent. For most, patent applications are submitted to the U.S. Patent and Trademark Office to secure U.S. patent protection. In FY 2020, new patent applications included technologies in the areas of air quality sensors, biosensors for analyzing pollutants in water, and remediation of chlorinated pollutants in various environmental media.

In FY 2021, EPA's FTTA team is focused on working with external partners to gain market information about its new technologies, and to actively market its existing patented technologies

to companies for commercialization. These inventions originated from EPA's mission to protect human health and the environment, and they are valuable tools that can be utilized by researchers, industry, and individuals outside the agency if commercialized.

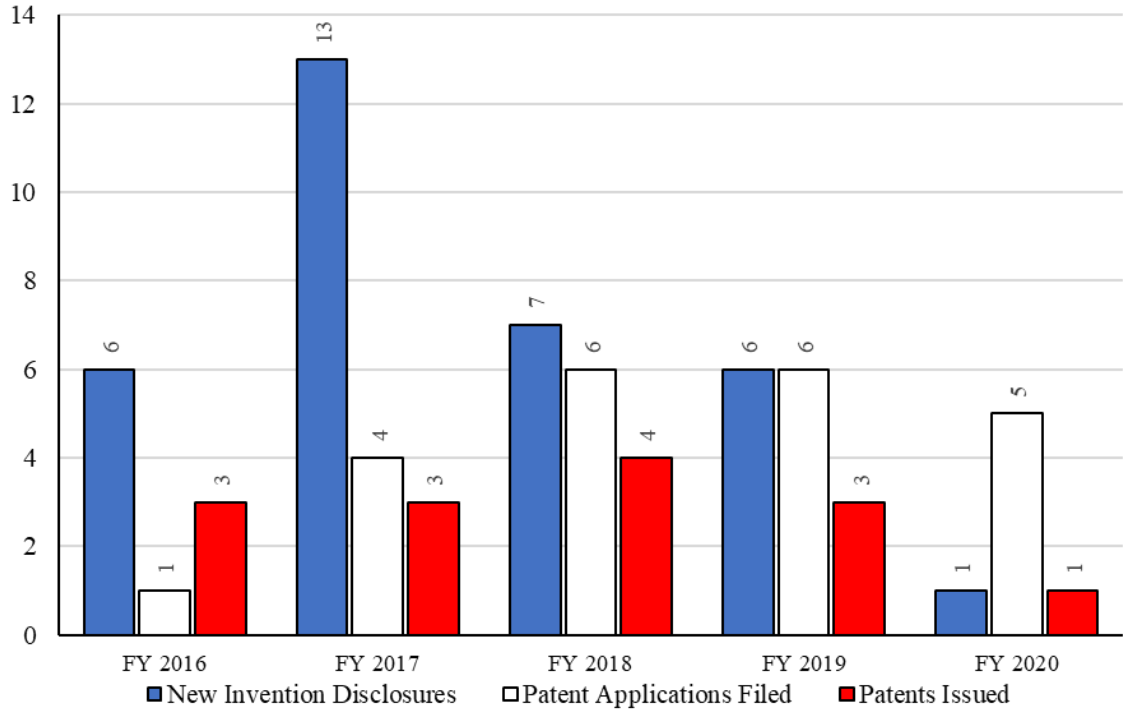
The EPA's annual technology transfer report is available online.

More information about EPA technology transfer activities is available online.

EPA Invention Disclosures and Patenting

Between FY 2016 and FY 2020, new inventions decreased by 83%, from 6 disclosures in FY 2016 to 1 in FY 2020. Patent applications filed increased by 400%, from 1 in FY 2016 to 5 in FY 2020. Patents issued decreased by 67%, from 3 in FY 2016 to 1 in FY 2020.

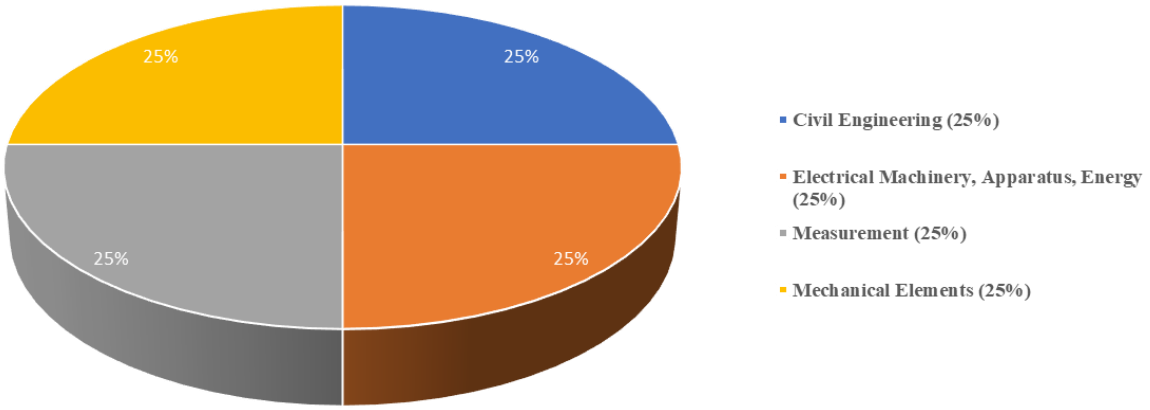
EPA Invention Disclosures and Patenting



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	6	13	7	6	1
Patent Applications Filed	1	4	6	6	5
Patents Issued	3	3	4	3	1

Patents issued to EPA in FY 2020 covered the technology areas Civil Engineering (25%), Electrical Machinery, Apparatus, Energy (25%); Measurement (25%); and Mechanical Elements (25%).[52]

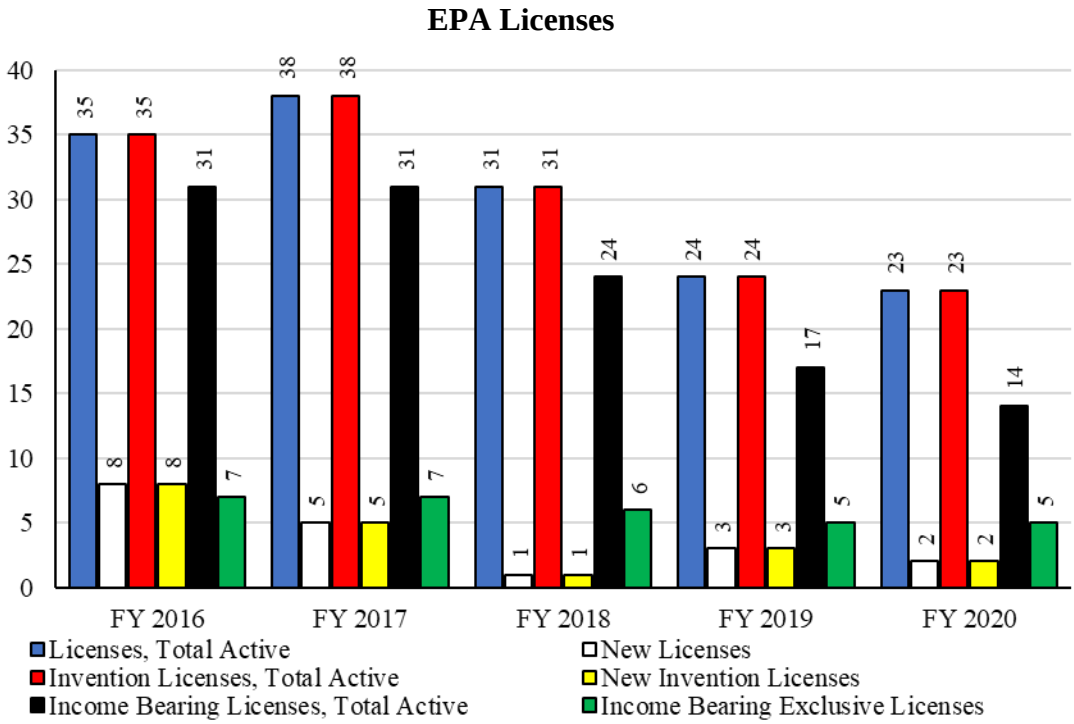
USPTO Patents Assigned to EPA by Technology Area: FY 2020



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

EPA Licenses

Between FY 2016 and FY 2020, total active licenses decreased by 34% from 35 licenses in FY 2016 to 23 licenses in FY 2020. New licenses decreased by 75%, from 8 in FY 2016 to 2 in FY 2020. All active licenses were invention licenses. Income-bearing licenses decreased by 55%, from 31 in FY 2016 to 14 in FY 2020. Exclusive income-bearing licenses decreased by 29%, from 7 in FY 2016 to 5 in FY 2020.

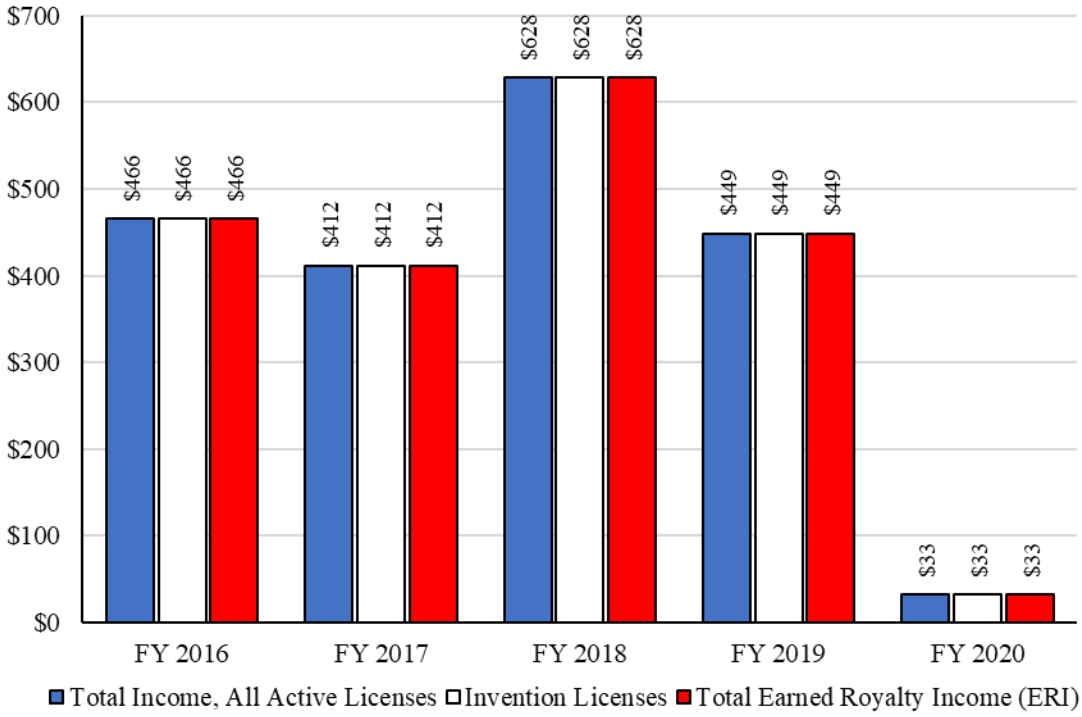


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	35	38	31	24	23
New Licenses	8	5	1	3	2
Invention Licenses, Total Active	35	38	31	24	23
New Invention Licenses	8	5	1	3	2
Income Bearing Licenses, Total Active	31	31	24	17	14
Income Bearing Exclusive Licenses	7	7	6	5	5

EPA Income from Licensing

Between FY 2016 and FY 2020, EPA reported that total income from all active licenses decreased by 93% from $466 thousand to $33 thousand in FY 2020. All income from licenses came from invention licenses. Total earned royalty income decreased 93% from $466 thousand in FY 2016 to $33 thousand in FY 2020.

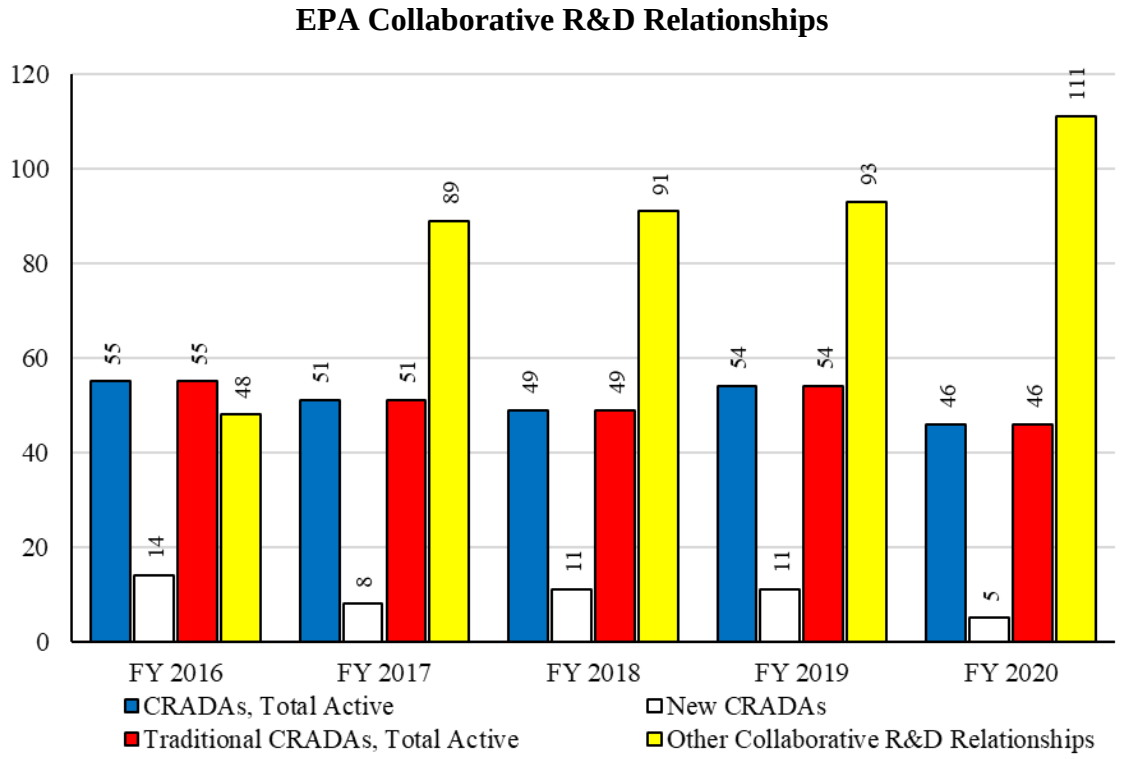
EPA Income from Licensing ($000s)



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$466	$412	$628	$449	$33
Invention Licenses	$466	$412	$628	$449	$33
Total Earned Royalty Income, (ERI)	$466	$412	$628	$449	$33

EPA Collaborative R&D Relationships

Between FY 2016 and FY 2020, total active CRADAs decreased by 16%, to from 55 agreements in FY 2016 to 46 in FY 2020. New CRADAs decreased by 64%, from 14 in FY 2016 to 5 new agreements in FY 2020. Traditional CRADAs decreased by 16%, from 55 in FY 2016 to 46 in FY 2020. Other collaborative agreements increased by 131%, from 48 in FY 2016 to 111 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	55	51	49	54	46
New CRADAs	14	8	11	11	5
Traditional CRADAs, Total Active	55	51	49	54	46
Other Collaborative R&D Relationships	48	89	91	93	111

EPA Downstream Success Stories

Characterizing Emissions and Activity from Heavy-Duty Vehicles and Nonroad Equipment
Mobile vehicle sources contribute significantly to ambient concentrations of air contaminants, including particulate matter. EPA's National Vehicle and Fuel Emissions Laboratory undertook a collaboration with the Texas A&M Transportation Institute (TTI) to determine the distribution of emissions for mobile sources (including nonroad and heavy-duty vehicles). In particular, nearly 5,000 pieces of nonroad equipment and over 60 heavy duty trucks and buses were studied in-depth for emissions data and activity data.

Under the CRADA, both parties provided technical expertise in mobile source test programs and the EPA contributed equipment and specialized expertise in statistical sampling and vehicle emissions measurement methodologies.

EPA also worked with TTI to evaluate newer equipment to remotely measure vehicle emissions on the road. As vehicles continue to get cleaner, measurement equipment needs to be able to measure accurately at very low levels of emissions. New analysis of the data collected from the CRADA has led to improvements in the signal to noise ratio of the measurements from remote sensing devices.

EPA is planning to continue this CRADA with TTI to gather activity and emissions data from heavy-duty and nonroad equipment and expand it to include light-duty vehicles. EPA has benefited from the CRADA through the ability to update and refine future versions of EPA's Motor Vehicle Emissions Simulator (MOVES). These updates will ensure that MOVES continues to be a state of the science model to estimate vehicle emissions and the most accurate tool for estimating emissions from the transportation sector. MOVES is used for a variety of applications, including assessment of the projected benefits of future emission standards and in state implementation plans as well as the transportation conformity analyses outside of California. In addition, the nonroad equipment testing results will be used to update EPA's nonroad models to improve the activity and emissions defaults.

TTI benefited from the CRADA via equipment loans and testing expertise. The EPA loaned several portable activity monitors for TTI to use in the heavy-duty activity gathering programs. The devices plug into vehicles and gather a lot of information about the engine and vehicle on a second by second basis. The EPA also shared/developed techniques to improve the quality of the data that was gathered and worked with TTI to design mobile source test programs.

Development and Application of Low-Cost Sensors to Support Improved Air Quality Measurement and Characterization
Air sensor technologies are smaller, lower cost, portable devices that can be used to measure air quality conditions. While the use of air sensors continues to rise, there is still a need to understand how the devices perform and the accuracy of the data over time. EPA's Office of Research and Development (ORD) is collaborating with Aeroqual, Ltd to investigate new applications, methodologies, and technologies for the lower cost measurement of outdoor air pollutants. In particular, air sensor technologies have been deployed and evaluated in six field

studies ranging from near-source, ambient air quality, and wildfire applications across the United States.

The CRADA combines EPA's technical expertise in air measurements and sensor evaluations with Aeroqual's expertise in the development of air sensor technologies. EPA has contributed to oversight of the field studies including site selection, site setup, instrument deployment to the field, ongoing maintenance activities, data retrieval and analysis and other logistics to maintain site operation. While Aeroqual has provided the sensor technologies, replacement parts, technical support, real-time access to data, and data retrieval and analysis support.

EPA has benefited from this CRADA by having access to a variety of sensor technologies that measure key air pollutants of interest such as ozone (O3), fine particulate matter (PM2.5), and nitrogen dioxide (NO2). Further, Aeroqual has developed several prototype technologies that measure volatile organic compounds (VOCs) and air toxics. These pollutants are of high interest for applications including fenceline monitoring and individual/community monitoring, where performance and accuracy is not well understood. By evaluating these technologies, both EPA and Aeroqual can better understand how the technologies perform and how they can be used for different applications.

Likewise, Aeroqual has benefited from this CRADA by having an opportunity to evaluate their technologies in a variety of locations with varying pollution levels and climates (from very hot to very cold). Additionally, both Aeroqual and EPA ORD are benefiting from information gained from field deployments with longer time frames (a year or more).

The collaboration will continue under this CRADA and upcoming activities will include additional field deployments of Aeroqual's sensor technologies and data analysis. Results of the sensor evaluations will continue to be shared via scientific presentations and future publications.

EPA Automobile Industry Government Emission Research (AIGER) Collaboration
Automobile Industry Government Emission Research (AIGER) is a CRADA between the Environmental Protection Agency, California Air Resources Board (CARB) and the United States Council on Automotive Research (USCAR) whose members include Fiat Chrysler Automobiles (FCA), Ford Motor Company, and General Motors Company (GM). AIGER CRADA goals are to ensure that the equipment, facilities, and procedures needed for the precise, accurate and efficient measurements of low-level automotive exhaust emissions will be readily available. The partners have been working together to develop improved measurement technologies, evaluating ancillary equipment used in automotive emission testing, and evaluating existing and proposed emission measurement procedures.

AIGER also works with other research entities such as academia, instrument manufacturers, independent researchers and others within the automobile emissions testing industry. AIGER has maintained a close relationship with the National Institutes of Standards & Technology (NIST) who develop and maintain many of the standard reference materials (SRMs) used by the AIGER member laboratories.

2020 AIGER Research Efforts and Accomplishments include:

- Continued development of particulate matter (PM) measurement technologies, processes and procedures, with focus on investigating the variability and sources of interlaboratory offsets. Tunnel contamination and the effect on measured PM was investigated by FCA and GM.
- Continued evaluation of hydrogen/nitrogen (H2/N2) flame ionization detector (FID) fuel for use with FID hydrocarbon analyzers. Many laboratories will be switching to this fuel due to the increased costs of the hydrogen/helium (H2/He) FID fuel. Instrument manufacturers have developed retrofit kits for their analyzers in anticipation of the switchover. FCA evaluated a Horiba conversion kit for their MEXA-One analyzers which showed some non-linearities. Horiba has since developed a new retrofit kit for their MEXA-One analyzers which will be evaluated by EPA in 2021.
- AIGER met with NIST in September 2020 to review the status of previous SRMs and new requested calibration gases (e.g., N2O, low NOx and low ethanol standards). Supply and quality issues were also addressed.
- All AIGER projects continued to investigate 40 CFR Parts 1065 & 1066 regulations with respect to test procedures and test site configurations. MY2022 vehicles require the use of 1066 methods, quality checks and procedures.
- Continued evaluation of low-level emission measurements with emphasis on NOx and continuous HC measurement. GM evaluated nitrogen oxide (Nox) analyzer accuracy at very low concentrations on Horiba MEXA-One CLD analyzers.
- AIGER published the Portable Emissions Measurement System (PEMS) Correlation Report. The correlation study was performed in 2019 and included AIGER laboratories along with the Environment & Climate Change Canada emission laboratory
- AIGER formed a new work group to focus on road speed cooling fans which track dynamometer speed. The use of these fans is now optional in Tier 3 Part 1066 for emission testing. Preliminary data shows that the fan specifications such as flow rate, discharge area, and distance from vehicle may impact representative cooling and test results.

National Aeronautics and Space Administration (NASA)

As the novel coronavirus started rapidly spreading across the United States, stay-at-home orders threatened workflow across the National Aeronautics and Space Administration (NASA). NASA's Technology Transfer Program saw this new way of life as an opportunity to adapt and improve — while inventors got to work creating new technology to help COVID-19 patients around the world. At NASA's Jet Propulsion Laboratory, the two efforts combined for the VITAL Ventilator, which, with over 30 agreements, is already the most-licensed NASA technology of all time.

Paper processes were, now more than ever, forced into automation through the NASA Technology Transfer System (NTTS). Crucial work from each center, such as the software release process and contract closeout, were consolidated at NASA's Stennis Space Center where a dedicated team focused on accuracy, security, and faster completion times. Technology screenings and assessments were added to a single contract, providing consistent, timely results. The patent decision-making process was standardized across the agency so that all new technology reports got the same consideration against the same criteria. Training was developed for licensing executives across the agency, which prevented work-stoppage in the event of retirements. The marketing team executed dozens of technology category campaigns that included social media, NASA.gov articles, email blasts, videos, and webinars.

These changes, along with VITAL's success, led to a record-breaking licensing year for Technology Transfer with 172 new technology license agreements executed. Software release also saw its second-best year in the program's history with 4,566 new software usage agreements completed. This can be directly attributed to consolidation of the software release process at Stennis.

On the heels of such success, Technology Transfer is already looking to beat records in FY 2021 by conducting ecosystem analyses across the United States to identify regions rich in commercialization resources.

A new program, Technology Transfer Expansion (T2X), is currently working to identify partner entities and activities for commercialization in more than 18 cities across the United States.

Information about NASA technology transfer activities is available online.

Program Achievements in FY 2020

Record-Breaking Year for License Agreements
As mentioned above, FY 2020 ended with 172 new license agreements executed, blowing away all previous licensing efforts in the program's history. This achievement can be directly attributed to:

Training New Licensing Executives.
New licensing executives across the agency are benefiting from a standardized method of training developed in collaboration with Acuity Edge (NASA's main technology screenings and

assessments contractor) and NASA's Marshall Space Flight Center Technology Transfer Office. Previously, each center was responsible for training new licensing executives, which led to inconsistent processes, "holes" in know-how, and unreliable techniques.

Targeted Marketing Efforts.
The marketing team has adopted an agency-level approach, marketing technologies by their category instead of by center. Each month, a new category (such as electronics, sensors, aeronautics, environmental, etc.) is selected. Marketing content is created and disseminated across multiple platforms such as Twitter, LinkedIn, YouTube, Facebook, and targeted email blasts. Webinars are also held on a monthly basis, allowing participants to get an up-close look at the technologies, as well as an introduction to the inventors.

Centralized Technology Screenings and Assessments.
In a cost-saving effort, Acuity Edge has taken over all technology screenings and assessments across the agency. Previously, several subcontractors were doing this, leading to inconsistent results. Acuity Edge conducts inventor interviews on new technology reports to determine whether patenting the technology is recommended. If so, centers can then have the technology assessed. Acuity Edge works with companies that could potentially be interested in the technology once patented. If the technology has a positive screening and assessment, it is recommended for patenting.

Standardized Patent Decision-Making Process
A big step in Technology Transfer's continuous efforts to improve consistency and efficiency was implementing the standardized patent decision-making process. Only inventions that have commercial potential proven by evidence provided by third-party subject matter experts from Acuity Edge and RTI are to be patented.

This process helps ensure consistent results while preventing work stoppage from decreasing patent budgets.

Entrepreneurship Training for NASA Inventors
NASA researchers continually invent new technologies critical to NASA's mission and program needs, and many of those inventions have other applications that can greatly benefit the public. However, expertise in engineering doesn't always translate to entrepreneurship. T2X offers this training through the NASA Entrepreneurship Training Academy.

Training NASA's workforce to think like entrepreneurs helps them better see the commercial potential in their areas of expertise and find ways to turn their unique technical knowledge into innovative products and processes that benefit the agency and society.

The four-week experiential training program is designed to help NASA scientists, engineers, project managers, and business development and technology transfer specialists learn about entrepreneurship in a practical environment.

The first session was held in October 2020. NASA partnered with the Newport News Tech Center Research Park to conduct the training. Eleven participants representing six NASA field centers gained valuable knowledge and experience from three highly qualified mentors.

At the end of the course, each participant gave a virtual presentation. Some pitched their ideas to the audience, while others discussed their experiences and explained what they learned through their interviews with the business community. Many also shared their plans for the next steps in their entrepreneurial and commercialization journeys now that they were armed with the knowledge and skills they gained from the course.

Significant Program Metrics

Despite several weeks of program disturbance due to workflow shifts from the pandemic, program metrics stayed healthy.

New Technology Reports.

New Technology Reports saw a 2 percent increase from the previous year. Agency leaders shifted to virtual in-reach events at each NASA field center, educating approximately 4,000 inventors in 2020. The field centers provided training on reporting new technologies using the electronic New Technology Reporting system (e-NTR).

U.S. Patent Applications Filed.

With a more strategic approach to patenting in place, the number of patents filed in FY 2020 (87) was similar to the previous year (85). This approach keeps taxpayer dollars from being wasted on maintenance fees on technologies that are unlikely to produce a license.

Patent Licenses.

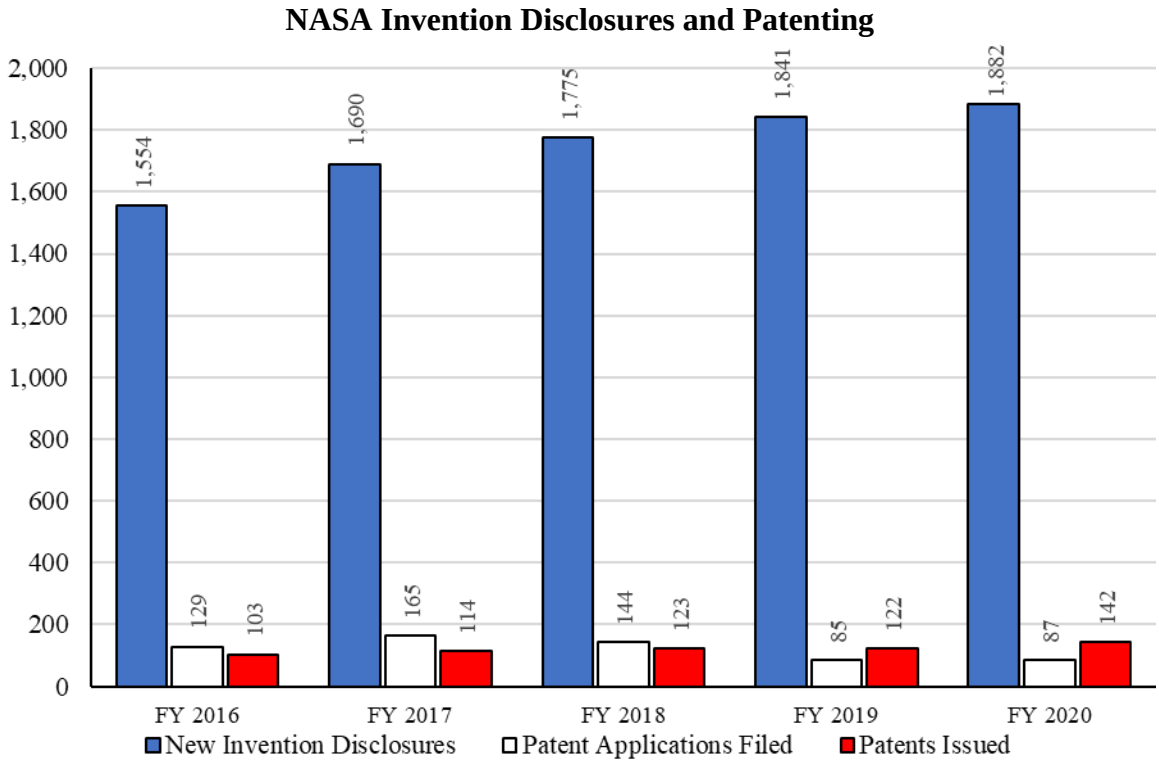
Licensing saw a 79 percent increase from the previous year, making it the most successful year for licensing in the program's history with 172 licenses executed. Significant improvements to the program to increase licensing include training for new licensing executives, improvements to NTTS (the data-entry system that feeds all of NASA Technology Transfer's work), and consistent marketing efforts which included social media, videos, and technology webinars.

Software Usage Agreements.

Software Usage Agreements (SUAs) continued a historically positive trend. With 4,566 SUAs executed, FY 2020 saw a 68 percent increase from 2019. A dedicated team at Stennis processed and released all of the SUAs for the agency, with an average release time of three days. Previously, it could take over three weeks to release one software program.

NASA Invention Disclosures and Patenting

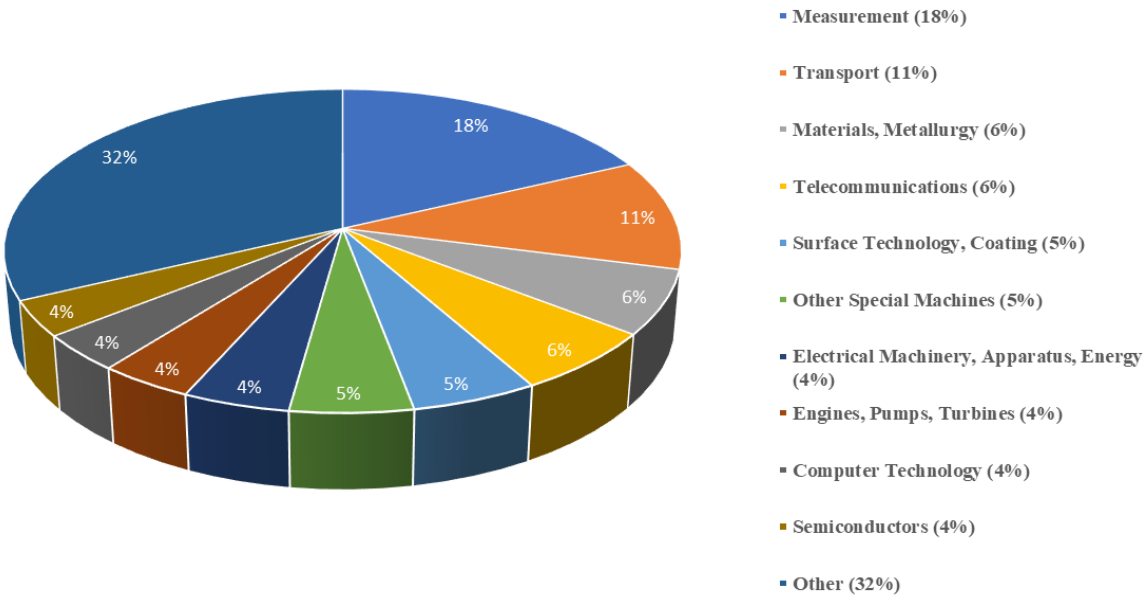
Between FY 2016 and FY 2020, new inventions disclosed increased by 21% from 1,554 in FY 2016 to 1,882 disclosures in FY 2020. Patent applications filed decreased by 33%, from 129 in FY 2016 to 87 in FY 2020. Patents issued increased by 38%, from 103 in FY 2016 to 142 patents in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
New Invention Disclosures	1,554	1,690	1,775	1,841	1,882
Patent Applications Filed	129	165	144	85	87
Patents Issued	103	114	123	122	142

Patents issued to NASA in FY 2020 covered many technology areas including Measurement (18%), Transport (11%), Materials, Metallurgy (6%), Telecommunications (6%), and Surface Technology, Coating (5%).[53]

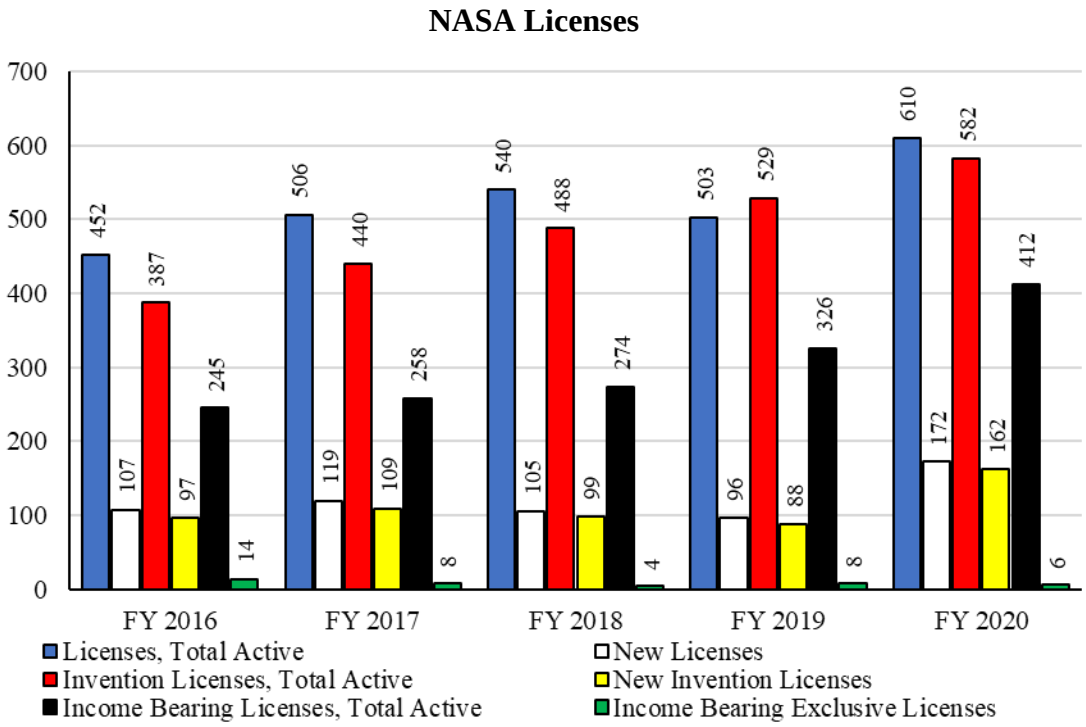
USPTO Patents Assigned to NASA by Technology Area: FY 2020



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

NASA Licenses

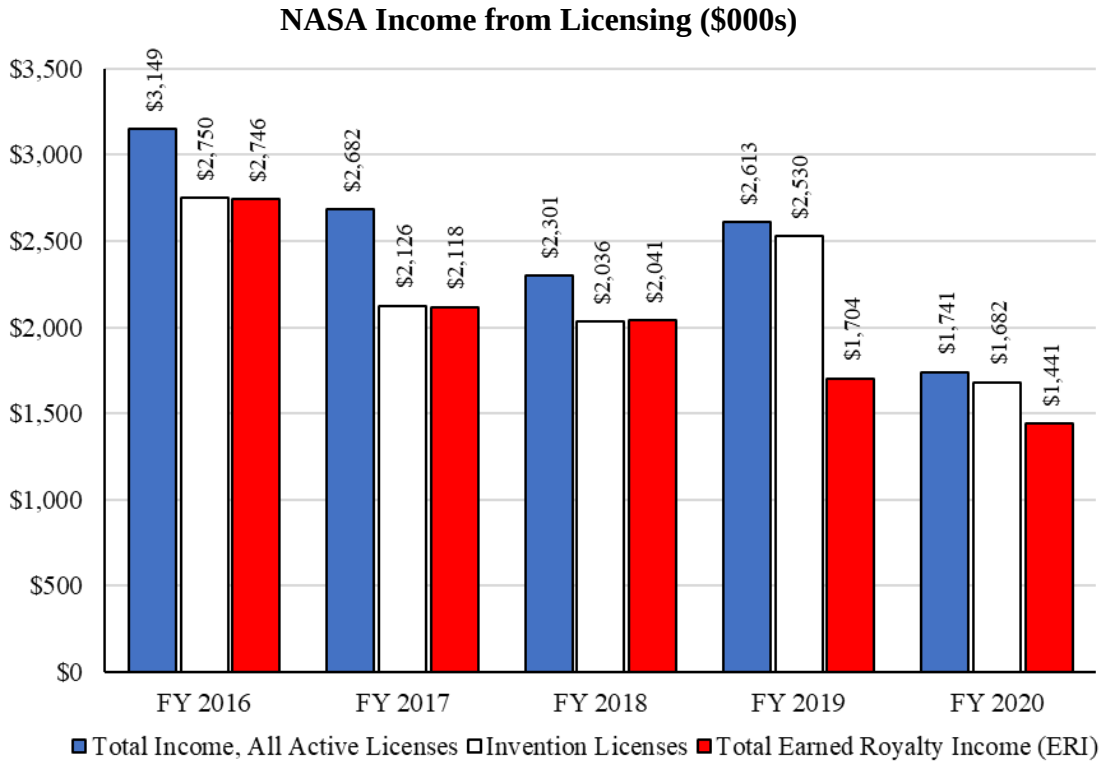
Between FY 2016 and FY 2020, total active licenses increased by 35%, from 452 in FY 2016 to 610 licenses in FY 2020. New licenses increased by 61%, from 107 in FY 2016 to 172 in FY 2020. Total active invention licenses increased by 50%, from 387 in FY 2016 to 582 in FY 2020. New invention licenses increased by 67%, from 97 in FY 2016 to 162 in FY 2020. Total active income bearing licenses increased by 68% to 412, while income-bearing exclusive licenses decreased by 57%, from 14 to 6.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Licenses, Total Active	452	506	540	503	610
New Licenses	107	119	105	96	172
Invention Licenses, Total Active	387	440	488	529	582
New Invention Licenses	97	109	99	88	162
Income Bearing Licenses, Total Active	245	258	274	326	412
Income Bearing Exclusive Licenses	14	8	4	8	6

NASA Income from Licensing

Between FY 2016 and FY 2020, NASA reported that the total income from all active licenses decreased by 45%, from $3.1 million in FY 2016 to $1.7 million in FY 2020. The income from invention licenses decreased by 39%, from $2.8 million in FY 2016 to $1.7 million in FY 2020. Total earned royalty income decreased by 48%, from $2.7 million in FY 2016 to $1.4 million in FY 2020.

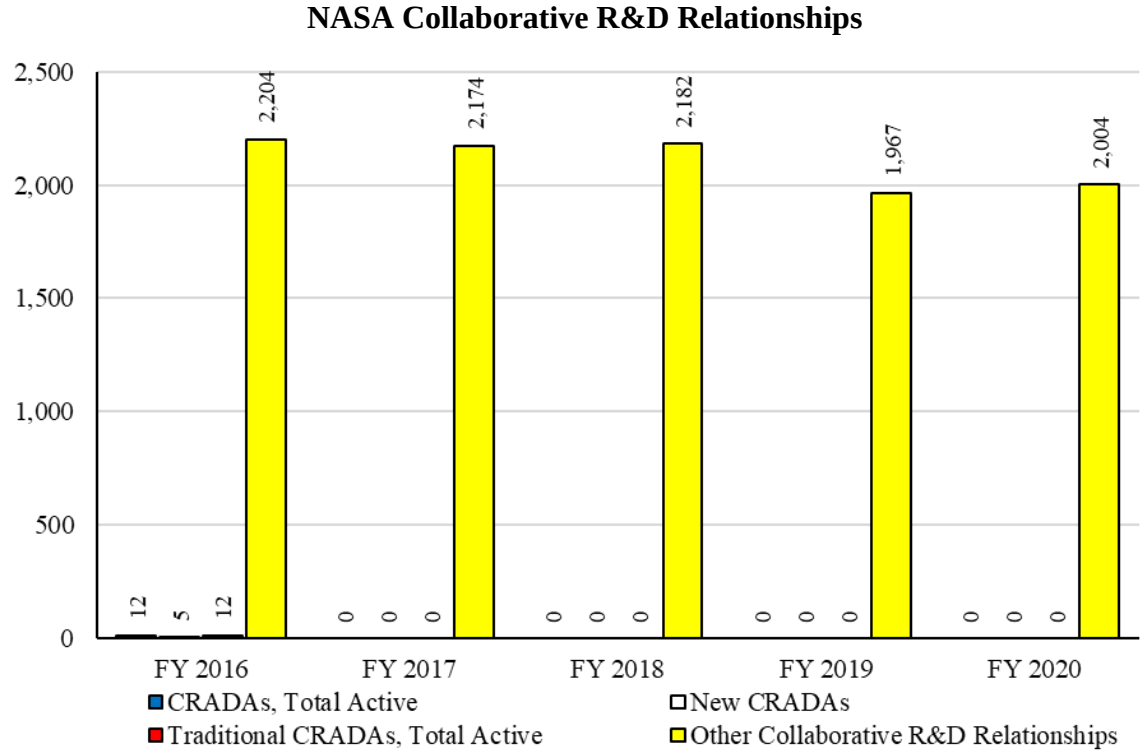


	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Income, All Active Licenses	$3,149	$2,682	$2,301	$2,613	$1,741
Invention Licenses	$2,750	$2,126	$2,036	$2,530	$1,682
Total Earned Royalty Income, (ERI)	$2,746	$2,118	$2,041	$1,704	$1,441

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 2016 and FY 2020, Space Act Agreements decreased 9% from 2,204 agreements in FY 2016 to 2,004 in FY 2020.



	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
CRADAs, Total Active	12	0	0	0	0
New CRADAs	5	0	0	0	0
Traditional CRADAs, Total Active	12	0	0	0	0
Other Collaborative R&D Relationships	2,204	2,174	2,182	1,967	2,004

NASA Downstream Success Stories
As in past years, in 2020, *Spinoff* told the stories of dozens of companies across the United States that are selling products derived from NASA technology.[54]

However, this year, Spinoff pivoted from the traditional book-centric, annual publication schedule to a year-round, web-first model, with a host of other changes designed to increase reach and make the content more accessible to readers.

This included a full website redesign, as well as the creation of a new story type focused by themes. This new publication schedule also allowed features to coincide with relevant mission milestones or external events, like a story on food safety that was published before Thanksgiving and one on a new airlock posted right before it launched to the space station.

The team also published a book with a fresh, new design in keeping with the above changes. It was shorter, more accessible, and more visually appealing.

The changes have paid off measurably, with an order of magnitude more visitors to the Spinoff website monthly (up from an average of around 8,000 monthly sessions to more than 40,000) and a similar sustained increase in social media metrics, with monthly impressions in the hundreds of thousands (topping a million three times in 2020), up from the typically 30-60K impressions in 2019.

Examples of successful technology transfer stories featured this year by Spinoff include:

Inside NASA's Pandemic Response Campaigns
As the pandemic started to grip the world in early 2020, NASA engineers, Technology Transfer offices, and commercial partners redirected their attention from space missions to the crisis at hand. In additional to VITAL, developed at JPL, inventors at Johnson Space Center created a manually powered ventilator ideal for developing countries, a team led by Armstrong Flight Research Center developed a positive-pressure oxygen helmet with an access panel, and Glenn Research Center partnered with industry to improve innovative sterilization tools.

The Rewards of Perseverance
Before the latest Mars rover even touches down, several of the technologies developed for Mars exploration and flying for the first time have already been commercialized, including an extremely sensitive spectrometer, improved circuit board manufacturing, and a specialized drill bit for geologists.

Food Safety Program for Space Has Taken Over on Earth
Faced with strict safety and reliability requirements for Apollo astronaut food, NASA and partners created a hazard-prevention system that has become the basis for food-safety programs all over the world. Here in the U.S., the system, called HAACP, forms the basis for the FDA and USDA's food safety requirements. Systems based on NASA's original scheme are required to

[54] *Spinoff* is a NASA publication that profiles technologies that have benefited from NASA investment and expertise. More information about *Spinoff* can be found online.

reduce the risk of contamination in any food produced here, whether Butterball turkeys, Ocean Spray cranberries, or Pillsbury pie crusts.

Cleaning Up a Toxic Legacy

Jackie Quinn, an engineer at Kennedy Space Center, created a new technology that absorbs polychlorinated biphenyls, more commonly referred to as PCBs, from sediment and groundwater. EcoSPEARS licensed it and now sells a system that is both cheaper and more effective than traditional cleanups.

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 2016 and FY 2020, there has been a 19% increase in invention disclosures, a 2% increase in patent applications, and a 14% increase in patents issued. In FY 2020, the largest number of Federal patents issued involved the technical areas of Measurement (11%) followed by Biotechnology (7%); Electrical Machinery, Apparatus, Energy (7%); Computer Technology (6%); Pharmaceuticals (6%); and Other Special Machines (6%).

Between FY 2016 and FY 2020, for agencies for which data were available, total active licenses increased by 2%, new licenses increased by 31%, invention licenses increased by 7%, new invention licenses increased by 22%, income-bearing licenses decreased by 5%, and exclusive income-bearing licenses decreased by 4%.

Between FY 2016 and FY 2020, for agencies for which data were available, income from all licensing decreased by 45%, income from invention licenses decreased by 49%, and total earned royalty income decreased by 32%.

Between FY 2016 and FY 2020, for agencies for which data were available, CRADAs increased by 19%, and new CRADAs decreased by 22%, traditional CRADAs increased by 19%, and other collaborative R&D relationships decreased by 15%.

In CY 2020, Federal researchers published 73,196 papers. More than half of these papers were in the fields of Health Sciences (27%), Biological and Biomedical Sciences (19%), Engineering (14%), and Physics (12%). In FY 2020, 20,309 papers cited in U.S. patents were authored or coauthored by Federal researchers. Of these papers, more than 90% involved research in the fields of Biological and Biomedical Sciences (38%), Health Sciences (22%), Engineering (12%), Physics (11%), and Chemistry (8%).

In summary, this report shows that agencies have made progress in several areas in their efforts to improve the transfer of technologies from Federal laboratories. Agencies are 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 2016	FY 2017	FY 2018	FY 2019	FY 2020
USDA	New Inventions Disclosed	244	166	320	243	213
	Patent Applications Filed	109	111	120	97	91
	Patents Issued	60	68	67	71	58
DOC	New Inventions Disclosed	64	43	77	60	70
	Patent Applications Filed	25	46	56	65	36
	Patents Issued	16	34	28	33	25
DoD	New Inventions Disclosed	782	978	839	839	804
	Patent Applications Filed	858	869	1,060	955	881
	Patents Issued	624	630	600	653	655
DOE	New Inventions Disclosed	1,760	1,794	1,748	1,891	2,021
	Patent Applications Filed	999	937	868	837	956
	Patents Issued	856	817	854	919	929
HHS	New Inventions Disclosed	320	354	322	268	309
	Patent Applications Filed	269	289	253	207	225
	Patents Issued	579	554	624	708	738
DHS	New Inventions Disclosed	15	20	22	14	33
	Patent Applications Filed	15	0	17	38	42
	Patents Issued	3	2	8	8	12
DOI	New Inventions Disclosed	8	12	9	8	4
	Patent Applications Filed	4	5	7	3	4
	Patents Issued	1	3	6	1	3
DOT	New Inventions Disclosed	0	3	12	2	3
	Patent Applications Filed	0	7	0	2	2
	Patents Issued	1	0	0	0	1
VA	New Inventions Disclosed	241	589	496	724	625
	Patent Applications Filed	104	163	255	274	248
	Patents Issued	54	50	72	82	59
EPA	New Inventions Disclosed	6	13	7	6	1
	Patent Applications Filed	1	4	6	6	5
	Patents Issued	3	3	4	3	1
NASA	New Inventions Disclosed	1,554	1,690	1,775	1,841	1,882
	Patent Applications Filed	129	165	144	85	87
	Patents Issued	103	114	123	122	142

Total	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
	New Inventions Disclosed	4,994	5,662	5,627	5,896	5,965
	Patent Applications Filed	2,513	2,596	2,786	2,569	2,577
	Patents Issued	2,300	2,275	2,386	2,600	2,623

Federal Licenses

Agency	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
USDA	Licenses, Total Active	441	448	472	512	582
	New Licenses	31	40	40	51	93
	Invention Licenses, Total Active	370	373	386	392	410
	New Invention Licenses	25	31	27	17	30
	Income Bearing Licenses, Total Active	439	437	471	522	594
	Income Bearing Exclusive Licenses	307	302	324	334	342
DOC	Licenses, Total Active	57	68	67	74	52
	New Licenses	15	19	11	15	15
	Invention Licenses, Total Active	57	68	67	74	52
	New Invention Licenses	15	19	11	15	15
	Income Bearing Licenses, Total Active	31	35	37	33	34
	Income Bearing Exclusive Licenses	20	19	22	20	19
DoD	Licenses, Total Active	515	552	480	575	627
	New Licenses	35	162	168	58	70
	Invention Licenses, Total Active	286	514	n.a.	470	581
	New Invention Licenses	57	24	n.a.	58	70
	Income Bearing Licenses, Total Active	185	396	306	283	336
	Income Bearing Exclusive Licenses	209	196	151	179	144
DOE	Licenses, Total Active	5,410	4,045	4,742	4,640	4,862
	New Licenses	621	567	662	686	700
	Invention Licenses, Total Active	943	916	844	822	816
	New Invention Licenses	145	128	100	98	105
	Income Bearing Licenses, Total Active	3,963	3,057	3,323	2,749	2,772
	Income Bearing Exclusive Licenses	231	190	181	113	141
HHS	Licenses, Total Active	1,750	1,806	1,867	1,933	2,028
	New Licenses	278	334	335	346	365
	Invention Licenses, Total Active	1,721	1,354	1,411	1,472	1,546
	New Invention Licenses	221	282	292	291	312
	Income Bearing Licenses, Total Active	837	907	978	1,001	1,059
	Income Bearing Exclusive Licenses	145	130	143	158	143
DHS	Licenses, Total Active	5	5	5	5	5
	New Licenses	1	0	0	0	0
	Invention Licenses, Total Active	5	5	5	5	5
	New Invention Licenses	1	0	0	0	0
	Income Bearing Licenses, Total Active	1	1	1	1	1
	Income Bearing Exclusive Licenses	0	0	0	0	0

Federal Licenses (continued)

Agency	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
DOI	Licenses, Total Active	22	15	17	18	71
	New Licenses	0	0	2	2	17
	Invention Licenses, Total Active	20	13	n.a.	16	71
	New Invention Licenses	0	0	n.a.	2	1
	Income Bearing Licenses, Total Active	17	13	13	16	9
	Income Bearing Exclusive Licenses	8	7	n.a.	7	5
DOT	Licenses, Total Active	2	5	5	5	5
	New Licenses	2	1	1	0	0
	Invention Licenses, Total Active	2	0	0	1	1
	New Invention Licenses	0	0	0	0	0
	Income Bearing Licenses, Total Active	2	2	5	6	4
	Income Bearing Exclusive Licenses	0	0	0	0	1
VA	Licenses, Total Active	261	262	n.a.	n.a.	n.a.
	New Licenses	1	1	n.a.	n.a.	n.a.
	Invention Licenses, Total Active	260	261	n.a.	n.a.	n.a.
	New Invention Licenses	1	0	n.a.	n.a.	n.a.
	Income Bearing Licenses, Total Active	42	42	210	281	261
	Income Bearing Exclusive Licenses	35	36	205	245	211
EPA	Licenses, Total Active	35	38	31	24	23
	New Licenses	8	5	1	3	2
	Invention Licenses, Total Active	35	38	31	24	23
	New Invention Licenses	8	5	1	3	2
	Income Bearing Licenses, Total Active	31	31	24	17	14
	Income Bearing Exclusive Licenses	7	7	6	5	5
NASA	Licenses, Total Active	452	506	540	503	610
	New Licenses	107	119	105	96	172
	Invention Licenses, Total Active	387	440	488	529	582
	New Invention Licenses	97	109	99	88	162
	Income Bearing Licenses, Total Active	245	258	274	326	412
	Income Bearing Exclusive Licenses	14	8	4	8	6

Total	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
	Licenses, Total Active	8,950	7,750	8,226	8,289	8,865
	New Licenses	1,099	1,248	1,325	1,257	1,434
	Invention Licenses, Total Active	4,086	3,982	3,232	3,805	4,087
	New Invention Licenses	570	598	530	572	697
	Income Bearing Licenses, Total Active	5,793	5,179	5,642	5,235	5,496
	Income Bearing Exclusive Licenses	976	895	1,036	1,069	1,017

Federal Income from Licensing ($000s)

Agency	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
USDA	Total Income, All Active Licenses	$4,784	$5,703	$3,835	$3,562	$3,244
	Invention Licenses	$4,456	$5,378	$3,495	$3,275	$2,969
	Total Earned Royalty Income, (ERI)	$3,633	$3,504	$2,716	$3,172	$2,679
DOC	Total Income, All Active Licenses	$149	$141	$147	$136	$191
	Invention Licenses	$149	$141	$147	$136	$191
	Total Earned Royalty Income, (ERI)	$149	$141	$147	$136	$186
DoD	Total Income, All Active Licenses	n.a.	n.a.	n.a.	$5,601	$9,137
	Invention Licenses	$554	n.a.	n.a.	$2,977	$6,126
	Total Earned Royalty Income, (ERI)	$5,823	$7,415	$6,802	$7,279	$8,670
DOE	Total Income, All Active Licenses	$31,149	$36,567	$21,085	$21,974	$24,842
	Invention Licenses	$27,364	$33,436	$17,237	$18,220	$21,095
	Total Earned Royalty Income, (ERI)	$16,273	$13,216	$10,239	$10,466	$15,756
HHS	Total Income, All Active Licenses	$132,833	$134,567	$110,709	$78,540	$54,383
	Invention Licenses	$130,701	$132,536	$108,276	$76,468	$52,076
	Total Earned Royalty Income, (ERI)	$110,193	$135,963	$111,628	$79,000	$64,098
DHS	Total Income, All Active Licenses	$12	$20	$36	$38	$44
	Invention Licenses	$12	$20	$36	$38	$44
	Total Earned Royalty Income, (ERI)	$12	$20	$36	$38	$44
DOI	Total Income, All Active Licenses	$83	$50	$51	$42	$123
	Invention Licenses	$83	$50	$51	$42	$123
	Total Earned Royalty Income, (ERI)	$83	$50	$51	$42	$123
DOT	Total Income, All Active Licenses	$15	$20	$13	$8	$19
	Invention Licenses	$0	$0	$0	$0	$19
	Total Earned Royalty Income, (ERI)	$15	$20	$13	$8	$19
VA	Total Income, All Active Licenses	$316	$491	$690	$1,166	$1,458
	Invention Licenses	$316	$491	$690	$1,166	$1,458
	Total Earned Royalty Income, (ERI)	$316	$491	$690	$1,166	$1,458
EPA	Total Income, All Active Licenses	$466	$412	$628	$449	$33
	Invention Licenses	$466	$412	$628	$449	$33
	Total Earned Royalty Income, (ERI)	$466	$412	$628	$449	$33
NASA	Total Income, All Active Licenses	$3,149	$2,682	$2,301	$2,613	$1,741
	Invention Licenses	$2,750	$2,126	$2,036	$2,530	$1,682
	Total Earned Royalty Income, (ERI)	$2,746	$2,118	$2,041	$1,704	$1,441

Total	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
	Total Income, All Active Licenses	$172,956	$180,653	$139,495	$114,130	$95,215
	Invention Licenses	$166,851	$174,590	$132,596	$105,301	$85,816
	Total Earned Royalty Income, (ERI)	$139,709	$163,350	$134,991	$103,460	$94,507

Federal Collaborative R&D Relationships

Agency	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
USDA	CRADAs, Total Active	238	330	212	260	221
	New CRADAs	79	91	61	95	84
	Traditional CRADAs, Total Active	238	330	182	260	221
	Other Collaborative R&D Relationships	5,628	6,125	3,369	1,888	1,987
DOC	CRADAs, Total Active	2,940	2,932	3,363	2,564	2,014
	New CRADAs	2,608	2,443	2,770	1,893	1,647
	Traditional CRADAs, Total Active	335	413	534	493	458
	Other Collaborative R&D Relationships	3,273	3,181	3,497	3,431	2,952
DoD	CRADAs, Total Active	2,603	2,995	4,976	6,090	6,962
	New CRADAs	774	813	949	936	1,048
	Traditional CRADAs, Total Active	2,273	2,424	3,010	3,768	4,207
	Other Collaborative R&D Relationships	330	571	1,966	2,322	2,755
DOE	CRADAs, Total Active	784	936	1,030	1,072	1,132
	New CRADAs	264	330	312	287	307
	Traditional CRADAs, Total Active	784	936	1,030	1,072	1,132
	Other Collaborative R&D Relationships	0	0	0	0	0
HHS	CRADAs, Total Active	590	588	577	575	665
	New CRADAs	134	112	87	93	120
	Traditional CRADAs, Total Active	391	462	465	476	493
	Other Collaborative R&D Relationships	147	126	112	99	172
DHS	CRADAs, Total Active	343	412	164	212	106
	New CRADAs	114	107	104	60	50
	Traditional CRADAs, Total Active	272	326	164	212	106
	Other Collaborative R&D Relationships	71	71	n.a.	n.a.	n.a.
DOI	CRADAs, Total Active	873	841	740	470	489
	New CRADAs	511	477	422	352	237
	Traditional CRADAs, Total Active	37	58	53	43	32
	Other Collaborative R&D Relationships	319	247	249	269	353
DOT	CRADAs, Total Active	68	65	63	44	49
	New CRADAs	22	6	7	10	7
	Traditional CRADAs, Total Active	62	66	63	43	46
	Other Collaborative R&D Relationships	152	355	121	125	0
VA	CRADAs, Total Active	2,613	1,785	1,688	1,686	1,587
	New CRADAs	502	575	512	536	432
	Traditional CRADAs, Total Active	2,359	1,619	1,518	1,526	1,403
	Other Collaborative R&D Relationships	0	0	0	0	0
EPA	CRADAs, Total Active	55	51	49	54	46
	New CRADAs	14	8	11	11	5
	Traditional CRADAs, Total Active	55	51	49	54	46
	Other Collaborative R&D Relationships	48	89	91	93	111
NASA	CRADAs, Total Active	12	0	0	0	0
	New CRADAs	5	0	0	0	0
	Traditional CRADAs, Total Active	12	0	0	0	0
	Other Collaborative R&D Relationships	2,204	2,174	2,182	1,967	2,004

Total	Metric	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
	CRADAs, Total Active	11,119	10,935	12,862	13,027	13,271
	New CRADAs	5,027	4,962	5,235	4,273	3,937
	Traditional CRADAs, Total Active	6,818	6,685	7,068	7,947	8,144
	Other Collaborative R&D Relationships	12,172	12,939	11,587	10,194	10,334

Appendix B

Technology Area Classification
Mapping of International Patent Classifications to Technology Area[55]

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.

[55] 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[56]

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

[56] 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