Annual Report on Technology Transfer: Approach and Plans, Fiscal Year 2015 Activities and Achievements

U.S. Department of Commerce

Report prepared by:

National Institute of Standards and Technology
National Oceanic and Atmospheric Administration
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Pursuant to the
Technology Transfer and Commercialization Act of 2000 (Pub. L. 106-404)

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FOREWORD

This report summarizes technology transfer activities and achievements of the Department of Commerce's (DOC's) Federal laboratories for fiscal year (FY) 2015. At DOC, technology transfer is a significant part of the mission and programmatic activities of the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), and the National Telecommunications and Information Administration's (NTIA's) Institute for Telecommunication Sciences (ITS). Accordingly, this report focuses on the activities of these agencies.

This report has been prepared in response to the statutory requirement for an annual "agency report on utilization" (15 U.S.C. Section 3710(f)) established under Section 10 of the Technology Transfer Commercialization Act of 2000 (Pub. L. 106-404). All Federal agencies that operate or direct one or more Federal laboratories or conduct other activities under Sections 207 and 209 of Title 35, United States Code, are subject to the requirements of this statute. Pursuant to the Presidential Memorandum – Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses (October, 2011), this report contains significantly expanded metrics on technology transfer from previous editions.

DOC's overall and laboratory-specific approaches and its plans for technology transfer are summarized within this report. The report focuses on current year activities and accomplishments and provides statistical information from FY 2011 through FY 2015.

NIST, NOAA, and ITS technology transfer offices have contributed to the organization and preparation of the material reported. An electronic version of this report and versions from previous fiscal years are available online at: http://www.nist.gov/tpo/publications/index.cfm.

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CHAPTER 1 Department of Commerce Overview

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

DOC conducts research and development (R&D) in areas of science and technology at the laboratory facilities of NIST, NOAA, and NTIA's ITS. Technology transfer, which is a key part of the programmatic activities in these laboratories, connects technological advances of DOC's science and engineering programs to the American economy.

In addition to the technology transfer efforts of DOC laboratories, DOC is responsible for coordinating technology transfer activities across Federal agencies. DOC coordinates the Interagency Workgroup for Technology Transfer (IAWGTT) through the facilitation by NIST of interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency transfer programs. [1] NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer (FLC), which provides a forum for federal labs to develop strategies and opportunities for linking technologies and expertise with the marketplace.

The Presidential Memorandum (PM) – *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses* (PM) of October 21, 2011 further expanded DOC's role in coordinating technology transfer activities across Federal agencies.[2] The purpose of this PM is to foster innovation by increasing the rate of technology transfer leading to a greater economic and societal impact from Federal investments in R&D.

The PM directs agencies with Federal laboratories to establish goals to measure performance, streamline administrative processes, and facilitate local and regional partnerships in order to accelerate technology transfer and support private sector commercialization. The aim is to increase significantly successful agency technology transfer and commercialization activities, while simultaneously achieving excellence in each agency's research activities. Section 2 of the PM specifically requires that "[t]he Secretary of Commerce, in consultation with other agencies, including the National Center for Science and Engineering Statistics, shall improve and expand,

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

[2] http://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commerciali

where appropriate, its collection of metrics in the Department of Commerce's annual technology transfer summary report, submitted pursuant to 15 U.S.C. Section 3710(g)(2)." [3]

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

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

[3] For a list of available reports see http://www.nist.gov/tpo/publications/doc-annual-reports-techtransfer.cfm

Summary of Technology Transfer Activities FY 2011 – FY 2015

This annual report provides comprehensive statistics on the technology transfer activities of DOC laboratories, including information regarding invention disclosures, intellectual property (patents/licenses), collaborative research and development agreements (CRADAs), and other technology transfer mechanisms. Examples of successful downstream results (e.g., commercially significant technologies) from technology transfer activities are also highlighted.

Section 10 of the Technology Transfer Commercialization Act of 2000 (Pub. L. 106-404, codified at 15 U.S.C. Section 3710(f)) requires each Federal agency, which operates or directs one or more Federal laboratories, or conducts activities under 35 U.S.C. Sections 207 and 209, to report to Congress the results of its technology transfer activities. Office of Management and Budget Circular A-11 also require this information. The tables in the following sections present the required data.[4]

Invention Disclosures and Patenting

In FY 2015, DOC researchers disclosed 61 new inventions. Of these, 46 invention disclosures were from NIST researchers and 15 were from NOAA researchers. There were 30 patent applications filed (26 for NIST and 4 for NOAA) and 20 patents issued (19 for NIST and 1 for NOAA).[5]

Table 1 – Invention Disclosure and Patenting

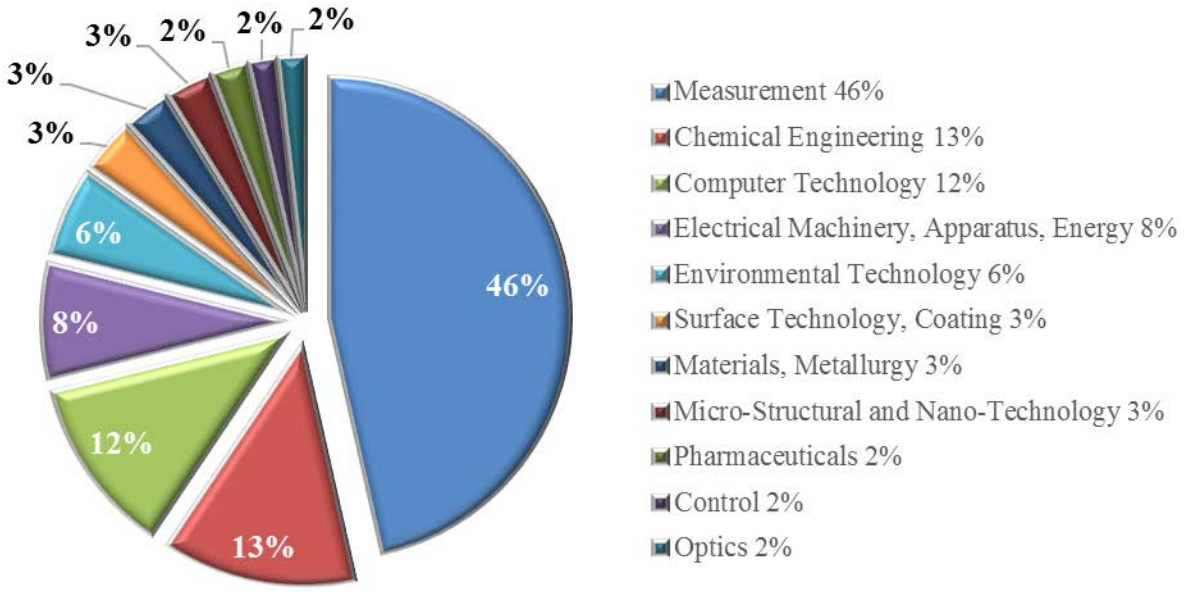
	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Invention Disclosures					
NIST	25	52	33	41	46
NOAA	1	0	8	6	15
ITS	0	0	0	0	0
Department Total	26	52	41	47	61
Patent Applications Filed					
NIST	17	24	23	21	26
NOAA	0	1	3	4	4
ITS	0	0	0	0	0
Department Total	17	25	26	25	30
Patents Issued					
NIST	14	12	20	19	19
NOAA	2	2	1	0	1
ITS	0	0	0	0	0
Department Total	16	14	21	19	20

[4] Technology transfer data is typically adjusted over time to account for new information resulting from changes in reporting procedures, patent decisions, programmatic changes, etc. Throughout this report, data prior to FY 2015 has been adjusted, where necessary, to reflect the most accurate estimates for each year reported.

[5] Note that the time required for a patent to be granted may take two years or more. Patents issued in FY 2015 were filed in prior years.

In addition to the number of patents issued to each agency, the National Science Foundation (NSF) provides additional insight into the technology areas addressed by DOC patents.[6] In FY 2014, 46% of DOC's patents were in the technical area of Measurement Techniques and Instruments. This includes techniques and use of instrumentation that measures, tests, inspects or analyzes a wide variety of materials or processes.[7]

Figure 1 – Percent of USPTO Patents Granted to DOC, by Technology Area – FY 2014



[6] NSF routinely researches a wide range of data for its publication "Science and Engineering Indicators" http://www.nsf.gov/statistics/. NIST requested that NSF provide the data in Figure 1 and this complies with NSF's goal of supporting agencies in their tasks of enhancing the measurement of technology transfer activities.

[7] Patents are credited on a whole-count basis (i.e., each participating federal agency is credited one count). However, when applying International Patent Classification (IPC) codes to identify technical areas fractioning is used to ensure that the sum of patents across technology areas is equal to the total number of patents as each patent can be assigned to more than one technology area. Source: Prepared by Science-Metrix using USPTO data indexed in LexisNexis (Elsevier). Used with permission.

Licensing

In FY 2015, there were 44 active patent licenses, the largest number in the last five fiscal years. Of these 44 licenses, NIST issued 40 and NOAA issued four.

Table 2 – Licensing – Profiles of Active Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Active Patent Licenses [(a)]					
NIST	37	39	36	35	40
NOAA	6	5	5	5	4
ITS	0	0	0	0	0
Department Total	40	41	40	40	44

(a) "Active" means an agreement in effect at any time during the fiscal year.

Of the 44 active patent licenses in FY 2015, 31 were income-bearing licenses. Of these, 17 were exclusive licenses and 12 were non-exclusive.

Table 3 – Characteristics of Income-Bearing Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income-Bearing Licenses					
Department Total	26	25	28	26	31
Patent Licenses					
NIST [(a)]	36	25	26	25	27
NOAA	3	3	5	5	4
ITS	0	0	0	0	0
License Types					
Exclusive					
NIST	12	12	15	15	16
NOAA	0	0	0	0	1
ITS	0	0	0	0	0
Department Total	12	12	15	15	17
Partially Exclusive					
Department Total	0	0	0	0	0
Non-Exclusive					
NIST	10	9	8	8	9
NOAA	3	3	5	5	3
ITS	0	0	0	0	0
Department Total	13	12	13	13	12

(a) Other licensing types not show here include Assignments and Custody Transfers.

In 2015, DOC's income-bearing licenses provided $164,456 in income. Of this amount, NIST licenses provided $124,823 and NOAA licenses provided $39,633.

Table 4 – Income from Licensing

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Licensing Income					
NIST	$169,347	$146,796	$102,532	$150,995	$124,823
NOAA	$107,220	$100,867	$48,798	$69,151	$39,633
ITS	$0	$0	$0	$0	$0
Department Total	$276,567	$247,663	$151,330	$220,146	$164,456

Collaborative Relationships for Research and Development (CRADAs)

In 2015, there were 2,751 CRADAs involving DOC researchers, the largest number in the last five fiscal years. There were 364 traditional[8] CRADAs and 2,387 non-traditional CRADAs involving laboratory accreditation, material transfer agreements or technical assistance. Of the 364 traditional CRADAs, NIST was involved in 329, NOAA was involved in 28, and ITS was involved in 56. These traditional CRADAs included 49 joint agreements involving NIST and ITS for Public Safety 700 MHz Broadband Demonstration.

Table 5 – Collaborative Relationships for Research and Development

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs					
Department Total	2,245	2,410	2,428	2,359	2,751
Traditional CRADAs					
NIST	104	140	179	206	329
NOAA	7	10	15	19	28
ITS	23	60	81	60	56
Department Total[(a)]	134	210	275	285	364
Joint CRADA Agreements (NIST and ITS)	35	57	79	79	49
Non-Traditional CRADAs					
NIST	2,138	2,255	2,231	2,074	2,387
NOAA	0	0	0	0	0
ITS	9	2	0	0	0
Department Total	2,147	2,257	2,231	2,074	2,387

(a) The Department adjusts its totals for traditional CRADAs to avoid double counting where NIST and ITS are jointly involved.

[8] Traditional CRADAs involve collaborative research and development projects by a Federal laboratory and non-Federal partners.

Scientific and Technical Publications

As discussed in the Department's response to the PM, technology transfer mechanisms include more than just counting CRADAs, patents, and licenses. [9] For example, DOC's scientific and technical publications also can lead to technology transfer. In FY 2015, NIST, NOAA, and ITS researchers published 3,205 scientific and technical papers in peer-reviewed journals, an increase of 71 over last year and nearly a 1,000 more than in FY 2011.

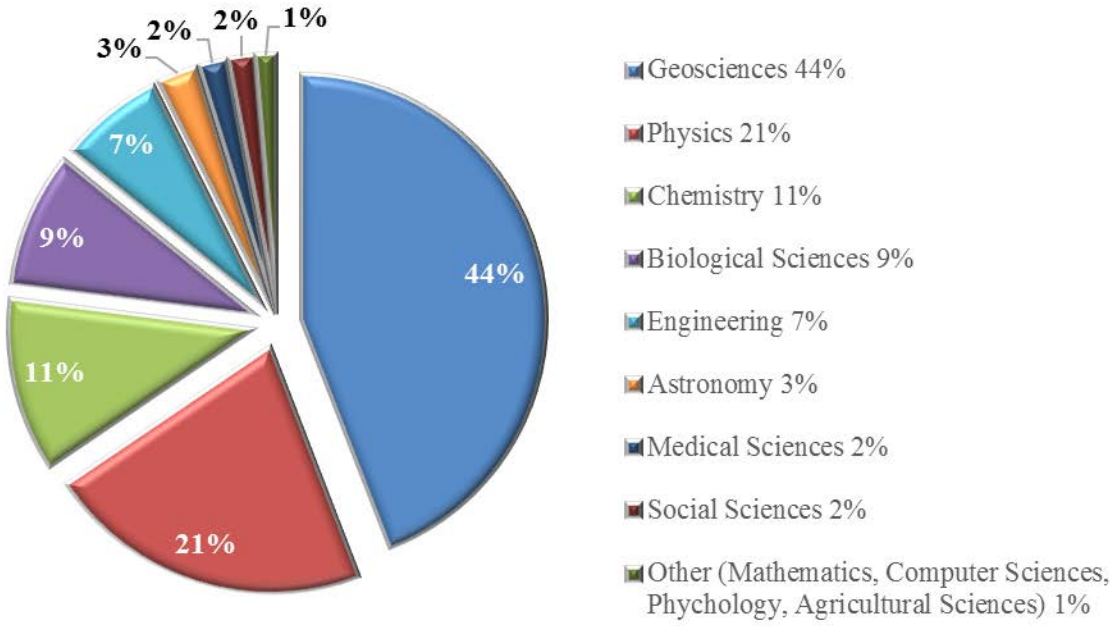
Table 6 – Scientific and Technical Publications

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Technical Publications					
NIST	1,210	1,335	1,393	1,359	1,323
NOAA	1,034	1,769	1,781	1,759	1,860
ITS	15	13	24	18	22
Department Total	2,259	3,117	3,198	3,136	3,205

[9] http://www.nist.gov/tpo/publications/upload/DOC-Tech-Transfer-Plan.pdf

In addition to the number of publications reported by each agency, NSF provides insight into the technology areas addressed by each Federal agency in its publications.[10] Using data from Thomson Reuters' Science Citation Information (SCI)[11] and Social Sciences Citation Index (SSCI)[12] databases, NSF finds that, for FY 2014, the most recent year available, the largest technology areas shown in Figure 2 covered by DOC publications are Geosciences (44%), followed by Physics (21%) and Chemistry (11%).

Figure 2 – Percent of Articles by Technology Area Authored by DOC Staff in FY 2014[13]



[10] NSF routinely researches a wide range of data for its publication "Science and Engineering Indicators" (http://www.nsf.gov/statistics/.) The data presented here has been provided at the request of NIST and is in compliance with NSF's goal of supporting agencies in their tasks of enhancing the measurement of technology transfer activities.

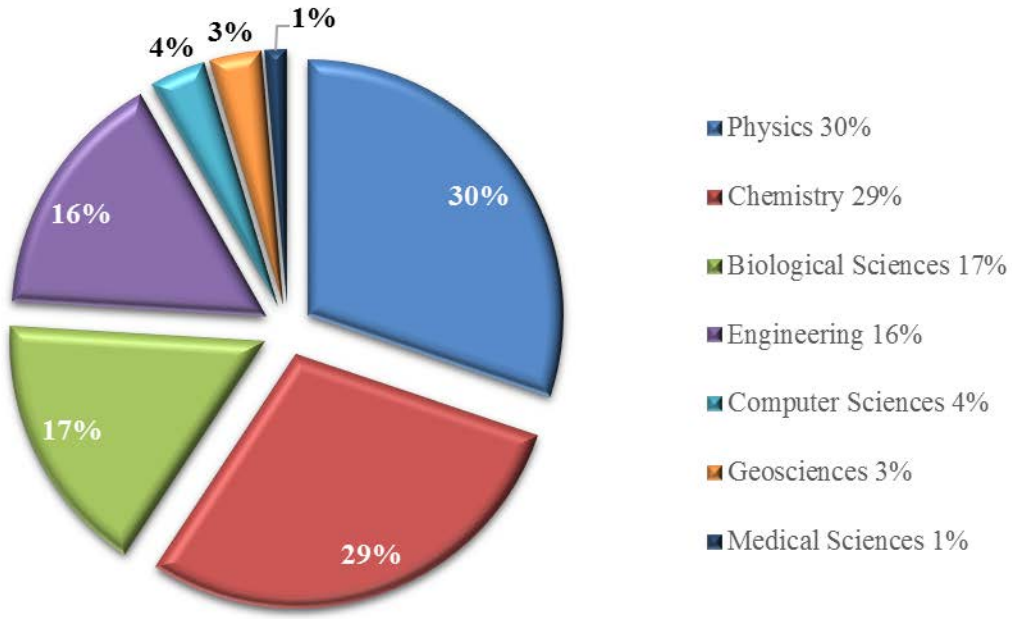
[11] http://ip-science.thomsonreuters.com/cgi-bin/jrnlst/jloptions.cgi?PC=K

[12] http://thomsonreuters.com/social-sciences-citation-index/

[13] The year assigned to an article is the one in which it entered the database, rather than the year of publication, and are assigned to a federal agency based on the institutional address or addresses listed in the article. Articles are credited on a whole-count basis (i.e., each participating federal agency receives one count). The sum of the number of articles for individual federal agencies may exceed the total when articles have authors from multiple federal agencies. Prepared by Science-Metrix using the Web of Science database (Thomson Reuters). Used with permission.

Data are also available on the number of times U.S. patents cite U.S. science and engineering articles authored by DOC staff. U.S. patents issued in FY 2014 cite 815 publications authored by DOC researchers. As shown in Figure 3, the largest technology areas citing DOC publications include Physics (30%), followed by Chemistry (29%) and Biological Sciences (17%).

Figure 3 – Percent of Articles by Technology Area Authored by DOC Staff and Cited in U.S. Patents in 2014[14]



The following chapters provide details on other agency-specific technology transfer activities such as technical support development for industrial standards and reference materials, public dissemination activities (meetings and workshops), collaborations with guest researchers, etc.

[14] Cited articles are classified by the year of publication, and are assigned to a federal agency on the basis of the institutional address or addresses listed in the article. Citations are classified on a whole count basis (i.e., each participating federal agency on a cited article receives one count). The basis for citation counts is an 11-year window with a 5-year lag (e.g., citations for 2012 are references in USPTO patents issued in FY2012 to articles published in 1997–2007. The sum of the federal agencies may exceed the total when cited articles have authors from multiple federal agencies. Prepared by Science-Metrix using the Web of Science database (Thomson Reuters). Used with permission.

CHAPTER 2 National Institute of Standards and Technology

NIST has a broad mission: to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improves our quality of life.

Rapidly evolving sectors like nanotechnology, biotechnology, homeland security, information technology, and advanced manufacturing need sophisticated technical support systems in order to flourish and grow. Therefore, an important part of accomplishing NIST's mission is to anticipate future measurement and standards needs of U.S. industry. NIST laboratories develop measurement techniques, test methods, standards, reference materials, reference data, and other technologies and services that support U.S. industry, scientific research, and the activities of many other Federal agencies. In carrying out its mission, NIST works directly with industry partners (individual companies and consortia), universities, standards organizations, other domestic and foreign associations, and other government agencies.

Approach and Plans for Technology Transfer

NIST designs its technology transfer activities to disseminate the results of fundamental research, measurements, and standards research to industry and other interested parties. In order to provide leading-edge scientific and technical work, NIST is required to have expertise in multiple disciplines, maintain high levels of collaboration with organizations and people with diverse capabilities, and have highly specialized facilities and tools. For more than a century, laboratories at NIST (and its direct predecessor agency: the National Bureau of Standards) have successfully collaborated with others to provide the measurement techniques and technical tools needed by America's innovators.[15]

NIST broadly defines technology transfer as:

> ***"… the overall process by which NIST knowledge, facilities, or capabilities in measurement science, standards and technology promote U.S. innovation and industrial competitiveness in order to enhance economic security and improve quality of life."***

NIST's definition of technology transfer reflects the many ways NIST reaches its external partners. The definition includes, *inter alia*: 1) the act of transferring knowledge from one individual to another by means of mentoring, training, documenting, or collaborating; and 2) commercialization, the adoption of a technology into the private sector through a business or other organization.

NIST has designed its technology transfer program to improve the transfer of its technology and work products directly and through collaborations. The following summarizes different technology transfer mechanisms NIST uses to promote innovation and to disseminate broadly the technologies that result from its research.

[15] Additional details on NIST's technology transfer program are available at http://www.nist.gov/tpo/index.cfm.

NIST Work Products and Collaborative Activities

NIST actively seeks to identify commercially valuable inventions that result from its research. The Patent Review Committee at NIST evaluates each reported invention's potential to promote U.S. innovation and industrial competitiveness. NIST will generally seek patent protection when a patent: (1) would enhance the potential for an invention's commercialization; (2) would have a positive impact on a new field of science or technology and/or the visibility and vitality of NIST; (3) would further the goals of a CRADA or other agreement; (4) would further U.S. manufacturing; or (5) would likely lead to a commercialization license.

NIST will continue to report on patents, licenses, age and size of companies licensing NIST technologies, number of jointly owned inventions, and other relevant information.

Chapter 1 presented summary information on patenting and licensing; additional details on licensing are included below.

NIST research has led to inventions in the following areas: bioscience and health, building and fire research, chemistry, math, physics, electronics and telecommunications, energy, environment/climate, information technology, manufacturing, materials science, nanotechnology, public safety and security, and transportation.

In FY 2015, there were 40 active NIST patent licenses with 11 of these licenses were issued in FY 2015. Of these, four licenses were issued to small companies (i.e., companies with less than 500 employees).

Table 7 – Profile of Active NIST Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Number of Active Licenses[(a)]	34	36	35	36	40
New Licenses Executed	5	6	5	7	11
Total Invention Licenses Active	34	36	35	36	40
New Invention Licenses Executed	5	6	5	7	11
Total Patent Licenses Active[(b)]	34	36	35	36	40
New Patent Licenses Executed	5	6	5	7	11
Total Material Transfer Licenses Active (Inventions)	0	0	0	0	0
New Material Transfer Licenses (Inventions)	0	0	0	0	0
Total Material Transfer Licenses Active (Non-Inventions)	0	0	0	0	0
New Material Transfer Licenses Executed (Non-Inventions)	0	0	0	0	0
Total "Other Invention Licenses" Active	0	0	0	0	0
New "Other Invention Licenses" Executed	0	0	0	0	0
Total "Other IP Licenses" Active	0	0	0	0	0
New "Other IP Licenses" Executed	0	0	0	0	0
Copyright Licenses (Fee-Bearing) Active	0	0	0	0	0
New Copyright Licenses Executed	0	0	0	0	0
NIST Licenses Issued to Small Companies	--	2	7	7	4

(a) "Active" means an agreement in force at any time during the fiscal year.
(b) Patent licenses include licenses to pending patent applications.

In FY 2015, the average time to negotiate a patent license was 7 months. The minimum time to negotiate a license was approximately .20 months (6 days) and the maximum time was 38.7 months.

Table 8 – Licensing Management

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
License Negotiation Time (Patent Licenses) [(a)(b)]					
Average (months)	1.9	2.9	6.0	4.0	7.0
Minimum (months)	1.0	2.4	2.3	0.23	0.20
Maximum (months)	4.5	5.5	13.5	17.3	38.7
Licenses Terminated for Cause					
Invention Licenses (Patent Licenses)	0	0	0	0	0

(a) Date of license application to date of license execution. The date of license application is the date the laboratory formally acknowledges the written request for a license from a prospective licensee and agrees to enter into negotiations.

(b) Patent licenses include licenses to pending patent applications.

Income from licensing comes from a variety of sources: license issue fees; earned royalties; minimum annual royalties; paid-up license fees; reimbursement for full-cost recovery of goods; and services provided by the laboratory to the licensee (including patent costs).

Table 9 – Characteristics of Licenses Bearing Income

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income Bearing Licenses [(a)]	26	25	26	25	27
Exclusive	12	12	15	15	16
Partially Exclusive	0	0	0	0	0
Non-Exclusive	10	9	8	8	9
Total Income Bearing Invention Licenses[(b)]	26	25	26	25	27
Exclusive	12	12	15	15	16
Partially Exclusive	0	0	0	0	0
Non-Exclusive	10	9	8	8	9
Total Other Income Bearing IP Licenses	0	0	0	0	0
Total Royalty Bearing Licenses	26	25	26	25	27
Total Royalty Bearing Invention Licenses	26	25	26	25	27
Royalty Bearing Patent Licenses	26	25	26	25	27
Other Royalty Bearing IP Licenses	0	0	0	0	0

(a) Other licensing types not show here include Assignments and Custody Transfers.

(b) Includes licenses to pending patent applications.

In FY 2015, NIST received $124,823 from all active licenses. The minimum amount received for a license was $640 and maximum was $62,833.

Table 10 – Income from Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Active Licenses[(a)]	$169,347	$146,796	$102,532	$150,995	$124,823
Invention Licenses (Patent Licenses)[(b)]	$169,347	$146,796	$102,532	$150,995	$124,823
Other IP Licenses, Total Active	$0	$0	$0	$0	$0
Total Earned Royalty Income (ERI)[(c)]	$169,347	$146,796	$102,532	$150,995	$124,823
Median ERI	$1,844	$9,971	$10,000	$6,250	$1,600
Minimum ERI	$1,500	$1,500	$640	$640	$640
Maximum ERI	$100,000	$64,185	$58,642	$74,575	$62,833
ERI from Top 1% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
ERI from Top 5% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
ERI from Top 20% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
Invention Licenses (Patent Licenses)	$169,347	$146,796	$102,532	$150,995	$124,823
Median ERI	$1,844	$9,971	$10,000	$6,250	$1,600
Minimum ERI	$1,500	$1,500	$640	$640	$640
Maximum ERI	$100,000	$64,185	$58,642	$74,575	$62,833
ERI from Top 1% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
ERI from Top 5% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
ERI from Top 20% of Licenses[(d)]	n.a.	n.a.	n.a.	n.a.	n.a.
Other IP Licenses, Total Active	$0	$0	$0	$0	$0

(a) Total income includes license issue fees, earned royalties, minimum annual royalties, paid-up license fees, reimbursement for full-cost recovery of goods and services provided by the laboratory to the licensee including patent costs and Standard Reference Data. “Active” means an agreement in force at any time during the fiscal year.

(b) Patent licenses include licenses to pending patent applications.

(c) “Earned Royalty Income” is a royalty based on use of a licensed invention (usually, a percentage of sales or of units sold). It is not a license issue fee or a minimum royalty.

(d) n.a. = not available. Data withheld to protect proprietary information.

Of the total licensing income received ($124,823), 36% ($44,936) was distributed to the NIST inventor and the remaining 64% ($79,887) was retained by the NIST inventor's Operating Unit.

Table 11 – Disposition of Invention License Income

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income Received[(a)]	$169,347	$146,796	$102,532	$150,995	$124,823
Invention Licenses (Patent Licenses)[(b)]					
Licensing Income to Inventor(s)	$56,698	$61,300	$38,732	$54,602	$44,936
	33%	42%	38%	36%	36%
Licensing Income to NIST	$112,649	$85,497	$63,799	$96,393	$79,887
	67%	58%	62%	64%	64%

(a) Income includes royalties and other payments received during the fiscal year.
(b) Patent licenses include licenses to pending patent applications.

Cooperative Research and Development Agreements (CRADAs)

Collaborative research and development projects between Federal laboratories, academia, and outside partners are an effective means of transferring technology. Beyond the improved know-how and new technologies that result, these joint efforts often help collaborators to leverage each other's resources and technical capabilities. They also provide mechanisms for collaborators to gain technical competencies and acquire new skills. CRADAs are agreements between a Federal laboratory and one or more partners to collaborate on defined R&D projects. They are a major mechanism for establishing joint relationships with industry, academia, and state and local governments to advance promising new technologies toward commercialization. These agreements Created under Stevenson-Wydler Technology Innovation Act of 1980, as amended by the Federal Technology Transfer Act of 1986 (Pub. L. 99-502).[16]

In FY 2015, there were 2,481 new NIST CRADAs. Of these, 143 were traditional and 2,338 were non-traditional. There were 3,125 guest researchers involved in these CRADAs, including foreign and domestic researchers and researchers working at NIST under Intergovernmental Personnel ACT (IPA) agreements, CRADAs, and Facility Use Agreements.

[16] http://www.nist.gov/tpo/collaborations/crada.cfm

Table 12 – NIST Collaborative Relationships for Research and Development

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
NIST CRADAs[(a)]					
Total Active CRADAs	2,241	2,916	2,410	2,280	2,716
New CRADAs Executed	2,173	2,810	2,252	2,092	2,481
Total Active Traditional CRADAs	104	140	179	206	329
New Traditional CRADAs Executed	51	53	48	50	143
Total Active Non-Traditional CRADAs	2,138	2,255	2,231	2,074	2,387
New Non-Traditional CRADAs Executed	2,122	2,236	2,204	2,042	2,338
Other Type of Collaborative R&D Relationships					
Guest Scientists and Engineers[(b)]	2,899	2,782	2,963	2,981	3,125

(a) Traditional CRADAs involve collaborative research and development projects by a Federal laboratory and non-Federal partners. Non-traditional CRADAs are used for special purposes, such as laboratory accreditation, materials transfer or technical assistance that may result in protected information.

(b) "Guest scientists and engineers" includes foreign and domestic guest researchers and researchers working at NIST under Intergovernmental Personnel Act (IPA) agreements, CRADAs, and Facility Use Agreements.

Scientific and Technical Publications
Technical publications are one of the major mechanisms NIST uses to disseminate the results of its research to industry, academia, and other agencies.

In FY 2015, NIST staff authored 1,323 publications in peer-reviewed journals,[17] including 384 papers (29.0%) published in 110 "top tier" journals where "top tier" includes any journal with a Thomson Reuters' Journal Impact Factor (IF) that falls within the top 10 percentile in its *Web of Science* Subject Category.[18]

Table 13 – NIST Publications in Top-Tier Journals vs. Total NIST Publications

	FY 2012	FY 2013	FY 2014	FY 2015
Number of NIST Papers	1,335	1,393	1,359	1,323
Number of NIST Papers in Top-Tier Journals	369	436	444	384
Percentage of NIST Papers in Top-Tier Journals	27.6%	31.3%	32.7%	29.0%

In FY 2015, NIST researchers collaborated and co-authored with researchers from around the world. NIST researchers co-authored papers with 4,585 unique non-NIST authors from 1,023 unique institutions in 63 countries.[19]

Table 14 – NIST Publications[20]

	CY 2011	CY 2012	FY 2013	FY 2014	FY 2015
Number of NIST Papers	1,351	1,327	1,393	1,359	1,323
Number of Unique Non-NIST Co-Authors	4,086	4,171	3,920	4,086	4,585
Number of Unique Institutions	1,034	1,003	922	965	1,023
Number of Countries	64	54	53	62	63

NIST also publicizes its planned, ongoing, and recently completed work in outlets followed by the organizations most likely to have an interest in NIST's research and services, such as the trade and technical press. In addition to news releases, websites, and contacts with the media, NIST publishes ***Tech Beat***, a biweekly, plain language newsletter of recent research results.[21]

In addition to the basic methods of transferring technology such as patents, licenses, and CRADAs, NIST researchers routinely transfer technological innovations through the following mechanisms.

[17] http://nvl.nist.gov
[18] For the purposes of this report, NIST defines a "top tier" journal as any journal with a Thomson Reuters Impact Factor (IF) that ranks within the top 10 percentile in its Web of Science Subject Category. For additional information see http://wokinfo.com/essays/journal-selection-process
[19] Unique co-authors and institutions were identified by performing a search for all NIST authored papers in the *Web of Science (WoS)* database. This includes publications in the peer-reviewed literature but excludes most conference proceedings papers and all NIST series publications.
[20] In 2011 and 2012, NIST reported publications on a calendar year data basis.
[21] http://www.nist.gov/public_affairs/tech-beat/index.cfm

Participation in Documentary Standards Committees
Documentary standards are shared sets of rules that specify, as examples, a test method or measurement methods, a product's properties, or standard practices. Econometric studies have concluded that standards contribute significantly to economic growth, and at least one study concluded the following: development of standards is integral to innovation; documentary standards contribute to economic growth at least as much as do patents; and the macroeconomic benefits of the development of standards extend beyond the benefits to the companies that use the standards.[22]

One mechanism used to transfer NIST measurement-science research and other technologies for market use is through participation in the development of consensus documentary standards.

During FY 2015, 469 members of NIST staff were involved with more than 165 standards organizations. Such participation helps NIST respond programmatically to the needs of the private sector and enables its scientists and engineers to bring NIST technology and know-how directly into standards-setting bodies. NIST reports its activities in standards development to the Office of Management and Budget and to Congress, as required by the National Technology Transfer and Advancement Act of 1995 (Pub. L. 104-113).[23]

The NIST Standards Coordination Office (SCO) maintains the Standards Committee Participation Database for employees to self-report their involvement, including leadership positions, within standards organizations. SCO has been proactively expanding the database to collect information on staff tenure on a standards committee, standard(s) developed with NIST staff participation, and other information relevant to NIST's contributions in new and existing documentary standards.

Standard Reference Data
The Standard Reference Data (SRD) program provides critically evaluated numeric data to scientists and engineers for use in technical problem solving, research, and development. Many types of reference data are critically important in engineering structures, optimizing chemical processes, and other industrial applications. Standard Reference Data are extracted from the scientific and technical literature, or developed from measurements conducted at NIST laboratories, and are critically evaluated for accuracy and reliability. NIST currently maintains 111 SRD databases that cover many areas of science, including analytical chemistry, atomic and molecular physics, biotechnology, and materials sciences.[24]

NIST laboratories conducted data evaluations and supplied the results to NIST customers through the Standard Reference Data Program. In FY 2015, NIST SRD distributions included 2,596 e-commerce orders, 9,807 units sold via distributor, 123 active distributor agreements, 57 active site licenses, 38 active internet subscriptions, 418 units shipped to the user, and 5,751 products downloaded from the NIST website (3,615 free downloads, 2,136 paid downloads).

[22] Peter Swann, G.M., Report for the UK Department of Business, Innovation, and Skills (BIS), 2010 https://www.gov.uk/government/publications/economics-of-standardisation-update-to-report
[23] http://gsi.nist.gov/global/index.cfm/L1-1
[24] http://www.nist.gov/srd/index.cfm

Table 15 – Standard Reference Data Program

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Standard Reference Data					
Products available (databases)	120	111	120	111	111
E-Commerce Orders	2,678	2,628	2,658	3,111	2,596
Units Sold via Distributor	4,261	4,446	5,495	5,142	9,807[(a)]
Active Distributor Agreements	64	52	62	101	123
Active Site Licenses	15	15	30	58	57
Active Internet Subscriptions	41	59	50	42	38
Units Shipped via UPS	550	547	430	595	418
Products Downloaded from the NIST Website	2,005	1,951	2,055	3,435	5,751
Free Downloads	913	1,137	1,399	1,352	3,615
Paid Downloads	2,005	1,951	2,055	2,083	2,136

(a) The increase in sales between FY 2014 and FY 2015 for "Units sold via distributor" reflects sales related to the release of a new version of the NIST Standard Reference Database 1A, NIST/EPA/NIH Mass Spectral Library and sales from Standard Reference Database 23, Reference Fluid Thermodynamic and Transport Properties.

Standard Reference Materials

Standard Reference Materials (SRMs) are a definitive source of various measurements in the United States. Measurements made using SRMs can be traced to a common and recognized set of basic standards that provide the basis for measurement compatibility among different laboratories. The certified property values for SRMs often depend on the development of unique measurement capabilities within NIST.[25]

NIST will continue to report on the number of SRMs sold and new SRMs developed while studying whether it can develop other meaningful impact information using existing customer data.

Table 16 – Standard Reference Materials

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Standard Reference Materials					
Units Available	1,177	1,298	1,299	1,281	1,240
Units Sold	32,864	33,441	32,267	32,636	33,490

User Facilities – Research Participants

NIST operates two unique and valuable laboratory facilities – the Center for Nanoscale Science and Technology (CNST) and the NIST Center for Neutron Research (NCNR) – that support U.S. industry, academic institutions, and other NIST and government laboratories. These facilities are a vibrant means by which NIST customers can tap directly into NIST measurement expertise to solve their problems

The CNST supports the development of nanotechnology from discovery to production. It operates a national shared-use nanofabrication and measurement facility (the NanoFab), complemented by a multidisciplinary research staff creating next-generation tools for advancing nanotechnology. The NCNR is a national center for research using thermal and cold neutrons.

[25] http://www.nist.gov/srm/index.cfm

Many of its instruments rely on intense beams of cold neutrons emanating from an advanced liquid hydrogen moderator.[26]

NIST User Facility "Research Participants" are those who directly participate in an NCNR experiment or CNST project. Research Participants include those who use the facility on-site or remotely, and their collaborators on the experiment or project. In FY 2015, there were 2,233 research participants at CNST and 2,436 at NCNR.

Table 17 – NIST Research Participants

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
NIST Research Participants					
CNST [(a)]	1,402	1,669	1,885	2,147	2,233
NCNR	2,265	1,976	2,148	2,271	2,436

(a) The FY 2015 Research Participant totals for CNST are preliminary.

[26] http://www.nist.gov/user-facilities.cfm

Postdoctoral Researchers

Technology transfer not only involves inventions, innovations, data, patents and licenses, but also the people who perform the actual research and development. Postdoctoral researchers, or "postdocs," working at NIST also play an important role in transferring NIST technology.[27] For the purpose of this report, NIST uses the NSF's description of a postdoctoral researcher[28] as one who has a temporary position taken within five years after the completion of a doctoral degree to gain scientific, technical, and professional skills.

In FY 2015, there were 174 NIST postdocs. Of these, 113 were located on the NIST campus in Gaithersburg, Maryland, 49 were located in Boulder, Colorado, and the remainder were located at five other NIST locations.

Table 18 – Postdoctoral Researchers

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
NIST NCR Postdocs, Total	142	130	140	172	174
Gaithersburg campus	72	84	88	115	113
Boulder campus	22	28	32	35	49
Joint Institute for Laboratory Astrophysics [(a)]	8	12	11	9	5
Joint Quantum Institute [(b)]	1	2	4	3	2
Hollings Marine Laboratory [(c)]	1	1	2	1	2
Institute for Bioscience and Biotechnology Research [(d)]	1	2	1	4	3
Advances in Biological and Measurement Science program [(e)]	0	1	2	5	5

(a) Joint Institute for Laboratory Astrophysics (JILA) was founded in 1962 as a joint institute of CU-Boulder and NIST. JILA is located at the base of the Rocky Mountains on the CU-Boulder campus in the Duane Physics complex. http://jila.colorado.edu/

(b) The Joint Quantum Institute (JQI) was founded in September 2006 as a collaboration between the University of Maryland and the NIST, with additional support from the Laboratory for Physical Sciences, a government facility in College Park. http://jqi.umd.edu/

(c) The Hollings Marine Laboratory (HML) is a world-class research facility in Charleston, South Carolina. HML's mission is to provide science and biotechnology applications to sustain, protect, and restore coastal ecosystems, with emphasis on links between environmental condition and the health of marine organisms and humans. http://www.nist.gov/mml/hml/index.cfm

(d) The Institute for Bioscience and Biotechnology Research (IBBR) is a joint research enterprise created to enhance collaboration among the University of Maryland College Park, The University of Maryland Baltimore and NIST. https://www.ibbr.umd.edu//

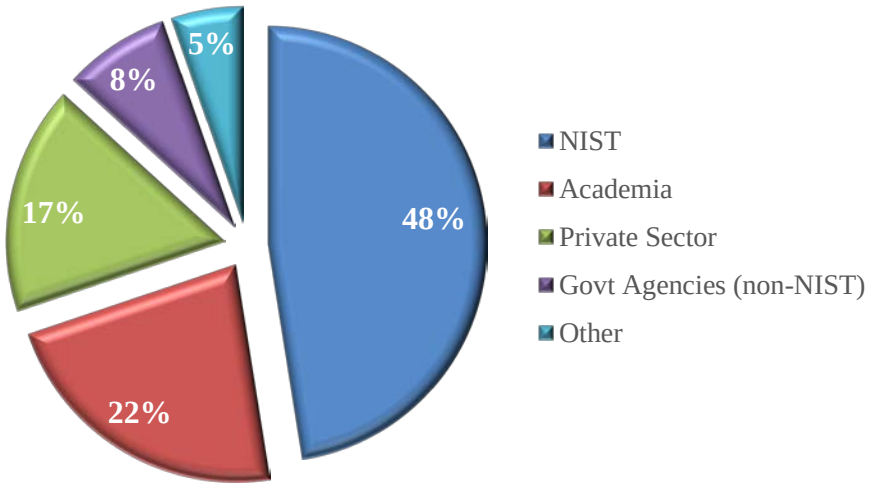
(e) The Advances in Biomedical Measurement Science program (ABMS) is co-led by Stanford University and NIST and is designed to enable significant improvements in the accuracy and comparability of vital data used to make important research, regulatory, clinical, and manufacturing quality control decisions. https://sites.stanford.edu/abms/

The number of postdocs is a measure of technology transfer because once their tenure at NIST ends they can take what they have learned and apply it to other projects outside of NIST. This is supported by efforts NIST has begun to track postdocs after their initial tenure at NIST. NIST surveyed 318 researchers who were postdocs with the NIST National Research Council (NRC)

[27] http://www.nist.gov/iaao/postdoc.cfm
[28] http://www.nsf.gov/statistics/seind12

program between FY 2011 and FY 2015. Roughly half of these postdocs went on to research careers outside of NIST. Specifically, 48% stayed at NIST,[29] 22% moved to academia, 17% moved to the private sector, 8% moved to other government agencies, and 5% either became independent researchers or were unemployed. As more data becomes available, NIST will employ advanced research tools, such as those utilized in the National Institute of Health's (NIH) Star Metrics Program,[30] to track and evaluate the post tenure work of postdocs from NIST.

Figure 4 – Tracking Researchers after Initial Postdoc Tenure at NIST (FY 2011 – FY 2015)



Guest Researchers

In addition to postdocs, each year, thousands of researchers visit NIST to participate in collaborative projects.[31] NIST hosts many term appointment researchers and non-NIST employees working as guest researchers, collaborators, and student fellows. Like postdoctoral researchers, many guest researchers seek career opportunities in academia, the private sector, or Federal agencies after their tenure at NIST. While some guest researchers' work at NIST may result in inventions, all guest researchers leave NIST with technical and research skills that place them on the cutting edge of their disciplines. Each researcher takes these skills, knowledge, and a desire to employ them in innovative ways to new careers and employers. Among these skills is the knowledge of how to collaborate with Federal laboratories and what Federal resources are available to assist companies in creating and developing new and improved technologies.

NIST will significantly expand efforts to gather information related to careers of NIST alumni from existing sources, and study linkages between the mined data and other metrics.

[29] Researchers who left their postdoc positions and stayed at NIST became career conditional / term employees (29%) or became non-career conditional or as term employees, i.e. contractors or guest researchers (19%).
[30] https://www.starmetrics.nih.gov
[31] http://www.nist.gov/tpo/collaborations/guestresearchers.cfm

Calibration and Accreditation Services
The NIST laboratories provide unique physical measurement services for their customers, including calibration services, special tests, and measurement assurance programs. NIST designs its calibration services to help manufacturers and users of precision instruments achieve the highest possible levels of measurement quality and productivity. NIST calibrations often serve as the basis for companies that provide commercial calibration services and calibration equipment.[32]

The NIST National Voluntary Laboratory Accreditation Program (NVLAP) is a voluntary and fee-supported program to accredit private sector laboratories that are competent to perform tests or calibrations.[33] In FY 2015, there were 13,906 calibration tests performed by NIST.

Table 19 – Calibration Services

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Calibrations					
Number of Calibration Tests Performed	18,195	17,206	14,974	15,401	13,906

Education Outreach Programs and Partnerships
NIST has received recognition as a vital contributor to the efforts to improve science, technology, engineering, and mathematics (STEM) education in the United States. As part of its mission, and to help create a long-term and well-qualified workforce for standards and measurement research, NIST has several education outreach programs and partnerships that enrich basic research programs such as:

- the Summer Undergraduate Research Fellowship (SURF) program;[34]
- the Summer High School Internship (SHIP) program;[35]
- the Pathways Program;[36]
- the NIST Summer Institute for Middle School Science Teachers;[37] and
- the Professional Research Experience Program (PREP).[38]

[32] http://www.nist.gov/calibrations/index.cfm
[33] http://www.nist.gov/nvlap/
[34] NIST's Summer Undergraduate Research Fellowship (SURF) program provides internships for college students majoring in science, mathematics and engineering. http://www.nist.gov/surfgaithersburg/index.cfm
[35] NIST's Summer High School Internship (SHIP) program provides summer intern program for high school students who are interested in scientific research. http://www.nist.gov/ohrm/staffing/ship.cfm
[36] The Pathways Programs offers high school, college and trade school students paid opportunities to work in a Federal agency and explore different career paths while continuing their education. http://www.nist.gov/ohrm/staffing/students.cfm
[37] NIST's Summer Institute for Middle School Science Teachers provides a two-week workshop for middle school science teachers featuring hands-on activities, lectures, tours, and visits with NIST scientists and engineers in their laboratories. http://www.nist.gov/iaao/teachlearn/index.cfm
[38] NIST's Professional Research Experience Program (PREP) provides undergraduate and graduate students, as well as post-doctoral researchers, the opportunity to gain hands-on research experience working with NIST researchers. http://www.boulder.nist.gov/bdprepo.htm

In FY 2015, there were 206 students enrolled in the SURF program, 48 students enrolled in the SHIP program, 97 students enrolled in the Pathways program, 22 students enrolled in the NIST Summer Institute for Middle School Science Teachers, and 164 students enrolled in the PREP program.

Table 20 – STEM Education

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
SURF	170	196	205	203	206
SHIP	34	47	55	60	48
Pathways Program	120	130	98	78	97
Summer Institute for Middle School Teachers	n.a.	n.a.	n.a.	22	22
PREP	n.a.	n.a.	n.a.	134	164

NIST also provides student and post-doctoral fellows with information on the use of science by industry, and co-sponsors a career fair with other Federal agencies and Rockville Economic Development Inc., Rockville, Maryland.

Conferences, Seminars, and Workshops

Some of the most important mechanisms for technology dissemination are communication, education, and interaction among researchers, developers and users of technology. NIST hosts numerous conferences, workshops, and other meetings each year to facilitate the transfer of technology.

For example, in FY 2015, the NIST Conference Program arranged for 118 conferences that attracted 11,490 researchers to NIST's facilities in Gaithersburg, Maryland and Boulder, Colorado. NIST's Office of Weights and Measures, which promotes uniformity in U.S. weights and measures laws, regulations, and standards, trained over 1,500 weights and measures administrators, laboratory meteorologists, and field enforcement officials during FY 2015.

Table 21 – Conferences, Seminars, and Workshops

	FY 2011[(a)]	FY 2012	FY 2013	FY 2014	FY 2015
NIST Conference Center					
Conferences and Workshops	77	80	86	80	118
Attendance	6,924	9,104	8,579	9,208	11,490
Office of Weights and Measures - Metrology Training					
Seminar Attendance	263	167	446	355	457
Webinar Attendance	135	448	110	133	266
Workshop Attendance	n.a.	n.a.	55	30	27
Students	398	615	633	518	750

(a) FY 2011 data for the NIST Conference Center includes Gaithersburg, Maryland campus only.

NIST is continuing to collect and retain current information on metrology training and is expanding its efforts in this area to include additional information on training activities NIST conducts for facility users. Further, NIST staff answers e-mail, telephone, and mail inquiries

from researchers requesting information and details about NIST technical developments and research results.

Streamlining Technology Transfer Processes

In response to the PM, NIST has undertaken several efforts to streamline and simplify the technology transfer process. NIST revised its standard CRADA to expedite review of these documents and reduce the overall size of these documents by approximately one third. NIST also implemented several new licensing programs to encourage small businesses to participate. These programs lay out terms in advance to ease concerns by small businesses about overall costs. NIST is conducting detailed analysis of the flow of documents to understand where significant delays occur within the system. In many cases, these delays are with the partner and NIST does not have direct control; however, by continued efforts to identify and understand issues experienced by partners, NIST expects to identify new ways to simplify and streamline technology transfer practices. In FY 2015, NIST experienced a 46-day reduction in the average number of days to prepare a patent application and a 45-day reduction in the average CRADA approval time.

Table 22 – Streamlining

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Streamlining Efforts					
Average Number of Days to Prepare a Patent Application[(a)]	410	348	401	456	410
Average CRADA Approval Time[(b)]	122	145	91	110	65

(a) The time between the receipt date of an invention disclosure and the filing date of the first non-provisional patent application filed by NIST.

(b) The time between the receipt of the memo related to the award of a CRADA and the time of approval for the memo.

Small Businesses, Start-ups and Young Entrepreneurial Companies

NIST recognizes the need to provide both funding and technological support for small businesses, start-ups, and young entrepreneurial companies. NIST and its joint institutes nurture young companies in high-growth technology areas by several means.

In addition to financial support provided by the SBIR program and technical support through CRADAs, NIST recently implemented several new licensing options to aid innovators and lower developmental risk for potential partners who wish to obtain and use NIST technology. For example, the Science/Technology Advancement Research (STAR) license provides a no-cost, non-exclusive field-of-use research license to explore and advance NIST technologies for commercialization.

In FY 2015, 68 small businesses were involved in traditional CRADAs and 794 small businesses were involved in non-traditional CRADAs. Non-traditional CRADAs included material transfer agreements (14 small businesses), calibration services (200 small businesses), and laboratory certifications (580 small businesses).

Table 23 - Number of Small Businesses Interacting with NIST

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
NIST Licenses	n.a.	2	7	7	4
Traditional NIST CRADAs	n.a.	20	31	37	68
Non-Traditional NIST CRADAs	n.a.	n.a.	n.a.	733	794
Phase I SBIR Awards	13	8	9	12	14
Phase II SBIR Awards	5	4	5	4	6

NIST recently has begun evaluating more than 25 start-up and young companies (existing for five years or less) that have either spun off technologies from NIST or that have received considerable support in their core area of technical development. One example is:

zeroK NanoTech
As part of a program to provide improved sources for focused ion beams, NIST researchers developed a new technology based on laser-cooled atoms that promises to produce ion beams with higher brightness, narrower energy spread, and a broader range of ionic species than conventional sources. NIST patented the technology, and the two postdoctoral researchers working on the project left NIST to form their own company to develop it further. The company, zeroK NanoTech, now operates out of commercial laboratory space in Gaithersburg, MD and employs three people. They have also successfully secured funding for further development of the technology from corporate sponsors.

Small Business Innovation Research (SBIR)
NIST's Small Business Innovation Research (SBIR) program funds science and technology based small businesses in the U.S. The program offers qualified small businesses the opportunity to propose innovative ideas that meet specific NIST research and development needs and have the potential for commercialization.[39] NIST has taken the following steps to improve its SBIR program:

1. Streamlining practices to reduce the administrative burden on small businesses and time needed to process and issue awards;
2. Reducing the number of topics and subtopics to balance the work required to obtain proposals while increasing the selection rate for worthwhile proposals. NIST Programmatic Investment Priority Areas in the NIST Three Year Programmatic Plan serve as topics to align SBIR priorities to NISTs mission. The goal is to bring the Phase 1 SBIR award rate up to the national average of 17%;
3. Implementing a two-step review process to evaluate technical feasibility and to maximize investments, catalyze commercialization, and achieve a strategic focus. The first step is a technical evaluation conducted by the NIST laboratories. The second step is prioritization

[39] http://www.nist.gov/tpo/sbir/index.cfm

of proposals considered meritorious in the laboratory review through the use of criteria based on the overall NIST strategy and SBIR program goals; and
4. Reducing, by 10%, the time from close of solicitation to award issuance.

Efforts to Promote Entrepreneurship
In 2013, NIST, in cooperation with the Technology Development Corporation of Maryland (TEDCO), established an Entrepreneurs-in-Residence (EIR) program to bring successful technology entrepreneurs into the NIST community for seminars and private consultations with NIST staff on matters relating to technology transfer and commercialization. Through this effort, EIR's guest researchers explore and evaluate licensable technologies developed at NIST for commercialization by private firms.

During FY 2015, the program also provided several training seminars for NIST staff researchers, temporary employees, and NIST associates covering topics such as small business formation, approaches to obtain funding for innovative technology, and career opportunities as technology entrepreneurs. NIST also provided an ongoing training program to enhance successful technology transfer activities by promoting entrepreneurial mind-sets among NIST's research staff and managers. This program provides NIST staff with a basic understanding of:

- mechanisms that NIST uses to transfer technologies from the laboratory to the commercial sector;
- practices and strategies that entrepreneurs use when developing new technologies into viable commercial opportunities;
- the importance of developing and protecting intellectual property rights;
- best practices for collaborating with private companies and working with NIST customers; and
- career opportunities for researchers interested in spinning off companies and becoming entrepreneurs.

Challenges
In FY 2015, NIST launched its first two competitions, both under the authority provided in section 24 of the Stevenson-Wydler Act that allows agencies to award prizes to stimulate innovation that has the potential to advance their mission.

- NIST, partnering with the National Football League, Under Armour, and GE, launched the Head Health Challenge III in February 2015 to catalyze the development of advanced materials with improved impact resistance. This challenge is ongoing and has a total prize purse of $2 million. Website: www.headhealthchallenge.com and official announcement: https://www.federalregister.gov/articles/2015/01/29/2015-01743/announcement-of-requirements-and-registration-for-head-health-advanced-materials-prize
- The Reference Data Challenge, designed to spur the development of mobile applications using NIST scientific reference data, was launched in July 2015. Offering $45,000 in prizes, this contest was part of ongoing efforts to modernize the availability and use of NIST scientific data. Website: http://nistdata.devpost.com/ and official announcement: https://www.federalregister.gov/articles/2015/07/22/2015-17865/announcement-of-requirements-and-registration-for-national-institute-of-standards-and-technology

Assessing the Economic Impact of Technology Transfer

NIST has had a long history of assessing the economic impact of standards and related technologies transferred from its research and standards programs.[40] Between 2000 and 2011, researchers performed sixteen microeconomic studies that assessed technologies transferred to nine different industries. Each of these studies measured economic impact in terms of the net benefits society experienced as a result of NIST's technology transfer activities. Measures of net benefits include net present value (NPV), social rate of return (SRR), and benefit to cost ratio (BCR).

NPV is the inflation-adjusted value of net benefits (benefits minus costs) discounted over the course of the study period. A positive NPV for a given mechanism indicates that it yields greater benefits than the cost to provide it. The SRR is similar to the internal rate of return metric, the interest rate that reduces the NPV to zero, commonly used to judge the worthiness of investment projects. However, the modifier "social" indicates that the value of this performance metric accounts for the benefits and costs that accrue to all beneficiaries, not just the project investors. The BCR is the ratio of the net present value of benefits to the net present value of costs. The BCR value indicates the benefits, in dollars, that have resulted from the technology transfer activity for each of the dollars invested adjusted for inflation.

For example, as shown in the table below, in 2000 a study did an assessment of the economic impact of NIST's standard reference materials (SRMs) used in the production of fossil fuels (*Economic Impact of Standard Reference Materials for Sulfur in Fossil Fuels*[41]). SRMs are materials that play a key role in manufacturing and, among other things, evaluate measurement accuracy and provide compatibility of measurement data. In this example, SRMs provide more accurate sulfur content information for fossil fuels manufacturers. Improving the accuracy of content information reduces the likelihood of disputes between sellers and purchasers of fossil fuels, such as coal companies and electric utilities. It also enhances production efficiency for the petroleum industry, resulting in reduced sulfur emissions into the environment. This study quantified a portion of the economic benefits associated with sulfur SRMs. Included in the measures of economic benefits were improvements in product quality, production efficiency, and reductions in transaction costs and sulfur dioxide emissions to the environment. In addition, the study identified and qualitatively described the impact of NIST SRMs on other less tangible areas, such as research and development programs.

This study estimated that industry significantly benefited from the development and transfer of NIST's sulfur SRMs. According to the measures of benefits and costs analyzed, NIST's sulfur SRMs yielded a NPV of $409 million in 1998 dollars, which equates to a SRR of 1056%. The study also estimated a BCR of 113 that indicates that for each dollar NIST spent on developing sulfur SRMs, $113 in net benefits accrued to those who used the SRMs in the manufacturing of fossil fuels.[42]

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[40] See http://nist.gov/tpo/economic-impact-studies.cfm

[41] See http://nist.gov/director/planning/upload/report00-1.pdf

[42] The study provides other measures that can be used to describe the same net benefits. For a discussion of alternative measures of economic impacts please see *Methods for Assessing the Economic Impacts of Government R&D, NIST Planning Report #03-1,* http://nist.gov/director/planning/upload/report03-1.pdf

Table 24 – NIST Economic Impact Studies 2000-2011

Impact Study/ Transfer Mechanism	Outcomes	BCR[(a)]	SRR[(b)]	NPV(Year)[(c)]
Building Technology				
"Benefits and Costs of Research: A Case Study of Construction Systems Integration and Automation Technologies in Commercial Facilities" (2001)	Increase productivity & reduced			
•Construction System Integration and Automation Technologies	costs	4	nc	$120M (1997)
"Benefits and Costs Of Research: A Case Study of Fire Dynamics Simulation" (2002)	Improved efficiencies &			
•Fire Dynamics Simulator	reduced R&D costs	75	27%	$282M (2000)
Chemicals				
"Economic Impact of Standard Reference Materials for Sulfur in Fossil Fuels" (2000)	Increased product quality & production efficiency,			
•Sulfur in Fossil Fuels/SRM	reduced transaction costs & pollution	113	1056%	$409M (1998)
"The Economic Impact of the Gas-Mixture NIST-Traceable Reference Materials Program" (2002)	Increase productivity, reduced			
•National Traceable Reference Materials, SRD; Calibration Services	costs	24	225%	$56M (2001)
Electronics				
"Economic Impact Assessment of the NIST's Josephson Volt Standard Program" (2001)	Increased product quality & production efficiency,			
•Josephson Voltage Standard/SRM	reduced development costs	5	877%	$45M (2000)
Information Technology				
"The Economic Impacts of NIST's Data Encryption Standard (DES) Program" (2001)	Increase productivity, reduced			
•Data Encryption Standards/Standard Conformance Test Methods	technical risks	102	270%	$768M (2000)
"The Economic Impact of Role-Based Access Control" (2001)	Increase productivity, reduced			
•Role-Based Access Control/Reference Models (RBAC)	R&D costs	109	62%	$292M (2000)
"Economic Impact Assessment of NIST's Text Retrieval Conference (TREC) Program" (2010)	Increase productivity, reduced			
•Search Engines (TREC)	R&D costs	4	189%	$51M (2009)
Manufacturing				
"Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries" (2002)	Improved system efficiencies,			
•STEP/STDS; Conformance Test Methods and Services	& reduced costs	8	32%	$180M (2001)
"Economic Analysis of Role-Based Access Control" (2010)	Improved system efficiencies,			
•Computer Security (RBAC)	& reduced downtime	249	nc	$835M (2000)
"The Economic Impacts of Documentary Standards: A Case Study of the Flat Panel Display Measurement Standard(FPDM)" (2011)	Improved system efficiencies,			
•Documentary Standards	reduced costs	4	48%	$56M (2010)
Materials				
"Retrospective Economic Impact Assessment of the NIST Combinatorial Methods Center" (2009)	Increased R&D, production &			
•Consortium-Based Combinatorial Methods Development and Transfer	technology adoption efficiency	9	161%	$118M (1998)
Pharmaceuticals				
"The Economic Impacts of NIST's Cholesterol Standards Program" (2000)	Reduced production costs,			
•Cholesterol Measurement/SRM	improved quality & accuracy	5	154%	$4M (1999)
Photonics				
"Economic Impact Assessment: NIST-EEEL: Laser and Fiberoptic Power and Energy Calibration Services" (2000)	Increase productivity, reduced			
•Laser and Fiber Optic Power and Energy Calibration/Calibrations	costs	9	136%	$20M (1999)
Semiconductors				
"Economic Analysis of NIST's Investments in Superfilling Research" (2008)				
•Superfilling Research Techniques	Reduced R&D costs	5	71%	$8M (2008)
"Economic Analysis of NIST's Low-K Materials Characterization Research" (2008)	Redcued R&D, adoption,			
•Low-K Materials Characterization	& production costs	8	nc	$17M (2008)

nc = not calculated

(a) BCR = Benefit to Cost Ratio

(b) SRR = Social Rate of Return

(c) NPV (Year) = Net Present Value and base year for dollars

Thirteen of the studies presented in the table estimated SRR. The SRR values for these studies ranged from a low of 27% to a high of 1,056%. The mean value is 254%, but given the standard deviation for this sample (327%), the median value of 154% is more representative of the typical study.

Sixteen studies calculated BCR. The BCR values ranged from a low of four to a high of 249. The mean value is 46 but again, given the standard deviation for the sample (69) the median value of nine is more representative of the typical study. This median value indicates that, typically, for each dollar NIST spent, the technology transferred created $9 in benefits. Note that given the data presented here, it is not possible to aggregate the NPV measures from different studies into one value because the studies use different base years to calculate benefits and costs.

Table 25 – Summary of NIST's Economic Impact Studies (2000 – 2011)[43]

	SRR (n=13)	BCR (n=16)
Minimum	27%	4
Maximun	1056%	249
Mean	254%	46
Standard Deviation	327%	69
Median	154%	9

Downstream Outcomes from NIST Technology Transfer Activities

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

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

[43] When multiple estimates were generated in a particular study, for example to reflect best and worst case scenarios, the average is reported.

with identifying, quantifying, and locating methane leaks compared to currently available technologies.

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

Researchers in NIST's Materials Measurement Laboratory (MML) have recently completed development of a soon-to-be promulgated ASTM Standard Practice for testing and scoring the performance of trace explosive detection systems. Instrument developers and manufacturers, testing laboratories, and international agencies responsible for enabling effective deterrents to terrorism will use this standard. The revised Standard Practice goes far in increasing chemical scope, testing levels, realism and practical aspects of explosive screening. MML distributed a white paper to outline the expanded tests and metrics and to elicit feedback regarding the performance criteria most important to trace detection. Interactions with Explosive Trace Detection (ETD) manufacturers, domestic and international agencies, subject matter experts, and stakeholder communities to better define the criteria and formulate a mechanism for scoring ETD performance that was fair and reasonable, technologically agnostic, and reflects the most important aspects of trace detection followed this. The revised standard also relaxes the requirement that an instrument identify a specific target compound, since some innovative screening technologies, such as thermo-energetic detectors and canines, cannot do this, but technologies that can provide identification get extra credit. The revision requires the use of a standard background challenge material, identified from NIST natural matrix SRMs, such as a natural dust or dirt ("standard schmutz") that represents the matter co-collected on swabs during the process of sampling. Because sample throughput is important at security checkpoints, the measurement of average throughput rate for background-loaded samples is required. Lastly, the revised Standard Practice provides a means to calculate a numerical performance score based upon all the mandated tests. There is no maximum score but a minimum score is specified based upon criteria from the original E2520-07. The scores will provide tangible measures of instrumental detection performance, useful for comparing systems worldwide and for enabling targeted improvements in next-generation detection systems.

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

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

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

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

NIST PET Phantoms Bring New Accuracy to Medical Scans

Teaming with a medical equipment company, researchers at NIST have demonstrated the first calibration system for positron emission tomography (PET) scanners directly tied to national measurement standards. Better calibrations of the machines can potentially increase the accuracy of their diagnostic images by several times, according to NIST scientists.

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

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

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

New NIST Reference Material Provides a Silver Lining for NanoEHS Research

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

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

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

NIST created RM 8398 with its partners in the Genome in a Bottle consortium, a group that includes stakeholders from industry, academia and the Federal government. Scientists from NIST and the U.S. Food and Drug Administration (FDA) helped organize the collaborative effort to provide the technical benchmarks (reference standards, reference methods, and reference data) needed to enable widespread clinical applications of whole genome sequencing and science-based regulatory oversight of the technology by the FDA.

The new reference material marks a significant step forward in addressing FDA's regulatory needs for evaluating next-generation gene sequencing and genetic testing as outlined in President Barack Obama's Precision Medicine (also known as "personalized medicine") initiative.
The reference material is the first complete human genome to have been extensively sequenced and re-sequenced by multiple techniques, with the results weighted and analyzed to eliminate as much variation and error as possible.

Awards

2015 FLC Award for Excellence in Technology Transfer
Physicist Michael Boss received the FLC Award for Excellence in Technology Transfer. Dr. Boss designed a phantom for calibrating magnetic resonance imaging (MRI) scanners. The head-sized phantom is designed to standardize imaging of the diffusion of water molecules, a technique that can be useful in diagnosing traumatic brain injury, neurodegenerative diseases such as Alzheimer's, and cancer in various parts of the body. To scale up production to meet demand, reduce phantom costs, and improve durability, Dr. Boss worked with Elizabeth Mirowski of High Precision Devices Inc. (Boulder, CO), the firm that commercialized the technology only a year after it was first conceived. NIST has applied for a patent on the phantom.

Innovation Award
Javier Atencia, a member of MML's Bioassay Methods Group and a University of Maryland Assistant Professor, won the Best Inventor Pitch at the UMD Professor Venture Fair this past

November. Javier's novel technique to detect pathogens in food was one of five selected to be presented to a team of regional venture capitalists and entrepreneurs. Food contamination outbreaks have health and financial consequences. The Economic Research Service of the USDA estimates that annually $6.9 billion in medical expenses and lost productivity are associated with foodborne illness. Although the identification of bacteria by genomic methods can be done in about an hour, it takes one-half to three days to enrich the bacteria to a level sufficient for detection because of the overwhelming presence of solids, foreign DNA and other cells in comparison to the pathogen. This means that food with a short shelf life may still reach the consumer before pathogen testing is complete. Atencia's innovation is the introduction of a disposable microfluidic chip to separate bacteria from an unenriched sample in less than an hour. This chip is robust and designed for ease of use allowing deployment in the field.

CHAPTER 3 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration's (NOAA) mission is to understand and predict changes in climate, weather, oceans, and coasts; to share that knowledge and information with others; and to conserve and manage coastal and marine ecosystems and resources. This mission will become ever more critical in the 21st century as national issues related to climate change, limited freshwater supply, ecosystem management, and homeland security intensify.

The NOAA technology and innovation enterprise consists of more than 50 laboratories, programs, and offices headquartered in Silver Spring, MD and staffed across the United States. These labs and offices support NOAA's four service-based Line Offices: the National Marine Fisheries Service, the National Ocean Service, the National Weather Service, and the National Environmental Satellite, Data, and Information Service, as well as thematic programs including Climate, Aquaculture, Arctic, Ocean Exploration and Research, Weather and Air Quality, and Ocean Acidification. While the service-based Line Offices each have an R&D component, a dedicated R&D Line Office, the Office of Oceanic and Atmospheric Research, supports the entire enterprise.

The aim of the research across NOAA's laboratories is to improve the ability of the operational components to accomplish their respective missions. Recent examples demonstrating the direction of NOAA's research are severe storm (hurricane, tornado, derecho winds) and drought forecasting, as well as physical forecasts for renewable energy siting. NOAA research also is in the areas of predicting fresh water resources, tsunami warnings, air quality measurement and solar emission forecasting. NOAA actively monitors fish stocks and species health, coastal habitats and pollution, invasive species, coral reef health, and ocean acidification. Finally, NOAA research covers coastal/ocean disaster response and restoration, charting ocean bottom topography, and a wide variety of climate research and the impacts of a changing climate on human health, coastal zone management, and oceans. NOAA's operational components use these research results to improve prediction, management, and other mission activities.

Benefits of NOAA Research: Medicines from the Sea

Ocean exploration often leads to new ideas, theories, and discoveries, even in the field of medicines. From slime to sponges, researchers are exploring the ocean's depths for new medications to treat cancer, bacterial infections, viruses, heart disease, pain, and other ailments.

The seas contain an uncounted number of species of plants and animals. These creatures provide a vast storehouse of chemical compounds unknown on land. An ocean commission report lists chemicals and biological materials from marine organisms now in use or development, including 10 anti-cancer drugs, drugs to fight inflammation, fungus, tuberculosis, HIV, malaria, and dengue.

"Bioprospecting" with NOAA

To uncover medical mysteries of the deep, NOAA has partnered with "bioprospecting" scientists to find marine organisms with chemical compounds capable of treating human diseases. The NOAA Ship Okeanos Explorer connects experts ashore to the scientific missions as they map the ocean and collect ocean specimens, some with potential medical and economic benefits.

With an increasing number of specimens collected from a variety of ocean projects, scientists may find that the ocean could become the biological focus for discovering 21st century medicines.

In the future, marine ecosystems could represent an increasingly important source of medical treatments, nutritional supplements, pesticides, cosmetics, and other commercial products. Drugs from the ocean are without question one of the most promising new directions of marine science today.

Approach and Plans for Technology Transfer

The NOAA Technology Partnerships Office (TPO), housed under the NOAA Office of Oceanic and Atmospheric Research (OAR), serves as the central technology transfer office for all NOAA labs, centers, programs, and external partners.

In FY 2012, in response to President Obama's request to accelerate technology transfer out of Federal labs, the TPO developed a 5-Year Plan to improve technology transfer from NOAA. The TPO has since accomplished most of the goals set forth in this plan, while the importance of others, because of various events, has diminished. The TPO will be updating and revising this technology transfer plan, as well as developing a broader strategic plan for the office, starting in FY 2016.

The following is a summary of the original technology transfer plan and the results achieved.

Objective 1: Optimize TPO Management and Staffing Structure

The TPO is the link between NOAA's intellectual property and its private sector customers. In order to provide the required level of service to both our internal and external customers, the TPO made recommendations in 2011 to increase staffing for the office.

> Progress to Plan:
> Since 2012, the TPO has operated at the recommended staffing level of a Program Manager for Technology Transfer and a part-time program assistant. The TPO has augmented its staffing and improved awareness of technology transfer through a series of detail assignments and by establishing a list of points of contanct for technology transfer within each of the NOAA labs and programs.

Next Steps:
Optimizing staffing and building a culture of technology transfer in the labs will continue to be a priority in the upcoming strategic plan. The TPO will continue to build a culture of technology transfer within the agency through communication at the lab level and at the management level. TPO staff will work closely with the NOAA Chief Scientist to develop corporate technology transfer strategies, policies, and goals.

The TPO will develop the human capital within the agency by continuing the successful detail assignment program and will explore the possibility of adding entrepreneurial education and training based on the NSF *Entrepreneur in Residence Program*. TPO staff will work closely with other agencies through the inter-agency Lab to Market process and the Federal Lab Consortium to determine best practices to apply within NOAA.

Objective 2: Central Management of Patents
NOAA's TPO is the central management point for intellectual property and patent applications coming out of NOAA's labs, centers, and programs; however, until recently, the cost and contracting burden for executing these agreements always has been with the individual lab, center or program. The TPO has been working to improve centralized management by building a set of funds in the TPO that can offset legal and patent fees. The goal of this effort is to develop a more robust and fair process for evaluating which new technologies have the highest licensing potential and the greatest need for patent protection (see Objective 4 below). Secondarily, the TPO believes central funding would offer significant benefits to the labs, centers and programs by saving time and effort in contracting for similar or repeat services.

Progress to Plan:
The TPO has established a central account with the US Patent and Trademark Office for the payment of maintenance and filing fees. It has used this account to offset all maintenance fees and most patent filing fees in FY 2015. While there will be request for funds each year to replenish the account, there is no guarantee funds will continue to be available.

In FY 2015, the TPO requested an additional budget allocation to cover legal fees for filing provisional and non-provisional patents and related expenses. TPO received a trial allocation and has created a second account to establish a contract for legal services in FY 2016. The services will be available to support all NOAA inventions on a first-come, first-served basis.

Next Steps:
TPO will monitor the use and usefulness of both accounts and, based on the results, will likely continue to request funding for both accounts moving forward. Central funding and management of patent activity through the TPO will continue to be a priority in the strategic plan, as it simplifies contracting, reporting, and ensures key deadlines are not missed.

Objective 3: Programmatic Advice and Guidance

The TPO will receive programmatic advice and guidance directly through the NOAA Chief Scientist and the NOAA Research Council. The TPO will continue to coordinate with NOAA Line Office Transition Managers to ensure TPO policies and procedures are consistent with their activities as guided by NOAA Administrative Order NAO 216-105.

Progress to Plan:

The TPO has successfully implemented this action and is looking for guidance from the Research Council and the Chief Scientist. The TPO has created a working group at headquarters to facilitate outreach and education, and is participating in the activities of the Line Office Transition Manager Committee for NOAA.

Next Steps:

The TPO will continue to work through its established network and through the Line Office Transition Manager Committee to ensure the commercialization of research is included in NOAA's transition planning and reporting. The TPO will reinforce the network to include lab liaisons (see Action 1) and, ideally, involve laboratory representatives directly in the training, meetings, and other activities of its regional Federal Laboratory Consortium group.

Objective 4: Establish a Technology Transfer Review Board

Determining technologies for which NOAA should seek patent protection is a key component of the technology transfer process. Currently, there is no corporate process in place for this activity. A NOAA review board would provide inventors the opportunity to present detailed information concerning their technology to a cross-agency group. The review board would determine which technologies should move forward based on which have the highest commercial potential. TPO will work with the Chief Scientist to determine the best path forward for establishing this proposed board.

Progress to Plan:

NOAA's annual invention disclosure rate, although increasing each year, still remains low, so the TPO has not moved to establish a board for the review of technology transfer. Instead, the decision to pursue a patent or other protection is determined through collaboration between the inventor, the lab director, the TPO, and NOAA General Counsel. Cost-benefit considerations, derived through rudimentary market assessments, have been the basis for patent decisions since 2014.

Next Steps:

NOAA's assessment process for disclosed technologies needs improvement if it is to provide the information needed to support a technology review board. The TPO will explore various methods for performing technology assessments, such as a request for funds for contract support and/or using temporary staff. As disclosures increase and assessments improve, TPO will work with the NOAA Chief Scientist to determine the need for a technology review board.

Objective 5: Enhance Internal Education on Patents and Technology Transfer Issues
TPO will provide NOAA laboratory and program personnel with training, website resources, forms and templates, as well as extensive background information on program benefits.

Progress to Plan:
The TPO continues to train NOAA staff at labs and Headquarters through a combination of on-site training, video-teleconference, telephone calls, and website materials.

Next Steps:
TPO will schedule training visits to at least two labs during FY 2016 and will conduct other training at Headquarters or through video teleconferencing as appropriate. The TPO also will work with the Chief Scientist, the Research Council, and Workforce Management to implement any Lab to Market recommendations within NOAA.

Objective 6: Increase Outreach to Industry
The TPO will conduct activities designed to inform the public of the processes and benefits of collaborating with NOAA for research and development activities. The activities will include:

- **Website Redesign**: Redesign the TPO website to feature pending opportunities, benefits, success stories, and answers to FAQs for staff, private companies, or other entities looking to collaborate with NOAA.
- **Trade Show Marketing**: Attend selected events and trade shows to meet with target audiences and distribute TPO marketing materials.
- **Targeted Meetings**: Meet with select trade associations and NGOs to increase awareness of technology transfer opportunities and brainstorm methods of increasing technology transfer activities with NOAA.
- **Joint Meetings with DOC Partners:** Collaborate with its sister bureaus in DOC and in other agencies to initiate joint outreach and promotional activities.

Progress to Plan:
The TPO has developed 2-page marketing summaries and a multi-page marketing brochure to advertise its licensing opportunities. TPO continues to update and refine its website, including enhancements to the "Open Opportunities" section to provide a more marketing-centric presentation for our technologies. In addition to the TPO website, the office has used NOAA's social media outlets (Facebook, Twitter) to reach a broader audience for key announcement and events.

Beyond the NOAA resources, TPO has taken advantage of broader efforts to advertise its available technologies. The TPO has provided comprehensive NOAA lab information to the Federal Labs Consortium Available Technologies Search Tool: https://flcbusiness.federallabs.org/FLCBiz/app/search-laboratories. The TPO is responsible for uploading and maintaining the full list of NOAA's Intellectual Property assets on the U.S. Data.gov platform under the President's Lab to Market Initiative.

The TPO has also undertaken a plan to work closely with state and local development offices. In conjunction with TPO's nation-wide SBIR program outreach, it is able to

provide technology transfer opportunities to economic development offices across the nation. It will continue to reach out to this network to market NOAA's licensing opportunities.

The TPO continues to support and work through the Mississippi Enterprise for Technology regional development office in Stennis, Mississippi. NOAA, along with NASA, other Federal agencies, and universities located at Stennis, is participating in a regional technology group with the goal of sharing best practices and encouraging technology transfer to the private sector in the Gulf region.

In FY 2015, the TPO began doing direct outreach at scientific gatherings where private sector companies are included. It will continue to focus on events that are local and/or those events that include cross-program (SBIR and Tech Transfer) opportunities for engagement with the private sector.

Next Steps:
Direct interaction with companies will continue moving forward. The TPO is developing a database of contacts from companies that have a primary interest in NOAA's technologies. It will continue to work through existing small business outreach resources to ensure a broad dissemination of NOAA's technology opportunities.

Objective 7: Develop a Database of NOAA Technologies and Opportunities
An important component of the TPO plan to improve management of NOAA's technology transfer activities will be a database to track easily and monitor basic information on CRADAs, MOUs, invention disclosures, and patents (including status and regular maintenance fees). Tracking this basic information will allow staff to develop regular reports without adding administrative burden to the labs and will provide easy tracking of metrics.

Progress to Plan:
TPO staff has built a rudimentary internal database to house technology transfer and SBIR information. While the database is limited in its functionality, TPO staff is now able to query quickly the information and report out on the status of the NOAA intellectual property portfolio.

As with last year's report, the database saved time by providing initial information for this year's annual report. This step simplified the data call to the labs by changing the focus to mostly data validation and reporting of missing information.

Next Steps:
Despite progress in this area, the TPO has a number of steps to improve this action. First, enhancements to the database capabilities will improve data query and report generation. TPO will continue with these enhancements in-house and at minimal expense. However, the TPO will continue to explore off the shelf technologies that will allow for better case and client management capabilities, as well as linking directly to the TPO website and (ideally) directly to the data.gov platform to allow for automatic updates to that website.

Objective 8: Improve Performance Measurement and Tracking

NOAA has identified eight performance measures as an initial basis to track the effectiveness of its technology transfer. TPO will review this set annually and update measures to ensure NOAA's ability to monitor its performance. Individual performance results will vary even under ideal programmatic circumstances; however, taken as a whole, this set of performance metrics will offer an accurate snapshot of NOAA's ongoing technology transfer activities and will provide valuable insight for TPO to structure its education and training activities in the future.

Progress to Plan:

This year's report began the differentiation between invention licenses and patent licenses, with the invention licenses on technologies that are not patented or have only a provisional patent application in place. These licenses will typically not yield royalty income, or will only include royalty income for the period of the provisional application.

To date, there only has been anecdotal reporting for visiting scientists and facilities use agreements. Reporting for visiting scientists is not always easy or obvious, as many of these "visiting" scientists are from Cooperative Institutes (CI) and are treated as regular staff at the labs.

Facilities use agreements are not a large part of NOAA's technology transfer portfolio, but could grow in the future if NOAA labs retain funds accrued because of others using its facilities. The ability to retain funds at the lab would provide the needed incentives for NOAA lab directors to open under-utilized or highly specialized lab resources for public and corporate use. The TPO is exploring ways other agencies are using CRADAs or other agreements to retain funds for facilities use and hopes to implement a similar program at NOAA in FY 2016.

The number of trademarks is no longer a reported metric. The Technology Partnerships Office does not directly process these applications, so tracking these applications has been too difficult to provide a meaningful metric. Similarly, there is no reporting of the number of Cooperative Institute staff receiving more than 50% of their funding from NOAA, as the number does not vary significantly across years and does not provide any meaningful representation of the technology transferred.

Next Steps:

The TPO will continue to gather data on the NOAA portfolio in an effort to get more complete and accurate reporting of valuable metrics. There also will be the exploration of additional measures that speak to the impact of NOAA science and technology transfer.

Additionally, the TPO will follow closely the efforts of interagency groups to establish meaningful measures across the Federal government. Over the next five years, it will adopt new measures to continue to improve its reporting at the least cost in terms of effort to the lab staff.

NOAA Work Products and Collaborative Activities

In addition to the internal transition of NOAA's Research and Development to operational products and services, NOAA science and data products are routinely provided to the public in service to the NOAA mission of protecting lives and property. Chapter 1 provides information on patenting and summary information on licensing. Additional details on licensing and other mechanisms are included below.

Licensing Details

NOAA signed two new license agreements in FY 2015 and converted one license from non-exclusive to exclusive. A long-standing NOAA patent expired in 2015, which resulted in the expiration of two income-bearing licenses during the fiscal year. NOAA now maintains six active licenses on its technologies and has three additional non-income bearing licenses maintained by the Cooperative Institute at the University of Oklahoma.

Table 26 – Profile of Active Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
All Licenses, Number Total Active[(a)(b)]	6	5	5	5	6
New, Executed	0	0	0	0	2
Invention Licenses, Total Active	6	5	5	5	6
New, Executed	0	0	0	0	2
Patent Licenses,[(c)] Total Active	6	5	5	5	6
New, Executed	0	0	0	0	2
Material Transfer Licenses Total Active[(d)] (Inventions)	0	0	0	0	0
New, Executed	0	0	0	0	0
Other Invention Licenses, Total Active	0	0	0	0	0
New, Executed	0	0	0	0	0
Other IP Licenses, Total Active	0	0	0	0	0
New, executed	0	0	0	0	0
Copyright Licenses (Fee Bearing)	0	0	0	0	0
New, Executed	0	0	0	0	0
Material Transfer Licenses, Total Active (Non-Inventions)	0	0	0	0	0
New, Executed	0	0	0	0	0
Other, Total Active	0	0	0	0	0
New, Executed	0	0	0	0	0

(a) Multiple inventions in a single license are counted as one license. Licenses that include both patents and copyrights (hybrid licenses) are reported as patent licenses and are not included in the count of copyright licenses.

(b) "Active" means an agreement in force at any time during the fiscal year.

(c) Patent license tally includes patent applications which are licensed. One-Time License only with onetime flat fee royalty

(d) NOAA is not currently tracking MTAs and related agreements

Table 27 – Licensing Management

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Elapsed Execution Time,[(a)] Licenses Granted					
Invention Licenses					
Average, Months	7	n.a.	n.a.	n.a.	3
Minimum	n.a.	n.a.	n.a.	n.a.	n.a.
Maximum	n.a.	n.a.	n.a.	n.a.	n.a.
Patent Licenses					
Average, Months	7	n.a.	n.a.	n.a.	n.a.
Minimum	n.a.	n.a.	n.a.	n.a.	n.a.
Maximum	n.a.	n.a.	n.a.	n.a.	n.a.
Licenses Terminated for Cause					
Invention Licenses	0	0	0	0	0
Patent Licenses	0	0	0	0	0

(a) No new licenses were executed in FY 2011, 2012, 2013 or 2014. Two invention licenses were granted in FY 2015. Date of license application to the date of license execution. (Date of license application is the date the lab formally acknowledges the written request for a license from a prospective licensee and agrees to enter into negotiations.)

Table 28 – Characteristics of Licenses Bearing Income

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
All Income Bearing Licenses, Total Number	3	3	5	5	4
Exclusive	0	0	0	0	1
Partially Exclusive	0	0	0	0	0
Non-Exclusive	3	3	5	5	3
Invention Licenses, Income Bearing	3	3	5	5	4
Exclusive	0	0	0	0	1
Partially Exclusive	0	0	0	0	0
Non-Exclusive	3	3	4	5	3
Patent Licenses, Income Bearing	3	3	5	5	4
Exclusive	0	0	0	0	1
Partially Exclusive	0	0	0	0	0
Non-Exclusive	3	3	5	5	3
Other IP Licenses, Income Bearing	0	0	0	0	0
Exclusive	0	0	0	0	0
Partially Exclusive	0	0	0	0	0
Non-Exclusive	0	0	0	0	0
Copyright Licenses (Fee Bearing)	0	0	0	0	0
Exclusive	0	0	0	0	0
Partially Exclusive	0	0	0	0	0
Non-Exclusive	0	0	0	0	0
All Royalty Bearing Licenses, Total Number	3	3	5	5	4
Invention Licenses, Royalty Bearing	3	3	5	5	2
Patent Licenses, Royalty Bearing	3	3	5	5	2
Other IP Licenses, Royalty Bearing	0	0	0	0	0
Copyright Licenses (Fee Bearing)	3	3	0	0	0

Table 29 – Income from Licenses

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Income, All Licenses Active [(a)]	$107,220	$100,867	$48,798	$69,151	$39,633
Invention Licenses	$107,220	$100,867	$48,798	$69,151	$1,000
Patent Licenses	$107,220	$100,867	$48,798	$69,151	$38,633
Other IP Licenses, Total Active	$0	$0	$0	$0	$0
Copyright Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income (ERI) [(b)]	$107,220	$100,867	$48,798	$69,151	$39,633
Median ERI	$34,000	$9,902	$11,000	$13,830	$500
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$500
Maximum ERI	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 1% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 5% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 20% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
Invention Licenses	$107,220	$100,867	$48,798	$69,151	$1,000
Median ERI	$34,000	$9,902	$11,000	$13,830	$500
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$500
Maximum ERI	$69,000	$89,965	$36,798	$50,000	$500
ERI from Top 1% of Licenses	$69,000	$89,965	$36,798	$50,000	$500
ERI from Top 5% of Licenses	$69,000	$89,965	$36,798	$50,000	$500
ERI from Top 20% of Licenses	$69,000	$89,965	$36,798	$50,000	$500
Patent Licenses	$107,220	$100,867	$48,798	$69,151	$38,633
Median ERI	$34,000	$9,902	$11,000	$13,830	$38,633
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$38,633
Maximum ERI	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 1% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 5% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
ERI from Top 20% of Licenses	$69,000	$89,965	$36,798	$50,000	$38,633
Other IP Licenses, Total Active	$0	$0	$0	$0	$0

(a) Total income includes license issue fees, earned royalties, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods & services provided by the lab to the licensee including patent costs.

(b) "Earned royalty" = royalty based upon use of a licensed invention (usually, a percentage of sales or of units sold) not a license issue fee or a minimum royalty.

Table 30 – Disposition of License Income

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Income Distributed [(a)]					
Invention Licenses, Total Distributed	$107,220	$100,867	$48,798	$69,151	$1,000
To Inventor(s)	$34,266	$35,331	$16,740	$22,845	$1,000
	32%	35%	34%	33%	100%
To Other	$72,954	$65,536	$32,058	$46,306	$0
	68%	65%	66%	67%	0%
Patent Licenses, Total Distributed	$107,220	$100,867	$48,798	$69,151	$38,633
To Inventor(s)	$34,266	$35,331	$16,740	$22,845	$11,588
	32%	35%	34%	33%	30%
To Other	$72,954	$65,536	$32,058	$46,306	$27,045
	68%	65%	66%	67%	70%

(a) Income includes royalties and other payments received during the fiscal year.

Cooperative Research and Development Agreements, MOUs, and Other Collaborations

NOAA's labs, centers, and programs executed 14 new CRADAs in FY 2015. Ten of these agreements were with small businesses. Factoring in the new and expiring agreements, the total NOAA CRADA portfolio is now 28 active agreements. The labs additionally have reported 47 MoU and Other Collaborative R&D Agreements:

- 5 Guest Researcher agreements,
- 42 Memoranda of Understanding
    - 12 International
    - 13 US Private (9 qualify as small businesses)
    - 15 Interagency/State
    - 1 Academia
    - 1 Non-Profit

Table 31 – Collaborative Relationships for Research and Development

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Traditional CRADAs,[(a)] Total Active[(b)]	7	10	15	19	28
New, Executed	2	4	7	8	14
Non-Traditional CRADAs, Total Active	0	0	0	0	0
New, Executed	0	0	0	0	0
Other Types of Collaborative R&D Relationships					
Guest Researcher Agreements	n.a.	n.a.	n.a.	n.a.	5
MOUs	n.a.	n.a.	14	50	42

(a) Traditional CRADAs involve collaborative research and development projects by a Federal laboratory and non-Federal partners.

(b) "Active" means an agreement in force at any time during the fiscal year. "Total active" is comprehensive of all agreements executed under CRADA authority (15 USC 3710a).

Recent CRADA: NOAA and Envera LLC: Exploring Probiotics for Shellfish Aquaculture

NOAA's Northeast Fisheries Science Center's Milford Laboratory in Connecticut has been studying shellfish since its founding in 1931. Historically, the Milford Laboratory has been supporting the shellfish farming (aquaculture) industry in the Northeast by conducting research in shellfish culture methods, improving the health of shellfish populations, and determining their interactions with the environment.

Eastern Oysters Source: NOAA

The Milford laboratory seeks to transfer new knowledge and technology directly to the U.S. aquaculture industry through key partnerships and collaborations. Most recently, the lab signed a CRADA with Envera LLC of West Chester, PA, to evaluate a newly isolated probiotic strain for possible commercial use in oyster hatcheries.

The use of probiotics in aquaculture first began in the mid-1980s as a way to increase the growth of water-based organisms (Martinez Cruz et al. 2012). NOAA Fisheries' researchers have been studying various probiotic strains and their potential usefulness to the aquaculture industry ever since. In 2011, NOAA researchers reported they had isolated and evaluated a naturally occurring probiotic isolate, OY15, from the digestive glands of adult Eastern oysters (Crassostrea virginica).

After determining this probiotic was safe to include in feed products for oysters, they discovered this particular probiotic strain improved the survival of growing shellfish larvae exposed to a shellfish larval pathogen by 20-35% (Lim et al. 2011, Kapareiko et al. 2011).

NOAA Researchers successfully have adapted flow cytometry techniques used in hospitals to assess 10 Bacillus strains commercially available through Envera for their effects on immune functions of oyster hemocytes. The CRADA with Envera will provide the Milford Laboratory the expertise and preliminary work to determine if OY15 can be cultured effectively and economically in large-scale production, as well as produced in a stable formulation for future marketing. Confirmation of these two steps is necessary to move toward commercialization and marketing of Milford probiotic strain OY15 as a product available for purchase by commercial oyster growers. Envera's innovative research and development expertise in large-scale production of microorganisms, product formulation, and shelf-life stabilization by freeze-drying or spray drying will provide the basis for eventual transfer of OY15 to commercial sale and use.

Data Products and Services

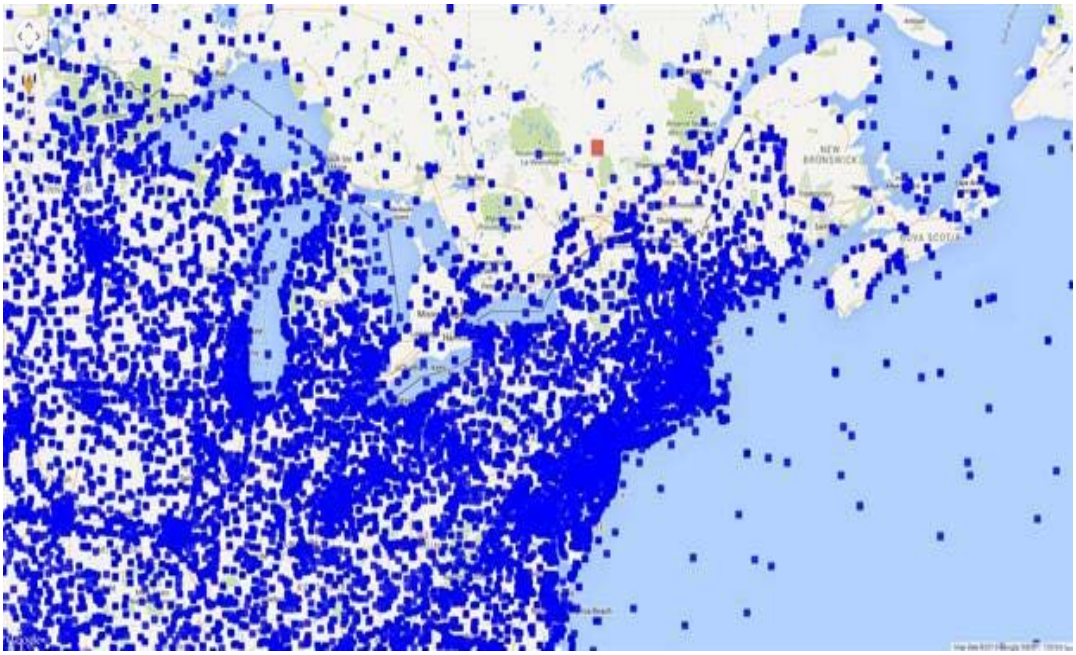
NOAA scientists provide details of their research and technology to the public in the form of products and services. These include weather and climate forecast data, El Niño prediction and monitoring, tides and currents, satellite imagery, fishery statistics, information on protected species, air quality, coastal conditions, beach temperatures, nautical charts, and databases on climate, oceans, ice, atmosphere, geophysics and the sun. These data are provided, often in real-time, through the network of NOAA data centers and websites.

Making Better Use of NOAA Data - The NOAA Big Data Project (BDP)
On April 21, 2015, NOAA and the Department of Commerce announced that they had entered into CRADAs with Amazon Web Services, Google Cloud Platform, IBM, Microsoft, and the Open Cloud Consortium. Under these agreements, NOAA and its collaborators will research and explore new ways to enable the use of NOAA data, furthering the Department of Commerce's goals of improving decision-making by government, industry, and citizens; growing the economy; and creating jobs. The CRADAs provide an environment where NOAA and its collaborators can work, with the help of data alliances, representative ecosystems of value-added providers and data customers organized around each participating cloud provider and share an interest in the use of NOAA's data.

Each of the CRADAs signed with the five anchor collaborators is identical. By working under the shared language of this CRADA, NOAA establishes a level playing field that both protects the public's interest in the data and allows private sector competitors to work in parallel to reduce the technical barriers and cost of efficient access to NOAA's vast data portfolio.

Decision Support Tools
NOAA's labs and programs develop a wide variety of dedicated decision support software that brings data to the public in a user-friendly format to enable effective decision-support. In many cases, the development of these sites is in conjunction with academia and private sector partners.

MADIS
The newly operational Meteorological Assimilation Data Ingest System (MADIS) collects, checks, and organizes more than 7 million weather observations each day from around the world to help improve weather forecasting and support weather-based decision-making. MADIS data are accessible to National Weather Service (NWS) forecasters, weather prediction models (both research and operational versions), NWS hydrometeorological applications, and to the public through the Web Service Portal at https://madis-data.noaa.gov/.



Density of weather data resources provided under MADIS system. Source: NOAA

The MADIS team developed partnerships with more than 160 non-NOAA international, federal, state, and local agencies, universities, volunteer networks, and the private sector to integrate observations from their stations with those of NOAA. The MADIS data integration, quality control, and delivery services provide the greater meteorological community with an easy to use, standardized, high-quality observational database and delivery system.

"MADIS data has proved incredibly helpful in increasing our overall awareness of major weather, especially wind, cold temperatures and storm systems," said Chris Thompson, the Geographic Information Systems Manager at the Virginia Department of Emergency Management. "This information helps us understand what's happening with the weather so we're able to respond appropriately to situations that arise."

Cooperative Institutes

NOAA supports a network of 16 Cooperative Institutes at 42 universities and research institutions across 23 states and the District of Columbia. Often, these Cooperative Institutes are in the same state as a NOAA laboratory, and Institute researchers are frequently co-located with NOAA scientists at NOAA labs. The work done through the Cooperative Institutes directly supports NOAA's mission activities and results in similar technology transfer opportunities. NOAA's Technology Partnerships Office works closely with the technology transfer offices from the Institutes to manage jointly intellectual property and seek out licensing partners.

Visiting Scientists - International Collaborations

In addition to NOAA's Cooperative Institutes, a number of NOAA labs transfer technology by hosting visiting scientists, both domestic and international. To ensure that the United States benefits from and fully exploits scientific research and technology developed abroad, NOAA collaborates and shares information with organizations in countries throughout the world.

Through these international relationships, NOAA receives technology that may eventually benefit U.S. industries and public users. For example, the understanding and forecasting of global phenomena that occur in the atmosphere, oceans, and on the sun require worldwide collaboration and information sharing. This is accomplished through formal agreements with individual countries and participation in international organizations, such as the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), and the International Astronomical Union (IAU).

NOAA participates in international scientific programs, such as in the Global Earth Observation System, and shares technology and scientific data with nearly 50 countries, the European Commission, and 29 international organizations. NOAA also provides technical assistance and training to individuals from other countries, and participates in an international visiting scientist program. Further, NOAA shares environmental data through its participation in the World Data Center program.

Publications[44]

In FY 2015, peer-reviewed publications by NOAA scientists totaled 1,860. The following charts show the breakdown of publications by subject, NOAA Line Office, R&D Unit, as well as co-authorship by institution and country.

Table 32 – Number of Publications per Subject (Top 10)

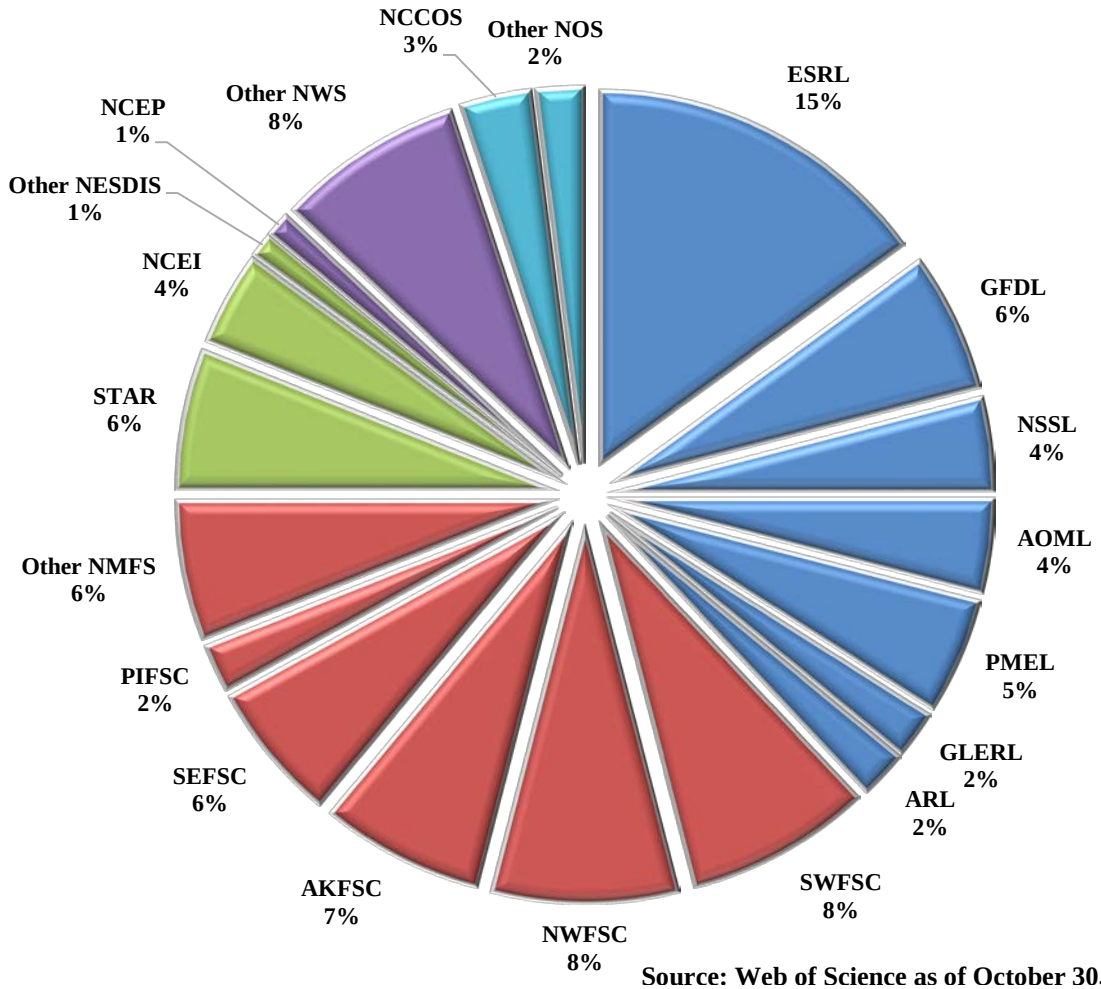
Subject	Publications
Meteorology Atmospheric Sciences	607
Marine Freshwater Biology	318
Oceanography	283
Fisheries	255
Environmental Sciences	211
Ecology	180
Geosciences Multidisciplinary	166
Multidisciplinary Sciences	108
Zoology	60
Engineering Ocean	57

[44] NOAA publications data for 2015 were derived on October 30, 2015, using queries through the Web of Science database. As a result of variations in titles and nomenclature, these data do not provide a comprehensive measure of all NOAA publications. This reporting includes only those publications by NOAA scientists that were captured by the search queries. Extramural publications funded by NOAA either directly or indirectly are also not included.

Table 33 – Number of Publications per Line Office

Line Office	Publications	% of NOAA
NESDIS	209	10.6%
NMFS	715	36.2%
NOS	109	5.5%
NWS	172	8.7%
OAR	764	38.7%
Other	5	0.3%

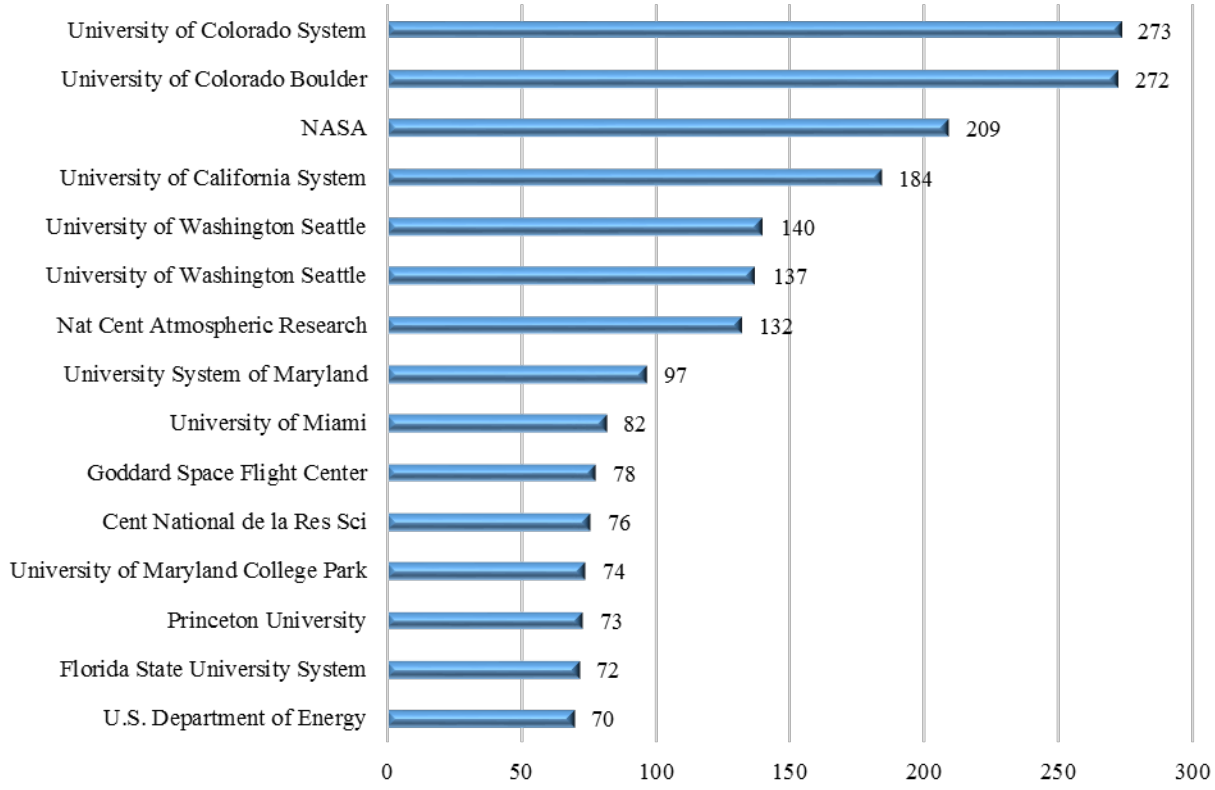
Figure 5 – Intramural Publications per R&D Unit



Source: Web of Science as of October 30. 2015

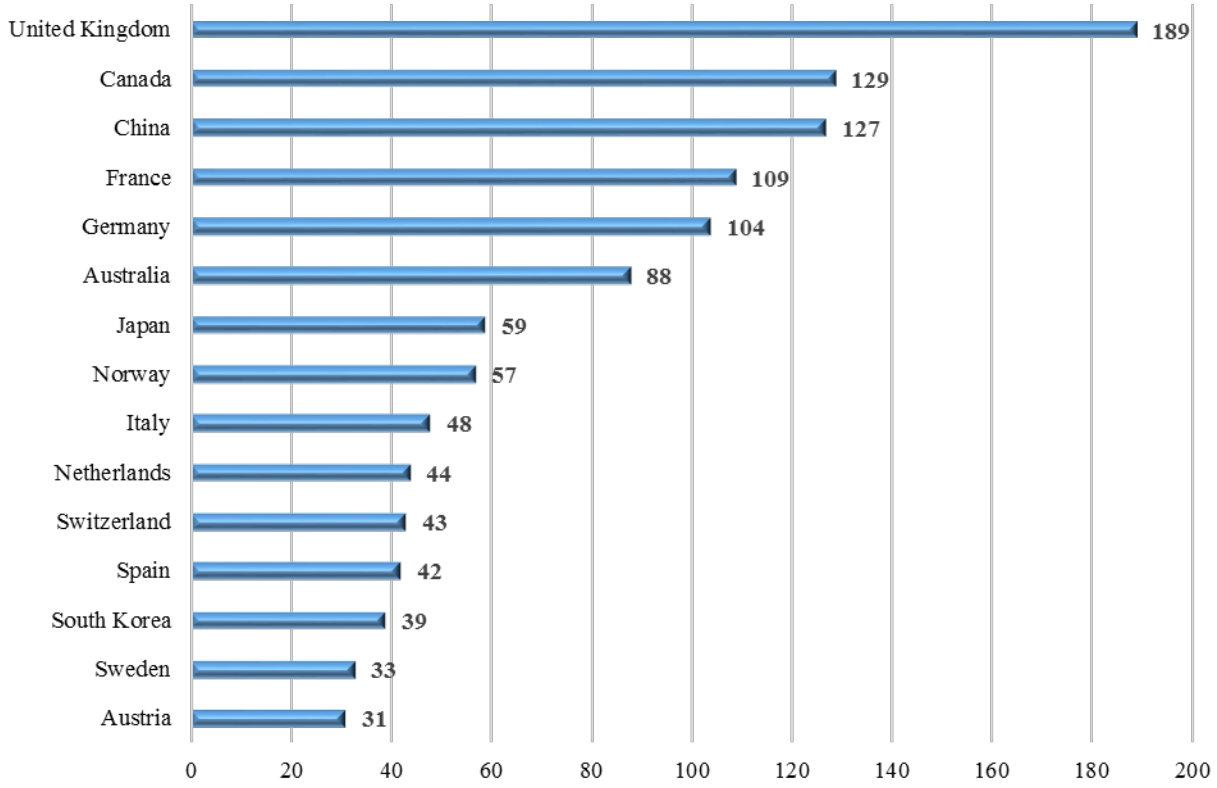
AKFSC	Alaska Fisheries Science Center
AOML	Atlantic Oceanographic Meteorological Laboratory
ARL	Air Resources Laboratory
ESRL	Earth Systems Research Laboratory
GFDL	Geophysical Fluid Dynamics Laboratory
GLERL	Great Lakes Ecosystems Research Laboratory
NCCOS	National Center for Coastal Ocean Sciences
NCDC	National Climate Data Center
NCEP	National Centers for Environmental Prediction
NEFSC	Northeast Fisheries Science Center
NESDIS	National Environmental, Satellite, Data and Information Service
NMFS	National Marine Fisheries Service
NOS	National Ocean Service
NSSL	National Severe Storms Laboratory
NWFSC	Northwest Fisheries Science Center
NWS	National Weather Services
PIFSC	Pacific Islands Fisheries Science Center
PMEL	Pacific Marine Environmental Laboratory
SEFSC	Southeast Fisheries Science Center
STAR	Center for Satellite Applications and Research
SWFSC	Southwest Fisheries Science Center

Figure 6 – Co-Authored Publications by Institution (Top 15)[45]



[45] Source: Web of Science as of October 30th, 2015

Figure 7 – Co-Authored Publications by Country (Top 15) [46]



Other Activities, Performance Measures Deemed Important

Challenges/Prizes

NOAA is not currently leading any challenges/prizes.

Facilities Use

While NOAA does not generally offer its facilities for public use, NOAA does regularly collaborate with the private sector and academia to test new technologies through its networks of testbeds and proving grounds.

NOAA Testbeds

NOAA's testbeds and proving grounds facilitate the transition of promising research capabilities to operational implementation through development and pre-deployment testing, and operational readiness/suitability evaluation. NOAA maintains 11 individual testbeds related to weather, climate, and severe weather activities. The annual Federal Funding Opportunities for these testbeds attract technologies from academia, the private sector, and NOAA labs. Testbeds also provide essential funding for bridging the gap between R&D and implementation into operational use.

[46] Source: Web of Science as of October 30th, 2015

NOAA Sterling, Virginia Field Support Center
The Sterling Field Support Center (SFSC) provides operational help to NOAA field personnel and the private sector through a combination of sensor testing, analysis and contact center support. The staff of the SFSC is comprised of a diverse mix of Meteorologists, Electrical Technicians, and Engineers. Collectively, SFSC personnel have many years of practical experience working with National Weather Service sensors and related equipment. The SFSC is responsible for the research, testing, and development of a variety of meteorological systems. These systems include the Automated Surface Observing System (ASOS), Radiosonde Replacement System (RRS), and Cooperative Observer Program (COOP).

Education and Outreach

National Ocean Sciences Bowl® Students Brief Leaders in Washington, DC
In June 2015, the National Champions of the 18th Annual National Ocean Sciences Bowl® (NOSB), Boise High School from Boise, Idaho, were invited to participate in Capitol Hill Oceans Week (CHOW), organized by the National Marine Sanctuaries Foundation. During the first-ever youth panel at CHOW, "The Wave of the Future: What Do the Youth of America Think?" Boise team captain, Nate Marshall, discussed how being part of NOSB has raised awareness of ocean issues and careers, as well as the impact residents of interior states have on the ocean.

The piece of legislation that students reviewed for the 2015 Science Expert Briefing (the mock congressional testimony that is a component of NOSB Final Competition) was the reauthorization of the Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009.

The top placing team in the 2015 Science Expert Briefing was Thomas Jefferson High School for Science and Technology (Alexandria, Virginia) while Boise High School placed second. At the request of Zdenka Willis, Director of the U.S. Integrated Ocean Observing System at NOAA, both teams presented and discussed their recommendations with her and other Federal agency representatives on June 10th in Washington DC.

Since 1998, NOAA has supported the National Ocean Sciences Bowl® with grants and volunteer time. The program introduces talented U.S. high school students to ocean-related science, technology, engineering, and math fields and career pathways. This program affords learning opportunities to the students as well as their teachers, schools, and local communities that result in increased knowledge of ocean sciences and interest in stewardship of ocean resources.

Downstream Outcomes from NOAA's Technology Transfer Activities

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

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

NOAA, Partners, Survey 'Amazingly Intact' Historic WWII-Era Aircraft Carrier

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

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

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

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

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

NOAA's Science On a Sphere® Animations Coming to your Desktop

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

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

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

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

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

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

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

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

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

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

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

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

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

NOAA Receives Patent for Novel Feeder for Juvenile and Larval Fishes

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

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

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

NOAA Licenses Two Aerosol Measurement Devices to Boulder, CO, Company Handix, LLC for Commercialization in China

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

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

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

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

Based on the Strength of Past Successes, NOAA and Google Extend their Cooperative R&D Agreement

In July 2015, NOAA and Google signed an extension to their 2010 Cooperative Research and Development Agreement with the goal of building on past successes. The new agreement allows for easier personnel exchanges between NOAA and Google, and has already resulted in a three-month detail for a staffer from the National Ocean Service to the Google campus. The previous iteration of the CRADA resulted in a wide range of successes including the release of Google Earth's Ocean View (http://www.google.com/earth/explore/showcase/ocean.html) in 2014.

Awards and Recognition

NOAA Microparticulate Feeder for Fish Wins Federal Laboratory Consortium Regional Award

The Federal Laboratory Consortium for Technology Transfer (FLC), which is a nation-wide network of Federal lab representatives helping to link Federal labs to the marketplace, awarded NOAA with its Outstanding Technology Development in the Far West Region for its newly patented fish feeder.

Tom Scott at NOAA's Northwest Fisheries Science Center in Seattle, Washington developed the Microparticulate Feeder for Larval and Juvenile Fish to meet research and development needs at the aquaculture facility. The device automatically feeds young fish on a recurrent basis while protecting the feed from oxidation and clumping. The device's precise dosing capabilities, along with its reliability over many feedings, have made it a

boon for the NOAA fisheries facility. The technology was also awarded a U.S. patent and is now available for licensing by a qualified U.S. company.

The FLC Far West Region awards were presented at the organization's annual awards dinner on Wednesday August 26th, 2015 as part of the Far West/Mid-Continent Regional Meeting in San Diego, CA.

NOAA Technology Transfer Awards

NOAA selected four projects to receive the Agency's Technology Transfer Award in 2015. These projects exemplified the highest standard for developing a new technology in cooperation with private sector partners in the service of NOAA's mission.

- **Elaine Harrell and Shawn Puyear**
  For developing a real-time, online monitoring and tracking system for Gulf of Mexico and Highly Migratory Species catch share programs.

- **Ian Taylor**
  For leading development, management, dissemination, and teaching of R4SS to improve the assessment and management of the nation's fisheries resources.

- **Timothy S. Hunter**
  For demonstrated success in, and commitment to, transferring hydrometeorological research and data products to international and Great Lakes constituents.

- **John A. Ogren, Patrick J. Sheridan, and James W. Wendell**
  For developing a small and robust instrument to monitor light absorption by atmospheric aerosols, and recruiting a manufacturer to produce it commercially.

CHAPTER 4 National Telecommunications and Information Administration: Institute for Telecommunication Sciences

ITS is the research and engineering arm of NTIA and performs telecommunications research to provide technical engineering support to NTIA. ITS also serves as a principal Federal resource for solving telecommunications concerns of other Federal agencies, state and local governments, private corporations and associations, and international organizations through Interagency Agreements and CRADAs. Three-quarters of ITS research programs involve other Federal agencies; state, local and tribal governments; private corporations and associations; or international organizations. This includes assisting the FCC and Federal defense, public safety, and other agencies that use Federal and non-Federal spectrum.

Approach and Plans for Technology Transfer

ITS efforts in technology transfer and commercialization foster cooperative telecommunications research in areas where U.S. companies can directly benefit from improved competitiveness and market opportunities. ITS uses three principal means for achieving technology transfer:

- Cooperative research and development;
- Technical publications; and
- Leadership and technical contributions in the development of telecommunications standards.

ITS Work Products and Collaborative Activities

Cooperative Research and Development

ITS is authorized under the Federal Technology Transfer Act of 1986 (FTTA) to enter into cooperative research agreements with private industry, universities, and other interested parties. ITS CRADAs protect proprietary information, grant patent rights, and provide for user licenses to private entities. They also provide the legal basis for shared use of government facilities and resources with the private sector.

In FY 2015, ITS participated, as it has for a number of years, in CRADAs with private-sector organizations to design, develop, test, and evaluate advanced telecommunication concepts. CRADAs provide ITS with insights into industry's needs for productivity, growth, and competitiveness. This enables ITS to adjust the focus and direction of its programs for effectiveness and value. The private industry partner benefits by gaining access to the results of research in commercially important areas that it would not otherwise be able to undertake.

To date, CRADAs achieved major contributions to personal communication services (PCS), local multipoint distribution service (LMDS), ultra-wideband (UWB), objective audio and video quality, advanced antennas for wireless systems, and remote sensing and global position (GPS) technologies. These have aided U.S. efforts to introduce new socially constructive communications technologies. More recently, CRADAs in the areas of high resolution laser radar (LADAR), autonomous networks for unmanned aerial vehicles (UAVs), and broadband air-interface and core network capabilities for Long Term Evolution (LTE) mobile communications have allowed ITS to contribute to the development of new products and services.

ITS is a partner program with the NIST Communications Technology Laboratory (CTL) in the Public Safety Communications Research (PSCR). The focus of PSCR is to improve first responder communications and interoperability through the development of communication standards, research, testing, and evaluation (RDT&E). This joint program has been operating for close to two decades on behalf of sponsors at the Department of Homeland Security (DHS) and the Department of Justice (DOJ). Since the First Responder Network Authority (FirstNet)[47] became operational, PSCR's research scope has expanded to support FirstNet's work toward creation of a nationwide broadband wireless network dedicated to public safety agencies through RDT&E of equipment that may help both build the network and communicate over it.

The vast majority of CRADAs ITS has entered into in the past five years are the Public Safety 700 MHz Broadband Demonstration Agreements. These agreements allow vendors, including equipment manufacturers and wireless carriers who intend to supply 700 MHz LTE equipment and service to public safety organizations, to operate various elements of an LTE network in the PSCR test bed and over-the-air (OTA) network (both hosted and managed by ITS). This allows these vendors to test the interoperability of public safety communications equipment under simulated field conditions, with the participation of public safety practitioners. At the close of FY 2015, 49 CRADAs were in place under this program. The CRADAs protect the intellectual property of vendors and manufacturers and encourage participation in testing that simulates real multi-vendor environments in the field. This is the first government or independent facility in the U.S. capable of testing or demonstrating public-safety-specific LTE implementation requirements.

Table 34 – Collaborative Relationships for Research & Development

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
CRADAs					
Number of Active CRADAs	32	62	81	60	56
Number of Newly Executed CRADAs	17	30	30	11	53
Active CRADAs with Small Businesses Involvement	--	--	17	12	12
Number of Small Businesses Involved in Active CRADAs	--	--	17	12	12
Traditional CRADAs					
Active Traditional CRADAs	23	60	81	60	56
Newly Executed Traditional CRADAs	10	28	30	11	53
Non-Traditional CRADAs[(a)]					
Active Non-Traditional CRADAs	9	2	0	0	0
Newly Executed Non-Traditional CRADAs	7	2	0	0	0

(a) ITS Telecommunications Analysis Services (TA Services), discontinued in FY 2012, provided Web-based analysis support on a cost-reimbursable basis for wireless system design/evaluation and site selection to private industry and public agencies through on-demand electronic CRADAs. The programing language used for TA Services is too old to update. Other service applications may be developed in the future depending on funding.

[47] http://www.firstnet.gov/

Technical Publications
Publication historically has been the means through which ITS has transferred research results to other researchers, the commercial sector, and government agencies. Many of ITS technical publications (internal reports, monographs, and peer-reviewed articles in external scientific journals) are standard references in several telecommunications areas and remain a principal means for ITS technology transfer. Most of these technical publications are released only after going through an internal peer review process managed by the ITS Editorial Review Board (ERB). Scientific journals or conference proceedings published externally approximately half of the publications released through the ERB process in FY 2015 and the other half became NTIA reports. At one time, ITS only tracked official NTIA publications, but recently it became apparent that journal articles and conference papers have equal, and sometimes greater, reach in transferring new tools and discoveries, so NTIA now counts all publications.

Technical Publications Downloaded
ITS makes all of its publications available to the public through its Web site and provides online users with advanced search capabilities that will locate relevant publications by keyword. To ensure a meaningful and realistic metric, ITS counts actual PDF downloads of publications rather than page views of the bibliographic summaries. In FY 2015, there were 9,048 downloads of ITS technical publications, a 17% increase over the prior year.

Consumer Digital Video Library Users Downloading Clips
In FY 2010, ITS began development of the Consumer Digital Video Library (CDVL), a web site hosted and maintained by ITS to provide researchers access to high quality, uncompressed video clips royalty-free for use in video processing and product development and testing. The technical committee for this collaborative project includes industry and academic representatives as well as ITS and Public Safety Communications Research staff.

ITS launched the site with 1,000 clips and clips continue to be added by ITS and other collaborators. There were over 2,000 different video clips downloaded from the library in FY 2015. Users must register for each download or upload session. The number of registrants who perform downloads each year was selected as the most significant measure of the impact of this resource, and collection of information on the number of registered users began in FY 2011. This number experienced a significant spike in FY 2013, probably due to the publication of a number of journal articles describing CDVL; annual rates of between 180 and 200 users are consistent with the target audience for this library.

Licensing
ITS stopped licensing software technology in FY 2008. Therefore, there are no reports of licensing metrics.

Software and Data Downloads
Instead of using licenses, ITS makes several software and data tools available via open-source download. Reliable and robust methods of counting downloads of these tools took some time to develop. Video quality measurement (VQM) downloads were reported for the first time in FY 2013 and other downloads were reported for the first time for FY 2014.

Propagation Prediction: ITS is, and has been for decades, a world leader in the development of models and methods for accurate prediction of radio propagation and ITS freely shares propagation prediction algorithms through publications. In addition, software developed to predict propagation for planned communications systems through input of specific parameters to these algorithms has been developed and shared over the years, as have some data sets for testing and validating propagation prediction models. The majority of software/data downloads on the ITS web site are for propagation prediction tools.

Audio Quality Testing: In FY 2013, ITS developed an objective estimator of speech intelligibility that follows the paradigm of the Modified Rhyme Test (MRT). The Articulation Band Correlation MRT (ABC-MRT) consumes a tiny fraction of the resources required by MRT testing and provides excellent estimates of MRT intelligibility results (Pearson correlations of .95–.99). ABC-MRT tools and MRT databases are available for download through the ITS web site, as well as a variety of other sample clips for audio quality testing.

Video Quality Measurement Software: ITS VQM software tools use an objective VQM method, that ANSI made a national standard to estimate the quality of video impairments, providing users an inexpensive alternative to viewer panels for testing new transmission technologies. In FY 2015, 507 users downloaded the VQM software. The Web-Enabled Subjective Test (WEST) software package, also freely available for download, facilitates the gathering of subjective testing data from multiple locations and multiple portable or computing devices. .

Table 35 – Other Performance Measures Deemed Important by the Agency

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Technical Publications Released	15	13	24	18	22
Technical Publications Downloaded	n.a.	n.a.	7,174	7,707	9,048
Consumer Digital Video Library Users Downloading	242	187	418	184	212
Video Quality Metric Software Users Downloading	n.a.	n.a.	591	685	507
Propagation Modeling Software Downloads	n.a.	n.a.	n.a.	717	798
Other Software/Data Downloads	n.a.	n.a.	n.a.	489	493

Development of Telecommunication Standards[48]

ITS works with industry to apply research results to the development of telecommunication performance standards and guidelines. For several decades, ITS has provided leadership and technical contributions to organizations, both national and international, responsible for developing telecommunication standards. ITS's technical inputs are relied upon as technically advanced, sound and unbiased by commercial interests.

ITS works collaboratively with the International Telecommunication Union (ITU), the Alliance for Telecommunications Industry Solutions (ATIS), and various Federal public safety groups to interpret and analyze standards and regulations. This method of ITS technology transfer directly addresses improvement of U.S. competitiveness in telecommunications. For example, a plurality of the technical recommendations of the ITU, a treaty organization, are based on research

[48] In 2004, ITS added a collaborative standards contributions measure for participation on standards committees. As standards bodies increasingly move towards digital collaboration methods using wikis, email threads, and discussion boards, it has become impossible to define what constitutes a single "contribution." This metric was discontinued in FY 2013.

conducted at ITS. In addition, key national quality-of-service standards developed under the ANSI T1 committee for video, audio, and digital data incorporate research results obtained at ITS. ITS continues to chair numerous committees and working groups in the ITU, ATIS, and other telecommunication standards organizations, providing technical leadership that is trusted by the commercial-sector participants.

In FY 2015, ITS staff held 36 positions on 32 different bodies in six standards development organizations. ITS staff filled numerous key leadership positions in the ITU Radio communication Sector (ITU-R), including International Vice-Chair and U.S. Chair of the ITU's Study Group 3 (SG3), International Chair of the SG3 Working Party 3K, and U.S. Chair or Co-chair of four other Working Parties and one Correspondence Group. ITS staff members also hold the positions of U.S. Chair of ITU Telecommunication Standardization Sector (ITU-T) Study Group 9 and Co-chair of the ITU Intersector Rapporteur Group on Audiovisual Quality Assessment. ITS also continued its technical leadership and contributions to communications standards for public safety, particularly for first responders.

Downstream Outcomes from ITS Technology Transfer Activities

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

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

Table Mountain Research
The ITS Table Mountain Field Site and Radio Quiet Zone in Colorado supports fundamental research in the nature, interaction, and evaluation of telecommunication devices, systems, and services. Each year, private companies, universities, and other organizations conduct research at Table Mountain under CRADAs.

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

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

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

Video Quality Research

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

Public Safety Broadband Demonstration Network

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

SUMMARY

Technology transfer is an essential mission of DOC, using our Nation's innovation and investment in science and technology to strengthen our economy and competitiveness in world markets. This report details the results of collaborative technology activities originating from DOC's Federal laboratories. Federal research is a complex process that provides the opportunity for new ideas and innovations to achieve practical application for the benefit of U.S. citizens. The success stories in this report provide examples of how society benefits from technology transfer activities across DOC's Federal laboratories. As knowledge advances and the needs of the economy change DOC, through its Federal laboratories, will continue to play a role in keeping America in the forefront of innovation and supporting our economy by aiding in the transfer and commercialization of innovative technologies.