Annual Report on Technology Transfer: Approach and Plans, Fiscal Year 2014 Activities and Achievements

U.S. Department of Commerce

Report prepared by:

National Institute of Standards and Technology
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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) 2014. 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 2010 through FY 2014.

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 NIST facilitating interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency technology transfer programs. [1] NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer (FLC), which is a nationwide network of federal laboratories that provides a forum to develop strategies and opportunities for linking laboratory mission technologies and expertise with the marketplace.

DOC's role in coordinating technology transfer activities across federal agencies was further expanded by the Presidential Memorandum (PM) – *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses* (PM) of October 21, 2011.[2] The purpose of this PM is to foster innovation by increasing the rate of technology transfer and the economic and societal impact from federal investments in R&D. The PM directs agencies with federal laboratories to take actions 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 the successful outcomes of agency technology transfer and commercialization activities significantly over the next 5 years, while simultaneously achieving excellence in each agency's focused research activities.

Section 2 of the PM calls for establishing performance goals, metrics, and evaluation methods, as well as implementing and tracking progress relative to those goals, specifically directing that "[t]he Secretary of Commerce, in consultation with other agencies, including the National Center

[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

for Science and Engineering Statistics, shall improve and expand, 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://www.noaa.gov/
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 2010 – FY 2014

This annual report provides comprehensive statistics on the technology transfer activities of DOC laboratories. Information is provided 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 these 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. This information is also required by Office of Management and Budget Circular A-11. The tables in the following sections present the required data.[4]

Table 1 – Invention Disclosure and Patenting

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Invention Disclosures					
NIST	30	25	52	33	41
NOAA	1	1	0	8	6
ITS	0	0	0	0	0
Department Total	31	26	52	41	47
Patent Applications Filed					
NIST	19	17	20	23	21
NOAA	1	0	1	3	4
ITS	0	0	0	0	0
Department Total	20	17	21	26	25
Patents Issued					
NIST	10	14	11	15	18
NOAA	2	2	2	1	0
ITS	0	0	0	0	0
Department Total	12	16	13	16	18

[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 2014 has been adjusted, where necessary, to reflect the most accurate estimates for each year reported.

In addition to the number of patents issued that are reported by each agency, the National Science Foundation (NSF) provides additional insight into the technology areas addressed by DOC patents.[5] For example, in FY 2013, 41% of DOC's patents were in the technical area of Measurement Techniques and Instruments. This includes techniques and use of instrumentation which measures, tests, inspects or analyzes a wide variety of materials or processes.[6]

Figure 1 – Percent of USPTO patents granted to DOC, by technology area: FY 2013

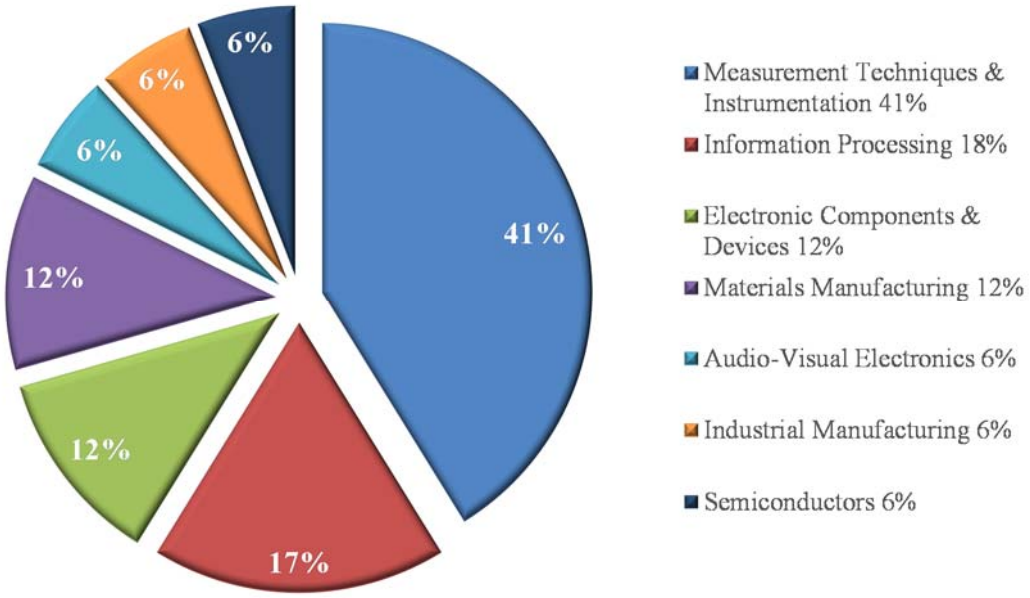


Table 2 – Licensing – Profiles of Active Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Active Patent Licenses [(a)]					
NIST	40	34	38	35	36
NOAA	6	6	5	5	5
ITS	0	0	0	0	0
Department Total	46	40	41	40	41

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

[5] NSF routinely researches a wide range of data for its publication "Science and Engineering Indicators" http://www.nsf.gov/statistics/. NSF 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.

[6] Sources: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2014). Used with permission.

Table 3 – Characteristics of Income-Bearing Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Income-Bearing Licenses					
Department Total	29	26	25	28	26
Patent Licenses					
NIST	25	23	22	23	21
NOAA	4	3	3	5	5
ITS	0	0	0	0	0
License Types					
Exclusive					
NIST	12	12	12	15	14
NOAA	0	0	0	0	0
ITS	0	0	0	0	0
Department Total	12	12	12	15	14
Partially Exclusive					
Department Total	0	0	0	0	0
Non-Exclusive					
NIST	7	7	6	5	5
NOAA	4	3	3	5	5
ITS	0	0	0	0	0

Table 4 – Income from Licensing

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Licensing Income					
NIST	$202,216	$169,347	$146,796	$102,532	$150,995
NOAA	$35,044	$107,220	$100,867	$48,798	$69,151
ITS	$0	$0	$0	$0	$0
Department Total	$237,260	$276,567	$247,663	$151,330	$220,146

Table 5 – Collaborative Relationships for Research and Development

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
CRADAs					
Department Total	2,253	2,245	2,410	2,428	2,359
Traditional CRADAs[(a)]					
NIST	66	103	140	179	206
NOAA	6	7	10	15	19
ITS	29	23	60	81	60
Joint CRADA Agreements (NIST and ITS)[(b)]	1	35	57	79	79
Department Total[(c)]	101	133	210	275	285
Non-Traditional CRADAs[(d)]					
NIST	2,141	2,138	2,255	2,231	2,074
NOAA	0	0	0	0	0
ITS	12	9	2	0	0
Department Total	2,153	2,147	2,257	2,231	2,074

(a) Traditional CRADAs involve collaborative research and development projects by a federal laboratory and non-federal partners.
(b) NIST and ITS have been jointly involved in several Public Safety 700 MHz Broadband Demonstration CRADAs.
(c) Department totals for Traditional CRADAs are adjusted to avoid double counting CRADAs where NIST and ITS are jointly involved.
(d) Non-traditional CRADAs are used for special purposes, such as laboratory accreditation, materials transfer or technical assistance that may result in protected information.

Scientific and Technical Publications

As discussed in the Department's response to the PM[7], technology transfer mechanisms include more than just accounting for CRADAs, patenting, and licensing. For example, technology transfer is also accomplished through DOC's scientific and technical publications. In FY 2014, NIST, NOAA, and ITS researchers published 3,136 scientific and technical papers in peer-reviewed journals.

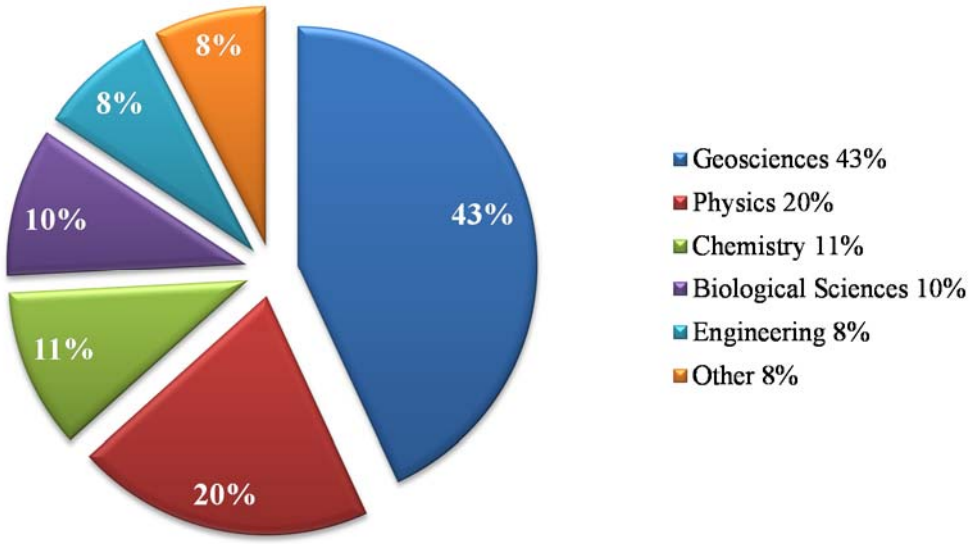
Table 6 – Scientific and Technical Publications

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Technical Publications					
NIST	1,243	1,210	1,335	1,393	1,359
NOAA	709	1,034	1,769	1,781	1,759
ITS	12	15	13	24	18
Department Total	1,964	2,259	3,117	3,198	3,136

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

In addition to the number of publications reported by each agency, the National Science Foundation (NSF) provides insight into the technology areas addressed by each federal agency.[8] Using data from Thomson Reuters' Science Citation Information (SCI)[9] and Social Sciences Citation Index (SSCI)[10] databases, NSF identifies the general technology areas addressed by each agency's publications. The latest data available from NSF is for calendar year 2013. As shown in Figure 2, the largest technology areas covered by DOC publications are Geosciences (43%), followed by Physics (20%) and Chemistry (11%).

Figure 2 – Percent of Articles by Technology Area Authored by DOC Staff in 2013[11]



Data is also available on the number of times U.S. patents cite U.S. science and engineering articles authored by DOC staff. These cited articles are from the set of journals covered by SCI and SSCI, classified by the year of publication, and assigned to a federal agency on the basis of the institutional addresses listed in the article. U.S. patents issued in 2013 cite 558 publications authored by DOC researchers. As shown in Figure 3, the largest technology areas citing DOC publications include Physics (32%), followed by Chemistry (26%) and Biological Sciences (18%).

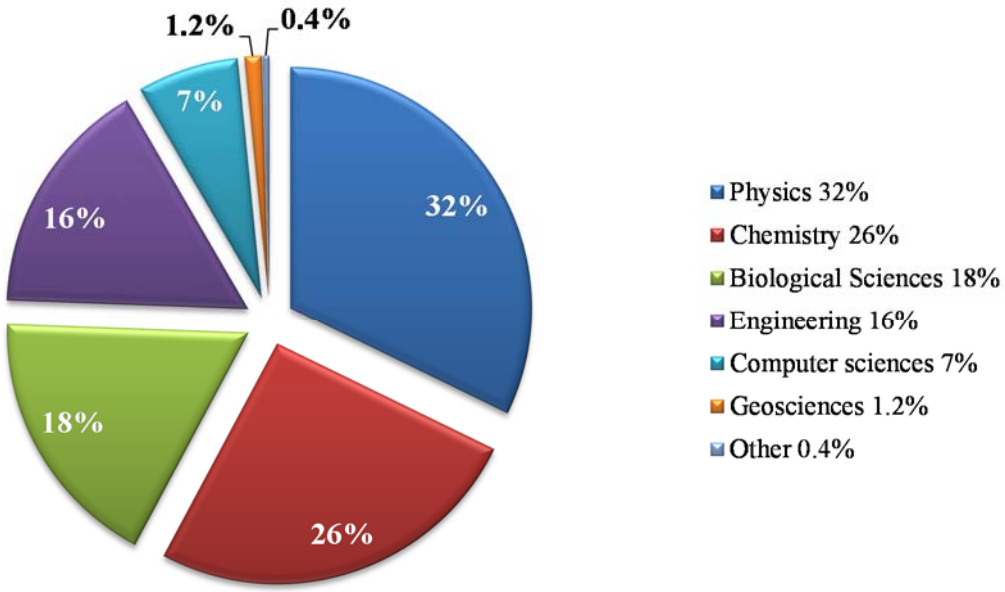
[8] The National Science Foundation routinely researches a wide range of data for its publication "Science and Engineering Indicators" (http://www.nsf.gov/statistics/.) The data presented here has been provided at the request of NIST and is in compliance with NSF's goal of supporting agencies in their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

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

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

[11] Publications are classified by the year they are entered into the database, rather than the year of publication, and are credited on a whole-count basis (i.e., each publication receives one count).

Figure 3 – Percent of Articles by Technology Area Authored by DOC Staff and Cited in U.S. Patents in 2013[12]



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.

[12] Cited articles are classified by the year of publication, and are classified on a whole count basis (i.e. each cited article receives one count). Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2013 are references in USPTO patents issued in FY2013 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.

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.

An important part of accomplishing NIST's mission is to anticipate future measurement and standards needs of U.S. industry. Rapidly evolving sectors like nanotechnology, biotechnology, homeland security, information technology, and advanced manufacturing need sophisticated technical support systems in order to flourish and grow. 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

Technology transfer activities at NIST are designed to disseminate fundamental research results, measurements, and standards research results 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.[13]

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."***

The broader definition of technology transfer for NIST intends to reflect the many means by which NIST reaches its external partners and transfers technology. The definition includes, *inter alia*: 1) knowledge transfer, the act of transferring knowledge from one individual to another by means of mentoring, training, documentation, or other collaboration; and 2) commercialization, the adoption of a technology into the private sector through a business or other organization.

NIST's technology transfer program supports two broad goals: 1) improving the transfer of NIST technology and work products; and 2) improving NIST technology transfer through collaborations. The following summarizes different technology transfer mechanisms NIST uses to promote innovation and ensure that the resulting technologies are broadly disseminated.

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

NIST Work Products and Collaborative Activities

Participation in Documentary Standards Committees

Documentary standards are shared sets of rules that specify, as examples, a test method, a product's properties or a practice. Documentary standards codify, among other things, measurement methods, standard practices, and product specifications. Econometric studies have concluded that standards contribute significantly to economic growth, and at least one study concludes 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.[14]

One mechanism used to transfer NIST measurement-science research and other technologies to market use is through participation in the development of consensus documentary standards. During FY 2014, NIST had 464 staff involved with more than 121 standards organizations. Such participation helps NIST respond programmatically to the needs of 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).[15]

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.[16]

Data evaluations conducted at NIST laboratories are supplied to NIST customers through the Standard Reference Data Program. In FY 2014, NIST SRD distributions included 3,111 e-commerce transactions, 5,142 units sold via distributor, 101 active distributor agreements, 58 active site licenses, 42, active internet subscriptions, 595 units shipped via UPS, and 3,435

[14] 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
[15] http://gsi.nist.gov/global/index.cfm/L1-1
[16] http://www.nist.gov/srd/index.cfm

products downloaded from the NIST website (1,352 free downloads, 2,83 paid downloads). NIST is currently studying SRD-related data to determine whether information regarding usage of databases is sufficiently centralized, and whether NIST can obtain comprehensive metrics for judging impact.

Table 7 – Standard Reference Data

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Standard Reference Data					
Products Available (databases)	120	120	111	120	111

Standard Reference Materials

Standard Reference Materials (SRMs) are a definitive source of measurement traceability 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 Standard Reference Materials often depend on the development of unique measurement capabilities within NIST.[17]

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

Table 8 – Standard Reference Materials

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Standard Reference Materials					
Units Available	1,283	1,177	1,298	1,299	1,281
Units Sold	31,667	32,864	33,441	32,267	32,636

Patents and Licensing

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.

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

Information on patenting and summary information on licensing is presented in Chapter 1. Additional details on licensing are included below.

Table 9 – Profile of Active NIST Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Number of Active Licenses[(a)]	40	34	36	35	36
New Licenses Executed	7	5	6	5	7
Total Invention Licenses Active	40	34	36	35	36
New Invention Licenses Executed	7	5	6	5	7
Total Patent Licenses Active[(b)]	40	34	36	35	36
New Patent Licenses Executed	7	5	6	5	7
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

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

Table 10 – Licensing Management

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
License Negotiation Time (Patent Licenses) [(a)(b)]					
Average (months)	3.0	1.9	2.9	6.0	4.0
Minimum (months)	2.0	1.0	2.4	2.3	0.23
Maximum (months)	4.0	4.5	5.5	13.5	17.3
Licenses Terminated for Cause					
Invention Licenses (Patent Licenses)	0	0	0	0	0

(a) Date of license application to date of license execution. (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 11 – Characteristics of Licenses Bearing Income

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Income Bearing Licenses	24	22	21	25	21
Exclusive Licenses	17	15	15	17	14
Partially Exclusive Licenses	0	0	0	0	0
Non-Exclusive Licenses	7	7	6	8	7
Total Income Bearing Invention Licenses (Patent Licenses)[(a)]	24	22	21	25	21
Exclusive	17	15	15	17	14
Partially Exclusive	0	0	0	0	0
Non-Exclusive	7	7	6	8	7
Total Other Income Bearing IP Licenses	0	0	0	0	0
Total Royalty Bearing Licenses	24	22	21	25	21
Total Royalty Bearing Invention Licenses	24	22	21	25	21
Royalty Bearing Patent Licenses	24	22	21	25	21
Other Royalty Bearing IP Licenses	0	0	0	0	0

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

Table 12 – Income from Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Income, All Active Licenses[(a)]	$202,216	$169,347	$146,796	$102,532	$150,995
Invention Licenses (Patent Licenses)[(b)]	$202,216	$169,347	$146,796	$102,532	$150,995
Other IP Licenses, Total Active	$0	$0	$0	$0	$0
Total Earned Royalty Income (ERI)[(c)]	$202,216	$169,347	$146,796	$102,532	$150,995
Median ERI	$3,438	$1,844	$9,971	$10,000	$6,250
Minimum ERI	$1,245	$1,500	$1,500	$640	$640
Maximum ERI	$100,000	$100,000	$64,185	$58,642	$74,575
ERI from Top 1% of Licenses[(d)]	--	--	--	--	--
ERI from Top 5% of Licenses[(d)]	--	--	--	--	--
ERI from Top 20% of Licenses[(d)]	--	--	--	--	--
Invention Licenses (Patent Licenses)	$202,216	$169,347	$146,796	$102,532	$150,995
Median ERI	$3,438	$1,844	$9,971	$10,000	$6,250
Minimum ERI	$1,245	$1,500	$1,500	$640	$640
Maximum ERI	$100,000	$100,000	$64,185	$58,642	$74,575
ERI from Top 1% of Licenses[(d)]	--	--	--	--	--
ERI from Top 5% of Licenses[(d)]	--	--	--	--	--
ERI from Top 20% of Licenses[(d)]	--	--	--	--	--
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). Not a license issue fee or a minimum royalty.
(d) Data withheld to protect proprietary information.

Table 13 – Disposition of Invention License Income

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Income Distributed[(a)]	$202,216	$169,347	$146,796	$102,532	$150,995
Invention Licenses (Patent Licenses)[(b)]					
Licensing Income to Inventor(s)	$72,157	$56,698	$61,300	$38,732	$54,602
	36%	33%	42%	38%	36%
Licensing Income to NIST	$130,058	$112,649	$85,497	$63,799	$96,393
	64%	67%	58%	62%	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 technology transfer. 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 a major collaborative mechanism for establishing joint relationships with industry, academia, and state and local governments. A CRADA is an agreement between a federal laboratory and one or more partners to collaborate on defined R&D projects. Created as a result of the Stevenson-Wydler Technology Innovation Act of 1980, as amended by the Federal Technology Transfer Act of 1986 (Pub. L. 99-502), a CRADA allows federal laboratories to participate in R&D partnerships with non-federal partners to advance promising new technologies toward commercialization.[18]

Table 14 – NIST Collaborative Relationships for Research and Development

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
NIST CRADAs[(a)]					
Total Active CRADAs	2,207	2,241	2,916	2,410	2,280
New CRADAs Executed	2,142	2,173	2,810	2,252	2,092
Total Active Traditional CRADAs	66	103	140	179	206
New Traditional CRADAs Executed	16	51	53	48	50
Total Active Non-Traditional CRADAs	2,141	2,138	2,255	2,231	2,074
New Non-Traditional CRADAs Executed	2,126	2,122	2,236	2,204	2,042
Other Type of Collaborative R&D Relationships					
Guest Scientists and Engineers[(b)]	2,897	2,899	2,782	2,963	2,981
Traditional CRADAs Involving Small Businesses	--	--	20	31	37
Total Number of Small Businesses involved in Traditional CRADAs	--	--	20	31	37
Total number of Small Businesses involved in Non-Traditional CRADAs	--	--	--	--	733

(a) CRADA = Cooperative Research and Development Agreement. 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.

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

Other Performance Measures Deemed Important

Software and Other Downloadable Products

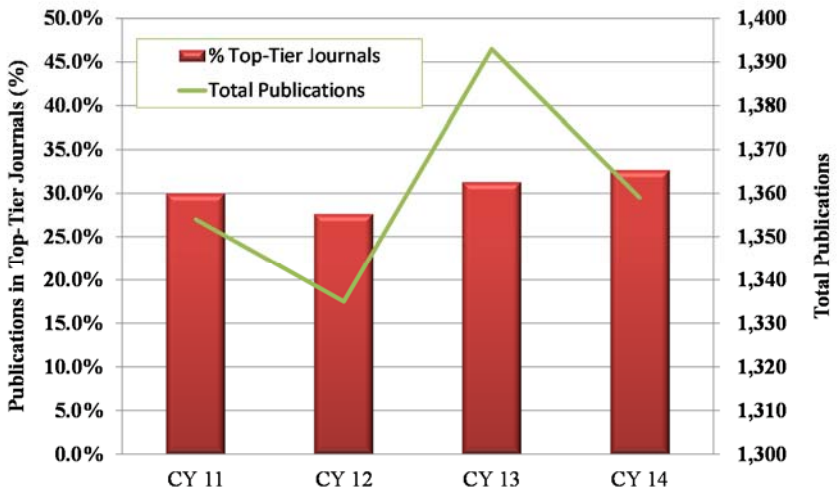
NIST provides a wide variety of application software programs, testing tools, and databases that are accessible via the Internet and available to U.S. industry, academia and other interested users. These applications are an important means of disseminating NIST research results and technical information.

NIST will explore methods for assessing significant technology transfer contribution made through downloads of NIST software and data.

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 2014, NIST staff authored 1,393 publications in peer-reviewed journals,[19] including 444 papers (32.7%) published in 102 "top tier" journals. "Top tier" is defined as any journal with a Thomson Reuters' Journal Impact Factor (IF) that falls within the top 10 percentile in its *Web of Science* Subject Category.[20]

Figure 4 – NIST Publications in Top-Tier Journals vs. Total NIST Publications



While the percentage of papers published every year in top tier journals has fluctuated since 2007, about one third of the NIST authored papers indexed in *Web of Science* are published in top tier journals each year.

In addition, NIST researchers collaborate and co-author with researchers from around the world. NIST researchers co-authored papers with 4,386 unique non-NIST authors from 1,207 unique

[19] http://nvl.nist.gov
[20] http://wokinfo.com/essays/journal-selection-process

institutions in 56 countries in 2013.[21] Table 14 summarizes the NIST publication collaboration data collected for the years 2009-2013 (the most recent data available).

Table 15 – NIST Publications (Calendar Year)

	2010	2011	2012	2013	2014
Number of NIST Papers	1,220	1,351	1,327	1,389	--
Number of Unique Non-NIST Co-Authors	3,560	4,086	4,171	4,386	--
Number of Unique Institutions	992	1,034	1,003	1,027	--
Number of Countries	62	64	54	56	--

NIST also publicizes its planned, ongoing, and recently completed work in the trade and technical press, which is typically followed by the organizations most likely to have an interest in NIST's research and services. In addition to news releases, websites and contacts with the media, NIST publishes ***Tech Beat***, a biweekly plain language newsletter of recent research results.[22]

User Facilities – Research Participants

NIST operates two unique and valuable laboratory facilities – the NIST Center for Neutron Research (NCNR) and the Center for Nanoscale Science and Technology (CNST) – for supporting U.S. industry, academic institutions, NIST laboratories, and other government laboratories. These facilities are a vibrant means by which NIST customers can tap directly into NIST measurement expertise to solve their problems. The NCNR is a national center for research using thermal and cold neutrons. Many of its instruments rely on intense beams of cold neutrons emanating from an advanced liquid hydrogen moderator. The CNST supports the development of nanotechnology from discovery to production. The CNST operates a national shared-use nanofabrication and measurement facility (the NanoFab), complemented by a multidisciplinary research staff creating next-generation tools for advancing nanotechnology.[23]

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.

Table 16 – NIST Research Participants

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
NIST Research Participants					
CNST[(a)]	970	1,402	1,669	1,885	2,086
NCNR	2,290	2,265	1,976	2,148	2,271

(a) Note: the FY 2014 Research Participant totals are preliminary. Totals will be updated and finalized in the FY 2015 TPO report.

Postdoctoral Researchers

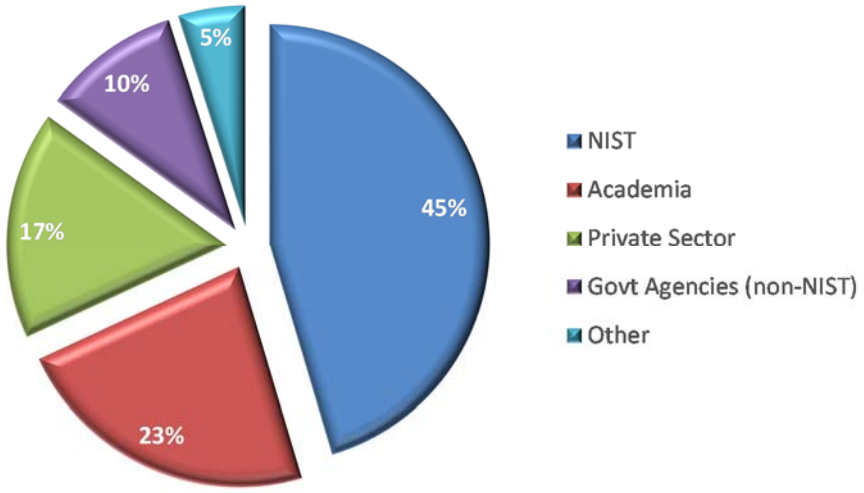
[21] Unique co-authors and institutions were identified by performing a search for all NIST authored papers in the *Web of Science (WoS)* database. This includes publications in the peer-reviewed literature but excludes most conference proceedings papers and all NIST series publications. The data is provided on a calendar year basis in order to be consistent with internal data collection practices.

[22] http://www.nist.gov/public_affairs/tech-beat/index.cfm

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

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 are therefore another important means by which NIST technology is transferred.[24] For the purpose of this report, NIST uses the National Science Foundation's description of a postdoctoral researcher[25] as one who has a temporary position taken within five years after the completion of a doctoral degree for the purpose of gaining scientific, technical, and professional skills. For FY 2014, there were 170 postdocs on the NIST campus. Postdocs are considered a measure of technology transfer because once their tenure at NIST ends they can take what they have learned at NIST and apply it to other projects outside of NIST. NIST has begun efforts to track postdocs after their initial tenure at NIST. A survey of 326 researchers, who were postdocs with the NIST NRC program between FY 2010 and FY 2014, shows that 45% stayed at NIST,[26] 23% moved to academia, 17% moved to industry, 10% moved to other government agencies, and 5% have either become independent researchers or are unemployed. As more data becomes available, NIST will employ advanced research tools, such as those utilized in the Star Metrics Program,[27] to track and evaluate the post tenure work of postdocs from NIST.

Figure 5 – Tracking Researchers after Initial Postdoc Tenure at NIST (FY 2010 – FY2014)



Guest Researchers

In addition to postdocs, each year, thousands of researchers visit NIST to participate in collaborative projects.[28] NIST hosts many term appointment researchers and non-NIST employees working as guest researchers, collaborators, and student fellows. Like postdoctoral

[24] http://www.nist.gov/iaao/postdoc.cfm
[25] http://www.nsf.gov/statistics/seind12
[26] Researchers who left their postdoc positions and stayed at NIST were either hired in career conditional / term appointments (27%) or hired in non-career conditional or as term employees, i.e. contractors or guest researchers (18%).
[27] https://www.starmetrics.nih.gov
[28] http://www.nist.gov/tpo/collaborations/guestresearchers.cfm

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. Further, these researchers ("NIST alumni") know how to collaborate with federal laboratories and what federal resources are available to assist companies in creating and developing new and improved technologies. This reflects NIST's views on technology transfer as involving "people" transferring new knowledge and innovative "things".

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.

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 calibration services are designed 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.[29]

The NIST National Voluntary Laboratory Accreditation Program (NVLAP) is a voluntary and fee-supported program to accredit private sector laboratories that are found competent to perform specific tests or calibrations, or types of tests or calibrations. Through NVLAP, NIST efficiently leverages its primary calibration services to support a broader base of secondary calibrations conducted within the private sector.[30]

Table 17 – Calibration Services

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Calibrations					
Number of Calibration Tests Performed	17,697	18,195	17,206	14,974	15,401

Education Outreach Programs and Partnerships

NIST has been recognized as a vital contributor to the efforts in improving 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;[31]
- the Summer High School Internship (SHIP) program;[32]

[29] http://www.nist.gov/calibrations/index.cfm
[30] http://www.nist.gov/nvlap/
[31] http://www.nist.gov/surfgaithersburg/index.cfm
[32] http://www.nist.gov/ohrm/staffing/ship.cfm

- the Pathways Program;[33]
- the NIST Summer Institute for Middle School Science Teachers;[34] and
- the Professional Research Experience Program (PREP).[35]

In FY 2014, there were 203 students enrolled in the SURF program, 60 students enrolled in the SHIP program, 78 students enrolled in the Pathways program, 22 students enrolled in the NIST Summer Institute for Middle School Science Teachers, and 134 students enrolled in the PREP program (83 postdocs, 33 graduate students and 18 undergraduate students).

NIST 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.

In addition, NIST jointly operates several research organizations that have been established to promote cross-disciplinary collaborations.[36] These include:

- JILA,[37] Boulder, Colorado, a world-class physics research institute jointly operated by NIST and the University of Colorado at Boulder;
- Institute for Bioscience and Biotechnology Research, Rockville, Maryland, an interdisciplinary partnership in cutting-edge biotechnology between NIST and the University of Maryland;
- Joint Quantum Institute, College Park, Maryland, a new institute for advancing quantum physics research that is jointly operated with the University of Maryland; and
- Hollings Marine Laboratory, Charleston, South Carolina, a national center for coastal ocean science, in which NIST is one of five federal, state, and university partners.

Start-ups and Young Entrepreneurial Companies

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

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.

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[33] http://www.nist.gov/ohrm/staffing/students.cfm
[34] http://www.nist.gov/iaao/teachlearn/index.cfm
[35] http://www.boulder.nist.gov/bdprepo.htm
[36] http://www.nist.gov/locations.cfm
[37] When first established by NIST and the University of Colorado-Boulder, JILA stood for "Joint Institute for Laboratory Astrophysics." At present, according to common usage, JILA simply denotes the joint NIST-UC research institute.

NIST has recently begun evaluating more than 25 young companies (existing for five years or less) that have either spun off technologies from NIST or that have receive considerable support in their core area of technical development. One company, Hexawise, Inc. a small company formed in 2009, was established to improve the efficiency and effectiveness of software testing by making powerful test design techniques accessible and easy to use. The company has adapted a software tool developed at NIST[38] which they use to provide consulting services for large IT organizations who are responsible for software test design and project management. NIST expects to eventually track the development of such companies and to assess how working with NIST enables technology transfer and promotes the economic success of start-ups and young entrepreneurial companies.

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 and streamline its SBIR program. NIST has implemented changes to administrative practices, proposal solicitation, and review process to reduce the administrative burden on small businesses and time needed to process and issue awards.

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

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 2014, the NIST Conference Program arranged for 80 conferences that attracted 9,208 researchers to NIST's facilities in Gaithersburg, Maryland and Boulder,

[38] http://csrc.nist.gov/groups/SNS/acts/index.html
[39] http://www.nist.gov/tpo/sbir/index.cfm

Colorado. NIST's Office of Weights and Measures, which promotes uniformity in U.S. weights and measures laws, regulations, and standards, trained over 1,000 weights and measures administrators, laboratory meteorologists, and field enforcement officials during FY2014.

Table 18 – Conferences, Seminars, and Workshops

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
NIST Conference Center					
Conferences and Workshops [(a)]	--	--	--	86	80
Attendance [(b)]	--	--	--	8,579	9,208
Metrology Training					
Office of Weights and Measures (Metrology Training)					
Seminars	--	--	167	446	355
Webinars	--	--	448	110	133
Workshops	--	--	--	55	30
Students	--	--	615	633	518

(a) A total of 72 conferences were held in Gaithersburg, Maryland and eight conferences were held Boulder, Colorado.

(b) A total of 7,988 attended conferences in Gaithersburg, Maryland and 1,220 attended conferences in Boulder, Colorado.

NIST will continue to retain current information on metrology training as a metric and is expanding its efforts to include additional information on OU-specific training activities that are conducted for facility users. Further, NIST staff answers e-mail, telephone, and mail inquiries from the public, including inquiries from researchers requesting information and details about NIST technical developments and research results.

Streamlining Technology Transfer

In response to the PM, NIST has undertaken several efforts to streamline and simplify the technology transfer process. NIST has performed a revision of its standard CRADA resulting in several internal updates to expedite review and reducing the overall size of the document by approximately one third. NIST has 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 will expects to identify new ways to simplify and streamline technology transfer practices.

Table 19 – Streamlining

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Streamlining Efforts					
Average Number of Days to Prepare a Patent Application[(a)]	395	410	348	401	456
CRADA Approval Time[(b)]	85	122	145	91	110

(a) The time between the date an invention disclosure was received and the date the non-provisional patent application was filed.
(b) The time between the receipt of the award memo and the time the memo was approved.

Assessing the Economic Impact of Technology Transfer

While the metrics summarized in this report demonstrate a robust use of technology transfer mechanisms, there has long been a desire to expand the type of metrics to include measures that assess the impact of federal technology transfer activities upon the economy. The 2011 Presidential Memorandum (PM) called on federal agencies to establish performance goals, metrics, evaluation methods, and implementation plans to improve the efficacy of federal technology transfer activities. In response to this directive, federal agencies have prepared and are currently implementing plans for improving the monitoring and assessment of their technology transfer operations.[40]

To facilitate access to these studies, NIST is gathering economic impact studies from each federal agency and posting them on a centralized web site.[41] This site will include past studies that agencies have performed to assess their performance and impact as well as future studies that have been performed to monitor the of changes resulting from compliance with the Presidential Memorandum.[42]

More recently, NIST has commissioned a study to assess economic impact of DNA forensic standards. Since the late 1980s, NIST scientists have been involved in DNA testing and have been engaged in research to improve measurement accuracy and quality control of forensic DNA tests. Working with the Department of Justice, NIST's Forensic Genetics Project Team has been called upon to develop standards for DNA forensic tests and technology evaluation. Their work has focused on the characterization of genetic polymorphisms and utilizes gel and capillary electrophoresis to characterization the size and sequence of polymorphisms. Among their many accomplishments, the team pioneered the use of short tandem repeat (STR) sequences for typing degraded samples and characterized new STR markers. The impact study now being prepared is designed to determine the value of NIST SRMs to the forensic DNA testing community.
NIST is also engaged in a study to develop a framework for estimating the economic impact of eliminating the technical gaps in advanced manufacturing technical infrastructure. In FY 2014,

[40] In response, federal agencies prepared plans for improving their technology transfer operations which were then submitted to the Office of Management and Budget and to the Office of Science and Technology Policy for clearance. These plans are available online at http://nist.gov/tpo/publications/agency-responses-presidential-memo.cfm
[41] The current collection of these studies can be found at http://nist.gov/tpo/publications/.
[42] Between 2000 to 2012, fourteen economic impact studies were conducted on NIST research programs. These studies show an overall return on investment ratio of approximately 36:1 The collection of these studies is available at http://nist.gov/tpo/economic-impact-studies.cfm

NIST prepared four case studies that identify industry trends, technical gaps, qualitatively discuss economic effects of technical gaps, and propose methodology for quantitative analysis.

In FY 2015, NIST will develop, field, and analyze novel survey of advanced manufacturing stakeholders. The objective of this study is to quantitatively assess and prioritize the economic impact of eliminating technical gaps in the advanced manufacturing technical infrastructure for each case study area.

Through all of these efforts, NIST will continue to improve its ability to measure and analyze the economic impact of its funding decisions and will work to remove barriers that prevent the efficient and timely transfer of technologies to industry.

Efforts to Promote Entrepreneurship

In 2014, NIST established a new 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.

In addition, NIST has established an "Entrepreneurs-in-Residence" program that brings successful technology entrepreneurs into the NIST community for seminars and private consultations with NIST staff in all matters relating to technology transfer and commercialization. This effort designates the "Entrepreneurs-in-Residence" as guest researchers who will explore and evaluate licensable technologies developed at NIST for commercialization by private firms. At present, NIST's current "Entrepreneurs-in-Residence" program is the result of a formal collaboration with the Technology Development Corporation of Maryland (TEDCO). Similar programs with other states are anticipated.

Downstream Outcomes from NIST Technology Transfer Activities

US companies commercializing NIST chip-scale atomic magnetometer technologies
Geometrics, the world leader in commercial atomic magnetometers, recently announced a Technology License and Development Agreement with leading semiconductor manufacturer Texas Instruments (TI) to develop and produce chip-scale atomic magnetometers based on technology invented by NIST. Geometrics and other companies use atom-based magnetometers for ultraprecise measurements of magnetic fields for everything from detecting concealed weapons, to locating underwater pipes and cables, to remote detection of vehicles and monitoring perimeters, to unique medical imaging of the heart and brain, and for fundamental research about the earth and other planets.

Atom-based magnetometers are among the most sensitive and accurate ways to measure magnetic fields, but have previously been relatively large, high-power devices, limiting their deployment and use in the field. NIST pioneered chip-scale atomic magnetometers about the size of sugar cube and using the equivalent of AA battery power. Geometrics and TI plan to use the NIST technology to develop commercial chip-scale magnetometers that can be deployed on unmanned aerial vehicles, made into large arrays for medical imaging, inserted into small spaces such as pipes, and for many other field applications not possible with existing large, power-hungry magnetometers. The partnership combines Geometrics' expertise in commercial magnetometer applications with TI's microfabrication capabilities.

NIST scientists consulted directly with Geometrics and Texas Instruments on the NIST technology, and the companies are also using NIST chip-scale atomic magnetometer patents that NIST placed in the public domain to encourage tech transfer. NIST scientists Drs. John Kitching (NIST Fellow), Svenja Knappe and Elizabeth Donley lead the NIST chip-scale atomic magnetometer technology development program and their accomplishments were recognized with a 2014 DOC team Gold Medal.

Mouse Cell Line Authentication
In 2013, NIST signed a Cooperative Research and Development Agreement with DNA Diagnostics Center, Inc. and has been working collaboratively with the company during 2014 to further develop NIST's mouse cell authentication technology invented by Dr. Jamie Almeida and Dr. Kenneth Cole. DNA Diagnostics Center has also obtained a non-exclusive license to commercially develop mouse cell line authentication test kits that use STR DNA technology to characterize mouse DNA. This product will provide researchers the appropriate quality control measures to ensure cell line integrity. NIST has also granted a research license to a cell biorepository so that further research can be done regarding the application of NIST's technology to cell authentication and quality control.

nSoft Consortium
In 2014, NIST extended the Cooperative Research and Development Agreements of the partners in NIST's nSoft Consortium. The consortium was started in 2012 to further NIST's mission to promote U.S. innovation and industrial competitiveness by advancing measurement science and reducing barriers for industrial research programs at peer-review based user facilities. Current partners include Chevron Phillips, Dow Chemical, DuPont, Genentech, Kimberly-Clark,

MedImmune, and Solvay. Through engagement of its partners, in the planning, development, and execution of research programs, nSoft is providing (1) predictable and timely access to neutron facilities, (2) research and development programs focused on high impact issues in soft materials manufacturing, and (3) increased scientific capacity through training programs and collaborative activities. The consortium is led by the NIST Polymers Division, featuring a long history of service to the U.S. economy through advanced characterizations of soft materials, and the NIST Center for Neutron Research (NCNR), a world leading neutron facility.

World's Smallest Reference Material is Big Plus for Nanotechnology

NIST recently issued Reference Material (RM) 8027, the smallest known reference material ever created for validating measurements of these man-made, ultrafine particles between 1 and 100 nanometers (billionths of a meter) in size.

RM 8027 consists of five hermetically sealed ampoules containing one milliliter of silicon nanoparticles—all certified to be close to 2 nanometers in diameter—suspended in toluene. To yield the appropriate sizes for the new RM, the nanocrystals are etched from a silicon wafer, separated using ultrasound and then stabilized within an organic shell.

"For anyone working with nanomaterials at dimensions 5 nanometers or less, our well-characterized nanoparticles can ensure confidence that their measurements are accurate," says NIST research chemist Vytas Reipa, leader of the team that developed and qualified RM 8027.

Silicon nanoparticles such as those in RM 8027 are being studied as alternative semiconductor materials for next-generation photovoltaic solar cells and solid-state lighting, and as a replacement for carbon in the cathodes of lithium batteries. Another potential application comes from the fact that silicon crystals at dimensions of 5 nanometers or less fluoresce under ultraviolet light. Because of this property, silicon nanoparticles may one day serve as easily detectable "tags" for tracking nanosized substances in biological, environmental or other dynamic systems.

Reliable RNA Analysis Now Easier with NIST 'Dashboard' Tool

A new, innovative "dashboard" from the National Institute of Standards and Technology (NIST) won't help you drive your car, but it will help enable reproducible research in biology.

In a recent paper in the journal Nature Communications, an international multi-laboratory team demonstrates a new software tool, the "erccdashboard," to evaluate the performance of experimental methods used to study gene expression. The analysis tool is designed for use with RNA spike-in controls developed by the NIST-hosted External RNA Controls Consortium (ERCC**). These ERCC controls are produced from the DNA Sequence Library for External RNA Controls (Standard Reference Material 2374) that was issued by the agency in 2013.

"In gene expression experiments, scientists try to understand how a cell's biological activities arise from the genetic information contained in its genome by simultaneously quantifying the thousands of RNA molecules expressed by that genome," says Sarah Munro, lead author on the Nature Communications paper.

Munro says that the validation provided by the “erccdashboard” is essential to ensure that these complex experiments are reproducible. “The results of gene expression experiments are often used in making medical decisions such as identifying which drug is best for a particular patient,” she explains. “Our new software tool gives researchers the ability to gauge the performance of their methods for any experiment, evaluate repeatability and reproducibility of experiments over time and between laboratories, and provide confidence that the results can be trusted.”

Previously, Munro says, there was no standard, technology-independent approach for analyzing the data obtained from gene expression experiments. “The ERCC control materials made the development of our new method validation tool, the “erccdashboard” possible,” she explains.

The new NIST software, Munro says, provides a simple ‘turnkey’ mechanism for biologists to assess any gene expression experiment. “Its performance metrics are designed to be independent of the type of measurement technology used for an experiment, so results can be compared as technologies improve over time,” she says. “Using the dashboard will enable reproducible research and prevent researchers from drawing erroneous conclusions from low-quality experimental data.”

Standardized Performance Testing for Emergency Response Robots

With support from the Department of Homeland Security, engineers in NIST’s Intelligent Systems Division pioneered the use of standardized performance testing for emergency response robots used in bomb-response and for urban search-and-rescue operations. Since 2005, 15 NIST tests have been adopted as standards by ASTM International, and about 40 more are under various stages of development or review. To date, more than 100 response robots, both experimental and commercial, have run the gauntlet of NIST test methods at Response Robot Evaluation Exercises and in support of robot procurements. Over the last few years, the suite of performance tests has been duplicated at sites around the United States and in Germany, Japan, and soon, Australia.

Advanced Computer Fire Modeling and Visualization Software

NIST’s Fire Research Division scientists and engineers recently enhanced the capabilities of NIST's advanced computer fire modeling and visualization software suite, the NIST Fire Dynamics Simulator (FDS) and Smokeview (SMV). This powerful suite of tools is used worldwide in research, fire investigation, firefighter training, and development of fire-protection design and standards. The just-released sixth version of the software features improved physics and more accurate numerical methods for predicting smoke concentrations and soot deposition, a new turbulence model, and other significant improvements. Since they were first issued for public use in 2000, FDS and Smokeview have proven to be a disruptive technology and the most important advance in the field of fire protection research and engineering in the last decade. In presenting the prestigious Sjölin Award to the FDS team, the International Forum of Fire Research Directors said that FDS "has become the tool of choice by both the fire research and fire engineering communities.”

Automated Fault Detection in Building Heating, Ventilating, and Air-Conditioning Systems
NIST enabled technology is now a requirement in the newest California building energy code (Title 24, Part 6), which became effective on July 1, 2014. One of the largest uses of energy in buildings is the heating, ventilating, and air-conditioning (HVAC) system. HVAC systems sometimes operate with mechanical faults and control logic errors that significantly increase the energy consumption because the problems are masked by the fact that comfort conditions are still met or nearly met. NIST researchers, supported in part by the California Energy Commission, have developed and demonstrated fault detection and diagnostic (FDD) algorithms suitable for implementation in existing building control equipment. These algorithms use data from sensors already installed in building systems to identify faults and alert building operators so that corrective action can be taken. Commercial products that implement FDD techniques based on NIST research are now available.

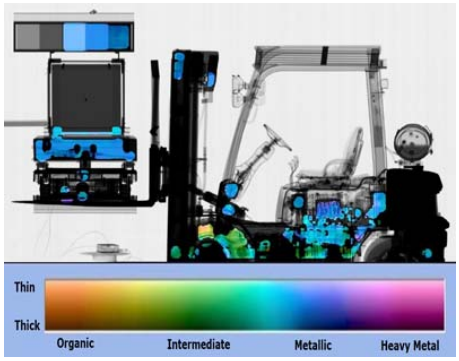
Detecting Neutrons with Light
Scientists at NIST and the University of Maryland have demonstrated that a process called "excimer scintillation" can be controlled and characterized precisely enough to serve the pressing national need to detect neutrons with high efficiency. Detecting neutrons emitted by radioactive materials is of critical importance to homeland security and counter-terrorism activities, such as screening cargo containers, as well as other vital applications in nuclear power instrumentation, workplace safety, and industry. Not surprisingly, demand for detectors has risen dramatically over the past decade.

For the past several years, Charles Clark of the PML's Quantum Measurement Division and colleagues from the University of Maryland's Institute for Physical Science and Technology have been investigating a process called excimer-based neutron detection The use of excimer scintillation – the emission of radiation from short-lived, exotic molecules created when a noble gas is excited by fission products – as an appropriately sensitive, accurate, and repeatable measure of incident neutrons. The NIST work, reported in the Journal of Applied Physics, brings a new degree of experimental control and repeatability that is available in the United States only at NIST. At NIST, the scientists were able to draw on the resources of the NIST Center for Neutron Research (NCNR), the Synchrotron Ultraviolet Radiation Facility (SURF III), and the Center for Nanoscale Science and Technology (CNST). The Maryland University Training Reactor (MUTR) was also used in the course of this work.

NIST's collaboration with the University of Maryland also contributed to the University's mission. Jacob McComb, the first author on the Journal of Applied Physics paper, received a Ph.D. in Nuclear Engineering for his work on this project, and is now employed as a nuclear engineer by the Defense Nuclear Facilities Safety Board. A patent for this invention was issued on August 26, 2014.

Better Cargo Inspection Standards at Border Crossings

As part of an Interagency Agreement between NIST and the Department of Homeland Security (DHS), PML's Radiation Physics Division recently completed a series of image quality measurements of a high-energy x-ray vehicle-screening system at a newly constructed port-of-entry near El Paso, TX.



An x-ray image showing a standard test object (upper left) held aloft by support apparatus and a forklift.

In their study, researchers compared the performance of two image quality standards – ANSI N42.26 and IEC 62523 – for cargo and vehicle screening systems. The purpose of the work was to provide feedback on the practical use of the two standards and recommend possible improvements, with a goal towards harmonization.

Key findings from the image quality tests were summarized in an interagency report to DHS. Recommendations included a design change to objects used in the IEC test, the addition of a material discrimination test method for the ANSI standard, and a provision to include blind testing to improve the objectivity in both standards.

These standards are recommendations by the American National Standards Institute (ANSI) and the International Electrotechnical Commission (IEC).

Awards

Five scientists at NIST have won major awards from the American Physical Society, the nation's largest professional organization of physicists. "These awards demonstrate not only the value of NIST research, but its breadth," says Willie May, NIST Acting Director and Acting Under Secretary of Commerce for Standards and Technology. "To have this many physicists honored in a single year shows that NIST discoveries continue to be at the vanguard of the physical sciences." NIST's winners of American Physical Society awards for 2015 are:

- Gretchen Campbell,
- Robert Celotta,
- Daniel Pierce,
- Ian Spielman, and
- John Unguris.

Three scientists from NIST's Center for Nanoscale Science and Technology have won the Joseph F. Keithley Award for Advances in Measurement Science. This award recognizes "physicists who have been instrumental in the development of measurement techniques or equipment that have impact on the physics community by providing better measurements."

- John Unguris
- Robert J. Celotta
- Daniel T. Pierce

Physicists John Kitching and Svenja Knappe of NIST’s Time and Frequency Division received 2014 Rank Prizes in optoelectronics "for the creation and demonstration of the first chip-scale atomic clock." Also sharing the prize is Leo Hollberg, who led their research group in 2004 when the chip-scale atomic clock was invented. The Rank Prizes are presented every two years by the charitable Rank Foundation in the United Kingdom. The prizes are awarded in London to individuals who have made a significant contribution to certain scientific fields, including optoelectronics, "where an initial idea has been carried through to practical applications that have, or will, demonstrably benefit mankind."

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, supporting 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, the entire enterprise is also supported by a dedicated R&D Line Office: the Office of Oceanic and Atmospheric Research.

Research across NOAA's laboratories is primarily aimed at improving 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, physical forecasts for renewable energy siting, predicting fresh water resources, tsunami warnings, air quality measurement, solar emission forecasting, monitoring and estimating of fish stocks and species health, coastal habitat monitoring and pollution, invasive species monitoring, coral reef health, ocean acidification, 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. Research results are transferred to NOAA's operational components to improve prediction, management, and other mission activities.

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, programs, and external partners.

During FY 2012, in response to President Obama's request to accelerate technology transfer out of federal labs, the NOAA Technology Partnerships Office developed a 5-Year Plan to improve technology transfer from NOAA. The following is an overview of our plan objectives, progress to plan, and planned next steps for 2015 and beyond.

Objective 1: Optimize TPO Management and Staffing Structure

The TPO is the link between internal laboratories and private sector customers. In order to provide the required level of service, the TPO reviewed staffing levels and made recommendations in 2011 for appropriate staffing.

Progress to Plan

The TPO reached recommended staffing levels in 2012 and is now operating with a Program Manager for Technology Transfer and a part-time program assistant.

Following on the 2013 report, the TPO has developed a list of technology transfer contact points within the NOAA labs and some programs. The TPO views these contacts as extension agents for the office and a focal point for information transfer between the TPO and the lab. To date, however, there is not a well-developed culture of technology transfer within the labs, and these "positions" are in the category of "other duties as assigned." As a result, the cohesion and functionality of this group is currently very low.

In response to the Cross Agency Priority (CAP) goal of developing human capital within the agency, the TPO kicked off an internal rotational assignment program for the office. The program allows staff from other parts of NOAA to learn first-hand about technology transfer, while educating the TPO staff on R&D capabilities across the agency and helping to uncover potential technologies for commercialization. The first rotational assignment was very successful, greatly increasing technology transfer communication, training, and awareness across the National Ocean Service.

Next Steps

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 recently appointed NOAA Chief Scientist to develop a corporate technology transfer strategy, policy, 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 interagency Lab to Market process and the Federal Lab Consortium to determine best practices to apply within NOAA.

Objective 2: Central Management of Patents

TPO will continue to explore the feasibility of setting aside a portion of its program funding to support patent application and ongoing patent maintenance fees. Centralized payment capabilities, as well as centralized management of NOAA patents by the TPO would reduce the administrative and cost burden on NOAA labs. The reduced cost may encourage staff to disclose their inventions to the TPO and more readily seek patent protection for new technologies. Once mature, a centralized management process would allow the TPO to develop a more robust and fair process for evaluating which new technologies have the highest licensing potential and have the greatest need for patent protection (see Action 4 below).

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. We have used this account to offset all maintenance fees and most patent filing fees in 2013-14; however, this account is

currently not included as a budget line item, so there is no guarantee funds will be available to maintain this account in the future.

Next Steps
TPO will consult with the NOAA Chief Scientist and the NOAA Chief Financial Officer to determine if TPO should include funding of this account in its annual budget request, and to determine if funding of all technology transfer fees (including attorney's fees) centrally through TPO would be a beneficial policy.

Objective 3: Programmatic Advice and Guidance
The TPO will work directly through the NOAA Chief Scientist and the NOAA Research Council for programmatic advice and guidance. 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 working through the Research Council and the Chief Scientist for guidance. The TPO has created a working group at headquarters to facilitate outreach and education, and is participating in the activities of Line Office Transition Manager Committee for NOAA. In 2014, TPO was able to accomplish some reporting of technology transfer for the Office of Oceanic and Atmospheric Research through a centralized data call provided for under NAO 216-105. This process was successful and will be repeated in 2015, which will further reduce reporting burdens on our labs.

Next Steps
The TPO will continue to work through its established network and to work through the Line Office Transition Manager Committee to ensure research to commercialization 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 their regional Federal Laboratory Consortium group.

Objective 4: Establish 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 remains low, so the TPO has not moved to establish a technology transfer review board to date. 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. The patent decisions in 2014 have been primarily based on cost-benefit considerations derived through rudimentary market assessments.

Next Steps

The TPO is working steadily to educate lab and headquarter staff on the importance of technology transfer in their work and the role of the NOAA TPO. As a part of that process, we are discovering and establishing a baseline of all NOAA technologies and innovations to be tracked. However, NOAA's technology assessment process for disclosed technologies will need to be improved in order to provide the information needed to support a technology review board. The TPO will explore requesting funding for contract support for technology assessments and/or using temporary staff or other resources (students) to perform technology assessments. 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. In 2014, we successfully trained staff at two labs in Miami, FL, multiple labs in Stennis, MS, and Boulder, CO. TPO staff were also able to provide training and outreach to three programs located in Silver Spring and one national program via video conference.

Next Steps

TPO will schedule training visits to at least two labs during 2015 and will conduct a series of brownbag seminars at the NOAA Library on technology transfer issues. The TPO is also participating in the interagency Lab to Market discussions for creating performance plan language for scientists, engineers, and managers related to technology transfer. Once the interagency working group has established recommendations, TPO will work with the Chief Scientist, the Research Council, and Workforce Management to best implement the recommendations within NOAA.

Objective 6: Increase Outreach to Industry

The TPO will conduct activities designed to better inform the public of the processes and benefits of partnering with NOAA for research and development activities. The activities will include:

- **Website Redesign**: We will redesign the TPO website to feature pending opportunities, benefits, success stories, and answers to FAQs for staff, private companies, or other entities looking to partner with NOAA.
- **Trade Show Marketing**: TPO staff will attend selected events and trade shows to meet with target audiences and distribute ORTA marketing materials.

- **Targeted Meetings**: TPO staff will 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:** TPO staff will 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 our licensing opportunities. TPO continues to update and refine its website, including enhancements to the Open Opportunities 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 our available technologies. The TPO has provided comprehensive NOAA lab information to the Federal Labs Consortium Business Portal, open license opportunities to CollectiveIP.com.[43] 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.[44]

The TPO has also undertaken a plan to work closely with state and local development offices on a regional level. In 2014, in conjunction with TPO's nation-wide SBIR program outreach, we were able to provide technology transfer opportunities to economic development offices across the nation. We will continue to reach out to this network to market NOAA's licensing opportunities.

More specifically, the TPO established a productive relationship with the Mississippi Enterprise for Technology regional development office in Stennis, Mississippi.[45] NOAA, along with NASA, other federal agencies, and universities located at Stennis, are 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.

The TPO also began work with the University of Colorado Technology Transfer Office (TTO) to establish a more robust collaborative relationship between our two offices.

TPO has worked closely with NIST on employee training and will continue to collaborate closely with their TPO for both best practices and training. In 2014, TPO worked with NIST to host a Technology Showcase of NIST and NOAA technologies at our facilities in Boulder, Colorado. The Showcase was well attended and resulted in some direct company inquiries for NOAA technologies.

[43] https://www.collectiveip.com/
[44] http://www.data.gov/
[45] http://www.mset.org/

Next Steps

The TPO will begin more direct outreach to market out opportunities in FY15. We will attend at least 3 industry trade events to meet with companies in the oceanic and atmospheric science and technology fields. The purpose of these visits will be to learn who the major players are in relevant sectors, build relationships with the appropriate decision-makers in these companies, and obtain feedback on our existing technology portfolio. Secondarily, we will are hoping these interactions will lead to license negotiations in the future.

TPO is hoping to implement a variety of programs in cooperation with the University of Colorado TTO. Specifically, we would like to establish connections between CU Business School students and scientists at the Earth System Research Laboratory to build an informal commercialization ecosystem. The program would allow students the opportunity to use real-world technologies for market assessments and possible commercialization activities.

Objective 7: Develop 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 easily track 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 have built a rudimentary internal database to house technology transfer and SBIR information. While the database is limited in its functionality, TPO staff are now able to quickly query the information and report out on the status of the NOAA intellectual property portfolio.

As with last year's report, the data call for this annual report was pre-populated with data from the database. 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, the database capabilities will need to be enhanced to improve data query and report generation. TPO will continue to with these enhancements in-house and at minimal expense while a planned NOAA-wide R&D database is completed. Eventually, we foresee including a technology transfer component into the full NOAA R&D database.

TPO will continue to explore off-the-shelf technologies which 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. To date, there has been no budget provided for this effort, so we are unable to fully comply with requirements for automated posting of intellectual property to data.gov under the Lab to Market initiative.

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 effectively monitor its performance. Individual performance results will vary even under ideal programmatic circumstances; however, taken as a whole, we believe 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

As with the previous year's report, we have included trademark filings as an anecdotal metric in this report and will continue to track new trademark filings as part of our intellectual property portfolio.

We have also maintained our 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 actually from our Cooperative Institutes (CI) and are treated as regular staff at the labs. For now, we have reported the number of CI staff receiving more than 50% of their funding from NOAA.

Facilities use agreements are not a large part of NOAA's technology transfer portfolio, but could grow in the future if NOAA labs are allowed to retain funds accrued as a result of others using our facilities. The issue of inconsistent authorities across federal R&D labs is currently being discussed as part of the interagency Lab to Market initiative. 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.

We are also gathering information on materials transfer agreements. As with facilities use, materials transfer is a smaller part of the portfolio, but one that could be tracked moving forward.

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. Materials transfer, facilities usage, and visiting scientists will all be a focus for future inclusion in this report.

In addition, we will carefully explore measures that speak to the impact of NOAA science and technology transfer. Specifically, we will look at citations on NOAA publications, not just the publications counts. We will also consider adding metrics for easily reported, but meaningful, web statistics (data downloads, number of partners using data sets or decision support tools) that demonstrate impact.

The TPO will also follow closely the efforts of interagency groups to establish meaningful measures across the Federal Government. Over the next five years, we will

adopt new measures to continue to improve our reporting at the least cost in terms of effort to our 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.

Data Products and Services

NOAA scientists provide details of their research and technology to the public in the form of information 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.

NOAA View

In November 2013, NOAA unveiled "NOAA View," an online educational tool that gives educators and the public interactive access to NOAA environmental data, enabling unique views of the world's oceans, land, atmosphere, cryosphere and climate. The NOAA View imagery portal provides a single point for experiencing NOAA data, including environmental information captured by satellites, inserted into scientific models and other data analyses.[46] Users can browse, animate and download high-resolution imagery from the NOAA Visualization Lab, making it an ideal tool for putting NOAA data into the hands of students in classrooms around the world.

NOAA View, which was developed by NOAA's Center for Satellite Applications and Research and the NOAA Visualization Lab, brings together more than 60 different sets of data, some even as far back as 1880, with new data sets being added regularly. Content is updated on a daily, weekly, monthly or annual basis as data observations and collections permit.

Examples of data contents include: wind speed, coral bleaching, ice cover, vegetation, precipitation, and views of the Earth at night. NOAA View lets users manipulate the display to change views of the world, data inputs and periods of time to observe the Earth.

NOAA's Coastal Mapping Program Offers Significant Economic Benefits

For every dollar American taxpayers spend on NOAA's National Geodetic Survey (NGS)[47] Coastal Mapping Program, they receive more than $35 in benefits, according to a 2012 independent socio-economic scoping study.[48]

[46] http://www.nnvl.noaa.gov/view/
[47] http://www.geodesy.noaa.gov/
[48] http://geodesy.noaa.gov/PUBS_LIB/CMP_Socio-Economic_Scoping_Study_Final.pdf

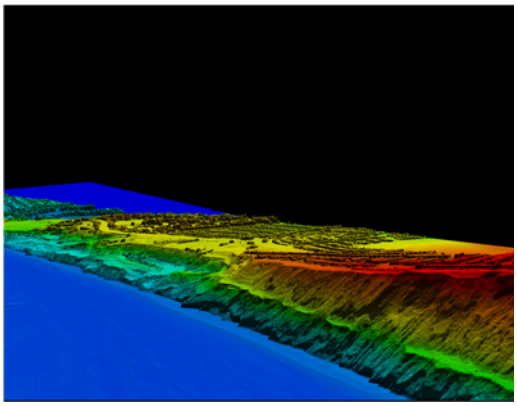
The program provides critical baseline data for accurately mapping America's official shoreline—important for national security, maritime shipping and navigation, and provides geographical reference data needed to manage, develop, conserve and protect coastal resources.

The study demonstrates the program's contributions in marine safety, geographic information, resource management, and emergency response and the wide range of economic and societal activities it supports.

Conducted by Leveson Consulting of Jackson, N.J., the study analyzed the benefits to the nation of NOAA's Coastal Mapping Program, which enhances coastal economies by providing accurate and consistent shoreline data.

Direct economic benefits of the program alone were estimated at $100 million—15 times program costs. The study estimated that NGS's Coastal Mapping Program further supports 1,500 jobs outside of the program. In addition to the economic data, the study also provides information on the program's customers and their uses of mapping data.

NOAA derives the shoreline data through various remote sensing technologies including aerial imagery, satellite imagery, Light Detection and Ranging (LiDAR), and Synthetic Aperture RADAR (SAR).



LIDAR imagery of an area south of San Francisco acquired by the NOAA aircraft. (Credit: NOAA)

Decision Support Tools

NOAA labs develop a wide variety of dedicated decision support software tools that enable the use of our data to meet specific public management and decision-support needs. In many cases these sites are developed in conjunction with academia and private sector partners.

Storm Surge Inundation Mapping Tool - SLOSH

This interactive web map allows anyone with a web browser to display a map of the near-worst case storm surge flooding scenarios.[49] With this education and awareness tool, anyone living in hurricane-prone coastal areas along the U.S. East and Gulf Coasts can now evaluate their own unique risk from severe storms. This map makes it clear that storm surge is not just a beachfront problem, with the risk of storm surge extending several miles from the immediate coastline in some areas. "You don't have to think very hard about it, just look at your location on the national map to find out if you are in an area at risk for storm surge from a future tropical storm or hurricane," said Brian Zachry, Ph.D., NHC storm surge specialist.

Cooperative Institutes

NOAA supports a network of 16 Cooperative Institutes at 41 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

[49] http://noaa.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=b1a20ab5eec149058bafc059635a82ee

NOAA scientists at NOAA labs. In 2014, over 900 researchers at the institutes received more than 50% of their funding to work on NOAA R&D projects.

NOAA Technology Partnerships Office to Partner with University of Colorado TTO
In 2014, NOAA's Technology Partnerships Office initiated discussions with the University of Colorado Technology Transfer Office to develop a collaborative technology evaluation program between at the University and the Earth System Research Laboratory in Boulder, Colorado. The proposed program would bring students to the lab to work closely with NOAA scientists and engineers to evaluate and potentially commercialize new and existing technologies. The goal of the program will be to develop an innovation ecosystem where promising new technologies can be more quickly identified and moved to commercialization. If successful, this pilot program could be expanded to other NOAA labs and cooperative institutes.

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. This effort involves 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[50]

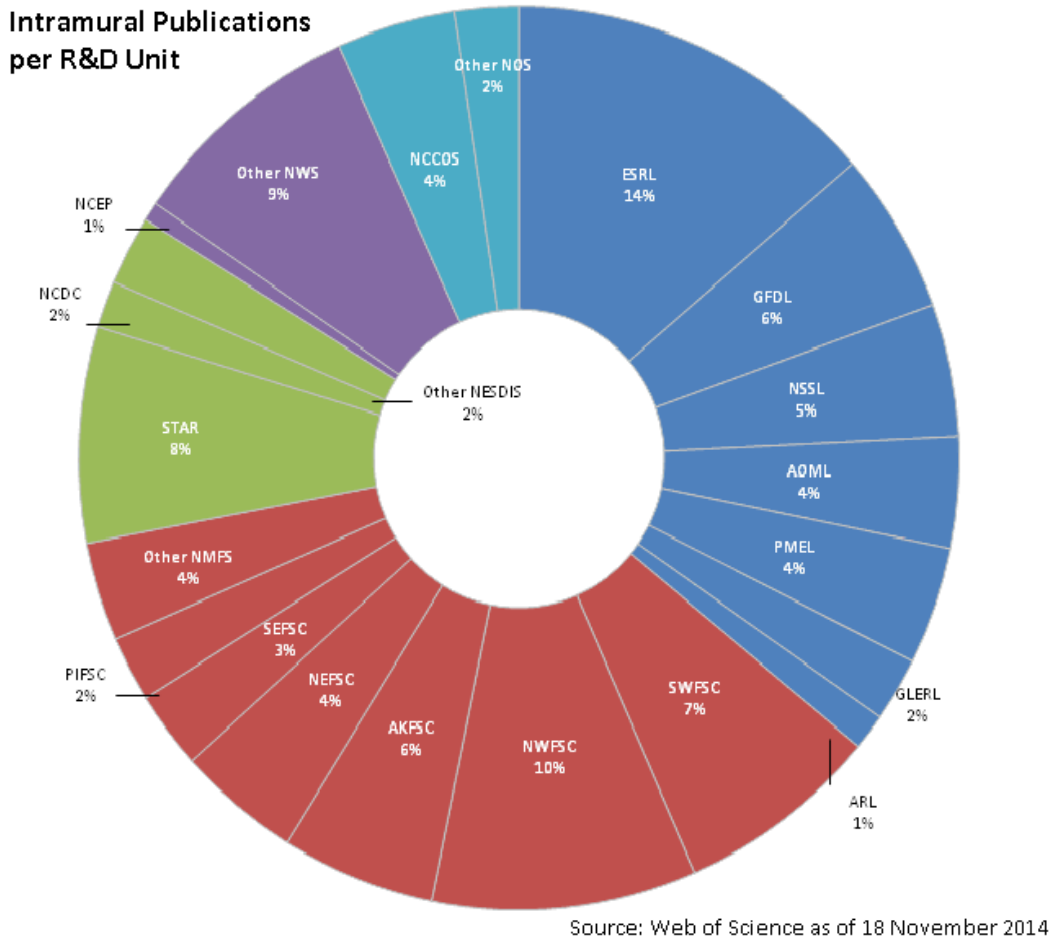
In FY 2014, peer-reviewed publications by NOAA scientists totaled 1,759. The following charts show the breakdown of publications by subject, R&D Unit, as well as co-authorship by institution and country. In the future, we hope to provide a more detailed analysis of citations for our publications to give a better sense of the impact of these publications.

Table 20 – Number of Publications per Subject (Top 10)

Subject	Publications
Meteorology Atmospheric Sciences	597
Marine Freshwater Biology	255
Environmental Sciences	251
Oceanography	206
Fisheries	174
Ecology	159
Geosciences Multidisciplinary	116
Multidisciplinary Sciences	92
Geochemistry Geosciences	63
Remote Sensing	62

[50] NOAA publications data for 2014 were derived on October 22, 2014, 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.

Figure 6 – Intramural Publications per R&D Unit



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 7 – Co-Authored Publications per Institution (top 15)

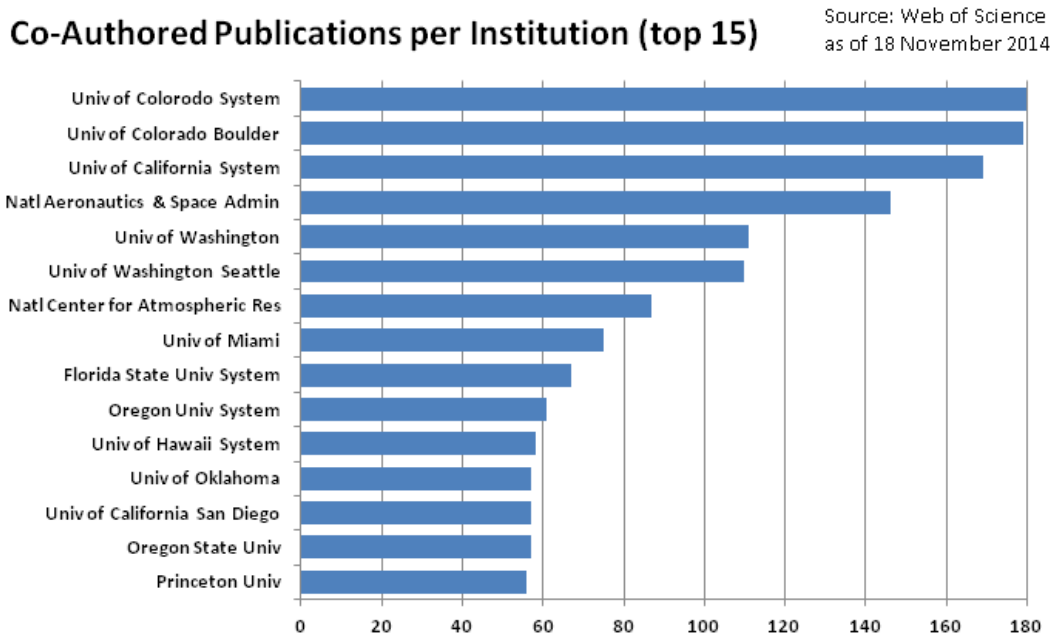
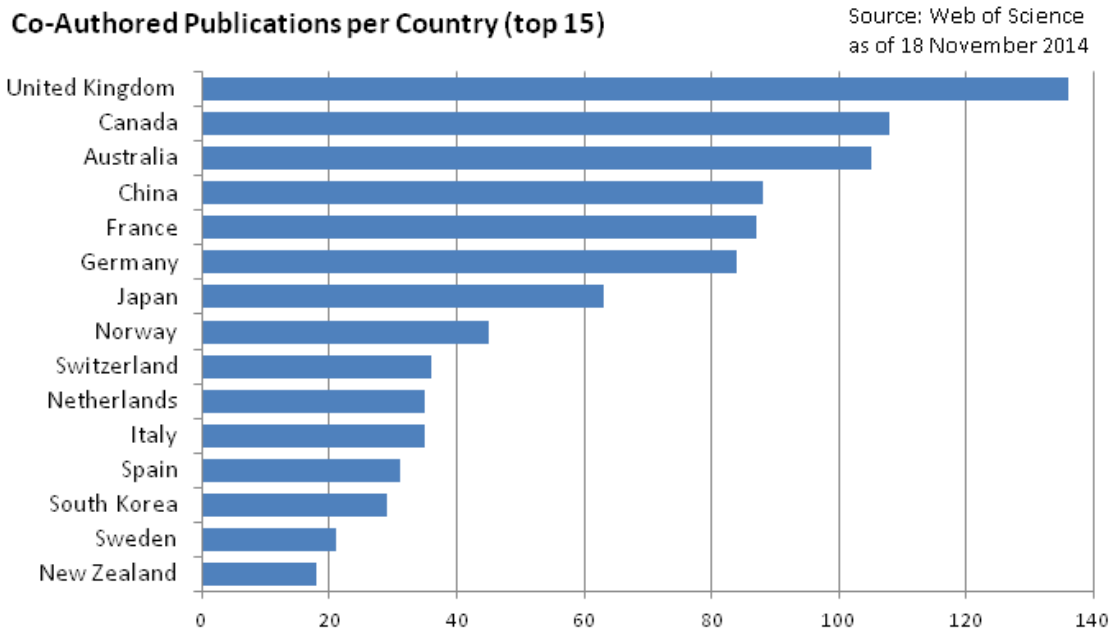


Figure 8 – Co-Authored Publications per Country (top 15)



Inventions, Patents, and Licensing

In 2014, NOAA researchers disclosed six new inventions and filed three provisional patent applications, and one full patent application. In 2014, NOAA voluntarily let one unlicensed patent expire, bringing its total issued patent portfolio (intramural and extramural) to 25. NOAA maintains five active licenses on its technologies and is actively pursuing licensing agreements on its newly patented technologies.

Table 21 – Invention Disclosure and Patenting

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
New Inventions Disclosed	1	1	0	8	6
Patent Applications Filed	1	0	1	3	4
Patents Issued	2	2	2	1	0

Trademark and Copyright

The TPO began requesting trademark data from our labs in 2013, but reporting of this information to date has been incomplete, at best. As a proxy, the TPO conducts a simple word search of the USPTO TESS database. This search has revealed a total of 125 live trademarks for NOAA products, services, and logos, as compared with a result of 82 in 2013.

With respect to copyrights, the Federal Government cannot assert copyright in our software and other written products; therefore, we rely on our cooperative institute and other partners to both assert copyright and notify the TPO of the action. To date, the TPO has not been able to accurately track these actions, so we are not providing these data in this annual report. We hope to have a more accurate tracking system for copyrights through our partners in the future. Additionally, the TPO will seek to work more closely with the Technology Transfer Offices at our Cooperative Institutes to actively license all jointly developed and copyrighted materials.

Table 22 – Trademark and Copyright [(a)]

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
New Trademarks Disclosed	--	--	--	2	0
New Copyrights Disclosed	--	--	--	0	0

(a) Trademark and copyright are new metrics NOAA is introducing for 2013. No trademarks were disclosed to the TPO, but a USPTO search revealed an increase of 43 trademarks. Copyright filings will be international or through university partners, if any.

Table 23 – Licensing Details Profile of Active Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
All Licenses, Number Total Active[(a)]	6	6	5	5	5
New, Executed	0	0	0	0	0
Invention Licenses, Total Active	6	6	5	5	5
New, Executed	0	0	0	0	0
Patent Licenses,[(b)] Total Active	6	6	5	5	5
New, Executed	0	0	0	0	0
Material Transfer Licenses Total Active[(c)] (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

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.

(a) "Active" means an agreement in force at any time during the fiscal year. NOTE: the FY 2013 license figure was inaccurately reported in the previous report. The figure has been corrected to show 5 active licenses.

(b) NOAA does not distinguish between invention license and a patent license (patent license would include patent *applications* that are licensed with a one-time license only with one-time flat fee royalty). The numbers reported for both invention and patent licenses are the same licenses.

(c) NOAA is not currently tracking MTAs and related agreements.

Table 24 – Licensing Management

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Elapsed Execution Time,[a] Licenses Granted					
Invention Licenses					
Average, Months	7	7	7	7	7
Minimum	--	--	--	--	--
Maximum	--	--	--	--	--
Patent Licenses [b]					
Average, Months	7	7	7	7	7
Minimum	--	--	--	--	--
Maximum	--	--	--	--	--
Licenses Terminated for Cause					
Invention Licenses	0	0	0	0	0
Patent Licenses [b]	0	0	0	0	0

Data included in this table (intentionally) addresses only invention licenses, with patent licenses distinguished as a sub-class.

No new licenses were executed in FY 2008, FY 2012, or FY2013.

(a) 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.)

(b) NOAA does not distinguish between invention license and a patent license (Patent license would include patent *applications* that are licensed with a one-time license only with one-time flat fee royalty). The numbers reported for both invention and patent licenses are the same licenses.

Table 25 – Characteristics of Licenses Bearing Income

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
All Income Bearing Licenses, Total Number	4	3	3	5	5
Exclusive	0	0	0	0	0
Partially Exclusive	0	0	0	0	0
Non-Exclusive	4	3	3	5	5
Invention Licenses, Income Bearing	4	3	3	5	5
Exclusive	0	0	0	0	0
Partially Exclusive	0	0	0	0	0
Non-Exclusive	4	3	3	4	5
Patent licenses,[(a)] Income Bearing	4	3	3	5	5
Exclusive	0	0	0	0	0
Partially Exclusive	0	0	0	0	0
Non-Exclusive	4	3	3	5	5
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,[(b)] Total Number	4	3	3	5	5
Invention Licenses, Royalty Bearing	4	3	3	5	5
Patent Licenses, Royalty Bearing	4	3	3	5	5
Other IP Licenses, Royalty Bearing	0	0	0	0	0
Copyright Licenses (Fee Bearing)	4	3	3	0	0

In general, license income can result from various sources: license issue fees, earned royalties, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee including patent costs.

(a) NOAA does not distinguish between invention license and a patent license (Patent license would include patent *applications* that are licensed with a one-time license only with one-time flat fee royalty). The numbers reported for both invention and patent licenses are the same licenses.

(b) Note that royalties are one component of total license income.

Table 26 – Income from Licenses

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Total Income, All Licenses Active [(a)]	$35,044	$107,220	$100,867	$48,798	$69,151
Invention Licenses	$35,044	$107,220	$100,867	$48,798	$69,151
Patent Licenses [(b)]	$35,044	$107,220	$100,867	$48,798	$69,151
Other IP Licenses, Total Active	$0	$0	$0	$0	$0
Copyright Licenses	$0	$0	$0	$0	$0
Total Earned Royalty Income (ERI) [(c)]	$35,044	$107,220	$100,867	$48,798	$69,151
Median ERI	$5,000	$34,000	$9,902	$11,000	$13,830
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
Maximum ERI	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 1% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 5% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 20% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
Invention Licenses	$35,044	$107,220	$100,867	$48,798	$69,151
Median ERI	$5,000	$34,000	$9,902	$11,000	$13,830
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
Maximum ERI	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 1% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 5% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 20% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
Patent Licenses	$35,044	$107,220	$100,867	$48,798	$69,151
Median ERI	$5,000	$34,000	$9,902	$11,000	$13,830
Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
Maximum ERI	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 1% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 5% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
ERI from Top 20% of Licenses	$17,044	$69,000	$89,965	$36,798	$50,000
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) NOAA does not distinguish between Invention License and a Patent License (Patent license would include patent *applications* that are licensed with a one-time license only with one-time flat fee royalty). The numbers reported for both Invention and Patent licenses are the same licenses.

(c) "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 27 – Disposition of License Income

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Income Distributed [(a)]					
Invention Licenses, Total Distributed	$35,044	$107,220	$100,867	$48,798	$69,151
To Inventor(s)	$14,514	$34,266	$35,331	$16,740	$22,845
	41%	32%	35%	34%	33%
To Other	$20,530	$72,954	$65,536	$32,058	$46,306
	59%	68%	65%	66%	67%
Patent Licenses, [(b)] Total Distributed	$35,044	$107,220	$100,867	$48,798	$69,151
To Inventor(s)	$14,514	$34,266	$35,331	$16,740	$22,845
	41%	32%	35%	34%	33%
To Other	$20,530	$72,954	$65,536	$32,058	$46,306
	59%	68%	65%	66%	67%

Invention licenses are the chief policy interest regarding disposition of income; content of table reflects this focus.

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

(b) NOAA does not distinguish between Invention License and a Patent License (Patent license would include patent *applications* that are licensed with a one-time license only with one-time flat fee royalty). The numbers reported for both Invention and Patent licenses are the same licenses.

Cooperative Research and Development Agreements, MOUs, and Other Collaborations

NOAA's labs executed eight new Cooperative Research and Development Agreements (CRADAs) in 2014, one agreement concluded, and another was deemed inactive, bringing the total reported NOAA CRADA portfolio to 19 active agreements. The Labs have additionally reported 50 MoU and Other Collaborative R&D Agreements:

- 8 Guest Researcher agreements,
- 41 Memoranda of Understanding
  - 8 International
  - 4 US Private
  - 26 Interagency/State
  - 3 Academia
- 1 Special Studies Agreement.[51]

CRADA with Trimble Navigation Ltd for Global Positioning System Meteorology (GPS-Met) Commercialization

The Global Positioning System Meteorology (GPS-Met) observing system project in the Earth System Research Laboratory Global Systems Division (ESRL/GSD) develops and assesses techniques to measure atmospheric water vapor amounts using ground-based GPS receivers. Estimates of the total column precipitable water (TPW) are assimilated into National Weather Service operational weather prediction models and used to fill observation gaps in weather satellite products generated by National Environmental Satellite Data and Information Service.

[51] Prior to 2013, the NOAA Technology Partnerships Office (TPO) has only tracked CRADA data. The TPO continues to request MoU information to provide a more comprehensive view of the collaboration portfolio. These data are preliminary, so they are not included in the official metrics section below. Once data are validated over the course of two or more reporting periods, we may revise our metrics to include MoU data.

Assimilation of these water vapor or precipitable water estimates has been shown to significantly improve the accuracy of hourly weather forecasts.

Under terms of the CRADA with Trimble Navigation Limited, ESRL/GSD will collaborate in joint research and development activities to evaluate, refine, and improve Trimble's capability to estimate both GPS zenith signal delay (ZTD) and TPW. Ideally, this CRADA will result in the successful implementation of the technology within the private sector leading to an on-going purchase of ZTD/TPW estimates by NOAA. Thus far Trimble has successfully processed observations from a limited set of GPS-Met sites demonstrating that it can provide the same accurate data as the ESRL/GSD system. In FY15, long-term tests will be conducted using more sites located in significantly different meteorological environments.

Increasing the rate of transition of lab technologies to the private sector is a stated goal of the Obama Administration under the new Lab to Market Cross Agency Priority Goal. ESRL's use of the CRADA to facilitate the transition of technologies that are not yet market ready is an excellent example for other NOAA labs to follow in the future.

Table 28 – Collaborative Relationships for Research and Development

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Traditional CRADAs,[a] Total Active[b]	6	7	10	15	19
New, Executed	2	2	4	7	8
Non-Traditional CRADAs, Total Active	0	0	0	0	0
New, Executed	0	0	0	0	0
Other Types of Collaborative R&D Relationships[c]					
MOUs	--	--	--	14	50

(a) CRADA = Cooperative Research and Development Agreement. 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) "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).

(c) Second year reporting of "Other" figures. Data will need multiple years of reporting to normalize.

Other Performance Measures Deemed Important

Challenges/Prizes
NOAA is not currently leading any challenges/prizes, but is actively participating in the White House Nutrient Challenge and the Wendy Schmidt Ocean Health X-Prize.

Facilities Use
NOAA labs do not currently have the authority to retain funds received for use of NOAA facilities, which has limited NOAA's participation in this form of technology transfer; however, NOAA does regularly engage with the private sector and academia through its testbeds and proving grounds.

NOAA Testbeds
NOAA's testbeds and proving grounds facilitate the transition of promising research capabilities to operational implementation through development testing in testbeds, and pre-deployment testing and operational readiness/suitability evaluation in operational proving grounds.[52] 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.

NOAA-Funded (Extramural) R&D

NOAA Sea Grant
The NOAA Sea Grant Model integrates research and outreach (including extension, communication, and education) for science with real world impacts. Sea Grant takes a multi-faceted approach to outreach through programs of education, extension, and communication. Specialists in each of these areas translate research into usable information and products for many audiences, ensuring that scientific information is delivered to those who need it, and in ways that are relevant.

Maryland Sea Grant Oyster Research leads Hatchery to Produce 1.2 Billion Spat for Aquaculture and Restoration
The state of Maryland has dedicated considerable resources to restoring oysters to the Chesapeake Bay. The estuary's oyster populations declined dramatically beginning in the 1950s as a result of overfishing and disease. The loss contributed to worsening water quality in the Bay and its tributaries and has deprived commercial watermen in Maryland of income.

Efforts to restore oyster populations are expected to provide habitat for fish and other animals, help to reduce nutrients and sediments in the estuary, and enhance the Maryland economy. Both wild oyster restoration projects and aquaculture businesses, however, require a supply of oyster shell and larvae in order to build new reefs and stocks.

[52] http://www.testbeds.noaa.gov/

The Horn Point Oyster Hatchery, directed by Maryland Sea Grant Extension Program's shellfish aquaculture specialist in partnership with government agencies and non-governmental organizations, is among the largest operations of its kind on the East Coast of the United States. Using new methods and technologies, the hatchery produces spat on shell -- oyster larvae that have attached to shells. The hatchery's partners use this oyster spat to seed or supplement restored oyster reefs in the Chesapeake Bay and its tributaries.

Regional oyster aquaculture growers also need large numbers of spat to produce the next generation of oysters at their growing sites. MDSG's aquaculture specialist directed the production of 1.2 billion spat on shell in 2013 at the Horn Point Oyster Hatchery, a record number. Additionally, the hatchery sold $113,000 worth of oyster shell to aquaculture enterprises in the state. To help reduce start-up costs for new aquaculture enterprises, the hatchery also donated spat valued at $156,000 to regional oyster aquaculture growers.

Crab Cake Success Keeps NC Processor in Business

North Carolina seafood processors need to develop value-added products in order to meet consumer demand while also competing with imported seafood that is cheaper but often of lower quality. A North Carolina crab processor came to North Carolina Sea Grant's seafood technologist in about 2006 for help in developing a retail line of crab cakes based on the flavor profile of a classic recipe. NC Sea Grant assisted with testing for commercial-scale production, as well as sensory panels. This included identifying ingredients and the respective sources. This effort resulted in the new product that continues to be widely available via seafood vendors and at least one grocery store.

The processor reports that the crab cake has kept the company going, including about 60 seasonal jobs. The price point is approximately $2 per cake wholesale. The company is producing about 1,000 crab cakes per day in season. To conservatively estimate 75 production days, that would be $150,000 per year. Additional profits are reaped by the next-level distributors, as the cakes are known to go for $5 each in some metro markets. Thus the total economic value of the product would be about $225,000 annually. Based on the crab cake success, the company has requested to again work with NC Sea Grant to develop new products in 2014-15.

Education and Outreach

National Weather Festival

The annual National Weather Festival highlights the many weather related organizations and activities in central Oklahoma. Visitors can view the National Weather Center's premier facilities including National Weather Service forecast operation areas.

This unique event features hourly weather balloon launches with local TV meteorologists, emergency response vehicle and equipment displays, LEGO® models and robots demonstration, children's activities, and weather related information and products.

Adopt a Drifter Program
Through the NOAA Adopt a Drifter Program, kids are learning about ocean currents in real time, as scientists collect and analyze ocean data.

First, drifting buoys are deployed from ships at sea. As they are carried along ocean currents, "drifters" measure and transmit sea surface temperature data and positioning coordinates via satellite for about 400 days. Students follow their adopted drifter and analyze the sea surface temperature data in their classrooms as it's posted online. The data are then used by both ocean scientists and students to track warm and cold currents.

Understanding where and how fast the warm and cold currents are flowing is useful in several ways. It helps provide more accurate weather forecasts, track oil spills, and learn where drifting plants, animals, and migrating species travel.

Adopt a Drifter is science in action – giving kids an inside view of how the ocean connects us all.

Downstream Outcomes from NOAA Technology Transfer

NOAA Funding Expands Uses of Commercial Environmental Sample Processor

The Environmental Sample Processor (ESP) provides *in situ* robotic collection and analysis of subsurface water samples for harmful algae, their toxins and other microrganisms. Funding from NOAA's National Centers for Coastal Ocean Science, Center for Sponsored Coastal Ocean Research (CSCOR) supports agency and partner expansion of the utility of the ESP, which was initially developed by the Monterey Bay Aquarium Research Institute (MBARI),[53] CSCOR sponsored projects are piloting ESP deployments to advance operational harmful algal bloom forecasting in the Gulf of Maine,[54] Puget Sound,[55] and Southern California Bight.[56] Other CSCOR funding is reducing ESP production costs and increasing its robustness under field conditions.[57] In October 2014 McLane Research Laboratories, Inc. was licensed by MBARI to manufacture, sell, and service the ESP.[58]

New Coastal Survey Technique Aids Coastal Managers and Navigation
After Tropical Cyclone (later termed Hurricane) Arthur roared up the coast of North Carolina and Virginia this summer, NOAA's National Geodetic Survey began flying survey missions to

[53] http://www.mbari.org/esp/
[54] http://coastalscience.noaa.gov/projects/detail?key=137
[55] http://coastalscience.noaa.gov/projects/detail?key=148
[56] http://coastalscience.noaa.gov/projects/detail?key=152
[57] http://coastalscience.noaa.gov/projects/detail?key=118
[58] http://www.mclanelabs.com/news_article/mclane-sells-esp-direct-researchers

take aerial photographs to document damage, erosion, and potential impacts to navigation. This collection of coastline imagery, now available online, employs new photographic techniques that NGS experts expect will lead to better post-storm surveys in the future.[59] For the first time, NGS surveyors collected oblique imagery, or images taken at an angle rather than straight down. The advantage to this type of approach is that it allows the team to photograph a wider area and also improves the visibility of vertical structures, such as the sides of buildings, as opposed to only the tops of buildings as typically seen in traditional imagery. This new layered approach provides better visual context than the imagery gathered by surveyors in past missions.

In the aftermath of events such as hurricanes, data contained in NOAA aerial photos provide emergency and coastal managers with the information they need to develop recovery strategies, facilitate search-and-rescue efforts, identify hazards to navigation and HAZMAT spills, locate errant vessels, and provide documentation necessary for damage assessment through the comparison of before-and-after imagery.

NOAA Space Weather Data and Products in Commercial Enterprises

The American Commercial Space Weather Association (ACSWA) is an association of companies that promotes space weather risk mitigation for critical national infrastructure related to national daily life, economic strength, and national security.[60] ACSWA, in conjunction with its member companies, is playing a vital role by identifying important data and technology gaps that can be filled by private or government actions and by developing value-added products and services for the benefit of human and property safety as well as for vibrant commerce.

Websites that display NOAA data

- www.Spaceweather.com
- www.spaceweathertext.com
- www.Space.com
- www.spaceweatherlive.com
- www.Spacew.com
- www.spaceweatherphone.com
- www.thewatchers.adorraeli.com
- www.spaceref.com
- www.talkspaceweather.com
- www.spacewx.com
- www.nwra.com/spawx/
- www.hamqsl.com/solar.html

[59] http://storms.ngs.noaa.gov/storms/arthur/oblique/index.html
[60] http://www.acswa.us/

Honorable mention to the following not-for-profit web site

- www.SolarHam.net

Smartphone Apps

- SpaceWX
- SWx Monitor
- Solar Monitor
- ASTRA Space Weather
- AFFECTS

Offshore Mariculture Monitoring Program

Catalina Sea Ranch is developing the "First Open Ocean Shellfish Ranch in United States Federal Waters" pursuant to NOAA's new aquaculture policy.[61] This project will create jobs and help reduce our nation's $10 billion seafood deficit.

Globally, filter-feeding bivalve shellfish are key players in ecologically sustainable aquaculture in the marine environment and as environmentally sensitive monitors and water purifiers. Shellfish are successfully farmed throughout the world and represent a legitimate use of the marine environment for sustainable food production.

In the United States, NOAA announced its national aquaculture policies establishing a framework to allow sustainable domestic aquaculture to contribute to the U.S. seafood supply. There is an emphasis on sustainable marine aquaculture through a “National Shellfish Initiative” for increasing shellfish farming and restoration.

The data from this 100-acre project will provide science-based solutions for marine spatial planning in a sustainable and responsible manner that protects the environment. NOAA has also provided a NOMAD buoy, which will be anchored in the middle of Catalina Sea Ranch. The 20x10x7 foot 16,000-pound aluminum boat-shaped hull can endure severe sea conditions for 24/7 real-time environmental monitoring and security protection.

[61] http://www.catalinasearanch.com/Catalinasearanch.com/Monitoring.html

Awards and Recognition

Climate.gov wins two Webby Awards and a People's Voice Award in 2014
NOAA's Climate.gov website was selected by the International Academy of the Digital Arts & Sciences to receive two Webby Awards in the "Government" and "Green" categories. They also garnered a People's Voice Award in the "Green" category (placing second overall in the "Government" category).

NOAA Technology Transfer Awards
NOAA selected four projects to receive the Agency's Technology Transfer Award in 2014. These projects exemplified the highest standard for developing a new technology in cooperation with private sector partners in the service of NOAA's mission.

- **Ralph Ferraro, Limin Zhao, Robert Kuligowski, and Donna McNamara, National Environmental Satellite, Data, & Information Service**
  For greatly increasing the usefulness of state-of-the-art NOAA polar satellite information to the television broadcast community.

- **James Farr, National Ocean Service**
  For providing the chemical industry, first responders, and emergency planners with comprehensive access to critical chemical compatibility predictions.

- **Frances VanDolah, National Ocean Service**
  For the commercialization and regulatory approval of NOAA biotechnology ensuring the safety of U.S. shellfish and reducing impediments to international trade.

- **Petrus Tans, Oceanic and Atmospheric Research**
  For developing and successfully transferring the revolutionary AirCore technology to industry to aid the collection of air samples with exceptional data resolution.

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 are undertaken for and with 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 2014, 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, 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 have been achieved through CRADAs. These have aided U.S. efforts to rapidly 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 in the Public Safety Communications Research (PSCR) program with the NIST Communications Technology Laboratory (CTL). PSCR is focused on improving 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) became operational, PSCR's research scope has expanded to supporting FirstNet's work toward creation of a nationwide broadband wireless network dedicated to public safety agencies through RDT&E of equipment that may be used to both build the network and communicate over it.

The vast majority of CRADAs ITS has entered into in the past four 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) in order to test interoperability of public safety communications equipment under simulated field conditions, with the participation of public safety practitioners. At the close of FY 2014, 51 CRADAs were in place under this program. The CRADAs protect the intellectual property of vendors and manufacturers, encouraging 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 29 – Collaborative Relationships for Research and Development

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
CRADAs					
Number of Active CRADAs	41	32	62	81	60
Number of Newly Executed CRADAs	15	17	30	30	0
Active CRADAs with Small Businesses Involvement	--	--	--	17	12
Number of Small businesses Involved in Active CRADAs	--	--	--	17	12
Traditional CRADAs					
Active Traditional CRADAs	29	23	60	81	60
Newly Executed Traditional CRADAs	9	10	28	30	14
Non-Traditional CRADAs[(a)]					
Active Non-Traditional CRADAs	12	9	2	0	0
Newly Executed Non-Traditional CRADAs	6	7	2	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.

Other Performance Measures Deemed Important

Technical Publications

Publication has historically been the means through which ITS has transferred research results to other researchers, the commercial sector, and government agencies. Many of ITS technical publications—both internal reports and monographs and peer-reviewed articles in external scientific journals—have become standard references in several telecommunications areas. Technical publication remains 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). Approximately one-third of the publications released through the ERB process in FY 2014 were approved for external publication in scientific journals or conference proceedings and two-thirds were published as NTIA reports. At one time, only official NTIA publications were counted, but recently it became apparent that journal articles and conference papers have equal, and sometimes greater, reach in transferring new tools and discoveries, and now all publications are being counted.

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. Changes in the Internet environment, in particular an explosion in the number of "bot hits," have rendered the "hit" and "page view" metrics unreliable, inflated, and meaningless. Therefore, in the first quarter of FY 2013, ITS implemented the more accurate metric of actual PDF downloads of publications. In FY 2014, ITS technical publications were downloaded 7,707 times, a 7% increase over the prior year.

Table 30 – Technical Publications and Downloads

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Technical Publications Released	12	15	13	24	18
Technical Publications Downloaded	--	--	--	7,174	7,707
Consumer Digital Video Library Users Downloading	--	242	187	418	184
Video Quality Metric Software Users Downloading	--	--	--	591	685
Propagation Modeling Software Downloads	--	--	--	--	717
Other Software/Data Downloads	--	--	--	--	489

Consumer Digital Video Library users downloading clips

In FY 2010, ITS began development of the Consumer Digital Video Library, a web site hosted and maintained by ITS that provides researchers access to high quality, uncompressed video clips royalty-free for use in video processing and video quality 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 1000 clips and clips continue to be added by ITS and other collaborators. Over 2,000 different video clips were downloaded from the library in FY 2014; 360 of those were downloaded at least 15 times each. 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 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
Since FY 2008, ITS no longer licenses software technology. Instead, software is made available via open-source download. Therefore, no licensing metrics are reported.

Software and Data Downloads
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. VQM downloads were reported for the first time in FY 2013 and other downloads are 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. Propagation prediction algorithms are freely shared through publication. 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, and some data sets that can be used to test and validate propagation prediction models are also available. 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 on the ITS web site, as well as a variety of other sample clips for audio quality testing.

Video Quality Measurement Software
ITS video quality measurement software tools use an objective video quality measurement method, which has been made a national standard by ANSI, to estimate the quality of video impairments, providing users an inexpensive alternative to viewer panels for testing new transmission technologies In FY 2014, 685 users downloaded the VQM software, a 16% increase over the prior year. The Web-Enabled Subjective Test (WEST) software package facilitates gathering subjective testing data from multiple locations and multiple portable or computing devices. This software is also freely available for download.

Development of Telecommunication Standards[62]
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 and sound, and as 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 conducted at ITS. Also, key national quality-of-service standards developed under the American National Standards Institute (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 2014, ITS staff held 36 positions on 30 different bodies in six standards development organizations. ITS staff filled numerous key leadership positions in the ITU-R, including the U.S. Chair of SG3, International Chair of SG3 Working Party 3K, and U.S. Chair or Co-chair of four other Working Parties and one Correspondence Group. An ITS staff member is also U.S. Chair of ITU-T Study Group 9. 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 substantially shaped the 17 technical contributions on various engineering issues and subject areas submitted by the U.S. during the 2014 ITU-R Study Group 3 meetings. In particular, ITS engineers volunteered to lead the Correspondence Group on Building Entry Loss. This group is critical to LTE deployment across the world and represents millions, if not billions of dollars, in potential commercial development.

Intense participation by ITS staff in the 3GPP standards development process on behalf of FirstNet resulted in Proximity Services and Group Communications requirements being included in the final agenda for 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 a prerequisite to allowing FirstNet to offer mission-critical voice (MCV) on the new Band Class 14 nationwide interoperable public safety communications network when these capabilities become available.

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[62] 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.

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

- In FY 2014, several companies used the Table Mountain site under a CRADA to safely test and demonstrate LADAR technologies under development in atmospheric conditions and at distances relevant to potential applications, to fully test the functionality of new antenna designs during product development, and to safely and accurately test an Adaptive Tactical Laser System (ATLAS) compensated beacon adaptive optics (CBAO) system under development.
- For the past eight 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 fourteenth 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
Both CDVL and the VQM tools are used by industry and academia for research into new techniques for transmitting video. The clips may be used to test codes, to evaluate new display technologies, or for validation testing of 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 facilitates accelerated development of testing for emerging LTE broadband equipment specific to public safety. The PSBB Demonstration Network was established in the ITS labs in FY 2010 by the Public Safety Communications Research program. This network provides a central and independent test bed/laboratory to help public safety 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 First Responder Network Authority (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 technology partnering activities originating from DOC's federal laboratories. Federal research is a complex process that provides the opportunity for new ideas and innovations to achieved 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 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 created by the Department's federal laboratories.