Annual Report on Technology Transfer:
Approach and Plans, Fiscal Year 2012 Activities and Achievements

U.S. Department of Commerce

Report prepared by:

National Institute of Standards and Technology
National Oceanic and Atmospheric Administration
National Telecommunications and Information Administration
Institute for Telecommunication Sciences

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) 2012. At the 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)) process 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.

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 2008 through FY 2012.

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 the Department of Commerce's (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 to 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 numerous areas of fundamental and advanced science and technology at the National Institute of Standards and Technology (NIST), the laboratory facilities of the National Oceanic and Atmospheric Administration (NOAA), and the National Telecommunications and Information Administration's (NTIA's) Institute for Telecommunication Sciences (ITS). Technology transfer is a key part of the programmatic activities in each of these agencies' Federal laboratories. Technology transfer is about connecting the technological advances from DOC's science and engineering programs to the American economy.

In addition to the technology transfer efforts of DOC's own laboratories, DOC is responsible for coordinating technology transfer activities across Federal agencies. Through NIST, DOC coordinates the Interagency Workgroup for Technology Transfer (IAWGTT),[1] which facilitates interagency discussion on policy, new approaches to technology transfer, and lessons learned from agency technology transfer programs. NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer, the 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 coordination role was further expanded by the October 21, 2011 Presidential Memorandum – *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses* (PM).[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 R&D investments. The PM directs that agencies with Federal laboratories take actions to establish goals and 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

[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

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 the establishment of 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 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. § 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/programs/tech_transfer/

[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 2008 – FY 2012

This annual report provides comprehensive statistics on the technology transfer activities of DOC Federal laboratories.[4] This information covers invention disclosures, intellectual property (patents/licenses), collaborative relationships for research and development, and other technology transfer mechanisms. This report also highlights examples of successful downstream results (e.g., commercially significant technologies) from these technology transfer activities.

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, Section 25.5. The tables below present the required data.

Invention Disclosure and Patenting

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
New Inventions Disclosures Prepared					
NIST	40	36	30	25	52
NOAA	0	5 (1)	4	1	0
ITS	0	0	0	0	0
Department Total	40	41 (1)	34	26	52
Patent Applications Filed					
NIST	18	19 (1)	19 (1)	17 (1)	20
NOAA	3	1	1	0	1
ITS	0	0	0	0	0
Department Total	21	20 (1)	20 (1)	17 (1)	21
Patents Issued					
NIST	2 (1)	7	10 (1)	13 (1)	11
NOAA	1	0	1 (1)	2	1
ITS	0	0	0	0	0
Department Total	3 (1)	7	11 (1)	15 (1)	12

(1) Reflects a correction of data previously reported.

[4] Note that numerical values from past years have fluctuated for a variety of reasons. Notices of revisions are retained to avoid confusion. The latest annual report will provide the most accurate estimates of available data.

Licensing – Profile of Active Licenses[1]

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● All Department of Commerce licenses	29	40	46[2]	40[2]	41
Patent licenses					
NIST	23	33	40[2]	34[2]	36
NOAA	6	7	6	6	5
ITS	0	0	0	0	0
Other invention licenses					
ITS	0	0	0	0	0

(1) "Active" means an agreement in force at any time during the fiscal year.
(2) Reflects a correction of data previously reported.

Characteristics of Licenses Bearing Income

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Total income-bearing licenses					
Department	25	27	28[1]	25[1]	24
Patent licenses					
NIST	21	22	24[1]	22[1]	21
NOAA	4	5	4	3	3
ITS	0	0	0	0	0
License types (exclusive, partially exclusive, or non-exclusive)					
NIST	14, 0, 7	15, 0, 7	17, 0, 7[1]	15, 0, 7[1]	15, 0, 6
NOAA	0, 0, 4	0, 0, 5	0, 0, 4	0, 0, 3	0, 0, 3
ITS	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
Department	14, 0, 11	15, 0, 12	17, 0,11[1]	15, 0,10[1]	15, 0, 9

(1) Reflects a correction of data previously reported.

Income from Licensing

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Total licensing income					
Department	$292,647	$335,889	$237,259	$276,567	$247,663
NIST	$223,640	$197,445	$202,216	$169,347	$146,796
NOAA	$69,007	$138,444[1]	$35,043	$107,220	$100,867
ITS	$0[2]	$0	$0	$0	$0

(1) Increase is attributed to a license for NOAA's Science on a Sphere for a one-time royalty of $75,000.
(2) ITS no longer licenses Video Quality Metric (VQM) technology. This software is available free of charge via open-source download.

Collaborative Relationships for Research and Development

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
CRADAs[1]					
Department	2,390	2,397	2,254[2]	2,280[2]	2,934
Traditional CRADAs					
NIST	121	65[3]	66	103[4]	140[5]
NOAA	4	5	6	7	10
ITS	6	31	29	23	60[5]
Department	131	101	101	133	156[5]
Non-traditional CRADAs					
NIST	2,224	2,284	2,141[2]	2,138[2]	2776
ITS	35[6]	12	12	9	2
Department	2,259	2,296	2,153	2,147	2778

(1) 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.
(2) Reflects a correction of data previously reported.
(3) Decrease is attributed to successful conclusion of multi-party CRADA Consortiums.
(4) Increase is attributed to new multi-party CRADA Consortiums.
(5) NIST and ITS together are involved in 54 Public Safety 700 MHz Broadband Demonstration Agreements. The Department total for Traditional CRADAs reflects these shared agreements.
(6) In 2008, ITS removed some of its telecommunication analysis services from the Web. These services provided network-based access to research results, models, and databases supporting applications in wireless system design and analysis. As a result, there was a significant decrease in the number of CRADAs between the government and industry that allowed for improvement to these models. ITS is working on a newer geographic information system (GIS)-based platform for the modeling services, which will be available in the future.

The Department's technology transfer activities include more than CRADAs, patenting, and licensing. Technology transfer is also accomplished through technical publications, technical support development for industrial standards and reference materials, other public dissemination such as meetings and workshops, and opportunities for guest researchers, post-doctoral fellows, students and other collaborating professionals from across the world to participate in Federal laboratory activities. Details on these activities and other agency-specific information are provided in the agency-specific chapters that follow.

CHAPTER 2

National Institute of Standards and Technology

Approach and Plans for Technology Transfer

The 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 improve 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.

NIST's technology transfer activities are designed to disseminate the Institute's fundamental research results and its 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, to maintain high levels of collaboration with organizations and people with diverse capabilities, and to have highly specialized facilities and tools. For more than a century, NIST's laboratories have successfully collaborated with others to provide the measurement techniques and technical tools needed by America's innovators.[5]

In order to implement the PM, the NIST Director established the NIST Technology Transfer Policy Committee (hereinafter, the Committee) and directed it to develop a more comprehensive definition of technology transfer, and to identify improvements to processes and metrics that would more accurately capture the full impact of our scientific enterprise. The Committee, comprised of senior NIST management, reviewed definitions of technology transfer used by NIST, other agencies, and the Federal Laboratory Consortium, and recommended the following new, broader definition of technology transfer for NIST to reflect the realities of the many ways that NIST reaches external partners:

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

NIST's new, broader definition of technology transfer is meant to reflect the many means by which NIST is transferring technology. The Committee recognized that the definition includes,

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

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.

The Committee reviewed NIST's policies governing formal, statutory means of technology transfer and discussed the many other means by which NIST transfers technology to benefit the Nation. The Committee discussed the need to encourage and facilitate formal mechanisms of technology transfer when these best suit the mission of NIST and the mission of its Operating Units (OUs). The Committee also advocated collecting measures of informal collaborations, when appropriate, as these are no less significant to NIST's mission.

Finally, the Committee reviewed metrics currently collected for the DOC's annual Technology Transfer report, as well as metrics that were described by representatives of the OUs in meetings with the NIST Technology Partnerships Office (TPO). Whenever possible, the metrics will be synchronized with metrics collected by NIST's other reporting requirements to allow consistency in NIST reports and to reduce the burden of information collection.

The Committee's recommendations supported two broad goals: 1) improving the transfer of NIST technology and work products; and 2) improving NIST technology transfer through collaborations. Specific metrics were recommended to evaluate progress towards these goals.

The following summary highlights the many different technology transfer mechanisms that NIST uses to promote innovation and ensure that the resulting technologies are broadly disseminated. Proposed changes recommended by the Committee are discussed below and the resulting changes will be included beginning with the FY 2013 annual DOC Technology Transfer Report.

1. NIST Technology and Work Products

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. The econometric work reviewed and evaluated by Swann (2010) [6] led that author to several conclusions. Among those conclusions: development of standards are 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.

NIST's participation in the development of consensus documentary standards is one of the mechanisms used to transfer NIST measurement-science research and other technologies to market use. NIST has nearly 400 staff involved with more than 100 standards organizations. NIST participation helps NIST respond programmatically to needs of the private sector and

[6] Peter Swann, G.M., Report for the UK Department of Business, Innovation, and Skills (BIS), 2010 http://www.bis.gov.uk/assets/biscore/innovation/docs/e/10-1135-economics-of-standardization-update.pdf

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). (See: http://gsi.nist.gov/global/index.cfm/L1-1)

The NIST Standards Coordination Office (SCO) maintains the Standards Committee Participation Database for employees to self-report their involvement, and 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 to creating new documentary standards and the maintenance of the Nation's catalog of 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 made at NIST laboratories, and are critically evaluated for accuracy and reliability. NIST's SRD databases cover many areas of science, including analytical chemistry, atomic and molecular physics, biotechnology, and materials sciences. (See http://www.nist.gov/srd/index.cfm)

NIST's data evaluations are supplied to NIST customers through the Standard Reference Data Program. NIST plans to study SRD-related data to determine whether information regarding usage of databases is sufficiently centralized, and whether more comprehensive metrics for judging impact can be obtained.

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.
(See: http://www.nist.gov/srm/index.cfm)

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.

Patents and Licensing

NIST actively seeks to identify commercially valuable inventions that result from its research. A NIST Patent Review Committee 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 and licenses and additional information, such as the age and size of companies licensing NIST technologies and the number of jointly-owned inventions.

Software and Other Downloadable Products
NIST provides a wide variety of application software programs, testing tools, and databases that are accessible over 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 how to better reflect the significant technology transfer contribution made through downloads of NIST software and data be implemented by creating a NIST-wide group to exchange effective practices and study appropriate metrics for assessing the impact of NIST published software.

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. NIST staff authored more than 1,300 publications in peer-reviewed journals in FY2012. (See: http://nvl.nist.gov/)

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. (See: http://www.nist.gov/public_affairs/tech-beat/index.cfm)

2. NIST Collaborations

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. The legal authority for CRADAs was created by the Federal Technology Transfer Act of 1986 (Pub. L. 99-502) with the aim of encouraging Federal laboratories to participate in R&D partnerships to advance promising new technologies toward commercialization. (See: http://www.nist.gov/tpo/collaborations/crada.cfm)

NIST will expand beyond the number of CRADAs into a comprehensive metric that encompasses the broad range of NIST formal and informal collaborations by (i) developing a definition of a credited "collaboration," (ii) developing processes and procedures to capture

credited collaborations, and (iii) conducting a feasibility study on whether impact data can be generated.

User Facilities – Research Participants
To support U.S. industry, academic institutions, NIST's own laboratories, and other government laboratories, NIST operates two unique and valuable laboratory facilities – the NIST Center for Neutron Research (NCNR) and the Center for Nanoscale Science and Technology (CNST). These facilities are a vibrant means by which NIST customers 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. (See: http://www.nist.gov/user-facilities.cfm)

The metric currently reported is the number of those who are registered in the NIST Associates database to be on the NIST campus to use the two User Facilities. For a variety of reasons, this metric currently undercounts both the utilization and direct impact of the facilities. Alternatively, the User Facilities have for many years used the "number of Research Participants" as a fundamental measure of their productivity. NIST User Facility "Research Participants" are those who directly participate in an NCNR experiment or CNST project. Participants include those who use the facility on-site or remotely, and their collaborators on the experiment or project. NIST will change the metric to "number of Research Participants."

Postdoctoral Researchers
Technology transfer involves not only inventions, innovations, data, patents and licenses, but also "people." Postdoctoral researchers, or "postdocs," working at NIST are therefore another important means by which NIST technology is transferred. (See: http://www.nist.gov/iaao/postdoc.cfm)

NIST will include post-NIST employment information as an additional technology transfer metric. The National Science Foundation's (NSF's) description of a postdoctoral researcher position as a temporary position taken after the completion of a doctorate … as a period of apprenticeship for the purpose of gaining scientific, technical, and professional skills,"[7] combined with the NRC-NIST's stipulation of there being five years since the Ph.D. was awarded, will be used to define this type of position.

Guest Researchers
In addition to postdocs, each year thousands of researchers visit NIST to participate in collaborative projects. (See: http://www.nist.gov/tpo/collaborations/guestresearchers.cfm). NIST hosts many term appointment researchers and non-NIST employees working as guest researchers, collaborators, and student fellows. As with postdoctoral researchers, many guest researchers will seek career opportunities in academia, the private sector, or the Federal

[7] National Science Board, Science and Engineering Indicators 2012, http://www.nsf.gov/statistics/seind12/

government agencies once their tenure at NIST ends. 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 individual takes to new careers and new employers these skills, knowledge and a desire to employ them in innovative ways. Moreover, these "NIST alumni" bring to their new employers knowledge of how to collaborate with Federal laboratories and knowledge of Federal resources that are available to assist companies as they create and develop new and improved technologies. This focus on NIST alumni reflects NIST's view that technology transfer involves "people" transferring new knowledge as well as innovative "things."

NIST will significantly expand the relevant information mined from existing sources of information and will study the linkages between these data and other metrics.

Start-ups and Young Entrepreneurial Companies
NIST has several different means by which it and its Joint Institutes nurture young companies, including "start-ups," in high-growth technology areas.

NIST will develop a list of NIST-related start-up and NIST-related young technology companies by end of first quarter of FY2014. NIST will explore ways to gauge the effectiveness of NIST's support of these young entrepreneurial companies. Such metrics, with inclusion of anecdotal information, are anticipated to include tracking the development of these companies over time.

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's 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 provide the basis for private sector companies that provide commercial calibration services and calibration equipment. (See: http://www.nist.gov/calibrations/index.cfm)

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. (See: http://www.nist.gov/nvlap/)

STEM Education
NIST has been recognized[8] as a vital contributor to encouraging and supporting the Nation's efforts in science, technology, engineering and mathematics (STEM) education. 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:

[8] The Federal Laboratory Consortium (FLC) gave its 2013 award for excellence in the support of STEM education to Dr. Mary Satterfield, a scientific advisor in the Material Measurement Laboratory at NIST.

- the Summer Undergraduate Research Fellowship (SURF) program (See: http://www.nist.gov/surfgaithersburg/index.cfm);
- the Summer High School Internship (SHIP) program (See: http://www.nist.gov/hrmd/staffing/ship.cfm);
- the NIST Summer Institute for Middle School Science Teachers (See: http://www.nist.gov/iaao/teachlearn/index.cfm); and
- the Professional Research Experience Program (PREP) (See: http://www.boulder.nist.gov/bdprepo.htm).

NIST provides student and post doc fellows with information on the use of science by industry, including co-sponsoring a career fair with other agencies and with Rockville Economic Development, Inc., located near the NIST Gaithersburg campus in Rockville, Maryland.

In addition, NIST jointly operates several research organizations that have been established to promote cross-disciplinary collaborations. (See: http://www.nist.gov/locations.cfm) These include:

- JILA,[9] 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.

Over the past five years, approximately 6,000 students have participated in NIST Seminars. In FY 2012, approximately 1,200 students participated in over 60 NIST measurement and documentary standards seminars. These seminars were taught by scientists from other national metrology institutes, officials from U.S. Federal agencies, weights and measures officials from state governments, laboratory staff from U.S. industry calibration laboratories, and middle-school science teachers. In addition to laboratory and classroom courses, NIST offers special webinars to participants.

NIST will retain STEM education activities as a metric. STEM education metrics will be expanded to include SURF, SHIP, and the Pathways Program.

Small Business Innovation Research (SBIR)

NIST's Small Business Innovation Research (SBIR) program provides funding to small high technology U.S. firms. The program offers qualified small businesses the opportunity to propose

[9] 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.

innovative ideas that meet specific NIST research and development needs, and have the potential for commercialization. (See: http://www.nist.gov/tpo/sbir/index.cfm)

NIST will take the following steps to improve and streamline SBIR practices. These changes to administrative practices and to proposal solicitation and review practices will reduce the administrative burden on small businesses and will reduce the time needed to process and issue awards.

1. Streamlining administrative practices to reduce the administrative burden on small businesses and reduce the time needed to process and issue awards.
2. Reducing the number of topics and subtopics to balance the work required to obtain proposals and increase 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, Workshops, and Inquiries

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. 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.

NIST will retain current information on metrology training as a metric and will expand that to include additional information on OU-specific training activities that are routinely conducted for facility users.

Assessing the Economic Impact of Technology Transfer

As a Federal research organization, NIST provides a wide range of public goods and services that would otherwise be inadequately provided or not be provided at all by private sector sources. While such public sector investments in areas of measurement science, standards and innovative technology solutions are deemed to be critical for the Nation's sustained economic security and growth, there is a continuing need to demonstrate the value of NIST's investments.

NIST regularly assesses the downstream impact of its research projects and technologies. NIST utilizes a diverse, yet complementary, set of performance indicators and measures to evaluate its programmatic performance over time. NIST's performance evaluation system accommodates the Institute's diverse products, and addresses the intrinsic difficulty of measuring the results of

Federal investments in scientific and technological products and services. NIST evaluates its performance and plans its work with assistance from peer reviews and other forms of external assessments including customer surveys and independent economic impact studies. From 2000 to 2012, 14 economic impact studies were conducted on NIST research programs. These studies were overseen by Dr. Gregory Tassey, Senior NIST Economist, and show an overall return on investment ratio of approximately 36:1. Additional details on NIST economic performance measures are available online at http://www.nist.gov/director/planning/impact_assessment.cfm.

NIST also reports its performance through Department of Commerce Government Performance and Results Act of 1993 (GPRA) documents, and the NIST Financial Statements.

NIST has established the Economic Analysis Office (EAO) to manage the development of prospective and retrospective economic impact studies that evaluate the effectiveness of NIST's investments.

EAO will:

1. establish data collection methodologies and make recommendations to NIST management regarding efforts to improve the collection of technology transfer metrics;
2. establish criteria to evaluate the feasibility of performing economic impact studies;
3. investigate novel sources of research data such as the National Science Foundation's Star Metrics project[10] and other methods that quantitatively analyze technical publications; and
4. develop training materials that explain how economic data are gathered, how the results of economic impact studies should be interpreted, and how these studies can be used to justify public sector investments in R&D.

EAO will commission a series of studies to assess economic impact utilizing the wider range of technology transfer metrics identified in this report and will initiate novel attempts to measure the broad impacts of critical outputs, such as standard reference materials, standards committee participation, CRADA participation, etc. These studies will begin during the initial years of the proposed five-year plan.

Working closely with staff from the NIST laboratories and building on ongoing analytic efforts by the Standards Coordination Office, NIST management will increase the regularity with which it implements lessons learned from these studies. In addition, NIST will engage with other bureaus within the Department of Commerce that have analytic capabilities and relevant responsibilities, such as the Economic and Statistics Administration (ESA) and the Patent and Trademark Office (PTO). NIST will also continue to engage with, participate in, and benefit from the work conducted by other Federal agencies and non-federal stakeholders, such as the Association of Public and Land-grant Universities (APLU) and the Association of University Technology Managers (AUTM), that are expanding the measurement and analysis of the impacts associated with university-based technology transfer.

[10] Julia Lane and Stefano Bertuzzi, 'The STAR METRICS Project: Current and Future Uses for S&E,' National Science Foundation, September 8, 2011.

Along with providing an effective response to the PM, NIST's efforts will address the Office of Science and Technology Policy's request to support the development and use of the "Science of Science Policy Roadmap" that calls on agencies to work together to develop new tools, methods, data, and data infrastructure to help science and technology policy-makers make better decisions.[11]

Through all of these efforts, NIST will 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.

[11] National Science and Technology Council, November 2008.

Additional Details in FY 2012

Pursuant to the reporting requirements of the Technology Transfer Commercialization Act of 2000 and other relevant legislation, NIST provides the following data on its transfer of knowledge and technology to the private sector. The data provide collaborative relationships for research and development (CRADAs and other kinds of relationships), invention disclosures, patenting, and licensing. The data also include other technology transfer mechanisms utilized by the NIST laboratories, e.g., Standard Reference Materials, Standard Reference Data, technical publications produced, calibration tests, and guest researcher collaborations.

Collaborative Relationships for Research and Development

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
CRADAs[1]					
Total Active[2] CRADAs	2,345	2,349	2,207	2,241	2,916
New CRADAs executed	1,577	1,492	2,142	2,173	2,810
Total Active Traditional CRADAs	121	65[3]	66	103[4]	140
New Traditional CRADAs executed	12	19	16	51[4]	53
Total Active Non-traditional CRADAs	2,224	2,284	2,141[5]	2,138[5]	2,776
New Non-traditional CRADAs executed	1,565	1,473	2,126[5]	2,122[5]	2,757
Other types of collaborative R&D relationships					
Guest scientists and engineers [6]	2,816	2,828	2,897	2,899	2,782
Traditional CRADAs involving small businesses (new metric in FY2012)	--	--	--	--	20

(1) 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.
(2) "Active" means an agreement in force at any time during the fiscal year. "Total active" includes all agreements executed under CRADA authority (15 U.S.C. 3710a).
(3) The decrease in CRADAs is attributable to the successful conclusion of multi-CRADA Consortiums.
(4) The increase in CRADAs is attributable to new multi-CRADA consortiums.
(5) Reflects a correction of data previously reported.
(6) "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.

Licensing Details
Multiple inventions included 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 counted as copyright licenses.

Profile of Active Licenses

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Total number of active licenses [(1)]	23	33	40	34	36
New licenses executed	2	11	7[(2)]	5[(2)]	6
Total invention licenses active	23	33	40	34	36
New invention licenses executed	2	11	7[(2)]	5[(2)]	6
Total patent licenses active [(3)]	23	33	40	34	36
New patent licenses executed	2	11	7[(2)]	5[(2)]	6
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	0	0	0	0	0
(non-inventions)					
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
New Licenses issued to small businesses (New metric for FY2012)	--	--	--	--	2

(1) "Active" means an agreement in force at any time during the fiscal year.
(2) Reflects a correction of data previously reported.
(3) Patent licenses include licenses to pending patent applications.

Licensing Management

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
License negotiation time[1] Invention licenses (Patent licenses) [2]					
Average (months)	10.5[3]	4.8	3.0	1.9	2.9
Minimum (months)	3.0[3]	3.0	2.0	1.0	2.4
Maximum (months)	18.0[4]	7.0	4.0	4.5	5.5
Licenses terminated for cause					
Invention licenses (Patent licenses)	0	0	0	0	0

(1) 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.)
(2) Patent licenses include licenses to pending patent applications.
(3) Numbers reflect an increase in income-bearing licenses, which take longer to negotiate than non-income bearing research licenses.
(4) Reflects a correction of data previously reported.

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).

Characteristics of Licenses Bearing Income

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Total income bearing licenses	21	22	24[1]	22[1]	21
Exclusive licenses	14	15	17[1]	15[1]	15
Partially exclusive licenses	0	0	0	0	0
Non-exclusive licenses	7	7	7	7	6
Total income bearing Invention licenses (Patent licenses)[2]	21	22	24	22	21
Exclusive	14	15	17	15	15
Partially exclusive	0	0	0	0	0
Non-exclusive	7	7	7	7	6
Total Other income bearing IP licenses	0	0	0	0	0
Total royalty bearing licenses [3]	21	22	24	22	21
Total royalty bearing invention licenses	21	22	24	22	21
Royalty bearing Patent licenses	21	22	24	22	21
Other royalty bearing IP licenses	0	0	0	0	0

(1) Reflects a correction of data previously reported.
(2) Patent licenses include licenses to pending patent applications.
(3) Royalties are only one component of total license income.

Income from Licenses

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Total income, all licenses active [1]	$223,640	$197,445	$202,216	$169,347	$146,796
Invention licenses (patent licenses) [2]	$223,640	$197,445	$202,216	$169,347	$146,796
Other IP licenses**,** total active	0	0	0	0	0
Total Earned Royalty Income (ERI) [3]	$223,640	$197,445	$202,216	$169,347	$146,796
Median ERI	$20,000	$15,625	$3,438	$1,844	$9,971
Minimum ERI	$640	$320	$1,245	$1,500	$1,500
Maximum ERI	$100,000	$100,000	$100,000	$100,000	$64,185
ERI from top 1% of licenses[4]	--	--	--	--	--
ERI from top 5% of licenses[4]	--	--	--	--	--
ERI from top 20% of licenses[4]	--	--	--	--	--
Invention licenses (Patent licenses)	$223,640	$197,445	$202,216	$169,347	$146,796
Median ERI	$20,000	$15,625	$3,438	$1,844	$9,971
Minimum ERI	$640	$320	$1,245	$1,500	$1,500
Maximum ERI	$100,000	$100,000	$100,000	$100,000	$64,185
ERI from top 1% of licenses[4]	--	--	--	--	--
ERI from top 5% of licenses[4]	--	--	--	--	--
ERI from top 20% of licenses[4]	--	--	--	--	--
Other IP licenses, total active	$0	$0	$0	$0	$0

(1) 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.
(2) Patent licenses include licenses to pending patent applications.
(3) "Earned royalty" 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.
(4) Data withheld to protect proprietary information.

Disposition of Invention License Income

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Income distributed [1] Invention licenses (patent licenses) [2]	$223,640	$197,445	$202,216	$169,347	$146,796
Licensing income to inventor(s)	$75,140 (34%)	$66,757 (34%)	$72,157 (36%)	$56,698 (33%)	$61,300 (42%)
Licensing income to NIST	$148,500 (66%)	$130,688 (66%)	$130,058 (64%)	$112,649[3] (67%)	$85,497 (58%)

(1) Income includes royalties and other payments received during the fiscal year.
(2) Patent licenses include licenses to pending patent applications.
(3) Reflects the redistribution of $1,500 of license income to the National Institutes of Health.

Other Performance Measures Deemed Important by the Agency

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Standard Reference Materials (SRMs) available [(1)]	1,282	1,283	1,283	1,177	1,298
Standard Reference Materials (SRMs) units sold [(2)]	33,373	29,769	31,667	32,864	33,441
Standard Reference Data (SRD) titles available [(3)]	102	120	120	120	111
Number of calibration tests performed [(4)]	25,944	18, 609	17,697	18,195	17,206
Technical publications in peer-reviewed journals[(5)]	1,271	1,463	1,243	1,210	1,335

(1) Direct and verifiable count of SRMs available to customers at the close of the fiscal year. The number of SRMs available for sale illustrates the breadth of measurements supported by NIST. Over time, NIST expects slight growth in the number of SRMs available.
(2) Direct and verifiable count of NIST SRM units sold during the fiscal year. In recent years, NIST had been expecting a continuing slight decline in the number of SRM units sold.
(3) Direct and verifiable count of SRD products developed and disseminated by NIST. Of the titles currently available, about 40% are available for sale, and 60% are free online systems. Over time, a larger percentage of SRDs will be distributed via the Internet.
(4) Calibration tests performed by the NIST laboratories.
(5) Annual number of NIST's technical publications appearing in scientific peer-reviewed journals.

Downstream Outcomes from NIST Technology Transfer Activities

700 MHz Public Safety Broadband Demonstration Network CRADA Consortia
Public safety agencies have long struggled with effective cross-agency radio communications due mainly to incompatible systems and non-contiguous spectrum assignments. But newly enacted Congressional legislation will soon make broadband spectrum in the 700 MHz band available to public safety, allowing for a unified system that would foster nationwide roaming and interoperability.

In support of this effort, NIST, through its Public Safety Communications Research Program (PSCR) and in collaboration with NTIA and the Department of Homeland Security's (DHS's) Office for Interoperability and Compatibility (OIC), has built a 700 MHz Public Safety Broadband Demonstration Network, which provides manufacturers and first responders a location for early deployment of their systems in a multi-vendor, neutral host environment. Emergency responders can see how these broadband systems will function and determine through hands-on experience whether these systems meet their unique needs.

This new public safety broadband communications network will allow for a unified system to foster nationwide roaming and interoperability.

NIST Releases Two New SRMs for Monitoring Human Exposure to Environmental Toxins
NIST, in collaboration with the Centers for Disease Control and Prevention (CDC), has developed two new Standard Reference Materials (SRMs) for measurements of human exposure to environmental toxins. Used as a sort of chemical ruler to check the accuracy of tests and analytic procedures, the new reference materials (SRMs 2668 and 3668) replace and improve

older versions, adding measures for emerging environmental contaminants such as perchlorate, a chemical that the Environmental Protection Agency has targeted for regulation as a contaminant under the Safe Drinking Water Act.

Because sample collection is non-invasive and the test results reflect exposures as recent as two days, urine is preferred for clinical diagnostics and monitoring of toxic environmental chemicals. Once collected, samples are frozen while they await testing.

In order to generate comparable results among tests, best practices in clinical chemistry require that a reference material should closely mimic how a specimen would respond to these tests. The best way to achieve such close resemblance is to make the physical, chemical and biological properties of the reference material match those of the specimen as closely as possible to the specimen.

In addition to NIST, the CDC, Mayo Clinic and the New York State Department of Health made certification measurements of the two SRMs to ensure their relevance for the intended applications. The development of SRMs 2668 and 3668 reflects NIST's commitment to continually improve chemical metrology to improve the health of the Nation.

NIST Standard Available for Better Diagnosis, Treatment of Cytomegalovirus

A new clinical SRM from NIST will help health care professionals more accurately diagnose and treat cytomegalovirus (CMV), a common pathogen that is particularly dangerous for infants and persons with weakened immune systems.

CMV is found in 50 to 80 percent of the population. It is a member of the herpes family of viruses that includes two herpes simplex viruses (the causes of cold sores and genital herpes), the varicella-zoster virus (the cause of chicken pox and shingles) and the Epstein-Barr virus (the cause of mononucleosis). Like its cousin herpes viruses, CMV generally remains latent in an infected person unless certain conditions trigger its activation. CMV poses a significant health risk to people who are immunocompromised (such as organ transplant patients or cancer patients undergoing chemotherapy) and to babies who receive the virus from their mothers before birth. Congenital CMV infections cause more long-term problems and childhood deaths than many other prenatal disorders including fetal alcohol syndrome, Down syndrome and neural tube defects such as spinal bifida.

If a CMV infection becomes dangerous, antiviral agents can be used to moderate the impact. Unfortunately, many of these compounds are toxic, so a physician must know the severity of the infection—a measure known as viral load (number of virus copies per microliter of blood)—to prescribe the optimal dosage and duration of treatment. The current means of measuring viral load is to use polymerase chain reaction (PCR)—the standard technique for "amplifying" or making multiple copies of a DNA segment or molecule—to amplify a region of the CMV gene and then use a calibration curve to estimate the number of virus particles in the original sample. Accuracy of these measurements can vary greatly from one test facility to another as there are many different PCR protocols used to determine viral load, including commercial and "in-house" (privately developed) laboratory assays.

The new NIST reference, SRM 2366, addresses the variability problem by providing a standardized CMV DNA. Consistency of the viral DNA in the standard was ensured by manufacturing it in *Escherichia coli* bacteria. Each of these recombinant *E. coli* cells contains a copy of the CMV genome in a "DNA construct"—an artificially constructed segment of nucleic acid that codes for a specific product, in this case, CMV DNA. The DNA copies made by this *E. coli* cell culture "factory" can then be purified and quantified using digital PCR. SRM 2366 consists of three solutions, each with a specific concentration of CMV DNA copies per microliter: 420; 1,702; and 19,641. These are designed to qualify prepared calibration samples (known as calibrants). They also can be used as quality control samples for diagnostic equipment. For added traceability, the SRM certificate of analysis includes the genetic sequences of the nine CMV genome regions copied for the standard.

SRM 2366 joins more than 50 reference materials produced by NIST for quality control in clinical testing.

PML's Pernstich Develops Open-Source Software to Automate Test Equipment

A free, easily customizable software program for automating test equipment via GPIB or RS232 bus may sound too good to be true, especially for smaller companies, graduate students, and hobbyists or for day-to-day laboratory work. But that's exactly what Kurt Pernstich of the PML's Semiconductor and Dimensional Metrology Division has created.

Instrument Control (iC) is a NIST open-source software program that can perform many of the same functions as the widely used licensed software systems currently available. iC has the added benefit of being easily extended, with users able to define new commands in simple text files; no programming knowledge is required. Pernstich has made iC available on-line, and a full description of the software will be published in an upcoming issue of the *Journal of Research of NIST*.

In the research, development, and production community, virtually everyone uses some type of data-acquisition software, because measurements are made faster—measuring 10 datapoints manually can take longer than measuring 200 datapoints using data-acquisition software—and can be performed while the researcher is back at his/her desk or home for the weekend. In short, data-acquisition software is essential in today's laboratories, and the availability of a free version of a customizable program is a tremendous benefit to the American public.

NIST Releases Gulf of Mexico Crude Oil Reference Material

NIST has released a new certified reference material to support the Federal government's Natural Resources Damage Assessment (NRDA) in the wake of the April 2010 Deepwater Horizon oil spill off the Louisiana coast. The new Standard Reference Material, Gulf of Mexico Crude Oil" (SRM 2779), will be used as a quality control material for the ongoing environmental impact analyses of the NRDA effort.

The Deepwater Horizon disaster resulted in the discharge of tens of thousands of barrels of oil per day from the seafloor into the Gulf of Mexico. In what has become the worst offshore oil spill in U.S. history, a wide expanse and variety of natural resources have been exposed to and potentially impacted by oil. During the NRDA, tens of thousands of environmental samples,

including oil in various forms, water, sediment and biological samples are being collected and analyzed to characterize both pre-spill and post-spill environmental conditions.

The petroleum crude oil for SRM 2779 was collected on May 21, 2010, on the drillship Discoverer Enterprise, from the insertion tube that was receiving oil directly from the Macondo well during response operations. The oil was collected in 2.5 liter glass bottles and transported via a defined chain of custody to a laboratory in College Station, Texas. A portion was subsequently provided to NIST under the authority of the National Oceanic and Atmospheric Administration (NOAA) for use in the preparation of SRM 2779.

Using the data from three independent methods of analysis performed at NIST, as well as one set of data from an interlaboratory study coordinated by NIST and NOAA, certified and reference values (as mass fractions) are provided for a number of polycyclic aromatic hydrocarbons (PAHs), along with reference values (as mass fractions) for a number of alkylated PAH groups, hopanes and steranes. These compound classes are among those used as indicators for the presence of petroleum crude oil. A unit of SRM 2779 consists of five ampoules, each containing 1.2 mL of crude oil. Technical details of SRM 2779, Gulf of Mexico Crude Oil, are available at https://www-s.nist.gov/srmors/view_detail.cfm?srm=2779.

Petroleum Volume: Getting Calibrations in the Can

The volume of oil and oil products moving through America's pipelines, waterways, roads, and rails borders on the unimaginable.

"Look at it this way," says John Wright, a Project Leader in PML's Fluid Metrology Group, "per capita consumption of petroleum in the United States is 10 liters per day. And there are 300 million people. That's three billion liters moving around each day and usually being metered several times along the way. The infrastructure requirements are mind-boggling."

So is the value. Three billion liters is about 19 million barrels, and with crude oil priced around $100 a barrel these days, approximately $2 billion worth of petroleum travels from multiple sellers to multiple buyers every 24 hours. Clearly, even tiny errors in measurement can amount to a great deal of money.

To ensure maximum accuracy, the U.S. petroleum industry relies on volume measurements traceable to NIST, and specifically to the Flow Metrology Group in PML's Sensor Science Division. Customers bring in their own "field test measures" – stainless steel containers ranging in capacity from four liters to 8,000 liters, made with graduated necks but informally called "cans" – to be calibrated.

The cans are used to calibrate various "prover" mechanisms that measure movement of volume per unit time, and the provers in turn are used to calibrate various kinds of flowmeters. Because the provers and meters differ widely in capacity, a variety of can sizes is typically necessary.

For example, private-sector calibrators spent two weeks at NIST calibrating 13 cans ranging from 1 to 500 gallons. That may seem like a long time, but the process is laborious and painstaking. Each can is cleaned and thoroughly dried, carefully leveled, and weighed empty.

Then the can is filled with purified water and weighed again. This entire process is repeated five times for cans of 380 liters or less, and at least twice for larger cans.

"We often calibrate over 100 measures a year here, from all sorts of customers," says Fluid Metrology technician Sherry Sheckels, "including some designed to be transported by barge out to offshore oil platforms for on-site calibrations."

Not surprisingly, there are industry standards specified by the American Petroleum Institute that govern each stage of the calibration operation. For example, cans smaller than 20 liters are drained by pouring through the neck while tilted to 70 degrees from horizontal (not 90 degrees, which is completely vertical) and there are standardized drainage and drip times.

Because the mass, density and temperature of the water are extremely well known, container volume can be determined to high accuracy after correcting for factors such as thermal expansion of the metal. The petroleum industry expects uncertainties less than 0.05 % for custody transfer or billing applications. NIST's can-volume calibrations are in the range of 0.01 % for very large cans.

The other variable of intense interest is how the measurements change or "drift" over time. "If our calibrations or our customers' calibrations or the pipe-provers' change too much," Wright says, "then there's a lot of retroactive money that changes hands. It can amount to very large sums because the volume is extraordinarily high."

State laws governing the volumetric accuracy of products delivered to the consumer usually specify 0.5% uncertainty, and end-point distribution has to be monitored from time to time. "Five gallon cans are used at gas stations by state labs to make sure that pumps are calibrated properly," Wright says.

Because petroleum and other products sold by volume can cross many national borders, it is highly important that international standards agree as closely as possible. This necessitates round-robin comparisons, and Wright is now preparing to test a set of precision containers from Mexico.

"In general, the agreement among different national metrology institutes is extremely good," Wright says. "But that doesn't mean we can ever stop measuring."

NIST Launches New Website to Educate Industry about Alternatives to Mercury Thermometers

As part of a larger effort to reduce the amount of mercury, a potent neurotoxin, in the environment, NIST has launched a new website to help industry scientists and engineers decide the best temperature measurement alternative for their purposes. The website also includes information about myths pertaining to mercury and temperature measurement and how to safely package and recycle mercury-containing products.

NIST stopped providing calibration services for mercury thermometers on March 1, 2011. This was motivated in part by NIST's work with the Environmental Protection Agency to eliminate as many sources of mercury in the environment as possible.

According to Greg Strouse, leader of NIST's temperature, pressure and vacuum programs, mercury thermometers are neither a superior nor a standard method for measuring temperature. "We haven't used mercury thermometers as a calibration standard since 1927 when the platinum resistance thermometer standard was adopted," says Strouse. "Our goal with this new website is to show that there is a temperature-sensing technology that will satisfy their needs as well as, or better than, a mercury thermometer, all without the added liability of containing a neurotoxin that is hugely expensive to clean up if released into the environment."

According to NIST researcher Dawn Cross, industrial scientists commonly object to replacing their mercury thermometers because they have grown accustomed to getting the same answer from their mercury thermometers over the years, even if it is less accurate than can be provided by modern digital thermometers.

"Some people who are used to using mercury thermometers think that they define temperature, and this simply isn't true," Cross says. "Graduations on a piece of glass filled with a fluid can never give as accurate a reading as a digital thermometer, based on how the conductivity of metals change as a function of temperature, something we know and can characterize very, very well."

Cross points out that other thermometers based on the principle of thermal expansion of a fluid, such as alcohol, are not hopelessly inaccurate. In fact, they are as accurate as mercury thermometers and are suitable for some applications that don't require stringent temperature control. For example, alcohol thermometers might be suitable for measuring the temperature of gasoline and other fuels, but they would be unsuitable for monitoring the temperature of vaccines, the viability of which relies on strict control of their temperature.

New NIST Screening Method Identifies 1,200 Candidate Refrigerants to Combat Global Warming

Researchers at NIST have developed a new computational method for identifying candidate refrigerant fluids with low "global warming potential" (GWP)—the tendency to trap heat in the atmosphere for many decades—as well as other desirable performance and safety features. The NIST effort is the most extensive systematic search for a new class of refrigerants that meet the latest concerns about climate change. The new method was used to identify about 1,200 promising, low-GWP chemicals for further study among some 56,000 that were considered. Only about 60 of these have boiling points low enough to be suitable for common refrigeration equipment, an indication of how difficult it is to identify usable fluids.

The ongoing NIST project is a response to U.S. industry interest in a new generation of alternative refrigerants that already are required for use in the European Union. The refrigerants now used in cars and homes in the U.S. are mainly hydrofluorocarbons (HFCs). They were adopted a generation ago in the effort to phase out chlorofluorocarbons (CFCs), which deplete the stratospheric ozone layer. An example is R-134a (1,1,1,2-tetrafluoroethane), which replaced ozone-depleting chemicals in automobile air conditioners and home refrigerators. R-134a now is being phased out in Europe because HFCs remain in the atmosphere for many years, yielding a high GWP. A compound's GWP is defined as the warming potential of one kilogram of the gas

relative to one kilogram of carbon dioxide. R-134a has a GWP of 1,430, much higher than the GWP of 150 or less now mandated for automotive use in Europe.

Promising low-GWP chemicals include fluorinated olefins, which react rapidly with atmospheric compounds and thus do not persist for long periods. "What industry is trying to do is be prepared, because moving from a GWP in the thousands or tens of thousands to a GWP of 150 is an enormous challenge, both economically and technologically," says NIST chemist Michael Frenkel. "We decided to leverage the tools NIST has been developing for the last 15 years to look into the whole slew of available chemicals."

The affected industry is huge: The U.S. air conditioning, heating and refrigeration equipment manufacturing industry ships about $30 billion in goods annually, according to the U.S. Bureau of the Census. NIST has extensive experience evaluating alternative refrigerants, having previously helped the refrigeration industry find replacements for CFCs.

The new NIST method estimates GWP by combining calculations of a compound's radiative efficiency (a measure of how well it absorbs infrared radiation) and atmospheric lifetime, both derived from molecular structure. Additional filtering is based on low toxicity and flammability, adequate stability, and critical temperature (where the compound's liquid and gas properties converge) in a desirable range. The method was applied to 56,203 compounds and identified 1,234 candidates for further study. The method, which was validated against available literature data, is accurate and fast enough for virtual screening applications. The approach is similar to the large-scale virtual screening and computational design methods for discovering new pharmaceuticals.

The screening is the initial stage of a larger study funded by the U.S. Department of Energy. The next step will be to further narrow down the candidates to a couple dozen suitable for detailed investigation in refrigeration cycle modeling.

NIST Plays a Central Role in Standards Agreement by 22 Federal Agencies
NIST's Physical Measurement Laboratory (PML) researchers played a central role in the establishment of new testing and evaluation standards for radiation and nuclear detectors about to be adopted by 22 Federal agencies.

The standards, now in the final stages of approval, cover a range of devices from personal-detection equipment to hand-held radionuclide identifiers for field use and portal monitors for vehicles and cargo containers.

Users of the equipment are military personnel and the Department of Defense, Federal and State first responders, and others from agencies including the DHS, the Food and Drug Administration, the Centers for Disease Control and Prevention, the Environmental Protection Agency, and the National Institute of Occupational Safety and Health.

"For people using this type of equipment," says Dr. Lisa Karam, Chief of PML's Radiation and Biomolecular Physics Division, "knowing that the detectors' performance is reliable and 'fit for purpose' is absolutely necessary for their confidence that the results they get are reliable."

The new standards are the first of a planned total of eight to be issued by an interagency panel, the Department of Defense Test and Evaluation Capabilities and Methodologies Integrated Process Team (TECMIPT). It was formed to address a lack of uniform standards and validation procedures for threat –detection equipment across the array of possible military situations, that lack of uniformity prevents inter-comparisons of measurements, resulting in costly redundant evaluation, and complicating procurement procedures.

Individual Staff Researcher Awards with Technology Transfer Impact

In 2012, NIST researchers received numerous external awards for their achievements in science and technology.

Nobel Prize in Physics
The 2012 Nobel Prize in Physics was shared by NIST Researcher David Wineland with Professor Serge Haroche of the Collège de France and Ecole Normale Supérieure "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems." Dr. Wineland is the fourth Nobel winner since 1997 to have worked at NIST.

AAAS Fellows
Four NIST researchers were elected as Fellows of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society. They include:

- Jeffrey Voas, from the NIST Information Technology Laboratory, for distinguished contributions in the development of trustworthy software systems and advanced software fault injection-based testing techniques.

- Jeffrey Nico, from the NIST Physical Measurement Laboratory, for distinguished contributions to precision measurements and fundamental symmetry tests using cold neutrons and to radiochemical determinations of the proton-proton fusion solar neutrino flux.

- Vijay Srinivasan, from the NIST Engineering Laboratory, for distinguished contributions to scientific theory, algorithms, and standards for computer-aided design and manufacturing.

- Cedric Powell, from the NIST Material Measurement Laboratory, for outstanding contributions to electron spectroscopies of solids, especially in application to quantitative analysis of surfaces and establishment of surface measurement standards.

American Physical Society
Two NIST researchers were recognized by the American Physical Society for their outstanding contributions to physics. They are:

- J. Alexander Liddle from the CNST Nanofabrication Research Group, for contributions to science and technology of nanofabrication and nanolithography.

- Ian Spielman from the NIST Physical Measurement Laboratory, for work in quantum phenomena at intersection of atomic and condensed matter physics using quantum simulation with ultracold atoms.

CHAPTER 3

National Oceanic and Atmospheric Administration

Approach and Plans for Technology Transfer

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.

NOAA is one of the Nation's premier scientific agencies. NOAA science and technology impact the daily lives of the Nation's citizens, and have a significant impact on the national economy. About one-third of the U.S. economy (approximately $3 trillion) is weather sensitive. Industries related to agriculture, energy, construction, health, travel, and transportation are almost entirely weather dependent. Weather data and forecasts play a critical role in these major economic sectors. NOAA's operations in the areas of weather and climate form the backbone of a thriving Weather and Climate Enterprise. This Weather and Climate Enterprise includes the Federal government (i.e., NOAA), the private sector, and the academic sector. Together all three sectors serve the Nation's need for weather and climate services. The private sector in the Weather and Climate Enterprise is a thriving business including the media, private consultants, and equipment manufacturers supporting the weather industry. Current estimates are that this is a $5 billion industry. The private sector relies on NOAA observations and forecasts as the foundation of their business. Transfer of these data to our partners in the private sector is important to the success of this industry.

Weather-related information is transferred to the industry and the public via the media, electronically (e.g., internet, data portals, experimental wireless services), and NOAA Weather Radio. Federal, state, and local governments and the public use weather warnings to save lives and prevent destruction of property. Television stations, and many weather related firms, use weather data and forecasts in their daily operations. Industry uses NOAA data in home construction and design, crop selection, disease control, and fuel delivery and supply. Weather data have been used for deciding such diverse applications as automobile fuel delivery system design, the best time to market umbrellas, and even for determining optimum conditions for breeding honeybees. Accurate and longer range weather forecasts depend on an ongoing program of research and development.

Research by NOAA's laboratories is primarily aimed at assisting NOAA's operational components. Recent examples demonstrating the direction of NOAA's research are severe storm (hurricane, tornado, derecho winds) 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.

NOAA provides details of its 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.

NOAA's primary technology transfer mechanism has historically been the open dissemination of scientific and technical information through our cooperative institutes, websites, data portals, and peer-reviewed scientific publications to individuals, industry, government, and universities. This means of transfer is consistent with the agency's mission and scientific tradition, and is critical to the ongoing growth of both the private and academic sectors of America's Weather and Climate Enterprise.

In addition, NOAA transfers certain intellectual property through patent licenses and Cooperative Research and Development Agreements (CRADAs) when it provides a competitive edge to U.S. companies. In 2011- 12, NOAA researchers were granted two new patents and are currently seeking licensing opportunities. We have expanded our internal training and have redesigned our website to greatly increase the availability of information about NOAA science that is ready for commercialization. The goal of these activities will be to increase the overall number of CRADAs, patents, and licenses in NOAA, as well as to speed the execution of these agreements.

NOAA collaborates with other Federal research agencies on many topics of joint interest in science and technology development. For example, a current collaboration with National Institute of Standards and Technology, the U.S. Forest Service, and other agencies provides research in support of operational fire weather forecasts. According to a 2008 report from NOAA's Science Advisory Board, costs for fire suppression and subsequent property damage extend into the billions of dollars, not to mention the lives lost in fighting or trying to escape wildfires.

To ensure that 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.

In the future, NOAA will continue to direct its technology transfer and international collaboration activities toward four mission goals:

1. **Climate Adaptation and Mitigation:** An informed society anticipating and responding to climate and its impacts;
2. **Weather-Ready Nation:** Society is prepared for and responds to weather-related events;
3. **Healthy Oceans:** Marine fisheries, habitats, and biodiversity are sustained within healthy and productive ecosystems; and
4. **Resilient Coastal Communities and Economies:** Coastal and Great Lakes communities are environmentally and economically sustainable.

Additional Details in FY 2012

Collaborative Relationships for Research & Development

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **CRADAs**[(1)]**,** total active [(2)]	4	5	6	7	10
- New, executed	1	2	2	2	4
▪ Traditional CRADAs, total active	4	5	6	7	10
- New, executed	1	2	2	2	4
▪ Non-traditional CRADAs, total active	0	0	0	0	0
- New, executed	0	0	0	0	0
● **Other types of collaborative R&D relationships**	0	0	0	0	0

(1) 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.

(2) "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).

Licensing Details
Profile of Active Licenses

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **All licenses**, number total active[1]	6	7	6	6	5
▫ New, executed	0	1	0	0	0
▪ **Invention licenses**, total active	6	7	6	6	5
▫ New, executed	0	0	0	0	0
- Patent licenses,[2] total active	6	7	6	6	5
▫ New, executed	0	0	0	0	0
- Material transfer licenses total active (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	0	0	0	0	0
(non-inventions)					
▫ 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.

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

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

Licensing Management

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **Elapsed execution time**,[1] licenses granted					
▪ **Invention licenses** ▫ Average, months ▫ Minimum ▫ Maximum		7.0	7.0	7.0	
- Patent licenses [2] ▫ Average, months ▫ Minimum ▫ Maximum		7.0	7.0	7.0	
● **Licenses terminated for cause**					
▪ Invention licenses	0	0	0	0	0
- Patent licenses [2]	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 or FY 2012.

(1) 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.)

(2) Patent license tally includes patent applications which are licensed.

Characteristics of Licenses Bearing Income

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **All income bearing licenses**, total number	4	5	4	3	3
▫ Exclusive	0	0	0	0	0
▫ Partially exclusive	0	0	0	0	0
▫ Non-exclusive	4	5	4	3	3
▪ **Invention licenses**, income bearing	4	5	4	3	3
▫ Exclusive	0	0	0	0	0
▫ Partially exclusive	0	0	0	0	0
▫ Non-exclusive	4	5	4	3	3
- Patent licenses,(1) income bearing	4	5	4	3	3
▫ Exclusive	0	0	0	0	0
▫ Partially exclusive	0	0	0	0	0
▫ Non-exclusive	4	5	4	3	3
▪ **Other IP licenses**, income bearing	0	0	0	0	0
▫ Exclusive					
▫ Partially exclusive					
▫ Non-exclusive					
- Copyright licenses (fee bearing)					
▫ Exclusive					
▫ Partially exclusive					
▫ Non-exclusive					
● **All royalty bearing licenses**,(2) total number	4	5	4	3	3
▪ **Invention licenses**, royalty bearing	4	5	4	3	3
- Patent licenses,(1) royalty bearing	4	5	4	3	3
▪ **Other IP licenses**, royalty bearing	0	0	0	0	0
- Copyright licenses (fee bearing)	4	5	4	3	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.

(1) Patent license tally includes patent applications which are licensed.

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

Income from Licenses

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **Total income**, all licenses active [1]	$69,007	$138,444	$35,044	$107,220	$100,867
▪ **Invention licenses**	$69,007	$138,444	$35,044	$107,220	$100,867
- Patent licenses [2]	$69,007	$138,444	$35,044	$107,220	$100,867
▪ **Other IP licenses**, total active	0	0	0	0	0
- Copyright licenses					
● **Total Earned Royalty Income** (ERI) [3]	$69,007	$138,444	$35,044	$107,220	$100,867
▫ Median ERI	$9,007	$19,000	$5,000	$34,000	$9,902
▫ Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
▫ Maximum ERI	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 1% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 5% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 20% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▪ **Invention licenses**	$69,007	$138,444	$35,044	$107,220	$100,867
▫ Median ERI	$9,007	$19,000	$5,000	$34,000	$9,902
▫ Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
▫ Maximum ERI	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 1% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 5% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 20% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
- Patent licenses [2]	$69,007	$138,444	$35,044	$107,220	$100,867
▫ Median ERI	$9,007	$19,000	$5,000	$34,000	$9,902
▫ Minimum ERI	$1,000	$1,000	$1,000	$1,000	$1,000
▫ Maximum ERI	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 1% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 5% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▫ ERI from top 20% of licenses	$25,000	$75,000	$17,044	$69,000	$89,965
▪ **Other IP licenses**, total active	0	0	0	0	0

(1) 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.

(2) Patent license tally includes patent applications which are licensed.

(3) "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.

Disposition of License Income

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
● **Income distributed** [1]					
▪ **Invention licenses**, total distributed	$69,007	$138,444	$35,044	$107,220	$100,867
- To inventor(s)	$22,802 (32%)	$45,153 (33%)	$14,514 (41%)	$34,266 (32%)	$35,331 (35%)
- To other	$46,205 (68%)	$93,291 (67%)	$20,530 (59%)	$72,954 (68%)	$65,536 (65%)
- Patent licenses, [2] total distributed	$69,007	$138,444	$35,044	$107,220	$100,867
- To inventor(s)	$22,802 (32%)	$45,153 (33%)	$14,514 (41%)	$34,266 (32%)	$35,331 (35%)
-To other	$46,205 (68%)	$93,291 (67%)	$20,530 (59%)	$72,954 (68%)	$65,536 (65%)

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

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

(2) Patent license tally includes patent applications which are licensed.

Other Performance Measures Deemed Important by the Agency

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Journal articles published	838	789	709	1,034	1,769
Technical reports published	258	186	161	151	250

Publication counts have been recently updated by the NOAA Laboratories for FY 2010 and FY 2011.

GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Website hits (HTML pages)	3,086,605	2,790,351	2,941,319	3,598,240	3,961,983
Website downloads (PDF pages)—brochures, research papers, technical memos, etc.	110,880	93,400	95,137	107,078	126,501

Downstream Outcomes from NOAA Technology Transfer Activities

Hail and Severe Storm Risk Management Initiative (NSSL)

Atmospheric and Environmental Research (AER) and the National Severe Storm Laboratory (NSSL) are collaborating to fuel the research and development of operational weather risk management solutions for insurance and other industries impacted by severe storms. AER also announced the AER Respond™ hail analysis service, which leveraged NSSL data to enable insurance carriers to reduce loss adjustment expense and cycle times by integrating property-specific analytics into the hail claims workflow.

The alliance combines NSSL's resources in weather radar data processing with AER's expertise in providing data-driven solutions that improve industry practice. As part of a Cooperative Research and Development Agreement (CRADA), NSSL provided AER access to high-

resolution radar data across the continental United States so AER could develop value-added products and test the products in the insurance industry. AER in turn provided insurance industry feedback and quality control assessments to NSSL for inclusion back into their radar algorithms.

Storm-related damage is a growing problem for insurance carriers and their customers. AER adds value through targeted scientific analysis and by building applications for business to pinpoint the location and severity of weather events like straight-line winds, hail, rain and tornadoes. The expanded real-time hail and rain capabilities complement AER's existing services related to hurricanes, wildfires and other natural hazards.

"NSSL is world renowned for their knowledge and leadership in storm observation and prediction," said Paul Walsh, AER senior vice president. "Pairing this data with the insurance expertise and analytic capabilities within our enterprise enables AER to provide a game-changing weather risk management capability for the insurance industry. An example is AER Respond which catastrophe teams can use to reduce expense and claims cycle times, determine resource demand and logistics, and validate the date of loss of each weather-related claim."

NSSL to collaborate with Willis Re Inc. on the development and validation of advanced radar products to estimate size and location of surface hail (NSSL)

Radar data provide a new potential source of information for the insurance industry. One of the expected uses is providing a more exact estimate of the location and size of large hail that may be used in modeling impacts from severe storms. NSSL collects, blends, and analyzes data from about 150 WSR-88D radars in the 48 contiguous United States in real-time. These radar data are combined with environmental temperature profiles in an algorithm to estimate hail size. This Hail Detection Algorithm has shown improved spatial coverage accuracy over spotter reports collected by the NWS. However, this algorithm estimates the size and area of hail cores aloft (usually 10,000 ft. to 50,000 ft. above the Earth's surface) does not specifically estimate the size of hail at the ground where damage to property is most likely to occur. Research will focus on improving the estimate of the hail size and coverage at the surface, which can differ from the hail areas aloft on a storm, through the use of high-resolution verification, environmental wind and storm type information, and new radar data types provided by the dual-polarization upgrade to the United States WSR-88D radar system that begins in 2011.

To improve the hail size estimates, NSSL will collect a unique, high-resolution hail verification data set using techniques developed by the Severe Hazards Analysis and Verification Experiment. Improvement to the spatial coverage and hail size estimates require a very high-resolution (1 km and 5 minutes; matching the radar data resolution) validation data set that includes reports of large (damaging) hail, small (non-damaging) hail, as well as the locations in and near a storm where no hail fell at all. Willis Re Inc. will provide feedback on the performance of these products as used in the insurance industry, to help improve the performance of the algorithm analysis.

Willis Re Inc., (Willis) is a reinsurance intermediary and risk advisor serving insurance companies, corporates and public sector institutions in the U.S. Willis funds the Willis Research Network (WRN) program, which supports research at approximately 50 public science institutions in the United States and abroad to improve the quality of reinsurance, risk

management, and resilience for exposed populations. This CRADA is being undertaken as part of the WRN research program, and it is expected that this will lead to additional WRN connections and inputs to support the project. Willis and the WRN will provide expertise in the development, use, and delivery of severe weather analysis applications to the insurance industry, and feedback on how products may be tailored and operated to provide maximum value in insurance industry and the populations they serve. Willis and the WRN will also provide expertise and feedback on algorithm performance based on insurance claims data as available, to quantify any biases in size or spatial coverage and help improve algorithm performance.

NSSL will provide expertise in the development of severe weather analysis applications based on data from radar and other remote sensing tools, as well as interpretation of those data sets. These "research-grade" products and data will be available to Willis Re Inc., and its clients and market partners for the purposes of improving their quality and performance and assessing the value they may provide to insurance industry. These "research-grade" data and products are intended to be used for research, development and evaluating their quality, impact and value. These services should not be sold as specific products, though it is understood that they will be distributed to clients of Willis for development, testing, and evaluation purposes. If Willis Re Inc. determines the products and data have value to the company such that they wish to commercialize them, then Willis Re Inc. will need to either purchase the real-time commercial-quality data from existing vendors or procure a license and invest in the infrastructure to produce the real-time data apart from NSSL. NSSL will also provide expertise in the high-resolution validation of severe weather events.

ESRL/GSD Software Used by U. Wisconsin and NESDIS to help develop Next-Generation Geostationary Operational Environmental Satellite (GOES) Products (ESRL GSD)
Global Positioning System water vapor estimates (GPS Met) are recognized around the world as an accurate and reliable way of monitoring total column precipitable water vapor under all weather conditions. Since 2005, GPS Met data and products produced by the Forecast Applications Branch of the ESRL's Global Systems Division have been used by NOAA's National Weather Service in its operational numerical weather prediction models; Regional Forecasters and the Storm Prediction Center in their short-range weather warnings and forecasts; the Upper-Air Program to monitor the performance of rawinsondes and assess the quality of rawinsonde improvements; and the Office of Science and Technology to evaluate moisture soundings made by commercial aircraft during ascent from and descent into U.S. airports across the country.

Most recently, software designed and developed by ESRL/GSD has been used by NESDIS and the NOAA Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison's Space Science and Engineering Center to assess next-generation data processing algorithms for operational and future U.S. (GOES-R) geostationary orbit environmental satellites. ESRL software compares Total Precipitable Water Vapor products produced from data acquired by operational and research satellites, as well as simulated data and products derived from these observations, with actual GPS Met observations made over CONUS in near real-time. This capability provides mission scientists, instrument designers and software developers with the ability to immediately assess the impact of changes in their codes and system

software for the first time, and allows them to evaluate the relative merits of different data processing schemes over long periods of time with high reliability.

Tsunami Training (PMEL)
The Pacific Marine Environmental Laboratory (PMEL) NOAA Center for Tsunami Research (NCTR) has developed and refreshed multiple training curricula to assist states and cooperating nations to improve tsunami readiness for their citizens. Training includes Tsunami Awareness aimed at emergency management, instruction in the development and implementation of tsunami forecast systems through the web-enabled ComMIT interface, and the award winning "Train-the-Trainer" classes aimed at emergency managers and decision makers for improving tsunami readiness at the local level. Tsunami Awareness training and the Train-the-Trainer training are now provided by local groups, but continue to use materials and scenarios developed by NCTR.

ComMIT Training
A Community Model Interface for Tsunami (ComMIT) provides an easily accessible avenue to transfer modeling expertise and capabilities from NOAA to, and between, worldwide coastal constituencies, such as Indian Ocean countries. USAID and UNESCO provided funding to PMEL to develop ComMIT and accompanying tools now available to enable government agencies and regional researchers to run tsunami models, using data from local or remote databases, with an internet-enabled interface. Access to tools for the construction of tsunami inundation maps under selectable scenarios and for real-time tsunami forecast applications provides an easily accessible, critical tool for building tsunami-resilient communities. This approach allows nations without a significant cadre of trained modelers to build tsunami modeling capability for forecast and hazard assessment, allows nations with restrictions on sharing geo-spatial data to input that data locally and not share it with other web-based model users. Most significantly, the internet-based approach creates a virtual regional and global community of modelers using the same tools and approaches to understand tsunami threats all the while providing the capability to share information and insights among themselves.
In 2012, ComMIT training was provided on the French Caribbean island of Guadeloupe and in Sydney, Australia to 32 students, bringing the total to 220 persons trained from a total of 51 countries. Funding was provided by USAID, UNESCO, and AusAID.

National Snow Analysis Web-based Information Portal (NWS)
The National Weather Service National Operational Hydrologic Remote Sensing Center (NOHRSC) hosts the National Snow Analysis (NSA) web site that distributes high resolution gridded snow pack state variables (e.g., water content of the snow pack, snow pack temperature) for the coterminous United States, Alaska, and Southern Canada. The snow pack is an important weather and climate feature accounting for most of the water supply in the western states and a major contributor to flood events in the central and eastern states. From a climate perspective, the snow pack is the most prominent surface feature during winter months, strongly influencing energy fluxes between the Earth and its atmosphere. The NSA products are widely used by NWS river forecast operations and in the preparation of water supply and flood outlooks, in Federal and state water resources decision support, by commercial sector clients whose enterprises are directly affected by snow, and by millions of private individuals. The NSA web site can be found at www.nohrsc.noaa.gov.

Hurricane Forecast Improvement Program (HFIP)
HFIP provides the basis for NOAA and other agencies to coordinate hurricane research needed to significantly improve guidance for hurricane track, intensity, and storm surge forecasts. It also engages and aligns the inter-agency and larger scientific community efforts towards addressing the challenges posed to improve hurricane forecasts. The goals of the HFIP are to improve the accuracy and reliability of hurricane forecasts; to extend lead time for hurricane forecasts with increased certainty; and to increase confidence in hurricane forecasts. These efforts will require major investments in enhanced observational strategies, improved data assimilation, numerical model systems, and expanded forecast applications based on the high resolution and ensemble-based numerical prediction systems.

The specific goals of the HFIP are to reduce the average errors of hurricane track and intensity forecasts by 20% within five years and 50% in ten years with a forecast period out to 7 days. The benefits of HFIP will significantly improve NOAA's forecast services through improved hurricane forecast science and technology. Forecasts of higher accuracy and greater reliability (i.e., user confidence) are expected to lead to improved public response, including savings of life and property. Experimental forecast guidance from various HFIP contributors is provided in a consolidated web-based information portal at http://www.hfip.org/products/

NOAA Atlas 14: Precipitation-Frequency Atlas of the United States – A Data Portal
In 1953, NWS began publishing general rainfall intensity frequency duration values or precipitation frequency estimates. NWS precipitation frequency estimates have traditionally been delivered in the form of Weather Bureau Technical Papers and Memoranda as well as NOAA Atlases, all hard copy documents. With the advent of the World Wide Web, these documents have been scanned and made available via a web-based data portal.

The National Weather Service specifically developed the Precipitation Frequency Data Server as the primary web portal to precipitation frequency estimates and associated information. Recent updates to NWS precipitation frequency are being delivered entirely in digital rather than hard copy form in order to make the estimates more widely available to the public and to provide the data in a broader and more accessible range of formats. Civil Engineers use probabilistic estimates of rainfall intensities for particular durations and locations for the design of a wide range of structures from urban storm water drainage systems to dams and spillways. More recently their use has extended beyond the realm of civil engineering to include a broad array of environmental management and analysis concerns including the Federal Emergency Management Administrations flood plain mapping program and the Environmental Protection Agency's pollution discharge regulations. In the last 12 months, there were approximately 300,000 data inquiries through this data portal.

Investigating New Dissemination Technologies to Communicate NOAA Information
NOAA/NWS has two Cooperative Research and Development Agreements (CRADA) in place with Weather Decision Technologies, Inc. (WDT) to investigate IP-based audio/visual streaming for television and web audiences. The goal is to develop new technologies to expand the reach of NOAA information to the public during high impact weather events. The first CRADA active during FY 2012 allowed WDT to collaborate with the NWS National Hurricane Center to provide streaming web and TV-based briefings during land-falling hurricanes. Current

audio/video dissemination systems were not designed to distribute feeds in a format that can directly connect to media servicers for public distribution. WDT's new technology delivers audio/video stream to television outlets and media websites, greatly expanding the reach of critical information to US citizens.

In FY 2012, NOAA (NWS Weather Forecast Office Los Angeles/Oxnard) signed a new CRADA with WDT, Inc. to explore use of this technology approach to enhance communication with the public at NWS local offices serving large population centers/media markets and the potential for use at regional operations centers. The research also expanded beyond that of the NHC-based CRADA to explore an interactive interview capability between media outlets and WFO Los Angeles/Oxnard. It is envisioned that the system will allow delivery of weather messages to threat zones where there is no direct communications links between them and the WFO.

Prestigious Awards for NOAA's Science and Technology received in 2012

NOAA Patent Award for "System for Monitoring, Determining, and Reporting Directional Spectra of Ocean Surface Waves in Near Real-Time from a Moored Buoy"
Dr. Chung-Chu Teng, Division Chief in NOS's CO-OPS Office, Richard Bouchard and Dr. Rodney Riley, both from the NWS National Data Buoy Center (NDBC), successfully patented a system for "measuring spectra of surface ocean waves in near real-time." Dr. Teng was also with NDBC during the time the patented work was developed.

The patent, which was awarded in June 2012, describes a "moored buoy floating at the ocean surface and anchored to the seafloor precisely measur[ing] acceleration, pitch, roll, and Earth's magnetic flux field of the buoy over a limited sampling period." NDBC has already received requests to license the new technology.

CHAPTER 4

National Telecommunications and Information Administration Institute for Telecommunication Sciences

Approach and Plans for Technology Transfer

The Institute for Telecommunication Sciences (ITS) is the research and engineering arm of the National Telecommunications and Information Administration (NTIA). ITS supports NTIA telecommunications objectives of promoting advanced telecommunications and information infrastructure development in the United States, enhancing domestic competitiveness, improving foreign trade opportunities for U.S. telecommunications firms, and facilitating more efficient and effective use of the radio spectrum. 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.

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.

Cooperative Research and Development

Cooperative Research and Development Agreements (CRADAs), authorized under the Federal Technology Transfer Act of 1986 (FTTA), allow ITS to enter into cooperative research agreements with private industry, universities, and other interested parties that protect proprietary information, grant patent rights, and provide for user licenses to private entities. The FTTA provides the legal basis for, and encourages, shared use of government facilities and resources with the private sector, aiding in the commercialization of new products and services as well as enhancing the capabilities of ITS laboratories.

In FY 2012, ITS' efforts in technology transfer and commercialization fostered cooperative telecommunications research in areas where U.S. companies can directly benefit from improved competitiveness and market opportunities. These efforts will continue in future years. ITS also 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), and Broadband over Power Line (BPL) 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 objective audio and video quality, advanced antennas for wireless systems, and remote sensing and global position (GPS) technology have allowed ITS to contribute to the development of new products and services.

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 these 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-half of the publications released through the ERB process in FY 2012 were approved for external publication in scientific journals or conference proceedings and one half were published as NTIA reports.

Development of Telecommunication Standards
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.
In FY 2012 ITS worked collaboratively with the International Telecommunication Union (ITU), the Telecommunications Industry Association (TIA), 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, ANSI T1 (now ATIS), and other telecommunication standards organizations, providing technical leadership that is trusted by the commercial-sector participants. In FY 2012, the ATIS annual Award for Outstanding Contributions was presented to an ITS engineer.

ITS released an important update to its the video quality measurement (VQM) software tools in FY 2012. These 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.
Also in FY 2012, ITS continued its technical leadership and contributions to communications standards for public safety, particularly for first responders. ITS's primary area of contribution in this area has been interoperability standards, testing procedures, and multi-vendor testing venues. In the area of international standardization, ITS staff authored a suite of about a dozen U.S. technical contributions to ITU-R Study Group 3 (SG3) planning meetings for the 2015 World Radio Conference, firmly establishing U.S. leadership in radio propagation. ITS staff hold 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.

Additional Details in FY 2012

Collaborative Relationships for Research & Development

Cooperative Research and Development Agreements	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
CRADAs, total active[1]	**41**	**43**	**41**	**32**	**62**
- New, executed	7	18	15	17	30
▪ Traditional CRADAs,[2] total active	6	31	29	23	60
- New, executed	6	10	9	10	28
▪ Non-traditional CRADAs,[3] total active	35	12	12	9	2
- New, executed	1	8	6	7	2

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

(2) CRADAs involving collaborative research and development by a Federal laboratory and non-Federal partners.

(3) ITS' Telecommunications Analysis Services (TA Services) is Internet-accessible through Web-based electronic CRADAs. TA Services provides analysis support to private industry and public agencies in the areas of wireless system design and evaluation, and site selection. The service is provided on a cost-reimbursable basis, 24 hours a day, 7 days a week, throughout the year. FY12 is the last year that TA services will be offered to the public. The program language used to develop these services is too old and complex to update. Other service applications will be developed in the future depending on funding.

The vast majority of Cooperative Research and Development Agreements (CRADA) ITS has entered into in the past two years and will likely continue to enter into for the next several years are the Public Safety 700 MHz Broadband Demonstration Agreements. These agreements allow vendors who intend to supply 700 MHz LTE equipment and service to public safety organizations to operate various elements of an LTE network in the Public Safety Communications Research 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. The CRADAs protect the intellectual property of vendors and manufacturers; encouraging participation in testing that simulates real multi-vendor environments in the field.

Summary of ITS CRADAs for FY 2012:

Type of Research	Number of CRADAs
700 MHz Broadband Demonstration Network	54
Use of Table Mountain Facilities	4
Other Research	4
Total	62

Licensing
Since FY 2008, ITS no longer licenses Video Quality Metric (VQM) technology. Instead, ITS has made this software available via open-source download. Therefore, no licensing metrics are reported. Since FY 2008, approximately 1,500 users have downloaded the VQM software.

Other Performance Measures Deemed Important by the Agency
In 2003, ITS added a new metric under the "Other Performance Measures" category: number of publications approved through the Editorial Review Board (ERB) process. This metric provides a useful working indicator of the number of quality publications released to the public. In 2004, ITS added a measure for participation on standards committees.

In 2006, ITS added another metric: the total number of hits on the publications listed on the "ITS Online Documents." This metric was intended to provide a more direct indication of ultimate benefit to the public. Changes in the Internet environment, in particular an explosion in the number of "bot hits," have rendered this metric unreliable, inflated, and meaningless. Therefore for FY 2012, the metric for publications was reported as unique page views of pages from which downloads are initiated; this served as an interim proxy for a count of actual PDF downloads, a metric implemented in the first quarter of FY 2013.

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. This is a collaborative project whose technical committee includes industry and academic, representatives as well as ITS and Public Safety Communications Research staff. ITS launched the site with 1000 clips and doubled that in FY 2011. Additional clips continue to be added by ITS and other collaborators. Users must register for each download or upload session, and the project tracks the number of registrants and the number of uploads and downloads. The number of registrants each year was selected as the most significant measure of the impact of this resource, and collection of that metric began in FY 2011, the first full year of operation.

Other Performance Measures Deemed Important by the Agency	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Technical publications produced - ITS	15	12	12	15	13
Unique pageviews of publication abstract pages	n/a	n/a	n/a	n/a	≈2000(1)
Collaborative standards contributions	25	21	21	25	28
Consumer Digital Video Library new users	n/a	n/a	n/a	242	187

(1) "Collection of unique page-view counts began in the middle of the second quarter; the figure given is annualized based on partial year counts.

Downstream Outcomes from ITS Technology Transfer Activities

The following are examples of downstream outcomes from ITS technology transfer efforts:

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 Cooperative Research and Development Agreements (CRADAs). The following are brief descriptions of some of these recent CRADAs:

- For the past six years, the University of Colorado's Research and Engineering Center for Unmanned Vehicles has conducted measurements on the performance of ad hoc wireless networks with both ground-based and airborne terminals at Table Mountain.
- In FY 2012, several companies performed antenna, Light Detection and Ranging (LIDAR)/Global Positioning Satellite (GPS), and other testing at the Table Mountain turntable facility under a CRADA.
- Lockheed Martin Coherent Technologies is in its thirteenth 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.

SUMMARY

Technology transfer is an essential mission of the Department of Commerce, 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 the Department of Commerce'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 the Department of Commerce's Federal laboratories. As knowledge advances and the needs of the economy change, the Department of Commerce 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 knowledge.