# National Institute of Standards and Technology

## Economic Contribution of Operations and Construction
## FY2014–FY2016


**Consulting Report by:**

Business Research Division
Leeds School of Business
University of Colorado Boulder

**Reviewed by:**

Towson University


**September 2017**

Page intentionally left blank.

## TABLE OF CONTENTS

## FINDINGS

- The National Institute of Standards and Technology (NIST) is a federal research laboratory with operations in Gaithersburg, Maryland, and Boulder, Colorado.
- In FY2016, NIST reported a budget of $1.1 billion and 3,273 full-time, part-time, and student employees, with average salaries of $108,580. Additionally, NIST reported 5,550 full-time and part-time associates at a cost of $247 million.
- The economic contribution from NIST operations and construction to the state of Maryland totaled $1.6 billion and 12,220 jobs in FY2016, demonstrating the ripple effect as the lab purchases goods and services from the domestic supply chain (indirect effect) and as employees and associates spend their earnings in their communities (induced effect).
- The economic contribution of NIST to the state of Colorado totaled $319 million in FY2016, and the lab employed and supported 2,823 jobs through the multiplier effect.
- Nationally, the impact totaled $2.7 billion in economic activity and 17,068 jobs in FY2016.
- Beyond the impact of business operations, NIST has numerous societal and economic benefits ranging from education to innovation.
- This report quantifies the economic contribution of NIST as a business unit, and does not quantify the value or economic impact of the basic research advancements or the licensed, commercialized products; prior studies have shown a 9-to-1 return on investment resulting from NIST investments in scientific research and development.

## EXECUTIVE SUMMARY

As part of the U.S. Department of Commerce (DOC), the National Institute of Standards and Technology (NIST) is a federal research laboratory with operations in Gaithersburg, Maryland, and Boulder, Colorado. The lab's mission is 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." The majority of NIST's funds are appropriated directly by Congress.

From FY2014–FY2016, NIST averaged 3,179 full-time, part-time, and student employees; in FY2016 alone, NIST reported 3,273 employees with average salaries of $108,580. Additionally, NIST reported 5,550 full-time and part-time associates at a cost of $247 million in FY2016. The Boulder and Gaithersburg facilities are each among the largest employers in their communities. NIST employs a highly educated staff, exceeding national and local educational attainment levels. In FY2016, one-third of NIST employees had a doctoral degree, 18% had a master's degree, and 23% had a four-year degree. Wages exceed the national average when compared to all industries, but are below the national average for comparable private industry wages for similar activities in the private scientific research and development services sector.

In FY2016, NIST reported a budget of $1.1 billion, an increase of 6.6% from FY2015. Most of this budget (85%) was devoted to NIST's Gaithersburg operations, while Boulder accounted for the remaining 15%. NIST reported $224 million in construction spending from FY2014–FY2016 on 669 projects—$121 million in FY2016 alone. Projects were wide ranging, from space renovation, to facility repairs and maintenance. More than 61% of the construction expenditures occurred at the Gaithersburg facility.

NIST Gaithersburg recorded an average annual budget of $925 million from FY2014–FY2016. Gaithersburg operations recorded an average of 2,742 employees and 4,047 associates over the three-year period, and construction spending of $137 million. The economic contribution from NIST operations and construction totaled $1.6 billion and 12,287 jobs in FY2016, demonstrating the ripple effect as the lab purchases goods and services from the domestic supply chain (indirect effect) and as employees and associates spend their earnings in their communities (induced effect).

NIST Boulder recorded an average annual budget of $153 million from FY2014–FY2016, with an average of 436 employees and 1,014 associates over the three-year period. The economic contribution of NIST on the state of Colorado totaled $319 million in FY2016, and the lab employed and supported 2,878 jobs through the multiplier effect. In addition to economic benefits stemming from operations, economic benefits were associated with NIST's $87 million in construction spending in Colorado.

This report quantifies the economic contribution of NIST as a business unit, and does not quantify the value or economic impact of the basic research advancements or the licensed, commercialized products. Beyond the impact of business operations, NIST has numerous societal and economic benefits ranging from education to innovation. Operations alone generated $2.7 billion in national economic activity and 17,064 jobs in FY2016.

## PURPOSE OF THE STUDY

The National Institute of Standards and Technology (NIST) contracted with the Business Research Division (BRD) at the Leeds School of Business, University of Colorado Boulder, to measure the economic contribution of NIST for fiscal years 2014, 2015, and 2016.

NIST has two campuses separated by about 1,500 miles—one in Gaithersburg, Maryland, and the other in Boulder, Colorado. Created 116 years ago, Congress established NIST to standardize measurement—something that was reportedly stifling U.S. industrial competitiveness. Today, as a unit of the U.S. Department of Commerce (DOC), NIST researchers continue to create standards, but also study technology that broadly leads to innovation through the public dissemination of research.

This study examines the economic contribution of NIST as an operating business unit—the economic contribution of the flow of funds. This report does not quantify the value or economic impact of the basic research advancements or the licensed, commercialized products.

## MODEL INPUT DATA AND ASSUMPTIONS

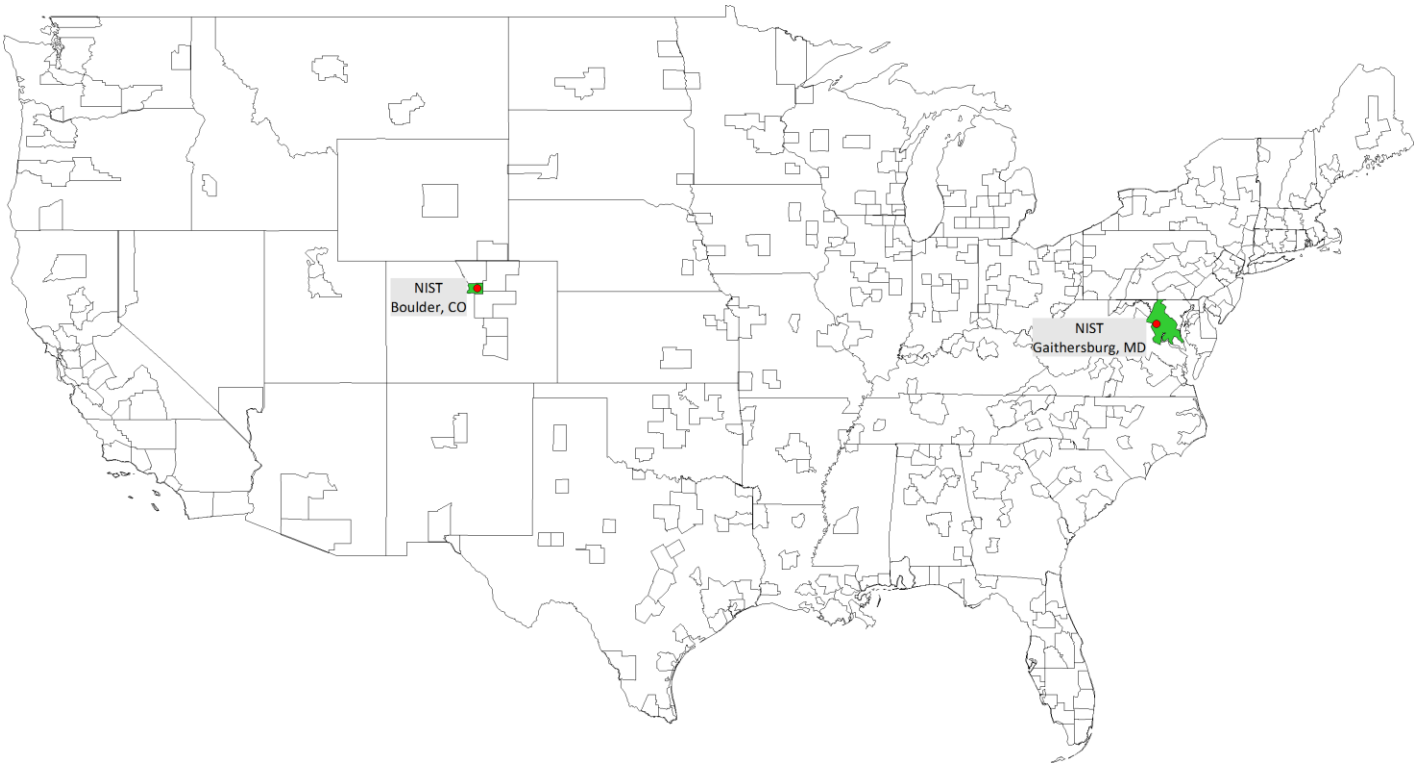
NIST Gaithersburg is located in Gaithersburg, Maryland, within about an hour's drive of five R1 research universities, six R2 or R3 universities, and 14 federally funded research and development centers (FFRDCs).[1][2] NIST Gaithersburg is within 40 miles of three major international airports, and 25 miles from Washington, D.C.

NIST Boulder is located in Boulder, Colorado, within about an hour's drive of two R1 research universities, six R2 or R3 universities, and 2 FFRDCs. NIST Boulder is 18 miles from Denver and within an hour of Denver International Airport.

[1]The Carnegie Classification of Institutions of Higher Education publishes a rating of colleges and universities by their research intensity and degrees conferred. According to the website, "For doctoral universities, the levels are based on a research activity index and for master's colleges and universities it is based on number of degrees conferred." R1 universities record the highest research activity, R2 universities record higher research activity, and R3 universities record moderate research activity.

[2]According to the Cornell University Law School, Legal Information Institute, "FFRDC's [Federally Funded Research and Development Centers] enable agencies to use private sector resources to accomplish tasks that are integral to the mission and operation of the sponsoring agency. An FFRDC, in order to discharge its responsibilities to the sponsoring agency, has access, beyond that which is common to the normal contractual relationship, to Government and supplier data, including sensitive and proprietary data, and to employees and installations equipment and real property."

**FIGURE 1: NIST GAITHERSBURG AND NIST BOULDER LOCATIONS**




## Budget and Expenditures

NIST's annual budget for Gaithersburg and Boulder summed to $995 million in FY2014, growing 4.6% to $1 billion in FY2015 and 6.6% to $1.1 billion in FY2016. In FY2016, NIST Gaithersburg accounted for more than 85% of the annual budget, compared to 15% for Boulder. The DOC is the single largest source for NIST funding (88%), followed by an agglomeration of reimbursements, sales, and services to the public (6%), the Department of Defense (2%), the Department of Homeland Security (1%), and other agencies (3%).

**FIGURE 2: NIST FUNDING BY SOURCE, FY2016**

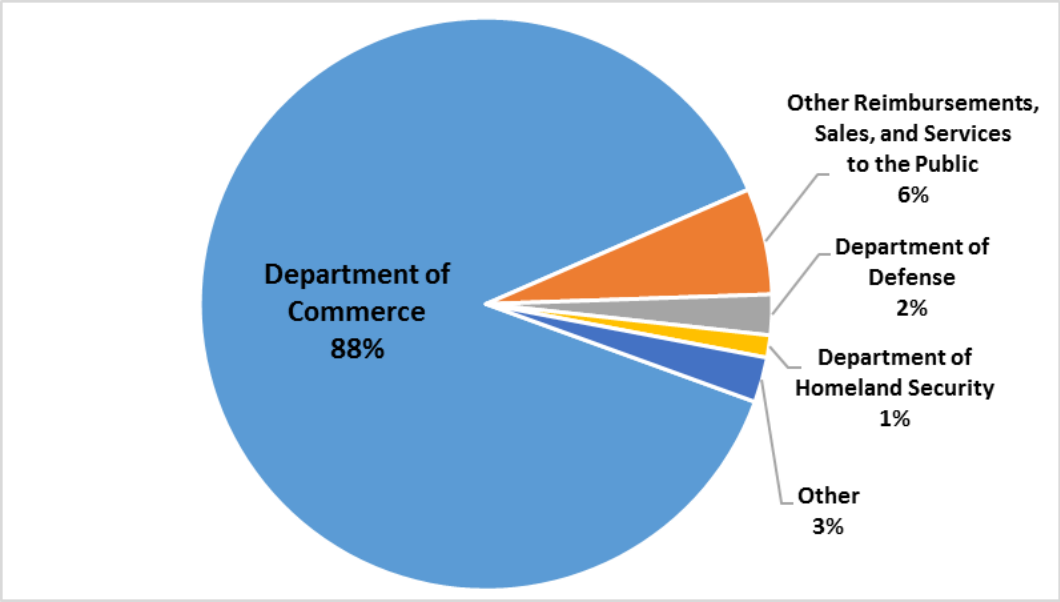
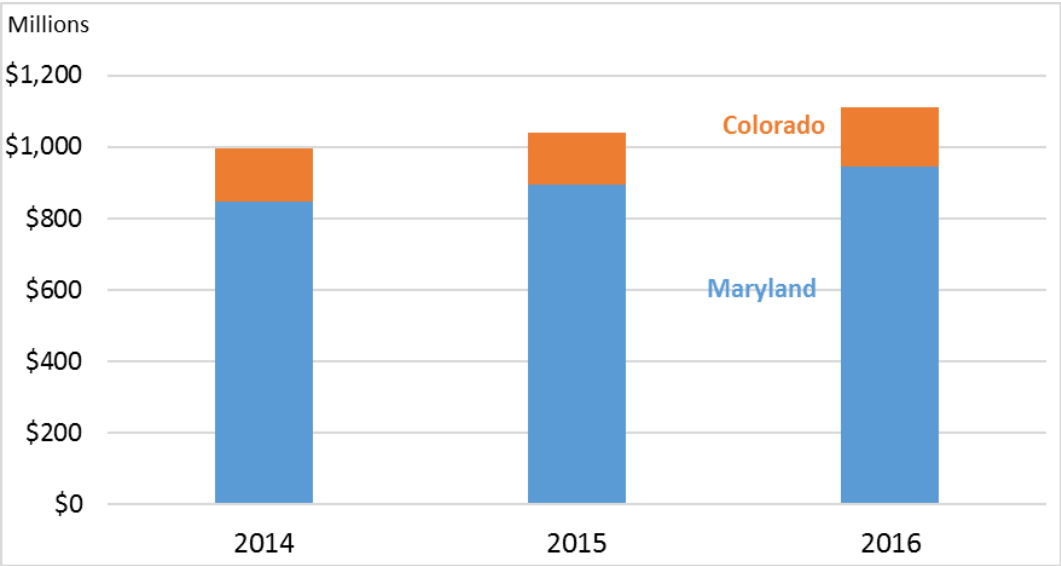



**FIGURE 3: NIST ANNUAL BUDGET, FY2014–FY2016**




NIST expenditures were delineated as operating and construction expenditures, with additional detail provided on employee compensation. Like many federally funded research facilities, NIST's spending on talent is one of the single greatest expenditures for the facility. In FY2016, an estimated 47% of expenditures were devoted to salary and benefits. Other expenditures ranged from everyday operations (building, utilities) to capital investments and research contracted to universities and private industry.

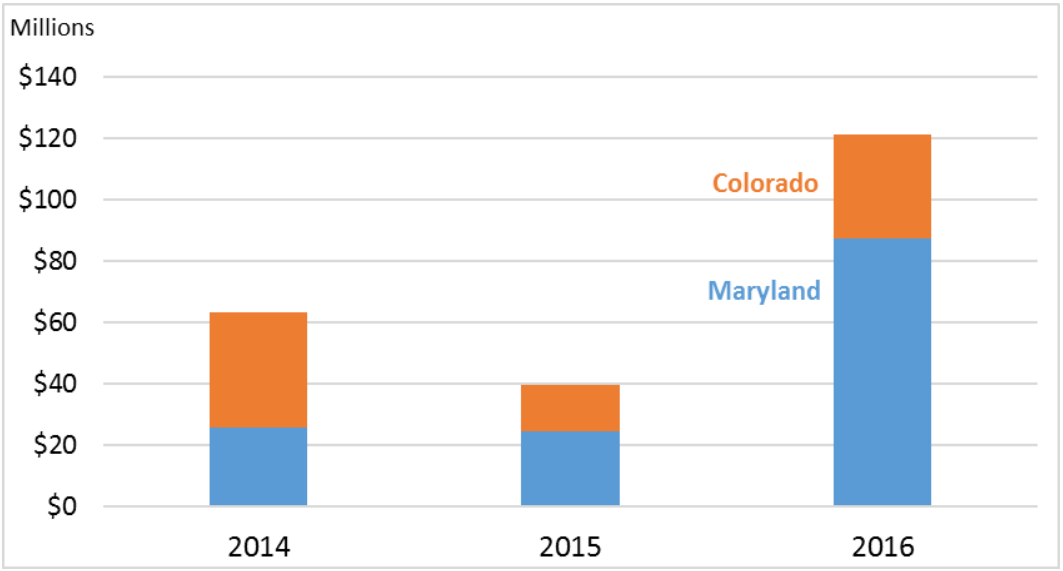
**TABLE 1: NIST EXPENDITURES, IN MILLIONS, FY2014–FY2016**

| Expenditures | FY2014 | FY2015 | FY2016 |
|---|---|---|---|
| Labor | $417.4 | $440.5 | $465.5 |
| Operating/Other Expenditures | $513.7 | $559.7 | $522.2 |
| Construction | $63.4 | $39.7 | $121.3 |
| **Total Direct Expenditures** | **$994.6** | **$1,040.0** | **$1,109.1** |

## Construction

NIST reported $224 million in construction spending from FY2014–FY2016 on 669 projects. These projects were completed by nearly 300 private-sector vendors. More than 61% of the spending occurred in Maryland—$137 million in total versus $87 million in Colorado. Gaithersburg projects ranged from expanding the National Fire Research Laboratory to roof replacement, HVAC restoration, fire alarm modernization, and road construction. Boulder projects were generally focused on renovations, repair, and maintenance, such as roof replacement, HVAC upgrades, solar installation, and electrical work. Given the type of construction activity reported by NIST over the three fiscal years, construction expenditures were modeled as new nonresidential building and as maintenance and repair construction of nonresidential structures. The model apportions activity into hard costs, soft costs (e.g., professional fees, engineering and design fees, environmental testing, and nondirect costs), and labor.

**FIGURE 4: NIST CONSTRUCTION, FY2014–FY2016**



## Nonlabor Operating Expenditures

NIST's operating and capital expenditures include supplies, materials, equipment, computers, software, training, maintenance, and subcontracted research. These estimates exclude labor, employee benefits, and construction costs. Operating costs and related expenditures totaled $514 million in FY2014, $560 million in FY2015, and decreased 6.7%, to $522 million, in FY2016.

## Employment

NIST directly impacts jobs in two ways—through direct employment and through contracted associates. NIST employment averaged 3,179 workers from FY2014–FY2016, and NIST associates averaged 5,161 over the same period.

### *NIST Employees*

NIST employed an average of 3,178 full-time and part-time workers from FY2014–FY2016 (including students). From FY2014–FY2016, the average number of employees at NIST Gaithersburg was 2,742; the average number at NIST Boulder was 436. Both locations are top 25 employers in their respective communities. NIST Gaithersburg accounted for 86% of overall NIST employment, or 2,810 workers, in FY2016, while Boulder counted 463 workers. NIST full-time and part-time employment increased 4.1% in FY2015 and 2.4% in FY2016, while employee costs (salary and benefits) increased 5.5% in FY2015 and 5.7% in FY2016. The average salary of these workers was $108,580 in 2016, and NIST estimated benefits at 23.7% of employee compensation for the year. Thus, the average employee *cost*, salary and benefits, totaled $142,240 for the year.

### *Full Time*

NIST reported 2,991 full-time workers in FY2014, growing to 3,128 in FY2015 and 3,192 in FY2016. Total salary and benefits also increased, up 5.8% and 5.5% in FY2015 and FY2016, respectively. Average salary (excluding benefits) for full-time workers was $105,080 in FY2014, $106,330 in FY2015, and $109,140 in FY2016.[3]

Employment and wages differed between the Boulder and the Gaithersburg establishments. NIST Gaithersburg recorded 2,741 full-time workers in FY2016, while Boulder had 451. Average full-time salaries by location were $109,410 and $107,510, respectively (excluding benefits).

[3]Salary estimates were derived from the total employee compensation (salary and benefits), less the benefits ratio provided by NIST.

### *Part Time*

NIST reported 61 part-time workers in FY2014, 54 in FY2015, and 60 in FY2016. Total salary and benefits also fluctuated, down 7.2% in FY2015 and up 8.7% in FY2016. The average salary (excluding benefits) for part-time workers was $101,040 in FY2014, $105,860 in FY2015, and $102,780 in FY2016.

NIST Gaithersburg recorded 51 part-time workers in FY2016, while Boulder had 9.[4] Average part-time salaries by location were $106,050 and $84,220, respectively (excluding benefits). Additionally, NIST reported 21 student employees in FY2016 at a cost of $1.1 million.

**TABLE 2: NIST EMPLOYMENT, FY2014–FY2016**

| Employees | FY2014 | FY2015 | FY2016 |
|---|---|---|---|
| Total Employment | 3,068 | 3,195 | 3,273 |
| Full-Time | 2,991 | 3,128 | 3,192 |
| *Percent of Total* | *97%* | *98%* | *98%* |
| Part-Time and Student | *77* | *67* | *81* |
| *Percent of Total* | 2.5% | 2.1% | 2.5% |
| Total Compensation (Millions) | $417 | $441 | $466 |

### *Employment by County*

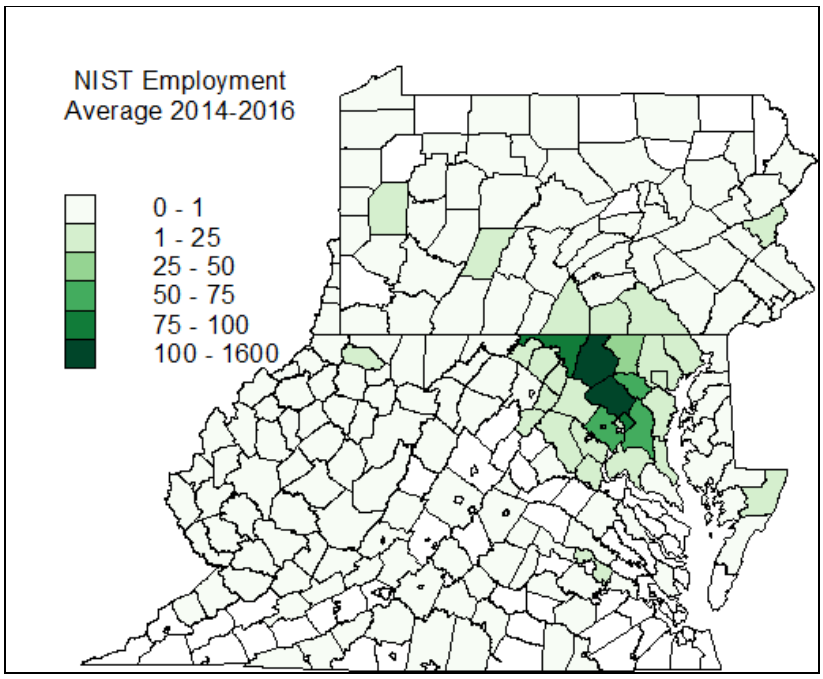
Located in Boulder, Colorado, and Gaithersburg, Maryland, the majority of NIST employees live in the primary counties of the two establishments. More than 58% of NIST Gaithersburg employees live in Montgomery County, Maryland, and another 30% commute from directly adjacent counties. The Washington-Arlington-Alexandria metropolitan statistical area (MSA) and the Baltimore-Columbia-Towson MSA are home to 94% of NIST Gaithersburg employees.

More than 59% of NIST Boulder employees live in Boulder County, Colorado, and another 30% commute from directly adjacent counties. The Denver-Aurora-Lakewood MSA and the Boulder MSA are home to 89% of NIST Boulder employees. The metropolitan Front Range accounts for more than 99% of employment.[5]

[4] Excluding student workers.

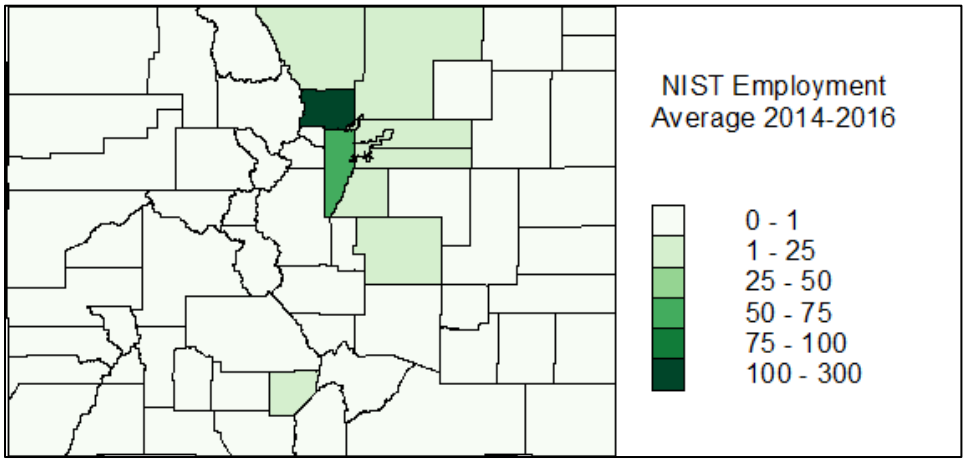
[5] The metropolitan Front Range is roughly defined as the area stretching from Fort Collins to Colorado Springs.

**FIGURE 5: NIST GAITHERSBURG EMPLOYEE LABOR SHED**




Note: Thirteen other states represent <0.5% of NIST Gaithersburg employee home of record.

**FIGURE 6: NIST BOULDER EMPLOYEE LABOR SHED**




Note: Four other states represent <0.5% of NIST Boulder employee home of record.

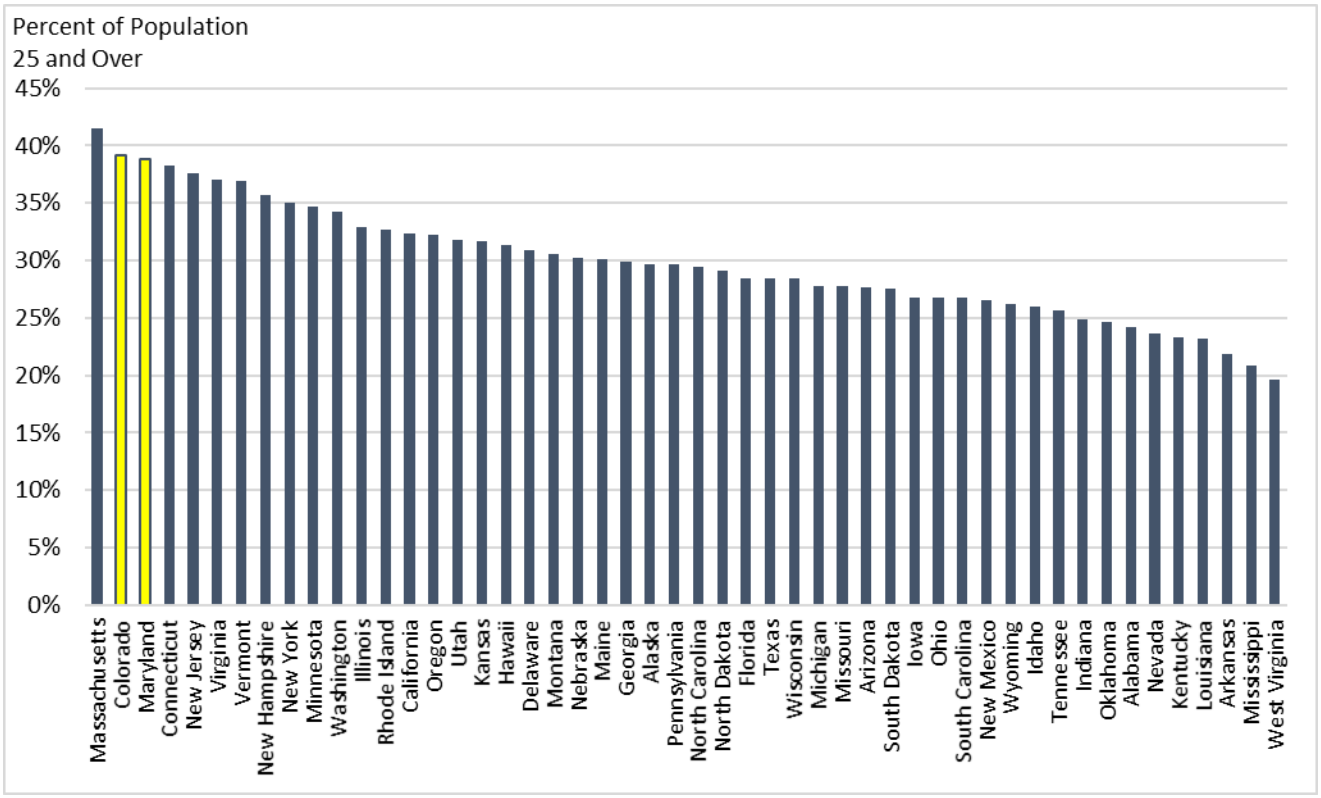
Maryland and Colorado are among the states with the highest level of educational attainment. American Community Survey data from the U.S. Census Bureau identify Colorado and Maryland as states with the second- and third-highest percentages of population 25 and over with a bachelor's degree, and the seventh- and second-highest concentrations of graduate or professional degrees. NIST's highly educated workforce contributes to the high overall educational attainment at the city, county, and state levels.

**TABLE 3: EMPLOYEE EDUCATIONAL ATTAINMENT, POPULATION 25 YEARS AND OVER**

| Place | Bachelor's Degree or Higher | Graduate or Professional Degree |
|---|---|---|
| City of Boulder | 73.0% | 39.8% |
| Boulder County | 60.6% | 26.8% |
| Colorado | 39.2% | 14.5% |
| Gaithersburg | 52.4% | 23.7% |
| Montgomery County | 58.0% | 30.9% |
| Maryland | 38.8% | 17.7% |
| U.S. | 30.6% | 11.6% |

Source: U.S. Census Bureau, 2015 American Community Survey 1-Year Estimates.

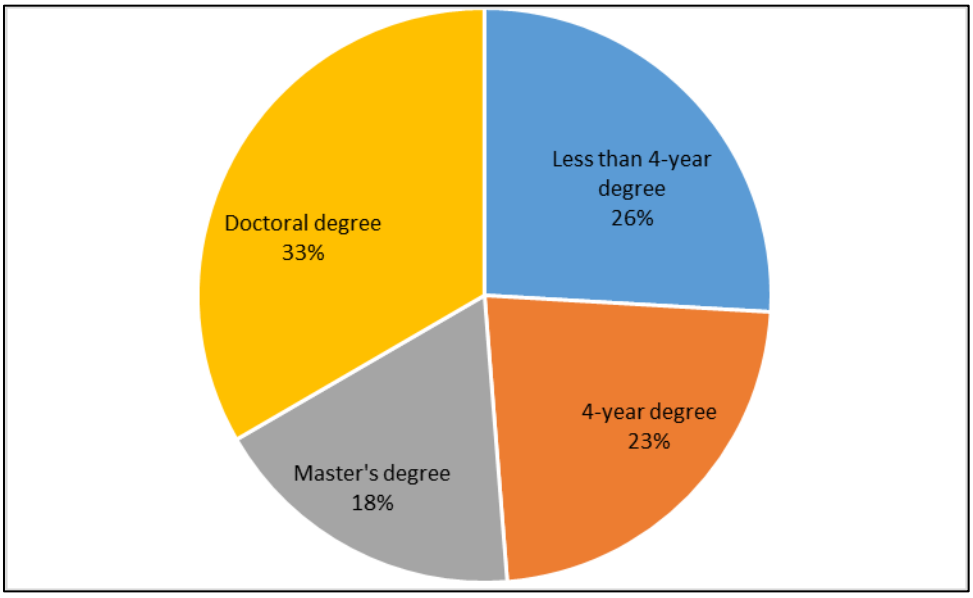
**FIGURE 7: BACHELOR'S DEGREES BY STATE, PERCENT OF POPULATION 25 AND OLDER**




Source: U.S. Census Bureau, 2015 American Community Survey 1-Year Estimates.

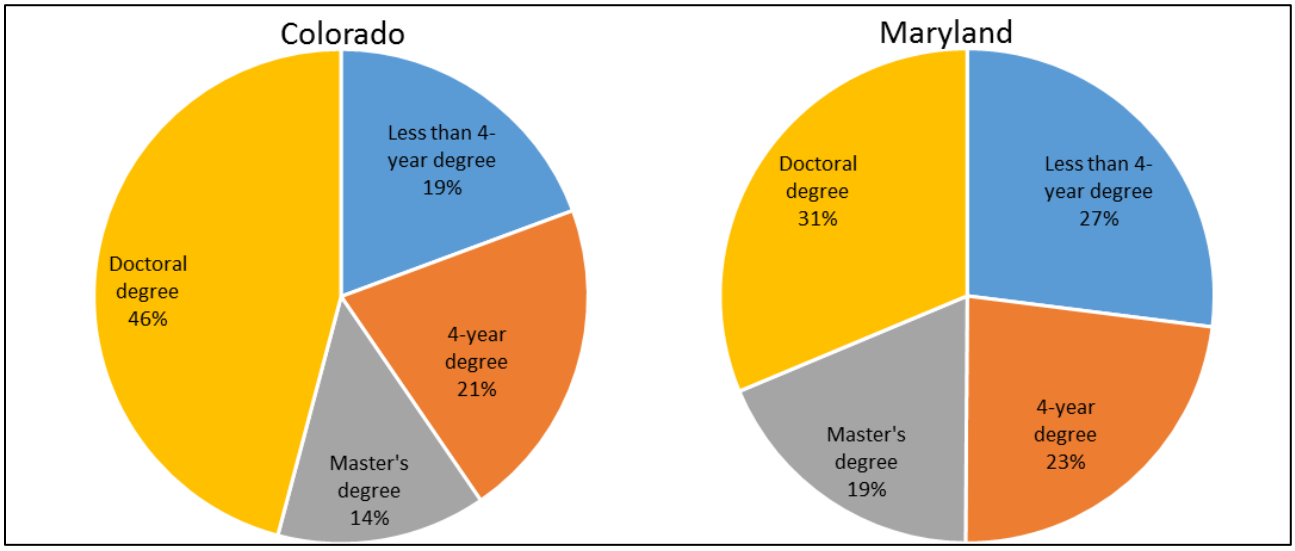
For NIST employees, the highest degree earned exceeds that of the communities where they operate. In FY2016, one-third of NIST employees had a doctoral degree, 18% had a master's degree, and 23% had a four-year degree. The remaining 26% had less than a four-year degree.

**FIGURE 8: NIST EMPLOYEE EDUCATIONAL ATTAINMENT, HIGHEST DEGREE EARNED**




The concentration of advanced degrees at NIST in Boulder exceeds those in Gaithersburg. Boulder operations reported nearly half (46%) of employees have a doctoral degree, 14% have a master's degree, and 21% have a bachelor's degree as their highest degree earned. NIST Gaithersburg reported about one-third (31%) have a doctoral degree, 19% a master's degree, and 23% a bachelor's degree.

**FIGURE 9: NIST BOULDER AND GAITHERSBURG EDUCATIONAL ATTAINMENT, HIGHEST DEGREE EARNED**

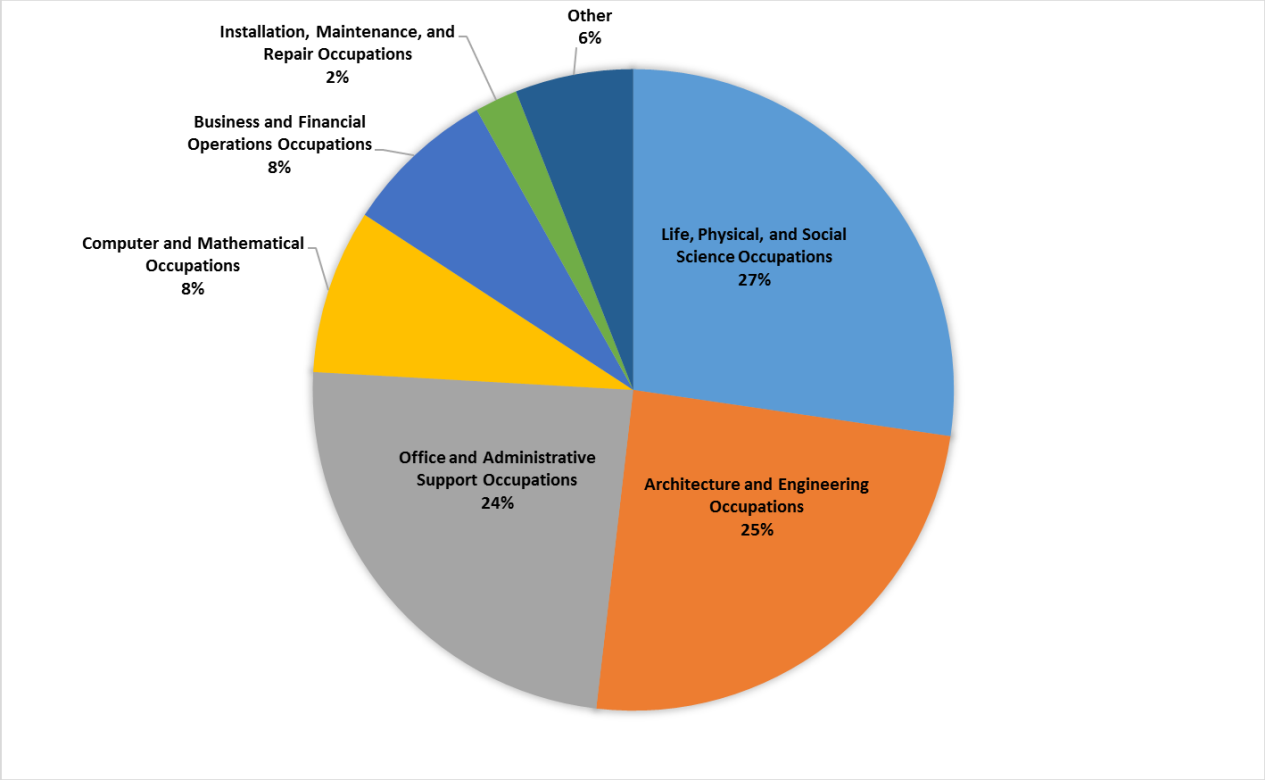



*Occupations*

As a federal research facility, NIST employees are largely performing basic and applied research functions in a wide range of occupations; however, operating a federal research facility is also the work of

individuals performing operational support functions. The 2016 occupations were converted to Standard Occupational Classification (SOC) codes. Based on NIST's 2016 occupations, an estimated 65% were in core research and development, while 35% were employed in educational, building, and business support operations.[6] Core positions include engineers, IT professionals, and research analysts. Support positions include human resources, budgeting, administration, and communications. NIST Boulder has a slightly greater concentration of core research occupations than NIST Gaithersburg (79% versus 63%, respectively).

**FIGURE 10: NIST EMPLOYEE OCCUPATIONS**




## Associates

NIST also works with associates, who perform work at NIST but are not directly NIST employees. These workers may be paid by NIST on a contract basis, or may be compensated by a partner institution (see Table 4 for a list of NIST associates by type). Associates totaled 4,662 in FY2014, growing 6.6% in FY2015, to 4,972, and increasing 11.6% in FY2016, to 5,550 (Table 5). From FY2014–FY2016, an average of 20% of associates were at the Boulder campus, while 80% were in Gaithersburg. Estimated compensation of associates totaled $205.8 million in FY2014, $222.6 million in FY2015, and $247 million in FY2016 (Table 6). More than 81.5% of estimated compensation went to Gaithersburg Associates over the three years.

[6]The split between research and support activities was based on job title alone.

**TABLE 4: NIST ASSOCIATES, BY TYPE**

| Associate Type |
|---|
| Domestic Guest Researcher - Research and Science |
| Domestic Guest Researcher - Special Programs |
| Domestic Guest Researcher - Technical |
| Facility User |
| Foreign Guest Researcher - Research and Science |
| Foreign Guest Researcher - Special Programs |
| Foreign Guest Researcher - Technical |
| Intergovernmental Agency Personnel Act |
| Non-Technical Support Personnel |
| Off-site Collaborator |
| Other |
| Research Associate |
| Sole Proprietor Contractor |
| Volunteer Student |

**TABLE 5: NUMBER OF ASSOCIATES BY CAMPUS, FY2014-FY2016**

| Year | Boulder Campus | Gaithersburg Campus | Total |
|---|---|---|---|
| FY2014 | 939 | 3,723 | 4,662 |
| FY2015 | 1,022 | 3,950 | 4,972 |
| FY2016 | 1,082 | 4,468 | 5,550 |

Compared to NIST employees, many more associates work less than full time. From FY2014-FY2016, 30% of associates were full time (i.e., working 35 hours or more per week), while 70% were part time (fewer than 35 hours per week), and 59% were working 50% or less per week. This study focuses on the headcount of workers, regardless of full-time or part-time status, which is how the Bureau of Labor Statistics counts employees.[7,8]

[7]"CES employment is an estimate of the number of nonfarm, payroll jobs in the U.S. economy. Employment is the total number of persons on establishment payrolls employed full- or part-time who received pay (whether they worked or not) for any part of the pay period that includes the 12th day of the month."
[8]The IMPLAN model, like the Bureau of Labor Statistics, uses a headcount for employment, not full-time equivalents.

**TABLE 6: ESTIMATED COMPENSATION OF NIST ASSOCIATES, FY2014–FY2016**

| Year | Boulder Campus | Gaithersburg Campus | Total |
|---|---|---|---|
| FY2014 | $37.2 | $168.6 | $205.8 |
| FY2015 | $41.3 | $181.3 | $222.6 |
| FY2016 | $46.2 | $200.8 | $247.0 |

## ECONOMIC CONTRIBUTION

The economic contributions from NIST operations were especially concentrated in the two primary NIST locations—Boulder, Colorado, and Gaithersburg, Maryland.

### Impact on Colorado

The economic contribution of NIST operations on Colorado totaled $289 million in FY2014, falling to $279 million in FY2015 before rebounding to $319 million in FY2016. There is less employment leakage in Colorado compared to Maryland given NIST's proximity to other MSAs in the state of Colorado, as well as the relative lack of MSAs immediately across the border in neighboring states. The decline in impact in FY2015 reflects a decreasing construction budget that ultimately rebounded in FY2016.

**TABLE 7: ECONOMIC CONTRIBUTION TO COLORADO (DIRECT, INDIRECT, AND INDUCED), FY2014–FY2016**

| Fiscal Year | Employment (Average) | Labor Income (In Millions) | Value Added (In Millions) | Output (In Millions) |
|---|---|---|---|---|
| 2014 | 2,561 | $152 | $205 | $289 |
| 2015 | 2,495 | $152 | $204 | $279 |
| 2016 | 2,823 | $175 | $233 | $319 |

### Impact on Maryland

The economic contribution of NIST operations on Maryland totaled $1.4 billion in FY2014, increasing to $1.5 billion in FY2015 and $1.6 billion in FY2016. NIST's location in the Washington-Arlington-Alexandria MSA, which includes three states and the District of Columbia, results in the facility pulling from a labor shed and supply chain that spans multiple states. Thus, the economic contribution of NIST's business operations not only benefits Maryland, but has spillover benefits in neighboring Virginia, West Virginia, Washington, D.C., and even Pennsylvania, based on commuting patterns.

**TABLE 8: ECONOMIC CONTRIBUTION TO MARYLAND (DIRECT, INDIRECT, AND INDUCED), FY2014–FY2016**

| Fiscal Year | Employment (Average) | Labor Income (In Millions) | Value Added (In Millions) | Output (In Millions) |
|---|---|---|---|---|
| 2014 | 10,487 | $745 | $953 | $1,425 |
| 2015 | 10,997 | $787 | $1,012 | $1,509 |
| 2016 | 12,220 | $864 | $1,102 | $1,595 |

### Impact on the Nation

The economic contribution of NIST operations and construction totaled $2.4 billion in FY2014, increasing to $2.5 billion in FY2015 and $2.7 billion in FY2016. About 66% of the impact was value added. The decrease in the operating budget was buffered by the increase in construction expenditures in FY2016—operating expenditures fell by 1.2% while construction expenditures nearly tripled. Thus, the economic contribution of NIST increased 8.6% in FY2016.

Total (direct, indirect, and induced) employment impacts summed to 16,864 in FY2014, impacted by business operations and by one-time construction expenditures. Labor income (direct, indirect, and induced) associated with operations and construction summed to $1.1 billion in FY2014. The employment and labor impact increased to 17,406 jobs and $1.2 billion in income in FY2015, and totaled 17,068 jobs and $1.3 billion in income in FY2016. Direct jobs are the sum of employees and associates. Direct employment totaled 3,273 in FY2016, while full-time and part-time associates totaled 5,550. While the economic contribution from construction increased notably in 2016, the majority of economic benefits continued to be derived from operations—largely employment.

**TABLE 9: NIST NATIONAL ECONOMIC CONTRIBUTION (DIRECT, INDIRECT, AND INDUCED), FY2014–FY2016**

| Fiscal Year | Employment (Average) | Labor Income (In Millions) | Value Added (In Millions) | Output (In Millions) |
|---|---|---|---|---|
| 2014 | 16,864 | $1,107 | $1,571 | $2,426 |
| 2015 | 17,406 | $1,157 | $1,640 | $2,519 |
| 2016 | 17,068 | $1,279 | $1,801 | $2,736 |

## OTHER IMPACTS

This report quantifies the economic contribution of NIST as a business unit, and does not quantify the value or economic impact of the basic research advancements or the licensed, commercialized products. Beyond the impact of business operations, NIST has numerous societal and economic benefits ranging from education to innovation.

NIST researchers provide a number of beneficial scientific contributions to society through their research, technology transfer, and educational work. By providing educational and training opportunities for students ranging from children in elementary school to postdoctoral graduate students, NIST increases the human capital (i.e., talent) of the national economy. NIST effectively disseminates information by publishing research and discoveries, which has the potential to have broad impacts on society. Prior studies have shown a median benefit-cost ratio of 9.0, meaning that the median the economic benefit associated with spending $1 on NIST is equal to $9 in increased economic output.

Finally, through transferring technology to the private sector, NIST promotes private industry's adoption of new technologies developed at the lab. In confirmation of their contribution to science, many NIST researchers have received prestigious awards recognizing their work.

### *Published Research*

NIST performs innovative research that has the potential to be used in numerous different technological products in a variety of fields. One way of measuring the impact of NIST research is through the dissemination of research in top-tier scientific journals. According to NIST, the lab uses the Thomson Reuter's Journal Impact Factor (IF) as way to distinguish top-tier journals from those journals that are not top tier (Makar and Malanowski 2016). This metric rates journals based on how often the average article in a specific journal has been cited over a period. Over the 10-year period from FY2007 to FY2016, an average of 31% of the papers authored by NIST were published in top-tier journals. In FY2016, nearly one-quarter (24.3%) of NIST papers were published in top-tier journals. The most frequent journals to publish articles originating from NIST during FY2016 were *Physical Review Letters,* with 33 articles; *Scientific Reports,* with 15 articles; *ACS Applied Materials & Interfaces* and *Nature Communications,* each with 12; and *Forensic Science International: Genetics,* with 11. In total, during FY2016, a total of 329 NIST articles were published in 114 separate top-tier journals.

### *Technology Transfer*

NIST operates a Technology Partnerships Office (TPO) that is focused on establishing and sustaining technology transfer partnerships between NIST laboratories and firms, local, state and federal agencies, as well as the general public (NIST Technology Partnerships Office). The TPO transfers technology through a number of different methods, including Cooperative Research and Development Agreements (CRADAs), Material Transfer Agreements (MTAs), Facility Use Agreements (FUAs), as well as through intellectual property transfer agreements.

Small Business Innovation Research (SBIR) contracts are awarded to U.S. firms to engage in federally funded research and development agreements for technologies with potential for commercialization. From 2003–2016, NIST awarded 293 SBIR awards to 276 companies totaling $44.1 million.

NIST also has an Entrepreneur-in-Residence (EIR) program in which guest and NIST researchers identify technologies with commercial potential and work with the private sector to facilitate the commercialization process. The researchers also learn about entrepreneurship and the commercialization process (National Institute of Standards and Technology 2016).

NIST participates in the Interagency Workgroup for Technology Transfer (IAWGTT), which was created by executive order in 1987 to "encourage and facilitate collaboration among Federal laboratories, State and local governments, universities, and the private sector, particularly small business, in order to assist in the transfer of technology to the marketplace" (National Archives). Led by NIST, this workgroup facilitates interagency knowledge and discussions related to technology transfer. NIST also hosts the Federal Laboratory Consortium for Technology Transfer (FLC), which is a network of federal laboratories that provides a forum for improving and linking the laboratory objective of transferring technologies to the private sector.

### *Education*

NIST offers a number of employment and internship opportunities for prospective students (NIST, Office of Human Resources Management 2016). Any student currently enrolled in an accredited high school, college/university, community college, or junior college is eligible to apply for a NIST internship. While working at NIST, these interns gain valuable experience, knowledge, and insight into research and laboratory work. After they graduate, these former interns bring their newly developed skills and knowledge to the private or public sector. The internship program provides U.S. firms with a source of highly skilled and productive researchers and laboratory workers to develop new goods and services and improve existing ones.

NIST also offers a program aimed at improving the knowledge and teaching skills of middle school science teachers through its NIST Summer Institute for Middle School Science teachers (NIST, Office of Human Resources Management 2016). This program, led by NIST researchers, combines tours, lectures, and activities that are designed to correlate with the middle school science curriculum and with NIST researchers' expertise in measurement sciences. Another educational program that NIST offers is Adventure in Science, Inc., which offers classes for young people ages 11–15 in numerous scientific disciplines.

NIST laboratories offer technically oriented guided tours for a number of different clients ranging from elementary school children to professionals working for universities, industry, and government, as well as in the scientific and technical communities (NIST, Office of Public Affairs 2016). Each tour is tailored to the interests of the group or individual visiting the facility. (It is important to note that due to security concerns NIST no longer offers tours to the general public.) NIST Gaithersburg reported more than 60 organized tours to high school students, college students, and educators from 2014–2016. In 2016 alone, the Gaithersburg operation recorded 28 tours to more than 600 individuals from over 20 unique

institutions. Developing human capital is one of NIST's main objectives as it seeks to promote domestic industrial competiveness and innovation.

The Summer Undergraduate Research Fellowship (SURF) is an 11-week summer internship program for students enrolled in two-year and four-year higher education institutions. Interns work on research and projects in a variety of different fields, such as chemical engineering, electrical engineering, information technology, materials science, and physics. Interns have the opportunity to work in either the NIST Boulder or the NIST Gaithersburg facility under the mentorship of a NIST scientist or engineer. In a survey conducted at the end of the 2016 SURF program, 95% of respondents reported that the SURF program had benefited their education and development. NIST also notes benefiting from the SURF program as interns bring with them new ideas and insights. Many SURF students come from universities and colleges located in Maryland and Colorado, including:

- University of Colorado Boulder, University of Colorado Colorado Springs, and Colorado School of Mines
- University of Maryland College Park, University of Maryland Baltimore County, Hood College, Towson University, Montgomery College, and Coppin State University

Also, NIST provides postdoctoral opportunities for advanced research with the NIST NRD Postdoctoral Research Associateship Program. This program allows for skills training and information transfer between NIST and external postdocs.

### *Employee Awards and Accomplishments*

NIST researchers have received numerous academic and organizational awards for their research and technological development efforts. In total, five NIST researchers have been awarded the Nobel Prize, including Dave Wineland (2012), Dan Shechtman (2011), Jan Hall (2005), Eric Cornell (2001), and Bill Phillips (1997) (NIST and the Nobel). This research has produced knowledge and technology that can be used in geological measurements, communications, and navigation.

NIST also holds an awards ceremony to recognize the service and achievements of staff members. Each year individuals receive awards for outstanding and significant achievements and contributions that benefit society and advance NIST's goals and mission (NIST Awards 2016). To illustrate, one group of researchers created standards that transformed magnetic resonance imaging into a quantitative tool that can be used to assist with the diagnosis and treatment of traumatic brain injury and cancer. The team later successfully transferred this technology to accelerate its development and adoption (NIST Awards 2016).

Additionally, employees contribute to the combined federal campaign, collectively donating $543,312 in 2016.

## CONCLUSION

NIST operations provided significant economic benefits to the nation, as well as to the two states of primary operations—Colorado and Maryland. As Maryland is the primary location for NIST research and administration, the state received the greatest economic benefit from operations in FY2016, with total output of $1.6 billion. Colorado, too, recorded significant economic benefits, totaling $317 million in FY2016. However, many other states recorded economic benefits as the workforce and the supply chain for operations and construction spill over beyond Maryland's and Colorado's borders. Additional economic benefits result from the research performed within NIST, but the impact of the knowledge dissemination and technology transfer are beyond the scope of this report.

## BIBLIOGRAPHY


Bureau of Labor Statistics. July 7, 2017. Current Employment Statistics - CES (National), Estimation Methods, Estimation Concepts. https://www.bls.gov/web/empsit/cesfaq.htm, accessed July 21, 2017.

Carnegie Classification of Institutions of Higher Education. Standard Listings. http://carnegieclassifications.iu.edu/lookup/standard.php, retrieved June 19, 2017.

Carnegie Classification of Institutions of Higher Education. Basic Classification Description. http://carnegieclassifications.iu.edu/classification_descriptions/basic.php, retrieved July 11, 2017.

Cornell Law School. Legal Information Institute, CFR, 35.017 Federally Funded Research and Development Centers, https://www.law.cornell.edu/cfr/text/48/35.017, accessed July 11, 2017.

IMPLAN. 2015. 536 FTE & Employment Compensation Conversion Table (2013). http://support.implan.com/index.php?view=document&alias=4-536-fte-a-employment-compensation-conversion-table&category_slug=536&layout=default&option=com_docman&Itemid=1764, accessed July 21, 2017.

IMPLAN. 2015. Controlled vocabulary of IMPLAN-specific terms, Jobs. http://support.implan.com/index.php?option=com_glossary&letter=J&id=231, accessed July 21, 2017.

Makar, Susan and Amanda Malanowski. November 22, 2016. *Top Tier Journals in which NIST Publishes, FY2016*. Information Services Office.

National Archives. Federal Register, Executive Orders, Executive Order 12591—Facilitating access to science and technology, https://www.archives.gov/federal-register/codification/executive-order/12591.html, accessed July 11, 2017.

National Institute of Standards and Technology. International and Academic Affairs Office. NIST NRC Postdoctoral Research Associateships Program. https://www.nist.gov/iaao/nist-nrc-postdoctoral-research-associateships-program, retrieved September 5, 2017.

National Institute of Standards and Technology. 2016. *Federal Laboratory Technology Transfer Fiscal Year 2014*. https://www.nist.gov/sites/default/files/documents/2016/10/26/fy2014_federal_tech_transfer_report.pdf, retrieved June 19, 2017.

National Science Foundation. Master Government List of Federally Funded R&D Centers. https://www.nsf.gov/statistics/ffrdclist/, retrieved June 19, 2017.

National Science Foundation. National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development: Fiscal Years 2015–17, https://www.nsf.gov/statistics/srvyfedfunds/ retrieved June 19, 2017.

NIST. December 15, 2016. Awards Recognize Staff for Outstanding Performance. https://www.nist.gov/news-events/news/2016/12/nist-2016-awards-recognize-staff-outstanding-performance, retrieved June 19, 2017.

NIST. International and Academic Affairs Office. August 25, 2016. Guide to NIST's STEM Education Activities. https://www.nist.gov/iaao/guide-nists-stem-education-activities, retrieved June 19, 2017.

NIST. NIST and the Nobel. https://www.nist.gov/nist-and-nobel, retrieved July 11, 2017.

NIST. Office of the Director. December 30, 2016. "Summary of NIST Laboratory Economic Impact Studies," https://www.nist.gov/director/summary-nist-laboratory-economic-impact-studies, retrieved June 19, 2017.

NIST. Office of Human Resources Management. August 25, 2016. Internship Program. https://www.nist.gov/ohrm/internship-program, retrieved June 19, 2017.

NIST. Office of Public Affairs. December 29, 2016. NIST Tours. https://www.nist.gov/director/pao/nist-tours, retrieved June 19, 2017.

NIST. Our Organization. January 26, 2017. NIST Mission, Vision, Core Competencies, and Core Values. https://www.nist.gov/about-nist/our-organization/mission-vision-values, retrieved June 4, 2017.

NIST. Public Affairs Office. March 20, 2017. NIST General Information. https://www.nist.gov/director/pao/nist-general-information, retrieved June 19, 2017.

NIST. Summer Undergraduate Research Fellowship (SURF). https://www.nist.gov/surf, retrieved August 30, 2017.

NIST. Technology Partnerships Office. https://www.nist.gov/tpo, retrieved June 19, 2017.

Office of Management and Budget. OMB BULLETIN NO. 15-01. https://obamawhitehouse.archives.gov/sites/default/files/omb/bulletins/2015/15-01.pdf, retrieved May 14, 2017.

U.S. Bureau of Economic Analysis. Gross domestic product (GDP) by state (millions of current dollars), www.bea.gov, accessed June 14, 2017.

U.S. Bureau of Economic Analysis. Real GDP by state (millions of chained 2009 dollars), www.bea.gov, accessed June 14, 2017.

U.S. Bureau of Economic Analysis. SA25 Total Full-Time and Part-Time Employment by SIC Industry, www.bea.gov, accessed June 14, 2017.

U.S. Bureau of Economic Analysis. SA25N Total Full-Time and Part-Time Employment by NAICS Industry, www.bea.gov, accessed June 14, 2017.

U.S. Census Bureau, American Community Survey 2015, www.census.gov, accessed June 4, 2017.

U.S. Small Business Administration. Small Business Innovation Research. https://www.sbir.gov/analytics-dashboard?view_by=Year&branch_tid%5B0%5D=105742, retrieved June 15, 2017.

## APPENDIX 1: METHODOLOGY

This study was conducted in cooperation with NIST. The research team collected data from NIST administrators about operating expenditures, construction, and community engagement. Data were collected for fiscal years 2014, 2015, and 2016, and were reorganized by function and applied to a 536-sector IMPLAN input-output model that quantified the economic contribution on Colorado, Maryland, and the nation as a whole. The 2015 state and national models from IMPLAN V3 (most current available) were used in this study.

Employee counts by ZIP code allowed for the distribution of employment and wages by state, which accurately adjusted for localized employee household spending. NIST did not provide estimates for the location of purchases for nonlabor operating and construction expenditures. For this spending, the research team deferred to the local purchasing coefficients within the IMPLAN model to determine purchasing leakage. Nonlabor operating expenditures were modeled as Scientific Research and Development Services (sector 456). Given the type of construction activity reported by NIST over the three fiscal years, construction expenditures were modeled in one aggregated construction sector that included Construction of New Commercial Structures, including Farm Structures (sector 57) and Maintenance and Repair Construction of Nonresidential Structures (sector 62). The model apportions activity into hard costs, soft costs (e.g., professional fees, engineering and design fees, environmental testing, and nondirect costs), and labor.

### Overview of Economic Contribution Analysis

Economic benefits refer to dollars generated and distributed throughout the economy due to the existence of an establishment. This study estimates the economic contribution using the IMPLAN input-output model. Results are disseminated in terms of direct, indirect, and induced impacts on employment, labor income, value added, and output.

Economic benefits refer to dollars generated and distributed throughout the economy. The sources of impacts that sum to economic benefits cover construction and operating expenditures, including the off-site spending by employees and the spending on goods and services within the supply chain.

The multiplier effect of spending within the supply chain, or the indirect impact, estimates the indirect employment and earnings generated in the study area due to the interindustry relationships between the facility and other industries. As an example, consider a manufacturing company operating in Denver, Colorado. The firm employs management, engineers, and support staff for its direct manufacturing operations. In addition, the company spends on goods and services to support its manufacturing operations, leading to auxiliary jobs in the community in transportation, accounting, utilities, retail goods, and so on—the **indirect impact**. Furthermore, employees spend earnings on goods and services in the community, leading to jobs in retail, accounting, entertainment, and so on—the **induced impact**.

Conceptually, the multiplier effect quantifies the economic ripple effect of economic activity. This ripple effect can be positive or negative depending if a company or industry is expanding or contracting. Multipliers are static and do not account for disruptive shifts in infrastructure without specifically addressing infrastructure changes.

## APPENDIX 2: DEFINITIONS

*Direct Impact*: Initial economic activity (e.g., sales, expenditures, employment, production, etc.) by a company or industry.

*Employment*: Full-time and part-time workers.

*Gross Domestic Product (GDP)*: A measure of economic activity, GDP is the total value added by resident producers of final goods and services.

*Gross Output (Output)*: The total value of production is gross output. Unlike GDP, gross output includes intermediate goods and services.

*Indirect Impact*: The upstream (backward) economic activity impacted by purchases along a company or industry supply chain.

*Induced Impact*: Economic activity derived from workers spending their earnings on goods and services in the economy.

*Labor Income*: Total compensation of employees (wages and benefits) and sole proprietors (profits).

*Metropolitan Statistical Area (MSA)*: According to the Office of Management and Budget, "Metropolitan Statistical Areas have at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties."

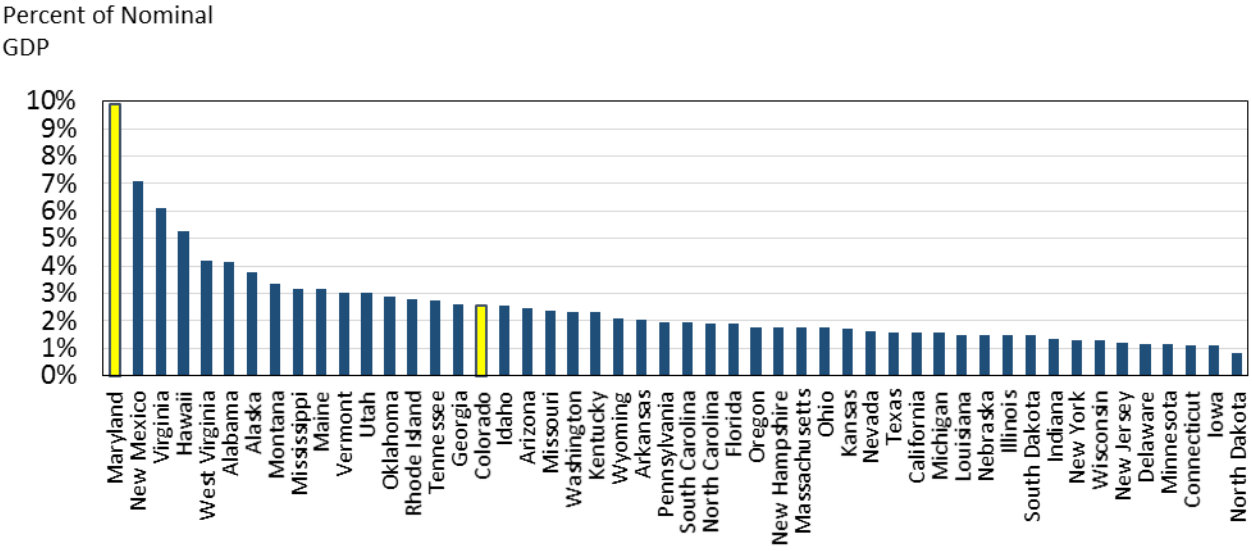
- Boulder MSA: Boulder County, CO
- Baltimore-Columbia-Towson: Anne Arundel County, Baltimore County, Carroll County, Harford County, Howard County, Queen Anne's County, Baltimore city.
- Denver-Aurora-Lakewood MSA: Adams, Arapahoe, Broomfield, Clear Creek, Denver, Douglas, Elbert, Gilpin, Jefferson and Park counties in Colorado
- Washington-Arlington-Alexandria MSA: District of Columbia; Calvert County, MD; Charles County, MD; Frederick County, MD; Montgomery County, MD; Prince George's County, MD; Arlington County, VA; Clarke County, VA; Culpeper County, VA; Fairfax County, VA; Fauquier County, VA; Loudoun County, VA; Prince William County, VA; Rappahannock County, VA; Spotsylvania County, VA; Stafford County, VA; Warren County, VA; Alexandria city, VA; Fairfax city, VA; Falls Church city, VA; Fredericksburg city, VA; Manassas city, VA; Manassas Park city, VA; Jefferson County, WV

*Value Added*: The contribution of an industry or region to total GDP, value added equals gross output, net of intermediate input costs.

## APPENDIX 3: ECONOMIC OVERVIEW

NIST employees and research activities are generally classified as federal civilian activity in federal statistics. Including activity across the 50 states, the contribution to GDP from the federal civilian sector accounted for 2.3% of nominal U.S. GDP in 2015.[9] The federal civilian contribution to state GDP was higher in both Colorado (2.5%) and Maryland (9.9%)—the two states with NIST labs. In 2015, Maryland recorded the highest contribution from the federal civilian sector in the nation, outside of the District of Columbia, while Colorado's concentration ranked 17th among the states.

**FIGURE 11: FEDERAL CIVILIAN NOMINAL GDP AS A SHARE OF TOTAL GDP, 2015**

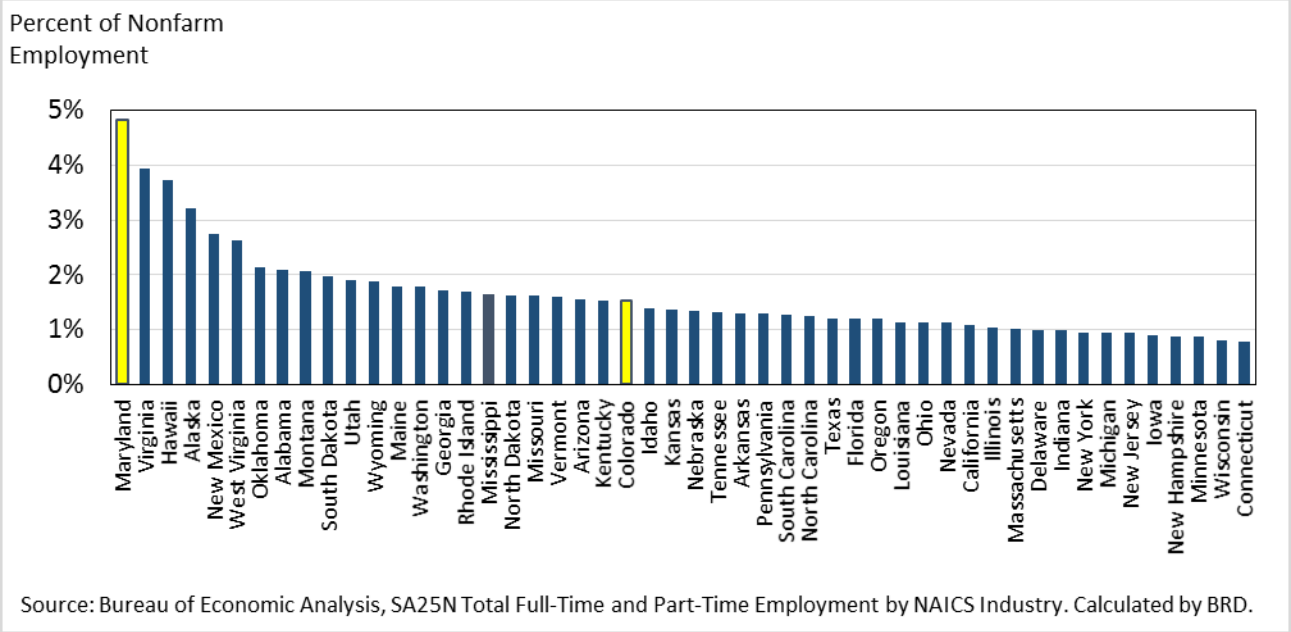



Source: Bureau of Economic Analysis, Gross domestic product (GDP) by state (millions of current dollars). Calculated by BRD.

While Maryland also has a higher concentration of federal civilian employment than the average nationally, Colorado is on par with the nation. Employment in the federal civilian sector accounted for 1.5% of U.S. total nonfarm employment in 2015. Federal civilian employment as a share of total nonfarm employment totaled 1.5% in Colorado and 4.8% in Maryland—the two states with NIST labs. In 2015, Maryland recorded the highest contribution from the federal civilian sector in the nation, outside of the District of Columbia, while Colorado's concentration ranked 23rd among the states.

[9]U.S. GDP by industry was sourced from the Bureau of Economic Analysis, gross domestic product (GDP) by state in order to provide a consistent comparison to national domestic averages. Alternatively, value added by industry for the United States may be sourced from the BEA, including international activity.

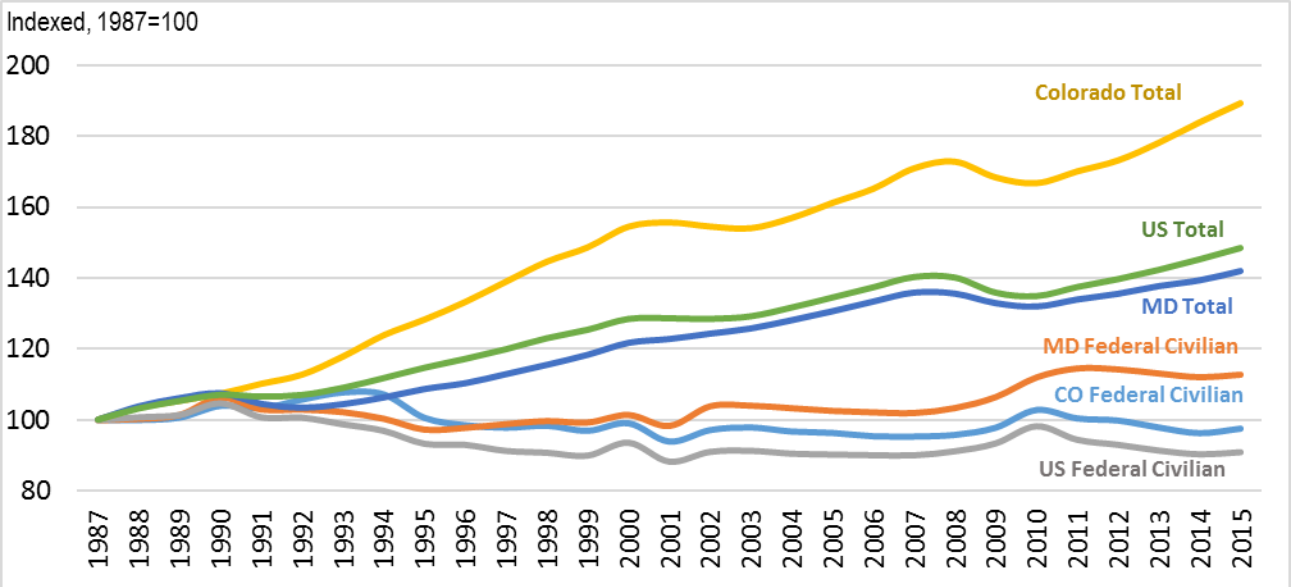
**FIGURE 12: FEDERAL CIVILIAN EMPLOYMENT AS A SHARE OF TOTAL NONFARM EMPLOYMENT, 2015**




Source: Bureau of Economic Analysis, SA25N Total Full-Time and Part-Time Employment by NAICS Industry. Calculated by BRD.

Despite the concentrations of federal civilian employment meeting or exceeding the national average, federal civilian employment has fallen short as a growth industry over the past 30 years. Federal civilian employment in Maryland increased 12.7% from 1987 to 2015, but fell in Colorado by 2.4% and nationally by 9%. During the same period, total nonfarm employment increased 41.8% in Maryland, 89.3% in Colorado, and 48.5% nationally.

**FIGURE 13: INDEXED EMPLOYMENT GROWTH, 1987–2015**

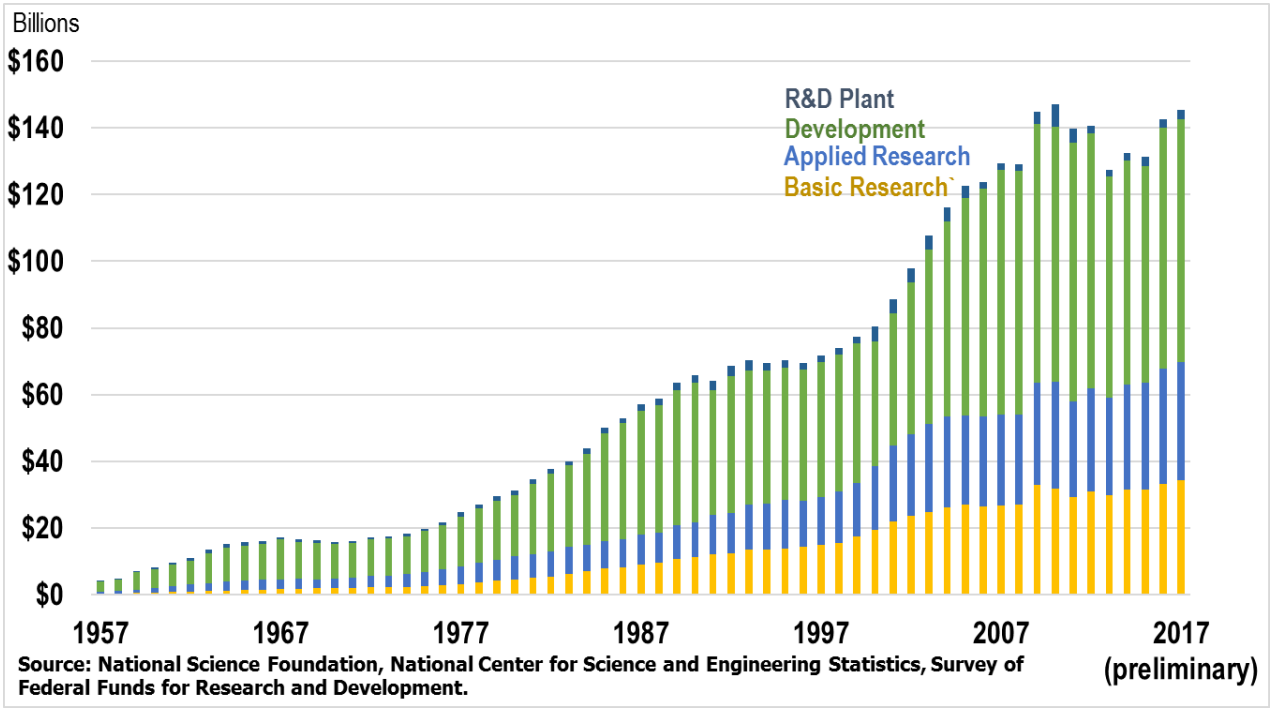



Source: Bureau of Economic Analysis, Total Full-Time and Part-Time Employment by Industry. BRD calculations.

## APPENDIX 4: FEDERAL RESEARCH FUNDING OVERVIEW

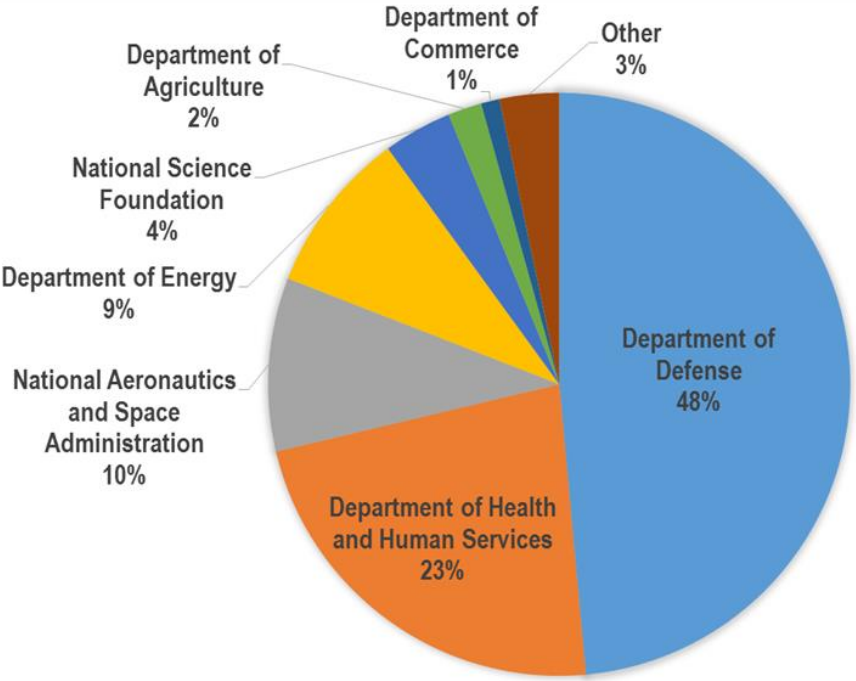
Federal obligations for total research and development continued to increase for the third consecutive year in 2017, with 2% growth from 2016 levels. Basic and applied research funding rose in 2017, each hitting record funding levels for the second year in a row. Development and plant funding also increased, but are well below past funding levels, remaining down 6% and 58%, respectively, from previous funding peaks. The majority of preliminary federal outlays for research and development from FY2015 through FY2017 were primarily devoted to the Department of Defense (48%), followed by the Department of Health and Human Services (23%). NIST's parent organization, the DOC, accounted for 1% of federal outlays for research and development. According to the National Science Foundation (NSF), the DOC ranked seventh for total research funding among federal agencies (Federal Obligations and Outlays for Research and Development, by Agency: FYs 2015–17). NIST received about 47% of DOC funding from FY2015 to FY2017.

**FIGURE 14: FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, 1957–2017**



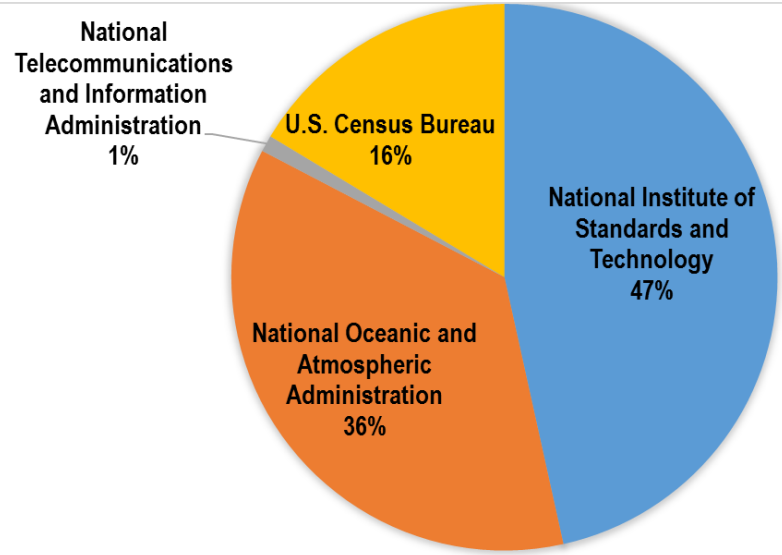

Source: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.

**FIGURE 15: FEDERAL OUTLAYS FOR RESEARCH AND DEVELOPMENT BY AGENCY, AVERAGE FY2015–17 (PRELIMINARY)**




**Source: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.**

**FIGURE 16: FEDERAL OUTLAYS FOR RESEARCH AND DEVELOPMENT DEPARTMENT OF COMMERCE, AVERAGE FY2015–17 (PRELIMINARY)**




**Source: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.**