Economic Contribution of Federally Funded Research Facilities in Colorado, FY2013–FY2015

A consulting report conducted for CO-LABS.

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EXECUTIVE SUMMARY

Federal research facilities provide economic benefits to the Colorado economy through direct facility employment and through the purchasing of goods and services. However, given the nature of the research and development (R&D) conducted at the various facilities, employment and expenditures represent only a fraction of the full benefits of federal research facilities in Colorado. These auxiliary benefits include the development and existence of high-tech firms that locate near the facilities, collaborations with Colorado universities on cutting-edge research, experience for higher-education students through internships and part-time jobs, world-renowned research conducted in the state, and the economic benefits associated with R&D programs.

This study quantified the economic impacts that federal research facilities and their university affiliates have on Boulder, Jefferson, and Larimer counties, and on the state of Colorado. This report estimates the economic benefits and fiscal impacts associated with these facilities, and identifies the intangible benefits, including spin-off companies, commercialized research, research awards, and strategic affiliates that contribute to the uniqueness of the federal research presence in the state. Primary data on operating and capital expenditures were collected from the facilities using a survey.

The economic benefits of federal research facilities and their affiliates totaled $2.5 billion in each FY2013 and in FY2014 in Colorado. Given moderate employment increase, this impact increased to an estimated $2.6 billion in FY2015. In total, these facilities accounted for nearly 7,800 full-time, part-time, contract, and student jobs in Colorado in FY2015, which supported an additional 9,800 jobs through the multiplier effect. Economic activity in Boulder, Jefferson, and Larimer counties totaled $1.1 billion, $654 million, and $195 million, respectively, in FY2015.

Overall, Colorado federal lab employees are a highly educated group, with 55% having attained a master's degree or doctorate, and 30% having attained a four-year degree (highest level attained). This exceeds the educational attainment of the general Colorado population: 14.5% have attained a graduate or professional degree (including doctorate) and 24.8% a bachelor's degree. This is expected as high levels of knowledge and training are necessary to perform the work and conduct research in these facilities.

Many metrics can be used to measure Colorado's rank for federal R&D. Data from the National Science Foundation (NSF) show that in 2014 Colorado received more than $3.6 billion in federal R&D expenditures, or 3.2% of the national total of $110.9 billion. Colorado ranked 11th for all science and engineering R&D funding in 2014. Colorado ranked in the top 25 states in terms of science and engineering R&D funding from 11 federal agencies, and was in the top 10 for funding received from 7 of them. Most notably, Colorado ranked 2nd for funding from the Department of Commerce and the Department of Interior, 3rd in the nation for funding from the National Aeronautics and Space Administration, and 5th for Environmental Protection Agency funding. These federal R&D expenditures impact both government research facilities and private contractors, and help support the high-tech industry clusters in the state.

Last, the economic and community impacts of labs stretch beyond operating expenditures, employment, and construction. Federal labs deliver scientific discoveries and engineering innovations. They collaborate with business on joint research and commercialization, with records of tech transfer, licenses, and spin-off companies. They are partners in education, with opportunities ranging from K–12 facility tours to graduate and doctoral programs. Nine research facilities indicated participation in technology transfer, six provided examples of licensed technologies, and four named spin-off companies from lab research. Additionally, three facilities reported public-private research opportunities.

STUDY OVERVIEW

The Business Research Division (BRD) at the Leeds School of Business was commissioned by the CO-LABS organization to objectively measure the economic impacts of federal research labs located in Colorado for fiscal years (FY) 2013, 2014, and 2015. This study is an update of economic impact studies conducted by the BRD for CO-LABS in 2008, 2010, and 2013.

CO-LABS is a consortium of federally funded scientific laboratories, universities, businesses, local governments, and community leaders organized to establish Colorado as a global leader in research, technology, and their commercialization (www.co-labs.org). In this study, 33 federal research facilities that receive significant federal funding were identified in Colorado, represented by 23 broad federal organizations (see Appendix 1 for a description of each facility):

- Bureau of Reclamation, U.S. Department of the Interior (BUREC TSC)
- Centers for Disease Control and Prevention (CDC-DVBD)
- Cooperative Institute for Research in the Atmosphere (CIRA)
- Cooperative Institute for Research in Environmental Sciences (CIRES)
- DOI North Central Climate Science Center (NC CSC)
- Institute of Arctic and Alpine Research (INSTAAR)[a]
- JILA
- Laboratory for Atmospheric and Space Physics (LASP)
- National Cybersecurity Center (NCC)[a]
- National Ecological Observatory Network (NEON)
- National Oceanic and Atmospheric Administration (NOAA)
    - Earth System Research Laboratory (ESRL)
    - National Geophysical Data Center (NGDC)
    - National Weather Service (NWS)
    - National Environmental Satellite, Data, and Information Service (NESDIS)
    - Space Weather Prediction Center (SWPC)
- National Institute of Standards and Technology (NIST)
- National Renewable Energy Laboratory (NREL)
- National Solar Observatory (NSO)[a]
- National Telecommunications and Information Administration (NTIA)
- University Corporation for Atmospheric Research (UCAR)
    - National Center for Atmospheric Research (NCAR)
- U.S. Department of Agriculture - Agricultural Research Service (ARS)
    - Natural Resources Research Center (NRRC)
    - National Center for Genetic Resources Preservation (NCGRP)
    - Crops Research Laboratory (CRL)
    - Central Great Plains Research Station (CGPRS)
- U.S. Department of Agriculture - Rocky Mountain Research Station (RMRS)
- U.S. Department of Agriculture - National Wildlife Research Center (NWRC)
- DOT/FRA-Transportation Technology Center (TTC)
- US Air Force Academy (USAFA)
- UNAVCO
- U.S. Geological Survey (USGS)

[a]Indicates addition to list from the 2015 study.

The National Cybersecurity Center in Colorado Springs was founded in 2016. Additionally, in 2016, the University of Colorado Boulder was awarded National Science Foundation (NSF) funding to create the Rocky Mountain Research Data Center (RMRDC). While not yet operational, this center will allow qualified researchers to access detailed federal data for scientific research. The RMRDC is anticipated to open in May 2017.

The research team strives for consistency in data gathering and assumptions. Variance inherently exists in estimating lab impacts as different assumptions may be made by new lab staff when gathering data, as the economy changes, and as the research team is presented with new data. For these reasons, caution should be exercised when comparing reports from different years. This report presents an estimate of the economic impacts of federally funded research facilities in Colorado.

RESEARCH AND DEVELOPMENT

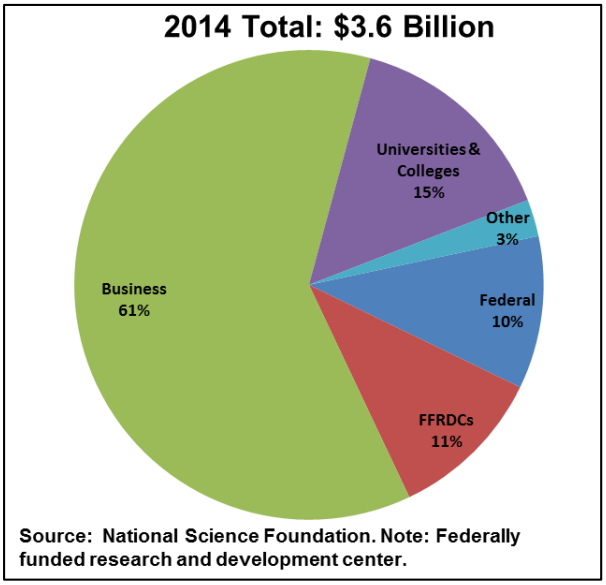
Federal R&D Rankings

A literature review was conducted to examine studies detailing the economic impacts of federal facilities and research collaborations, as well as the broader impact of research and development (R&D) on economic activity across the country. According to the NSF's *Science and Engineering Indicators 2016*, the United States remains the single-largest R&D performing country, with a total of nearly $457 billion expended in 2013, or 27% of the $1.67 trillion that was expended globally. North America accounted for 29%.

According to the NSF data, the United States (U.S.) ranked 11th in 2013 (newest available data) for gross domestic expenditures on R&D as a *percent of GDP*. The leading countries for share of GDP spent on research are Israel, South Korea, Japan, Finland, Sweden, and Denmark. The major economies ahead of the U.S. are South Korea, Japan, and Germany (nearly tied with United States). At 2.73%, U.S. spending on R&D as a percent of GDP is below 2009 levels, but was the 6th-highest percentage over the past 33 years.

The business sector still accounts for most of the U.S. R&D activity, performing an estimated $322.5 billion of R&D in 2013, or 71% of the U.S. total. The academic sector is the second-largest performer of U.S. R&D, accounting for an estimated $64.7 billion in 2013. The federal government is the second-largest funding source of U.S. R&D, providing $121.8 billion in 2013. According to the *Science and Engineering Indicators 2016,* the size of the U.S. science and engineering workforce was estimated between 6 million and 21 million in 2013.

FIGURE 1: 2014 COLORADO SCIENCE AND ENGINEERING R&D OBLIGATIONS BY PERFORMING SECTOR



Colorado R&D Rankings

It is difficult to quantify exactly how states rank in terms of their federal R&D activity. Whether it is funding, number of labs, or another metric, rankings inevitably fail to capture the whole federal R&D picture for a state. Nevertheless, rankings can offer insight into how successfully a state competes for federal R&D and the benefits that come with it, such as highly skilled labor, higher wages, and technological and economic development. Data from the NSF show that, in 2014, the most recent year for which data are available, Colorado received more than $3.6 billion in federal R&D expenditures, or 3.2% of the national total of $110.9 billion. Colorado ranked 11th for all science and engineering R&D funding in 2014.

In 2014, Colorado ranked in the top 25 states in terms of science and engineering R&D funding from 11 federal agencies, and was in the top 10 for funding received from 7 of them. Most notably, Colorado ranked 2nd for funding from the Department of Commerce and the Department of Interior, 3rd in the nation for funding from NASA, and 5th for EPA funding. These federal R&D expenditures impact both government research facilities and private contractors, and help support the high-tech industry clusters in the state.

TABLE 1: COLORADO FEDERAL OBLIGATIONS FOR S&E R&D BY FEDERAL AGENCY

Funding Agency	Amount Received (in thousands)	Percent of Agency Total	National Ranking
National Aeronautics and Space Administration	$1,472,651	40.8%	3
Department of Defense	802,477	22.2	18
Department of Energy	359,102	9.9	9
Department of Health and Human Services	331,290	9.2	20
National Science Foundation	265,292	7.3	6
Department of Commerce	192,960	5.3	2
Department of the Interior	52,041	1.4	2
Department of Agriculture	50,635	1.4	14
Department of Homeland Security	36,645	1.0	6
Environmental Protection Agency	28,772	0.8	5
Department of Transportation	19,492	0.5	14

Source: National Science Foundation.

While Colorado's high educational attainment is not solely attributable to federal R&D, the state enjoys a relatively large, highly educated workforce in the fields of science and engineering. As of December 2016, Colorado ranked 24th in the country for high-tech employment as a percentage of total employment (16%). High-tech employment consists of jobs within the Manufacturing; Information; and

Professional, Scientific and Technical Services sectors. In 2015, Colorado ranked 4th in the nation for the percentage of its workforce in science and engineering occupations, at 7.7%.

The Federal Laboratory Consortium for Technology Transfer (FLC) is a nationwide network of federal labs that provides a forum to develop strategies, partnerships, and other opportunities for linking lab technologies and expertise to the market.

Out of 341 labs in the FLC, Colorado is home to 15, tying with Ohio for the 4th-most FLC labs, behind Maryland (71), California (26), and Virginia (23). Colorado also ranks 4th among the 50 states, not including the District of Columbia, for population per FLC lab, with Maryland, Mississippi, and Virginia holding the top three spots. Other studies of the economic impact of research facilities helped inform this research study; a summary of these reports may be found in Appendix 1.

TABLE 2: POPULATION PER FLC LAB, TOP 10 STATES

Rank	State	Population per FLC Lab
1	Maryland	84,739
2	Mississippi	271,702
3	Virginia	365,731
4	**Colorado**	**369,370**
5	North Dakota	378,976
6	South Dakota	432,727
7	New Hampshire	444,932
8	New Mexico	520,254
9	Montana	521,260
10	Rhode Island	528,213

Sources: Lab data from the Federal Laboratory Consortium and population data from the Census Bureau. Calculations by BRD staff.

ECONOMIC AND DEMOGRAPHIC OVERVIEW OF AREA

Federal labs impact the communities in which they operate through direct spending and employment, high educational attainment, or the clustering effect of companies and industries. Boulder, Jefferson, and Larimer counties receive the greatest direct economic boost from research facilities in Colorado due to the location of these facilities.

The City of Boulder, located in Boulder County, is home to:

- Cooperative Institute for Research in Environmental Sciences (CIRES)
- Institute of Arctic and Alpine Research (INSTAAR)
- JILA
- Laboratory for Atmospheric and Space Physics (LASP)
- National Ecological Observatory Network (NEON)
- National Oceanic and Atmospheric Administration (NOAA)
    - Earth System Research Laboratory (ESRL)
    - National Geophysical Data Center (NGDC)
    - National Weather Service (NWS)
    - National Environmental Satellite, Data, and Information Service (NESDIS)
    - Space Weather Prediction Center (SWPC)
- National Institute of Standards and Technology (NIST)
- National Solar Observatory
- National Telecommunications and Information Administration (NTIA)
- University Corporation for Atmospheric Research (UCAR)
    - National Center for Atmospheric Research (NCAR)
- UNAVCO

In Jefferson County, Golden and Lakewood host:

- Bureau of Reclamation, U.S. Department of the Interior (BUREC TSC)
- National Renewable Energy Laboratory (NREL)
- U.S. Geological Survey (USGS)

Larimer County, specifically Fort Collins, is home to:

- Centers for Disease Control and Prevention (CDC-DVBD)
- Cooperative Institute for Research in the Atmosphere (CIRA)
- DOI North Central Climate Science Center (NC CSC)
- U.S. Department of Agriculture - Agricultural Research Service (ARS)
    - Natural Resources Research Center (NRRC)
    - National Center for Genetic Resources Preservation (NCGRP)
    - Crops Research Laboratory (CRL)
    - Central Great Plains Research Station (CGPRS)
- U.S. Department of Agriculture - Rocky Mountain Research Station (RMRS)
- U.S. Department of Agriculture - National Wildlife Research Center (NWRC)

The DOT/FRA-Transportation Technology Center (TTC) is located in Pueblo. The National Cybersecurity Center and the U.S. Air Force Academy are located in Colorado Springs. Additionally, many federal facilities have offices elsewhere in the state, such as the U.S. Department of Agriculture - Agricultural Research Service (ARS) in Akron (Washington County).

Furthermore, the University of Colorado Boulder, the Colorado School of Mines, and Colorado State University are also located in these three counties. The surrounding counties also receive an economic benefit, primarily from the spending of the employees who reside in those respective counties.

While Boulder, Jefferson, and Larimer counties comprise only 3.9% of the state's land area, 22.3% of Colorado's population resides in this region.[1] The full overview of basic demographic and economic information and county comparisons within the region may be found in Appendix 3. Some excerpts from the overview include:

- Population in the three counties grew faster than the state from 1970 to 2000, but slower than the state from 2000 to 2015.
- The population in Boulder, Jefferson, and Larimer counties recorded more bachelor's, graduate, and professional degrees than the state and national average and the Denver Metro region in 2015.
- Per capita personal income in Boulder and Jefferson counties is higher than the state and nation, but slightly lower than the state in Larimer County in 2015.
- Per capita personal income growth in Boulder and Jefferson counties grew below the national and state average between 2005 and 2011, between 2010 and 2011, and between 2014 and 2015.

[1]https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml, as of February 6, 2017.

- Federal employment declined from 2010 to 2015 in Boulder, Jefferson, and Larimer counties, in the Denver metropolitan statistical area (MSA), and in the state of Colorado. However, employment increased year-over-year for all five of these areas.
- For the primary counties with federal research facilities, the federal government sector recorded higher than average county wages in 2015—this is observed in many counties around the nation with federal research facilities.

METHODOLOGY

Researchers from the BRD met with representatives from CO-LABS to modify the survey instrument that was used in the previous CO-LABS study. The facilities were informed of the survey by the CO-LABS Board, as well as by BRD researchers. Surveys were subsequently sent via e-mail to the facility representatives.

Primary data for the study were derived from a survey that was delivered to administrators at 21 research facilities in the state. Their responses included answers representing subsidiary affiliates. The BRD received formal responses from 17 of the 21 primary facilities. Responses were solicited for FY2013−FY2015.

The facilities represented in this study are based on 17 survey responses. Surveys were received from:

- Centers for Disease Control and Prevention (CDC-DVBD)
- Cooperative Institute for Research in the Atmosphere (CIRA)
- Cooperative Institute for Research in Environmental Sciences (CIRES)
- Institute of Arctic and Alpine Research (INSTAAR)
- JILA
- Laboratory for Atmospheric and Space Physics (LASP)
- National Ecological Observatory Network (NEON)
- National Oceanic and Atmospheric Administration (NOAA)
- National Institute of Standards and Technology (NIST)
- National Renewable Energy Laboratory (NREL)
- University Corporation for Atmospheric Research (UCAR)
- UNAVCO, Inc.
- U.S. Department of Agriculture - Agricultural Research Service (ARS) (Fort Collins)
- U.S. Department of Agriculture - Agricultural Research Service (ARS) (Akron)
- U.S. Department of Agriculture - Rocky Mountain Research Station (RMRS)
- U.S. Department of Agriculture - National Wildlife Research Center (NWRC)
- U.S. Geological Survey (USGS)

This study used the IMPLAN input-output model to quantify the economic impacts of federal research facilities and their affiliates. The economic impact of the nonresponding entities was estimated based on the level of employment by facility applied to the scientific research and development services sector within the IMPLAN model. The model estimates total output, value added, and compensation based on industry averages within the region. Spending patterns for all facilities were derived from IMPLAN, deferring to the model's data on industry interactions.

Economic benefits refer to dollars generated and distributed throughout the economy due to the existence of an establishment. The sources of impacts that sum to economic benefits derive from operations, capital expenditures (construction), and offsite employee effects.

Operating costs include the purchases of materials and equipment, maintenance costs, utilities, and salaries and benefits. Construction comprises new construction, tenant improvements, and additions. Economic benefits arise from expenditures on materials, architectural and engineering services, and construction labor. Off-site employee effects include the impact of employees incurred outside the workplace. Benefits encompass employee spending, including expenditures on housing (rent or own), retail purchases, transportation, entertainment, and other disposable income expenditures. The off-site impacts rest primarily in the county of employee residence rather than in the locale of the facility.

Secondary effects, or the multiplier effects, estimate the indirect and induced employment and earnings generated in the study area due to the interindustry relationships between the facility and businesses. As an example, consider a federal lab operating in Boulder County. The lab employs scientists, managers, engineers, and support staff for its direct operations. In addition, the facility makes purchases of goods and services to support its operations, leading to auxiliary jobs in the community in transportation, utilities, wholesale goods, and so on—the indirect impact. Furthermore, employees spend their earnings on goods and services in the community, leading to jobs in retail, accounting, entertainment, and so on—the induced impact.

Conceptually, multipliers quantify the number of jobs. Multipliers are static and do not account for disruptive shifts in infrastructure without specifically addressing infrastructure changes. This study was conducted using the IMPLAN model and the underlying 2015 dataset (most current). Public revenues and public costs are not tabulated due to the unknown residence dispersion of secondary employees.

DEFINITIONS

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.

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

MODEL INPUT DATA AND ASSUMPTIONS

Annual Budget

The 17 facilities that provided data included information on their annual budgets. Estimated budgets for FY2015 totaled $1.15 billion. More than 56% of the $1.15 billion was from Boulder County facilities, 33.9% from Jefferson County facilities, 9.5% from Larimer County, and less than 1% from other counties.

Of the 17 responding facilities, 16 also provided a breakdown of their FY2015 annual budget by funding source. The Department of Energy and the National Science Foundation provided nearly 60% of the funding; add the Department of Commerce and NASA and the total for the four sums to over 80%. NREL is the primary reason the Department of Energy (DOE) appears as the top funding source, with nearly $330 million of its funding coming from the DOE alone. While these funding agencies account for a plurality of the funding reported by the 17 labs, a wide variety of other sources contribute as well, ranging from state government and higher education to private companies.

Construction

Total direct construction impacts at the research facilities are limited to those reported in the survey instrument. Facilities were surveyed about their estimated construction expenditures. The commercial and institutional buildings multiplier was applied to construction. Eight of the surveyed research facilities reported $51 million in FY2013, $34 million in FY2014, and $26 million in FY2015. Over this three-year period, facilities in Boulder County recorded the greatest construction spending, followed by Jefferson, Larimer, and Washington counties. Construction projects ranged from renovations to new construction, such as the new NEON tower and support facility in Boulder.

Employment and Wages

Colorado labs reported a total of 7,787 full-time employees, part-time employees, student employees, and contract workers in 2015. Average salary and benefits totaled $103,644 across all facilities. Reported benefit rates for full-time workers averaged 33.6% of total compensation, including retirement and health benefits.

TABLE 3: TOTAL EMPLOYMENT BY COLORADO FEDERAL LAB LOCATION, FY2015

Primary County	Employees and Contract Workers	Total Compensation (Millions)[a]	Average Compensation[a,b]
Boulder	3,883	$388	$99,840
Jefferson	2,823	$305	$108,113
Larimer	889	$71	$80,074
Other	192	$19	$96,401
Colorado	7,787	$783	$100,498

[a]Compensation includes salary and benefits.

[b]Average compensation excludes contract workers and compensation.

Off-Site Employee Effects

Facilities were asked to provide the total number of employees living in each ZIP code in Colorado in order to assign off-site economic benefits to their respective counties. ZIP codes were provided by all but four facilities. The employee labor shed was extrapolated for the remaining facilities based on prior study responses.

Nearly 75% of lab workers live in the primary counties of operations (Boulder, Jefferson, Larimer, Pueblo, and Washington counties). Likewise, with the federal labs concentrated along Colorado's Front Range, most lab employees live along the metropolitan Front Range from Fort Collins to Pueblo: Boulder MSA (45%), Denver MSA (35%), Fort Collins-Loveland MSA (7%), and other (7%). Nearly 6% of the remaining lab employees live in other areas in the state or out of state. Lab employees reside mostly in Colorado's 2nd Congressional District (67%) and 1st Congressional District (10%), followed by the 7th and 4th Congressional Districts, with 7% and 5%, respectively.

TABLE 4: COUNTY RESIDENCES OF COLORADO FEDERAL LAB EMPLOYEES

County	Percentage
Boulder	45%
Jefferson	19%
Larimer	7%
Denver	5%
Adams	4%
Broomfield	3%
Pueblo	3%
Weld	3%
Arapahoe	2%
Douglas	1%
Other Colorado	2%
Colorado Total	95%
Total	**100%**

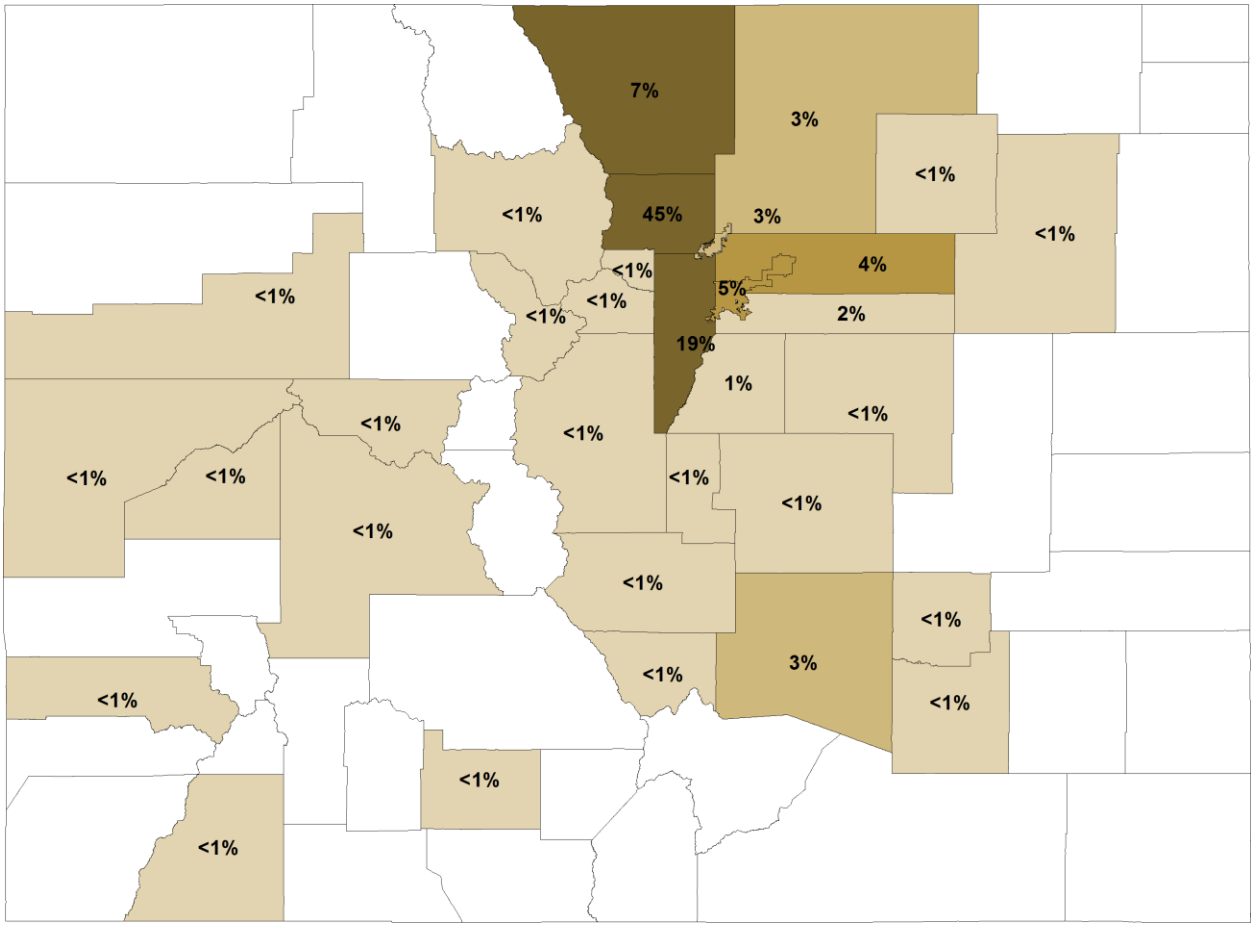
TABLE 5: CITY RESIDENCES OF COLORADO FEDERAL LAB EMPLOYEES

City	Percentage
Boulder	27%
Longmont	7%
Louisville	6%
Fort Collins	6%
Denver	5%
Broomfield	5%
Golden	5%
Arvada	4%
Lakewood	4%
Littleton	3%
Colorado Total	95%
Lab Total	**100%**

TABLE 6: LAB EMPLOYEE RESIDENCES BY CONGRESSIONAL DISTRICT

Colorado Congressional District	Percentage
1	10.4%
2	66.7%
3	3.3%
4	5.1%
5	0.7%
6	2.0%
7	6.8%
Total Colorado	95.0%
Lab Total	**100.0%**

FIGURE 2: EMPLOYEE LABOR SHED OF COLORADO FEDERAL LABS BY COUNTY



Multiplier Effects

Multipliers were selected based on the published North American Industrial Classification System (NAICS) codes. IMPLAN multipliers were obtained from MIG by matching the NAICS description to IMPLAN's corresponding disaggregated sectors. Employment, earnings, and output multipliers were based on NAICS Professional, Scientific, and Technical Services Sector 541.

ECONOMIC CONTRIBUTION OF RESEARCH FACILITIES

Impact on Colorado

With annual budgets totaling an estimated $1.2 billion in FY2015, the economic impact of Colorado's federal labs on the state's economy totaled $2.6 billion, led to $1.8 billion in value added (nested in total output), and supported 17,600 jobs. While federal labs drive millions in spending on goods and services across the state, only a portion of those goods and services may be sourced locally. The largest local lab expenditure is on labor—7,787 full-time, part-time, student, and contract lab workers work for Colorado federal labs, most of whom live in the state. Collectively, federal research facilities accounted for an estimated 7,400 lab workers living in Colorado. Salaries and benefits of workers at Colorado facilities totaled $783 million in FY2015. The economic contribution from construction in fiscal years 2013–2015 primarily reflects repair and maintenance activity, as well as some new construction.

TABLE 7: IMPACT OF COLORADO FEDERAL LABS ON COLORADO, FY2013–FY2015

Impact	2013	2014	2015
Output (Millions)	$2,522	$2,521	$2,606
Value Added (Millions)	$1,674	$1,668	$1,775
Employment	17,217	16,893	17,607

Impact on Boulder County

With annual budgets totaling an estimated $606 million in FY2015, the economic impact of Colorado's federal labs on Boulder County totaled $1.1 billion, led to $698 million in value added, and supported 7,627 jobs. While federal labs drive millions in spending on goods and services across the state, only a portion of those goods and services may be sourced locally. The largest local lab expenditure is on labor—3,883 full-time, part-time, student, and contract lab workers work for Boulder federal labs, not all of whom live in Boulder County. Collectively, federal research facilities accounted for an estimated 3,276 lab workers living in Boulder County. Salaries and benefits of workers at Boulder facilities totaled $388 million in FY2015.

TABLE 8: IMPACT OF COLORADO FEDERAL LABS ON BOULDER COUNTY, FY2013–FY2015

Impact	2013	2014	2015
Output (Millions)	$1,070	$1,093	$1,099
Value Added (Millions)	$643	$664	$698
Employment	7,367	7,592	7,627

Impact on Jefferson County

With annual budgets totaling an estimated $413 million in FY2015, the economic impact of Colorado's federal labs on Jefferson County totaled $654 million, led to $507 million in value added, and supported 4,620 jobs. While federal labs drive millions in spending on goods and services across the state, only a portion of those goods and services may be sourced locally. The largest local lab expenditure is on labor—2,823 full-time, part-time, student, and contract lab workers work for Jefferson federal labs, not all of whom live in Jefferson County. Collectively, federal research facilities accounted for an estimated

1,607 lab workers living in Jefferson County. Salaries and benefits of workers at Jefferson facilities totaled $305 million in FY2015.

TABLE 9: IMPACT OF COLORADO FEDERAL LABS ON JEFFERSON COUNTY, FY2013–FY2015

Impact	2013	2014	2015
Output (Millions)	$644	$639	$654
Value Added (Millions)	$491	$481	$507
Employment	4,695	4,413	4,620

Impact on Larimer County

With annual budgets totaling an estimated $110 million in FY2015, the economic impact of Colorado's federal labs on Larimer County totaled $195 million, led to $132 million in value added, and supported 1,592 jobs. While federal labs drive millions in spending on goods and services across the state, only a portion of those goods and services may be sourced locally. The largest local lab expenditure is on labor—889 full-time, part-time, student, and contract lab workers work for Larimer federal labs, not all of whom live in Larimer County. Collectively, federal research facilities accounted for an estimated 605 lab workers living in Larimer County. Salaries and benefits of workers at Larimer facilities totaled $71 million in FY 015.

TABLE 10: IMPACT OF COLORADO FEDERAL LABS ON LARIMER COUNTY, FY2013–FY2015

Impact	2013	2014	2015
Output (Millions)	$190	$201	$195
Value Added (Millions)	$133	$134	$132
Employment	1,516	1,578	1,592

Educational Attainment

Overall, Colorado federal lab employees are a highly educated group, with 55% having attained a master's degree or doctorate, and 30% having attained a four-year degree. Comparing this to all Colorado residents, 14.5% have attained a graduate or professional degree and 24.8% a bachelor's degree. This is expected as high levels of knowledge and training are often necessary to perform the work and conduct research in these industries. Higher than average wages at these federal labs often reflect, and are commensurate with, higher educational attainment.

FIGURE 3: EMPLOYEE EDUCATION

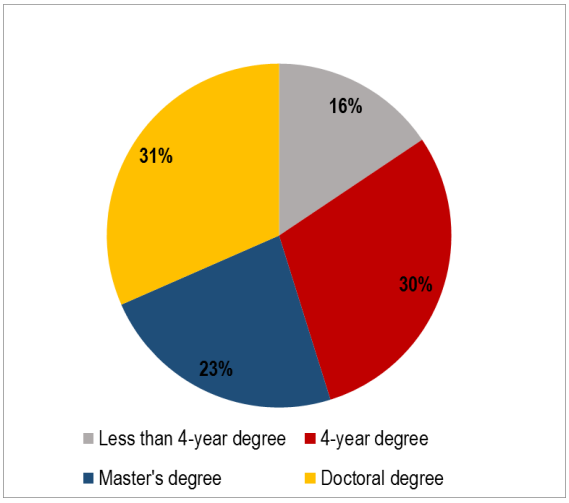


TABLE 11: EDUCATIONAL ATTAINMENT IN PRIMARY COUNTIES

Degree	United States	Colorado	Boulder County	Jefferson County	Larimer County
High school graduate or higher	87.1%	91.2%	94.6%	94.4%	95.8%
Bachelor's degree or higher	30.6%	39.2%	60.6%	43.2%	46.2%
Bachelor's degree	19.0%	24.8%	33.8%	27.3%	27.7%
Graduate or professional degree	11.6%	14.5%	26.8%	15.9%	18.5%

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

Intangible Benefits

Beyond their measurable economic impact, the federal facilities create a number of intangible benefits for their local communities, the state, and broader social structure in general. These labs help spur the development of new technologies, spawn tech transfer and spin-off companies, and work collaboratively with private business, resulting in greater business investment in the state. The facilities and the employees foster community relationships through education and volunteerism; and employees have earned many prestigious awards reflecting their scientific accomplishments, ranging from the Governor's Award for High Impact Research to the Nobel Prize.

Nine research facilities indicated participation in technology transfer, six provided examples of licensed technologies, and four facilities named spin-off companies from lab research. While tech transfer is common in many federal research facilities, there are few opportunities for companies to interact directly with the facilities. Three facilities—NREL, JILA, and LASP—reported public-private research opportunities; 11 facilities explicitly indicated no opportunities for shared equipment or lab space; and 7 did not provide a response.

TABLE 12: COMMERCIALIZATION

Tech Transfer	Licensed Technology	Patents	Spin-off Companies	PPP-Shared Equipment/Space[a]
NOAA	NOAA	NOAA	JILA	JILA
JILA	INSTAAR	NREL	NREL	NREL
INSTAAR	NREL	NWRC	UCAR	LASP
NREL	NWRC	UCAR	CIRES	
NWRC	RMRS	CIRES		
RMRS	CIRES			
UCAR				
USDA				
CIRES				

Note: Facilities not included in this list indicated "N/A" or left the answer blank.

[a]PPP=Public-Private Partnership, referring to opportunities for private companies to utilize space and equipment at the federal research facilities.

TABLE 13: SAMPLE OF SPIN-OFF COMPANIES

Facility	Company
CIRES	Aktiv-Dry LLC
CIRES	Aerovironment
JILA	BiOptix (formerly AlphaSniffer)
JILA	ColdQuanta
JILA	High Precision Devices
JILA	KM Labs
JILA	Micro-g-Lacoste
JILA	Precision Photonics
JILA	Stable Laser Systems (formerly Hall Stable Lasers)
JILA	Vescent Photonics
JILA	Winters Electro-Optics
JILA	Beam Imaging
NREL	BePower
UCAR	GWC
UCAR	STAR
UCAR	ARC

The facilities surveyed reported donating to charitable organizations, including the Combined Federal Campaign, Community Shares Colorado, Mile High United Way, Salvation Army Adopt-a-Family, Feds Feed Families, and other national local charities. Employees participate in educational outreach, service on national boards, participate in food drives and fundraisers, and are mentors for K–12 students. These projects enrich the cultural, intellectual, and social fabric of communities around the state.

Aside from the work with community-service organizations, researchers and scientists educate school children and the public. Employees are intricately involved with all levels of the education community—from kindergarten to graduate and doctoral programs. They participate as judges at science fairs and as volunteers at after-school science programs, and give presentations.

Many of the facilities offer employees opportunities for training, scholarships, tuition reimbursement, research fellowships, postdoctoral programs, internships, work-study positions, research assistantships, tuition waivers, and apprenticeships. These opportunities facilitate crossover and cooperation between universities and government facilities that conduct advanced research. These relationships help improve and develop intellectual capital and research potential.

The federal research labs in Colorado maintain extensive alliances with other research institutions and associations within the state, across the nation, and around the globe. These include industry organizations, nonprofits, federal agencies and programs, private research companies, and universities across the country.

Last, federal facilities host onsite and offsite visitors for the purposes of operational meetings, training, research, and conferences. Benefits accrue from the visitors' expenditures on hotels and motels, vehicle rentals, dining, and other miscellaneous expenditures, as well as marketing the state to future visitors.

CONCLUSION

Economic benefits from federal research facilities and their university affiliates in the state of Colorado are quantified in the billions of dollars. The impact fluctuates with varying budgets, staffing patterns, and construction outlays. With annual budgets totaling an estimated $1.2 billion in FY2015, the economic impact of Colorado's federal labs on the state exceeded $2.6 billion, led to $1.8 billion in value added, and supported 17,600 jobs (both direct and indirect). While federal labs drive millions in spending on goods and services across the state, only a portion of those goods and services may be sourced locally.

The largest local lab expenditure is on labor—nearly 7,800 full-time, part-time, student, and contract lab workers work for Colorado federal labs, not all of whom live in the state. Collectively, federal research facilities accounted for an estimated 7,400 lab workers living in Colorado. Salaries and benefits of workers at Colorado facilities totaled $743 million in FY2015.

Boulder, Jefferson, and Larimer counties were the primary beneficiaries of the research facilities due to their physical location in these counties, as well as the residences of a majority of the facilities' employees. Economic benefits in Boulder, Jefferson, and Larimer counties totaled an estimated $1.1 billion, $654 million, and $195 million, respectively, in FY2015.

Beyond the numbers, research and information are delivered to many constituents through outreach to schools, seminars, and public and private research collaborations. Colorado businesses and residents are among the beneficiaries of research conducted at these facilities. Companies that locate in Colorado to be near federal and academic research centers also benefit. Federal labs facilitate business through technology transfer, spin-off companies, and technology assistance.

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APPENDIX 1: FACILITIES

The following facility summaries were generated from comments provided by facility representatives in current and prior surveys, and from facility websites.

Bureau of Reclamation Technical Service Center (BUREC TSC)
Department of Interior
Denver Federal Center
6th and Kipling, Building 67
Denver, CO 80225-0007
https://www.usbr.gov/tsc/

As the largest wholesaler of water in the United States, the Bureau of Reclamation brings water to more than 31 million people, provides irrigation water for 10 million acres of farmland, and is responsible for the production of 25% of the nation's fruits and 60% of the nation's vegetables. It is the second-largest producer of hydroelectric power in the nation.[2] The Bureau of Reclamation has also constructed over 600 dams and reservoirs in 17 western states, including the Hoover Dam. The laboratory at the Technical Service Center provides material, hydraulic, and biologic testing and research for the Bureau of Reclamation. The center also provides technical expertise to other federal and state agencies, as well as private entities.

Centers for Disease Control and Prevention, Division of Vector-Borne Diseases (CDC-DVBD)
Centers for Disease Control and Prevention
U.S. Department of Health and Human Services
3156 Rampart Road
Fort Collins, CO 80526
www.cdc.gov

The Centers for Disease Control and Prevention (CDC), Division of Vector-Borne Diseases (DVBD), located in Fort Collins, Colorado, is uniquely responsible for protecting the American public from domestic and invasive endemic and epidemic diseases carried by blood-sucking arthropods (vectors)—mosquitoes, ticks, and fleas.

The CDC-DVBD

- Conducts surveillance, investigations, and studies of vector-borne viral and bacterial diseases and plague to define disease etiology and to develop effective methods and strategies for diagnosis, prevention, and control;
- Conducts research on the biology, ecology, and control of arthropod vectors as a basis for development of new and/or modification of existing measures for more effective prevention and control;

[2] U.S. Department of the Interior, Bureau of Reclamation, http://www.usbr.gov/main/about/, retrieved May 29, 2013.

- Conducts or participates in clinical, field, and laboratory studies to develop, evaluate, and improve laboratory methods and materials and therapeutic practices used for diagnosis, prevention, and treatment of vector-borne infectious diseases;
- Provides epidemic aid and epidemiologic consultation, and reference/diagnostic services, upon request, to state and local health departments, other federal agencies, and national and international health organizations;
- Conducts research and collaborates on development and evaluation of immunizing agents;
- Provides scientific and technical assistance to other CDC components when the work requires unique expertise or specialized equipment not available in other components;
- Provides intramural and extramural technical expertise and assistance in professional training activities; and
- Serves as designated national and international reference centers for vector-borne viral and bacterial diseases.

Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University
CSU 1375 Campus Delivery
Fort Collins, CO 80523
www.cira.colostate.edu/

The Cooperative Institute for Research in the Atmosphere (CIRA) is a cooperative institute between NOAA and Colorado State University. CIRA conducts interdisciplinary research within the field of atmospheric sciences.

CIRA's research is concentrated into several theme areas, including:

- Satellite Algorithm Development, Training and Education
- Regional to Global-scale Modeling Systems
- Data Assimilation
- Climate and Weather Processes
- Data Distribution
- Education/Outreach
- Societal and Economic Impact Studies

The mission of CIRA is to serve as a nexus for multidisciplinary cooperation among CIRA and NOAA research scientists, university faculty, staff and students in the context of NOAA-specified research theme areas in satellite applications for weather/climate forecasting. Important bridging elements of the CIRA include the communication of research findings to the international scientific community, transition of applications and capabilities to NOAA operational users, education and training programs for operational user proficiency, outreach programs to K–12 education and the general public for environmental literacy, and understanding and quantifying the societal impacts of NOAA research.

Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado Boulder
216 UCB
Boulder, CO 80309-0216
http://cires.colorado.edu/

At the Cooperative Institute for Research in Environmental Sciences (CIRES), more than 800 environmental scientists work to understand the dynamic Earth system, including people's relationship with the planet. Founded in 1967, CIRES is a partnership of NOAA and the University of Colorado Boulder. Areas of expertise include:

- Weather and climate
- Change's at Earth's poles
- Air quality and atmospheric chemistry
- Water resources
- Solid Earth sciences

CIRES is a global leader in environmental science and graduate education: CIRES scientists collaborate widely, earn national awards and recognition, and lead international assessments. CIRES is home to four centers, the largest of which is the National Snow and Ice Data Center, NSIDC, an internationally recognized source of data and information on Earth's frozen realms. CIRES also includes the Center for Limnology; the Center for Science and Technology Policy Research; and the Earth Science and Observation Center. CIRES supports other programs, as well, including the Western Water Assessment—a NOAA-funded program to improve the intermountain West's ability to prepare for and adapt to climate variability and change—and a robust Education and Outreach program. CIRES' vision is to be instrumental in ensuring a sustainable future environment by advancing scientific and societal understanding of the Earth system.

Department of the Interior North Central Climate Science Center (NC CSC)
Colorado State University
1476 Campus Delivery
Fort Collins, CO 80523-1476
https://nccwsc.usgs.gov/northcentralcsc

The North Central Climate Science Center combines the newest data, knowledge, and tools regarding climate change and works with resource managers to promote client-informed conservation strategies. The North Central CSC provides an opportunity for top climate change researchers to work in an engaged and proactive research community.

The North Central CSC was established in 2011 and opened in late 2012 as one of eight regional climate centers created by the U.S. Department of the Interior in order to assist land and resource managers nationwide. The North Central CSC is hosted by a consortium of nine institutions: Colorado State University - Fort Collins, University of Colorado, Colorado School of Mines, University of Nebraska - Lincoln, Montana State University, University of Wyoming, University of Montana, Kansas State University, and Iowa State University. Together, these institutions provide expertise in the fields of climate science, ecology, impact assessment, modeling, urban environments, and advanced information technology.

Through its ReVAMP model, The North Central CSC is focusing on three foundational science areas: (1) drivers of regional climate change; (2) impact analysis of climate change on regional resources; and (3) adaptive capacities of communities and natural resources.

Federal Railroad Administration Transportation Technology Center (TTC)
55500 DOT Road
Pueblo, CO 81001
http://www.fra.dot.gov/Page/P0153

The Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) sits on 52 square miles of land in Pueblo, Colorado. It has played an important part in the research, development, and testing of rail infrastructure and equipment since 1971. There are approximately 50 miles of test track at TTC used for various different test cases. The short High Tonnage Loop is used primarily to test track components under heavy axle load, while the 13.5-mile Railroad Test Track is used for high-speed testing up to 165 mph. The Transit Test Track is equipped with third rail electrification and a maximum speed of 90 mph, and various other test tracks are used to evaluate vehicle performance over a range of different track conditions. Other buildings within the TTC include offices, test halls, and laboratories. Impact testing is also performed on a crash wall within the TTC. The Security and Emergency Response Training Center at TTC has also been training first responders to handle hazardous materials accidents. Recently, the Transportation Security Administration created the Surface Technology Security Training Center at TTC as well, providing training to Department of Homeland Security inspectors and other federal, state and local security partners.

Institute of Arctic and Alpine Research (INSTAAR)
4001 Discovery Drive
Boulder, CO 80309
https://instaar.colorado.edu/

The Institute of Arctic and Alpine Research (INSTAAR) develops scientific knowledge of natural and anthropogenic physical and biogeochemical environmental processes at local, regional, and global scales. INSTAAR applies this knowledge to improve society's awareness and understanding of environmental change. The world's high-altitude and high-latitude regions are the institute's traditional focus, but the pursuit of understanding of these regions has led INSTAAR to a geographically wide range of interdisciplinary studies of quaternary and modern environments, which include research in geochronology, human and ecosystem ecology, hydrology, oceanography, landscape evolution, biogeochemistry, and climate. INSTAAR's national and international research leadership in these areas is augmented by strength in graduate education and exposure of undergraduates to the research process, as well as by outreach to the public both locally and nationally.

JILA
A partnership between NIST and University of Colorado Boulder
440 UCB
Boulder, CO 80309-0440
http://jila.colorado.edu/

JILA is a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology. The institute supports a research program that fosters creative collaborations among scientists. The wide-ranging interests of JILA's scientists have made the institute one of the nation's leading research institutes in the physical sciences. Research topics range from the small, frigid world governed by the laws of quantum mechanics through the physics of biological and chemical systems to the processes that shape the stars and galaxies. JILA science encompasses seven broad categories: astrophysics, atomic and molecular physics, biophysics, chemical physics, nanoscience, optical physics, and precision measurement.

Laboratory for Atmospheric and Space Physics (LASP)
Laboratory for Atmospheric and Space Physics at University of Colorado
1234 Innovation Drive
Boulder, CO 80303
http://lasp.colorado.edu/

The Laboratory for Atmospheric and Space Physics is a research institute reporting to the Vice Chancellor for Research and Innovation at the University of Colorado in Boulder. It traces its history back to the formation of the Upper Air Laboratory in 1947, taking advantage of captured V-2 rockets to make the first measurements of the Earth's upper atmosphere. LASP has been a leader in exploring the Earth's upper atmosphere and the solar system. LASP is the only research organization (other than NASA itself) to have sent a science instrument to every planet in the solar system, including Pluto.

Today, LASP research includes the Earth's atmosphere and upper atmosphere, interactions with the Sun and the solar wind, observations and basic physics of the Sun, exploration of the solar system, and the study of extrasolar planets. Researchers engage in multiple approaches to understanding these systems, including:

- The design, construction, and operations of instruments in space making key measurements of processes in our areas of interest;
- Analysis of data from these instruments and from other ground-based, airborne, and space-based platforms;
- Laboratory measurements of relevant processes and basic physical parameters;
- Theoretical and numerical modeling of basic Earth and planetary systems, to help us understand the context of how they operate.

In addition, LASP scientists participate and are leaders in helping to define the next generation of important scientific questions that can be addressed in space science. They do this through their participation in national advisory committees and through development of their scientific results. As a result, LASP is often described as carrying out "end to end" or "full cycle" science—from the science questions to implementation of approaches designed to elucidate information that will help answer those questions to definition of the next round of questions.

National Cybersecurity Center (NCC)
2940 North Prospect St. 7477
Colorado Springs, CO 80933
https://www.nationalcybersecuritycenter.org

Located in Colorado Springs, the National Cybersecurity Center (NCC) is a nonprofit organization providing collaborative cybersecurity knowledge and services to the nation. Its stated mission is to provide collaborative cybersecurity response services with comprehensive knowledge and capabilities through training, education, and research. The NCC comprises three pillars. The first, the Rapid Response Center, assists organizations in the instance of a security breach, providing immediate assistance and sharing solutions with other member organizations to prevent similar attacks. The Cyber Research, Education, and Training Center (CRETC), which is yet to be fully developed, will publish work and inventions through research and development in cyber security to increase awareness and overall security. The CRETC will also offer courses and integrated programs to national, state, and local government officials, volunteer organizations, and the private sector. The center will provide students with real-time education for immediate impact in the workforce. Finally, the Cyber Institute is an education facility specifically for representatives from federal agencies, states, cities, and local governments to engage with the latest information on cyber trends, security, best practices, and education resources to increase the prevalence and sophistication of cybersecurity policy.

National Ecological Observatory Network (NEON)
1685 38th Street, Suite 100
Boulder, CO 80301
www.neonscience.org/

The National Ecological Observatory Network (NEON) is a continental-scale observatory designed to gather and synthesize data regarding the impacts of climate change, land use change, and invasive species on natural resources and biodiversity. NEON's observatory is design to collect standardized, high-quality data from 81 field sites across the United States. These sites are selected to represent various regions of vegetation, landforms, climate, and ecosystem performance, and collected data are accessible. NEON is sponsored by the National Science Foundation, with many other U.S. agencies and nongovernmental organizations cooperating.

National Institute of Standards and Technology (NIST)
National Institute for Standards and Technology, Boulder Labs
Department of Commerce
325 Broadway
Boulder, CO 80305
www.nist.gov

The National Institute of Standards and Technology (NIST), founded in 1901, is a nonregulatory agency within the U.S. Department of Commerce. NIST'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. For over 100 years, NIST has served U.S. industry, science, and the public with a mission and approach unlike any other agency of government. Two

principal research installations are operated by NIST—the headquarters facility in Gaithersburg, Maryland, and NIST Boulder in Boulder, Colorado, which was dedicated in 1954.

NIST Boulder Labs provides research, measurements, technology, tools, data, and services that enable innovation and improve the quality of our lives. NIST Boulder Labs collaborates with industrial, academic and government laboratories across the nation and around the world. Many Colorado companies rely on NIST Boulder Labs measurements and research for innovation in nanotechnology, electronics, biosciences, aerospace, defense, energy, and homeland security. NIST Boulder Labs and the University of Colorado jointly operate JILA, a world leader in atomic, molecular, and optical physics and precision measurements. JILA is home to two NIST Nobel Laureates—John "Jan" Hall and Eric Cornell—and one MacArthur "Genius Award" winner. NIST Boulder Labs is also home to David Wineland, 2012 winner of the Nobel Prize in Physics. NIST Boulder Labs have more than 350 scientific, technical, and support staff and more than 300 visiting researchers, students, and contractors.

National Oceanic and Atmospheric Administration (NOAA)
Department of Commerce
325 Broadway
Boulder, CO 80305
www.noaa.gov

The National Oceanic and Atmospheric Administration (NOAA) pursues the systematic study of the ocean, atmosphere, and related ecosystems to provide intelligence about the environment to support commerce, enhance public safety, and deepen our understanding of our planet. NOAA's diverse suite of products and services, including daily weather forecasts, severe weather warnings, climate outlooks, fisheries management, coastal restoration, and support of marine commerce are relied on by companies and institutions responsible for more than one-third of U.S. gross domestic product.

NOAA's flagship facility in Colorado is the David Skaggs Research Center, located on the Department of Commerce Campus at 325 Broadway in Boulder. Several NOAA line offices operate from the 900-foot long, state-of-the-art research center, which is named for former U.S. Rep. David Skaggs.

The primary tenant is NOAA's **Earth Systems Research Laboratory**, the largest of seven research labs operated by the Office of Oceanic and Atmospheric Research. The building is also home to the National Weather Service's Denver-Boulder Weather Forecast Office, the Space Weather Prediction Center, and one of four National Centers for Environmental Information. NOAA works in close collaboration with University of Colorado Boulder's Cooperative Institute for Research in Environmental Sciences, and Colorado State University's Cooperative Institute for Research in the Atmosphere. Approximately 1,000 federal civil servants, contractors and associates with the two cooperative institutes are employed there.

The four ESRL labs perform fundamental and applied research to develop products that will advance NOAA's environmental information and services on global-to-local scales.

- The Global Monitoring Division conducts long-term, continuous measurements of atmospheric gases, particles and radiation to better understand climate forcing, ozone depletion and air quality.

- The Chemical Sciences Division studies the chemical processes in the Earth's atmosphere that affect climate, air quality, and the ozone layer.
- The Physical Sciences Division studies the atmosphere, ocean, cryosphere, and land in order to improve local to global weather and climate predictions. The National Integrated Drought Information Service is a program of PSD.
- The Global Systems Division conducts applied research and develops new tools and technologies to improve weather forecasts and climate prediction.

The **National Weather Service's Denver-Boulder Weather Forecast Office** is a continuously operational forecast center that provides weather, hydrologic, and climate forecasts and warnings for the Denver-metro area and northern Colorado. The Boulder office also hosts the Colorado Avalanche Information Center, which provides avalanche information, education and promotes research for the protection of life, property and the enhancement of the state's recreation economy. The National Weather Service also maintains Weather Forecast Offices in Pueblo and Grand Junction.

The **Space Weather Prediction Center (SWPC)** continuously monitors and forecasts solar storms that can affect people and equipment working in the space environment, and power, communication, and navigation systems on Earth. SWPC is the nation's official source for space weather alerts, watches, and warnings. As one of only four National Critical Systems in the National Weather Service, it partners with the Air Force Weather Agency at Offutt AFB in Nebraska, which is responsible for supplying space weather guidance to the defense and intelligence community.

The Boulder office of the **National Centers for Environmental Information** collects data and conducts research in the areas of natural hazards, Earth observations from space, marine geology, geophysics and bathymetry, space weather and solar events, and geomagnetism. The Paleoclimatology Branch operates the World Data Center for Paleoclimatology, an Applied Research Center for Paleoclimatology, and partners with national and international science initiatives around the world to expand the use of paleoclimatological data. It is the world's largest archive of climate and paleoclimatological data. NCEI is part of NOAA's National Environmental Satellite, Data and Information Service.

National Renewable Energy Laboratory (NREL)
15013 Denver West Parkway
Golden, CO 80401-3393
www.nrel.gov

The Energy Department's National Renewable Energy Laboratory (NREL) advances energy science and technology innovations for America. NREL's world-class research accelerates discoveries in power, fuels, transportation, buildings and energy systems. The lab's impacts strengthen U.S. economic competitiveness, increase jobs and deliver secure, energy independence.

NREL stimulates break-through technologies working with nearly 700 public, private and academic partners, while reducing risk of investment for energy companies and manufacturers, and governments. Research dollars are leveraged via access to NREL's scientific brain-trust, research capabilities, systems performance, testing and optimization, component modeling, analysis and characterization, and research user-facilities.

NREL is managed by the Alliance for Sustainable Energy, LLC for the U.S. Department of Energy. For more information about NREL visit: http://www.nrel.gov.

National Solar Observatory (NSO)
3665 Discovery Drive
Boulder, CO 80303
http://nso.edu/

The mission of the National Solar Observatory is to advance knowledge of the Sun, both as an astronomical object and as the dominant external influence on Earth, by providing forefront observational opportunities to the research community. The mission includes the operation of cutting edge facilities, the continued development of advanced instrumentation both in-house and through partnerships, conducting solar research, and educational and public outreach. NSO accomplishes this mission by:

- Providing leadership for the development of new ground-based facilities that support the scientific objectives of the solar and solar-terrestrial physics community.
- Advancing solar instrumentation in collaboration with university researchers, industry, and other government laboratories.
- Providing background synoptic observations that permit solar investigations from the ground and space to be placed in the context of the variable Sun.
- Providing research opportunities for both undergraduate and graduate students, helping develop classroom activities, working with teachers, and mentoring high school students.
- Innovative staff research.

National Telecommunications and Information Administration (NTIA)
Institute for Telecommunication Sciences
325 Broadway
Boulder, CO 80305-3328
www.its.bldrdoc.gov

As the primary research and engineering laboratory for the National Telecommunications and Information Administration (NTIA), The Institute for Telecommunication Sciences (ITS) provides support in the development of telecommunications policy and the management of the spectrum. The ITS performs cutting-edge telecommunications research and engineering with both government and private partners. Research done by the ITS for the NTIA enables the U.S. Government, global standards organizations, and members of the private industry to manage the radio spectrum and ensure new technologies are recognized and effective. The ITS also acts a primary resource for solving telecommunications concerns for federal, state, and local governments, as well as private corporations and organizations.

National Wildlife Research Center (NWRC)
United States Department of Agriculture, Animal and Plant Health Inspection Service
4101 LaPorte Avenue
Fort Collins, CO 80521
www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/programs/nwrc

The National Wildlife Research Center (NWRC) is the research arm of the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service's (APHIS) Wildlife Services program. NWRC is the only Federal research facility in the United States devoted entirely to developing effective wildlife damage management methods. The Center applies scientific expertise to address human-wildlife conflicts involving a range of issues: agriculture, human health and safety, property damage, invasive species, and threatened and endangered species.

NWRC employs more than 160 scientists and support staff at its headquarters in Fort Collins, CO, and at field stations throughout the United States. NWRC's scientists have expertise in animal behavior, chemistry, economics, epidemiology, genetics, immunology, population modeling, reproductive physiology, statistics, toxicology, wildlife biology, wildlife sensory biology, and veterinary medicine.

NWRC scientists study birds, mammalian predators, rodents, and other wildlife that cause serious but localized damage problems. The Center designs studies to ensure that the methods developed to alleviate animal damage are biologically sound, effective, safe, economical, and acceptable to the public. Through the publication of results and the exchange of technical information, the Center provides valuable data and expertise to the public and the scientific community, as well as to APHIS's Wildlife Services program. The mission of USDA APHIS Wildlife Services is to provide Federal leadership and expertise to resolve wildlife conflicts to allow people and wildlife to coexist.

Rocky Mountain Research Station (RMRS)
U.S. Department of Agriculture
U.S. Forest Service
240 West Prospect
Fort Collins, CO 80526
www.fs.fed.us/rmrs/

The Rocky Mountain Research Station (RMRS) is a research arm of the U.S. Department of Agriculture (USDA). The mission of the RMRS is to develop and deliver scientific knowledge and technology that will help people sustain our forests, rangelands, and grasslands.

United States Department of Agriculture – Agricultural Research Service (ARS)
2150 Centre Ave, Building D, Suite 320
Fort Collins, CO 80526
https://www.ars.usda.gov/

The Agricultural Research Service (ARS) conducts research to develop and transfer solutions to agricultural problems of high national priority and provide information access and dissemination to:

- Ensure high-quality, safe food, and other agricultural products;
- Assess the nutritional needs of Americans;
- Sustain a competitive agricultural economy;
- Enhance the natural resource base and the environment;
- Provide economic opportunities for rural citizens, communities, and society as a whole; and
- Provide the infrastructure necessary to create and maintain a diversified workplace.

Included in the Agricultural Research Service, the mission of the **Center for Agricultural Resources Research** (CARR) is to conduct research to ensure the security of agricultural resources in a changing climate. This mission is accomplished through research on: (1) irrigated agriculture including integrated computer models of agricultural systems to support research and farm/ranch-level decisions; (2) soil, fertilizer, and plant nutrient management; (3) development of new knowledge and genotypes to modify host-pathogen relations that affect disease resistance, pathogenesis, and epidemiology in sugarbeet; (4) interaction of plants, animals, soil, water, and weather on grazing lands including development of systems computer models to evaluate the sustainability of management practices; and (5): research to more effectively acquire, evaluate, preserve and provide a national collection of plant, animal, and microbial genetic resources to secure the biological diversity that underpins a sustainable U.S. agricultural economy through diligent stewardship, research, and communication.

U.S. Department of Agriculture – Agricultural Research Service
Central Great Plains Research Station
40335 County Road GG
Akron, CO 80720
https://www.ars.usda.gov/plains-area/akron-co/cgprs/

Established in 1907, the mission of the Central Plains Resource Management Unit is to enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for maximum utilization of soil and water resources. Emphasis is placed on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation. The Central Great Plains Research Station utilizes 550 acres of cultivated, dryland research land in order to provide producers agricultural research, emphasize efficient use of soil and water resources, and enhance the economic and environmental aspects of agriculture.

U.S. Geological Survey (USGS)
Core Research Center
Denver Federal Center
Building 810
Denver, CO 80225
https://geology.cr.usgs.gov/crc/

The U.S. Geological Survey (USGS) provides reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance our quality of life. It is the nation's largest water, earth, biological science, and civilian mapping agency, and specializes in being an independent fact-finding agency that provides unbiased and impartial information that is valuable on a planet where natural resources are in increasing demand. Researchers collect, monitor, analyze, and provide scientific understanding about natural resource conditions and issues.

The Core Research Center (CRC) was established in 1974 by the U.S. Geological Survey (USGS) to preserve valuable rock cores for use by scientists and educators from government, industry, and academia. The cylindrical sections of rock are permanently stored and available for examination and testing at the core storage and research facility in Denver, Colorado. The CRC is currently one of the largest and most heavily used public core repositories in the United States. The CRC encourages use of its facility by all interested parties.

University Corporation for Atmospheric Research (UCAR)
3090 Center Green Drive
PO Box 3000
Boulder, CO 80301
www2.ucar.edu

The University Corporation for Atmospheric Research (UCAR), founded in 1960, is a nonprofit consortium of over 100 universities and colleges in North America. They focus on research and training relating to atmospheric and Earth system sciences. UCAR, sponsored by the National Science Foundation, operates the National Center for Atmospheric Research (NCAR) which provides research and education about the atmospheric and related sciences.

The mission of the University Corporation for Atmospheric Research (UCAR) is to support, enhance, and extend the capabilities of the university community, nationally and internationally; understand the behavior of the atmosphere and related systems and the global environment; and foster the transfer of knowledge and technology for the betterment of life on Earth.

UNAVCO Inc.
6350 Nautilus Drive
Boulder, CO 80301-5394
303-381-7500
www.unavco.org

UNAVCO was established as the University NAVSTAR Consortium in 1984 within the University of Colorado, Boulder. UNAVCO is now a non-profit university-governed consortium (200+ institutions) that facilitates geoscience research and education using geodesy. UNAVCO's primary tools include high precision ground-based GPS/GNSS stations and networks, meteorological instruments, borehole geophysical stations, and ground-based LiDAR instruments. UNAVCO maintains an extensive and freely accessible archive of data, data products, and data tools. UNAVCO provides technology development, technical support, geophysical training, workforce development, student internships and educational materials. It is a critical facility for geosciences and space sciences research and education supported primarily by the National Science Foundation with additional support from NASA, NOAA and USGS.

UNAVCO supports research from the Earth's core to the uppermost atmosphere, with a focus on the structure and dynamics of the crust, hydrosphere, cryosphere, oceans, and the atmosphere. On a global scale, UNAVCO's efforts support defining Earth's shape, gravity and rotation and understanding the global influences of plate tectonics, oceanic changes and atmospheric changes.

UNAVCO helps with preparedness, forecast, response and mitigation of significant hazards, including earthquakes, volcanic unrest, landslides, wildfires, flooding, drought, severe weather, hurricanes, tsunamis and space weather. UNAVCO's GPS stations provide 1 to 2 centimeter real-time positions for survey-grade GPS work. Precise position data contributes to surveying and engineering by the public and private sectors. UNAVCO supports the development and modernization of the International Terrestrial Reference Frame (ITRF). The ITRF is essential for all position, navigation and timing, which is foundational for security, government, commerce and all land and space uses (e.g., precision agriculture and satellite navigation).

APPENDIX 2: LITERATURE REVIEW

Argonne National Laboratory, Illinois
(Anderson Economic Group, LLC 2011)

In 2011, Anderson Economic Group, LLC published an economic analysis of the Argonne National Laboratory for the University of Chicago. Notable parts of the report include:

- Argonne is responsible for almost 5,000 new jobs in Illinois.
- Argonne has generated almost $700 million in net new earnings for households and businesses in 2010.
- The laboratory supports U.S. science by hosting important science infrastructure and contributing to the pipeline of future scientists and engineers.

Berkeley Lab, Economic Impact Study
(CBRE Consulting 2010)

In 2010, CBRE Consulting was commissioned to conduct an economic impact analysis demonstrating the benefits of Lawrence Berkeley National Laboratory (LBNL) to the Cities of Berkeley, Emeryville, and Walnut Creek, the Bay Area region, the State of California, and the United States. LBNL operates a campus in each of the cities chosen. CBRE Consulting focused on job generation, wages, and local and regional spending. The study determined that during FY 2009, which spans from October 1, 2008, through September 30, 2009, Berkeley Lab contributed approximately $501.0 million directly to the Bay Area economy through the lab's spending. Including indirect and induced spending, the contribution rises to approximately $690.1 million. Of this total, about $236.1 million occurred in Berkeley, Emeryville, and Walnut Creek. The total spending impacts on California for the same period were estimated at $794.5 million, and Berkeley Lab's gross economic impact on the U.S. economy was estimated to be nearly $1.6 billion.

Brookhaven National Laboratory Economic Impact Report
(Appleseed, Inc. 2009)

In 2009, Appleseed Inc. published an economic analysis of the Brookhaven National Laboratory. Findings include:

- In FY 2009, $704 million in economic impact was generated by the lab and its visitors.
- In FY 2009, 5,400 jobs were created throughout New York State.
- In FY 2009, of the 3,000 employees, 98% were living on Long Island.
- In FY 2009, of the more than 3,000 visiting researchers from university, corporate, and government institutions, nearly 700 were from New York State.
- Employment grew 12% from 2006 to 2009.
- In FY 2009, 2 million in goods and services were purchased from New York State companies, including $62.7 million from Long Island companies.
- A total of $45.1 million was paid to New York State contractors, including $34.9 million to Long Island-based contractors.

Economic Contribution of the Department of the Navy Technology Transfer Program
(Slaper 2010)

This study by the Indiana Business Research Center at Indiana University's Kelley School of Business, titled *The Economic Contribution of the Department of the Navy Technology Transfer Program*, highlights the economic impact of a sample of technology transfer agreements implemented between Navy labs and various partners between 2005 and 2009. Specifically, the study focused on 103 of 620 technology transfer agreements during that period, and found that overall, the 103 agreements were directly responsible for 670 civilian jobs and indirectly responsible for approximately 2,600 jobs. Compensation for these jobs averaged more than $79,000 per year, and tax receipts at all levels of government from the economic activity generated by these agreements totaled roughly $60 million. Overall, the estimated direct economic output associated with these agreements totaled $200 million, with an additional $345 million in indirect activity, for a total of over half a billion dollars in economic impact. Cooperative Research and Development Agreements (CRADAs) accounted for 64% of the 103 agreements and 30% were patent licensing agreements (PLAs). On average, CRADAs supported 8 jobs each, while PLAs supported 10.

Economic Impact Assessment, Sandia Science & Technology Park
(Watkins and Sussman 2012)

In May 2012, the Mid-Region Council of Governments published an economic impact assessment of the Sandia Science and Technology Park located in southeast Albuquerque. Highlights include:

- The average annual salary across all industries in the park is more than $70,000, about $30,000 higher than in the Albuquerque area. This average salary includes Sandia National Laboratory employees, who represent about 42% of all employees in the SS&TP and earn about $90,000 per year on average.
- In addition to nearly 2,500 direct jobs at the end of 2011, the analysis indicates that for every job within the SS&TP, 1.7 additional jobs were created in the region.
- Because most of the impacts from the SS&TP are the result of employment and wages, the secondary benefits are expected to be sustained.
- The park represents a viable and attractive location for other high-tech companies.

The Economic Impact of Fermi National Accelerator Laboratory
(Anderson Economic Group 2011)

Fermi National Accelerator Laboratory (Fermilab) is responsible for 4,529 jobs in Illinois, consisting of 1,942 full-time equivalent employees and indirect creation of 2,587 jobs, including 1,000 on-site research positions. Fermilab's estimated economic output in FY2010 was $643 million. New household income totaled $196.6 million. In FY2010, Fermilab had total in-state expenditures of $288 million, generating a total economic output of $564.6 million. The lab also had an estimated additional $36 million in annual expenditures from visiting research facility users. In FY2010, Fermilab received $459 million in total funding, 94% of which was received from the federal government, primarily from the Department of Energy.

Economic Impact of Pacific Northwest National Laboratory on the State of Washington in FY 2014
(U.S. Department of Energy 2015)

In FY2014, the Pacific Northwest National Laboratory (PNNL) received $939 million in total government funding, primarily from the Department of Energy, and directly contributed $1.02 billion to Washington's gross state product. The laboratory directly and indirectly supported $1.45 billion in economic output and $517 million in Washington wage income. PNNL purchased domestic goods and services valued at $339 million in 2014, and had a total payroll of $402 million. PNNL directly employed 4,308 personnel, 93% of whom resided within the state, in addition to 2,524 indirect and induced jobs. PNNL experienced 22% employment growth from 2000 to 2014. The lab reported 99 spin-off companies operating as of 2014, a total of 71 of which are located within the state.

Economic Impact of the National Energy Laboratory Hawaii Authority Tenants on the State of Hawai'i
(The Economic Research Organization at the University of Hawai'i 2012)

In 2012, the Economic Research Organization at the University of Hawai'i (UHERO) published an economic impact of the NELHA Ocean Science and Technology Park located in Kailua-Kona, Hawaii. Report highlights include:

- Total expenditures from businesses at NELHA in 2010 were $81.0 million, of which about $50 million was paid to Hawaii entities.
- In 2011, NELHA generated 583 jobs in Hawai'i.
- UHERO estimated the total economic output to the greater Hawaii economy was $87.7 million, which generated $4.5 million in state tax revenue in 2010.

Federal Laboratory Technology Transfer, Fiscal Year 2010, Summary Report to the President and the Congress
(U.S. Department of Commerce, National Institute of Standards and Technology 2012)

According to the *Federal Laboratory Technology Transfer, Fiscal Year 2010, Summary Report to the President and Congress*, prepared by the National Institute of Standards and Technology within the Department of Commerce, federal technology transfer programs across 11 agencies produced more than 3,100 new Cooperative Research and Development Agreements (CRADAs) in 2010. Federal labs also disclosed nearly 4,800 new inventions, filed over 1,800 new patents, managed more than 13,500 active licenses, and generated nearly $143 million total income on all active licenses. These activities helped to support such vital national interests as tsunami training and readiness, diagnostic testing for avian flu, energy efficiency, and high-tech infrastructure development. The Departments of Defense and Commerce had the highest number of active CRADAs, with 3,248 and 2,399, respectively, while NASA and the Department of Energy disclosed the greatest number of new inventions, at 1,722 and 1,616, respectively. Combined, the Department of Energy, NASA, and the Department of Health and Human Services were responsible for the most active licenses, 89% of all licensing. In general, these figures suggest that the return on the U.S.'s investment in research and development at federal labs remained a bright spot despite the struggling economic recovery in 2010.

Idaho National Laboratory FY15 Economic Summary

(Research and Business Development Center 2016)

In FY2015, Idaho National Laboratory (INL) had a direct economic impact of over $917 million, an indirect economic impact of $258 million, and an induced economic impact of $409 million for a total economic output of more than $1.58 billion. This was a 12% increase from the previous year. As of FY2015, INL employed 3,771 people, with indirect and induced impacts on employment of 2,043 and 3,479 jobs, respectively. Cumulatively, INL accounted for more than 1.4% of Idaho's employment and nearly 2.5% of statewide economic output. INL had a value-added economic impact of $942 million, and created $702 million in state labor income in FY2015. INL employees had an average annual base salary of $88,635. INL had an economic output, employment, labor income, and value-added multipliers of 1.73, 2.46, 1.45, and 1.63, respectively.

Impact of Los Alamos National Laboratory on the Economies of Northern New Mexico and the State as a Whole

(University of New Mexico, Bureau of Business and Economic Research 2011)

In FY2009, the Los Alamos National Laboratory (LANL) had a total economic impact of $2.9 billion in output, 23,641 in employment, and $1.6 billion in labor income. Within the northern New Mexico region, LANL had $2.3 billion in economic output, consisting of $1.4 billion direct and $932 million indirect. LANL's total regional employment impact as of FY2009 was 20,351 jobs and $1.4 billion in labor income. LANL had total in-state expenditures of $1.6 billion, creating $1.1 billion in direct labor income and employing 11,685 direct in-state workers. The employment distribution consisted of 7,303 regular staff, 1,601 contractors, 782 students, 1,357 construction workers, 350 limited term employees, 281 postdoctoral researchers, and others. Within New Mexico, LANL had 3,050 retirees with pension benefits totaling $140 million, which was estimated to have supported an additional 821 jobs and $26 million in labor income.

Intellectual Property and the U.S. Economy: Industries in Focus

(Economic and Statistics Administration and the United States Patent and Trademark Office 2012)

This report identifies and analyzes 75 intellectual property-intensive industries and examines trends within these industries and their contribution to the broader U.S. economy. Together, these industries supported more than 40 million jobs (direct and indirect) and contributed over $5 trillion to U.S. gross domestic product (GDP) in 2010. The intellectual property (IP) industries accounted for more than one-quarter of all jobs in the United States and over one-third of total GDP in sectors, including computers, audio and video equipment manufacturing, newspaper and book publishing, pharmaceuticals and medicines, and semiconductors, among others. While overall employment in IP-intensive industries has lagged other industries over the past two decades due mainly to losses in the manufacturing sector, IP-intensive employment grew 1.6% in 2010 and 2011. Average weekly wages for IP-intensive industries were $1,156 in 2010, or 42% higher than the $815 average weekly wage in other nonintensive private industries. Additionally, patent- and copyright-intensive industries wages recorded strong growth in recent years, with the wage premium in patent-intensive industries increasing from 66% in 2005 to 73% in 2010 and the premium in copyright-intensive industries rising from 65% to 77%. The comparatively high wages in IP-intensive industries correspond to the fact that these businesses rely heavily on educated workers.

National Economic Impacts from DoD License Agreements with U.S. Industry
(TechLink and Bureau of Business and Economic Research, University of Montana)

Approximately 500 active licensing agreements between the Department of Defense (DOD) and U.S. industry partners were responsible for creating or sustaining more than 163,000 jobs with an average annual wage of $65,000 during the period 2000−2011. Nearly half of the companies associated with those licenses reported over $13.4 billion in total sales and $1.3 billion in military sales (in 2011 dollars), collectively. These are some of the findings of a study commissioned by the U.S. Air Force to assess the "extent to which [all DOD licensing agreements with U.S. industry] (1) contributed to new economic activity and job creation in the United States, and (2) resulted in the transition of new technology to U.S. military use." The study authors contacted 505 companies with active licensing agreements with the DOD during the study period, reflecting 602 licenses (some had multiple licenses) with 60 different DOD facilities. Participants were asked about total sales of new products and services directly related to their DOD license agreements, as well any license-related sales to the military. Total economic impacts related to these identified sales were then extrapolated using IMPLAN impact-assessment software. That assessment focused on total economic output, value added, employment, labor income, and tax revenues. The study reports that total economy-wide sales, as measured by output, were estimated at $36.3 billion. Value added was estimated to be $17.4 billion, representing new wealth creation in the economy. Employment impacts included 163,067 jobs with an average wage of $65,000. Labor income in 2011 was estimated at $10.6 billion. The $13.4 billion in sales and its economy-wide effects generated about $2.3 billion in federal tax revenues and over $1.3 billion in state and local tax revenues.

Sandia National Laboratories: Economic Impact on California and the San Francisco Bay Area
(Center for Economic Development, California State University-Chico 2011)

According to this study conducted by the Center for Economic Development at California State University-Chico, the Sandia National Laboratories generated nearly $1 billion in both direct and indirect economic output in California in 2010. This economic output included $163 million in purchases and contracts to California businesses, $155 million in employee compensation and benefits, and $1.4 million in state corporate tax revenue. Combined, these three components directly totaled $319 million. Indirectly, impacts of Sandia's spending were responsible for an additional $24 million in revenue to California's state government and $612 million in additional revenue to other businesses and organizations in the state. The total output impact was roughly $955 million. About half of Sandia's economic impact in California occurs in the San Francisco Bay area. According to the report, California households saw nearly $498 million in financial benefits, including direct employee compensation plus $342 million in payroll, self-employment, and other household income paid by other California businesses and organizations. The household income benefit supports more than 4,800 California jobs.

NETL [National Energy Technology Laboratory] 2009 Economic Impacts Methodology Report
(U.S. Department of Energy 2011)

In 2011, the U.S. Department of Energy published an economic impact assessment of NETL in 2009 on Oregon, Pennsylvania, and West Virginia, as well as the nation as a whole. Using an input-output model, highlights of the report include:

- In FY2009, 689 jobs were created in the United States, as well as more than 300 in both Pennsylvania and West Virginia, and 57 in Oregon.
- In FY2009, $81 million was paid in federal wages and salaries to the United States, including more than $30 million in both Pennsylvania and West Virginia, and over $7 million in Oregon.
- In FY2009, the total direct impact on the United States was $1.2 million.

Sandia National Laboratories Economic Impact on the State of New Mexico
(Sandia National Laboratories 2011)

In 2011, an economic impact analysis of the Sandia National Laboratory on the state of New Mexico was conducted. Notable findings include:

- In FY 2011, out of 1,658 new hires, 584 graduated from a New Mexico university and 457 students were participating in year-round internships.
- In FY 2011, of the $920.8 million paid in total contract-related payments, 42% or $386.6 million was directly paid to New Mexico businesses.
- Of the FY 2011 total contract-related payments in New Mexico, 77%, or $296.1 million, was paid to small businesses.
- In FY 2011, more than $1.4 billion was paid in labor and noncontract-related payments.

Science and Engineering Indicators 2016
(National Science Foundation 2016)

The National Science Foundation's *Science and Engineering Indicators 2016* highlights major developments in international and U.S. science and technology with an emphasis on broad trends in areas such as education, workforce, and R&D expenditures. From 2008 through 2013, U.S. R&D expenditures grew 0.8% annually (adjusted for inflation) compared to 1.2% for GDP growth. R&D expenditure growth outpaced GDP growth in the United States. Globally, R&D expenditures were estimated at $1.7 trillion in 2013. The United States remains the single-largest R&D performing country, with a total of $428.7 billion expended in 2011, $436.1 billion in 2012, and $457 billion in 2013. The United States accounted for 27% of the world total in 2013, and North America accounted for 29%.

The business sector still accounts for most of the U.S. R&D performance and funding, performing an estimated $322.5 billion in R&D in 2013, or 71% of the U.S. total, and funding an estimated $297.3 billion.

The academic sector is the second-largest performer of U.S. R&D, accounting for an estimated $64.7 billion in 2013. The federal government is the second-largest funding source of U.S. R&D, providing $121.8 billion in 2013.

Technology Transfer and Commercialization Landscape of the Federal Laboratories
(Hughes et al. 2011)

The U.S. government has founded close to 1,000 federal laboratories since the establishment of the first laboratory in 1846. Approximately one-third of the $103.7 billion in FY 2008 federal research and development (R&D) expenditures was devoted to intramural R&D performed by federal laboratories (including federally funded research and development centers). The definition of what constitutes a federal laboratory is not straightforward. The federal laboratories substantially vary from one another in terms of mission, agency, research portfolio, and budget. Federal laboratories include both government-owned, government-operated (GOGO) and government-owned, contractor-operated (GOCO) laboratories. Contractors who operate laboratories for the government include for-profit companies, nonprofit companies, and universities both singly and in consortia. GOGO and GOCO laboratories have different legislative authorities.

Table A-1. Characteristics of Selected Agencies

Agency	Year Established	Number of Laboratories	Intramural R&D ($M FY 2008)[a]	Year Technology Transfer Program Established
DHS	2002	5	$372	2008
DOC NOAA	1970	—	$447	—
DOD	1947	67	$16,185	1995
DOD ONR	1946	—	$5907[b]	—
DOE	1977	21[c]	$6,077	2005/2007[d]
DOI USGS	1879	35[e]	$490	—
EPA	1970	14	$395	—
HHS FDA	1927[f]	8	$108	1995[g]
HHS NIH	1930	21	$5,2483	1989[g]
NASA	1958	10	$2,280	1958
USDA	1862	100+	$1,448	—
VA	1930	89	$442	2000

[a]National Science Foundation/Division of Science Resources Statistics, preliminary federal obligations (including intramural, industry FFRDC, university FFRDC, and nonprofit FFRDC) for research and development, by agency and performer, FY 2008.
[b]Includes all Department of Navy.
[c]The DOE cites that they have 21 federal laboratories and technology centers. See http://www.energy.gov/organization/labs-techcenters.htm. They also cite that they have 17 federal laboratories. See http://science.energy.gov/laboratories/.
[d]Established following the Energy Policy Act of 2005; staffed in 2007.
[e]The USGS says it has 35 major laboratories and 100s of field offices.
[f]Formed in 1927 and transferred to Department of Health, Education and Welfare (now HHS) in 1953. See http://www.fda.gov/AboutFDA/WhatWeDo/History/Origin/ucm124403.htm.
[g]The FDA Technology Transfer Program manages the patenting and licensing portion of its activities through an interagency agreement with the NIH Office of Technology Transfer, because FDA does not have the staff to carry out the processing.

World Intellectual Property Indicators – 2012 Edition
(World Intellectual Property Organization)

Despite a global economy that continues to underperform, intellectual property (IP) protection filings grew significantly in 2011. As the 2012 annual report from the World Intellectual Property Organization indicates, the total number of patent applications filed exceeded 2 million for the first time (1.36 million resident and 0.78 million nonresident) in 2011, reflecting a 7.8% growth rate. China led the way in patent applications, with 526,412, followed by the United States with 503,582 and Japan with 342,610. From these applications, nearly 1 million patents were granted worldwide in 2011 (606,800 issued to residents and 390,000 issued to nonresidents), showing a growth rate of 9.7%. The number of total patents in force also grew in 2011 by 6.9%, to an estimated 7.9 million. With 2.1 million patents already in force, the United States Patent and Trademark Office had the largest number, followed by its Japanese counterpart, with more than 1.5 million. The number of trademark applications doubled between 2005 and 2011, from roughly 2 million to 4.2 million, with China accounting for almost 62% of this growth.