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The NASA Glenn Research Center:

An Economic Impact Study Fiscal Year 2016

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CENTER FOR ECONOMIC DEVELOPMENT

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EXECUTIVE SUMMARY

- Located at Lewis Field (next to Cleveland Hopkins International Airport) and Plum Brook Station (Sandusky, Ohio), the NASA Glenn Research Center performs research and development to advance aviation, enable exploration of the universe, and improve life on Earth. Its scientists and engineers deliver advanced flight systems for spacecraft and improve efficiency and safety in aircraft, often in partnership with U.S. companies, universities, and other government institutions. The center's core capabilities concentrate on air-breathing and in-space propulsion, aerospace power systems, aerospace communications, materials for extreme environments, biomedical technologies and high-value space experiments in the physical sciences--all focused on solving important, practical aerospace problems and opening new frontiers (scientific, technological, and economical) for our nation.[1]

- NASA Glenn's campus includes more than 150 buildings that contain a unique collection of world-class laboratories and test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $930 million has been invested in NASA Glenn's campus. The estimated replacement cost is approximately $3.5 billion. The Lewis Field site and Plum Brook Station each host large-scale facilities that are uniquely and specifically designed to test aviation and spaceflight hardware.

- During the period covered in this report, NASA Glenn has had several leadership roles that are critical to programs and projects in all of NASA's missions: Exploration, Science, Space Operation, Space Technology, and Aeronautics Research. Within the **Human Exploration & Operations** mission portfolio, NASA Glenn provided engineering and technical services and performed a variety of analyses and integration tasks to support development of the Orion Multi-Purpose Crew Vehicle and Space Launch System; led aspects of the Human Research Program, which performs research in support of astronaut health; developed next-generation systems that support humans reaching farther into space, and initiated projects within the Advanced Exploration Systems (AES) program, which is contributing technological advancements for future robotic and human spaceflight missions beyond low Earth orbit. NASA Glenn is leading AES projects in spacecraft fire safety, advanced modular power systems, and power, avionics, software, and communication technologies for extra-vehicular activity applications. In addition, NASA Glenn provided vital support to the Space Communication and Navigation program and led spectrum management for the agency. NASA Glenn also developed numerous microgravity science experiments that were operated on the International Space Station.

[1] For further information, use the following link: http://www.nasa.gov/centers/glenn/home/index.html#.U7R0kpRdUwA

- NASA Glenn's Science mission support included managing the Radioisotope Power Systems Program and developing associated technologies; co-managing (with the Department of Energy) the Advanced Stirling Radioisotope Generator (ASRG) project; managing the In-Space Propulsion Technology (ISPT) Program and developing its associated technologies including propulsion systems (e.g. solar electric propulsion), spacecraft bus (e.g. power, extreme environments), sample return, and re-entry; developing new scientific instruments and mission concepts for planetary surfaces (e.g. Venus, Mars) and Earth science (e.g. fresh water); and supporting NASA Headquarters with assessments and panel membership for Planetary Science which includes high altitude balloon research, technology/ tools coordination, and science advisory groups.

- In support of the **Space Technology** mission, NASA Glenn led technology demonstration projects to advance solar electric propulsion capability as well as cryogenic fluid management technologies to enable future missions. NASA Glenn also led game-changing technology projects related to advanced space power systems, nuclear systems, and other technologies.

- In support of the **Aeronautics** mission**,** NASA Glenn continues to build on its world-class aeronautics heritage through its leadership of a wide variety of propulsion research, engineering and testing as related to Acoustics, Combustion, Turbo-machinery, Electrified Aircraft Propulsion, power management, propulsion systems analysis, materials and Communications for subsonic, supersonic, hypersonic and vertical lift aircraft systems, and through its program management efforts to support efficient, quiet, and reliable flight in any atmosphere at any speed. A vast array of research and technology development projects in support of these attributes are performed by NASA Glenn, culminating in partnerships to test integrated systems to demonstrate capabilities meeting long-term objectives for the Aeronautics Mission Directorate's Strategic Implementation Plan.

- The report structure is as follows: Sections A and B consist of the report's introduction and background. Section C provides an economic overview of NASA Glenn, including information related to employment and occupations, employee residences, payroll, expenditures, awards to academia and other institutions, revenues, and taxes paid by NASA Glenn employees. Section D provides estimates of the economic impact generated by NASA Glenn for an 8-county Northeast Ohio region and the state of Ohio during FY 2016. This report is an update of several earlier studies that estimated and measured NASA Glenn's economic impact on Northeast Ohio and Ohio.

ECONOMIC IMPACT GENERATED BY NASA GLENN RESEARCH CENTER SPENDING

- Economic impact estimates the benefits within the regional economy generated by an economic activity of an entity for an affected region. This study uses an input-output (I-O) model to estimate the effect of NASA Glenn Research Center's spending on the economies of Northeast Ohio (NEO) and Ohio. This analytical tool measures economic impact in terms of growth in output (sales), value added (output less intermediary goods), number of new and supported jobs, labor income, and tax revenues. This year's study uses the same methodology to measure NASA Glenn's impact on the economies of Northeast Ohio and Ohio as was used for the previous studies. This report accounts for direct NASA Glenn spending across diverse economic sectors and illustrate what impact it makes on the regional economics of Northeast Ohio and Ohio. The table below summarizes NASA Glenn's economic impact on Northeast Ohio and the state of Ohio during FY 2016.

Economic Impact	Northeast Ohio	State of Ohio
Output	$1,400.0 million	$1,427.6 million
Value Added	$715.2 million	$719.5 million
Employment	7,004 jobs	7,184 jobs
Labor Income	$488.7 million	$494.1 million
Taxes	$125.3 million	$126.2 million

Note: Labor income accounts for the income of all NASA Glenn employees, both residents of the study area and those who live outside of the study area and spend only a portion of their income in the region (commuter spending). Direct value added impact was assessed as a percentage of output, whereas in studies prior to FY 2013 we accounted only for labor income as a direct value added impact.

- NASA Glenn's $639.3 million worth of expenditures[2] originating primarily from outside of the region resulted in an output (sales) change of $1.4 billion across all industry sectors. The value added increased by $715.2 million as a result of NASA Glenn's activities. In addition, 7,004 jobs were created and supported in the region, and labor income in Northeast Ohio increased by $488.7 million. NASA Glenn's activities in Northeast Ohio also generated $125.3 million in local, state, and federal taxes.

[2] Inflated to 2017 dollars using Ohio IMPLAN model inflation coefficient.

- NASA Glenn's activities in Ohio in FY 2016, stimulated by $639.3 million in direct spending originating primarily from outside of the state, generated an increased demand in output (sales) for products and services produced across the state valued at $1,427.6 million.
- Ohio value added increased by $719.5 million as a result of NASA Glenn's activities in the state. In addition, 7,184 jobs were created and supported in Ohio, and labor income across the state increased by $494.1 million. NASA Glenn operations in Ohio also generated $126.2 million in local, state, and federal taxes.

- Direct NASA Glenn spending had the greatest impact in the areas of scientific research and development services, facilities support services, maintenance and repair construction of nonresidential structures, computer related services, educational services, investigation and security services, and architectural, engineering, and related services.
- Spending by NASA Glenn personnel and other workers was in line with typical consumer spending patterns. Industries that benefited the most from NASA Glenn spending included owner-occupied dwellings, real estate and rental services, hospitals and healthcare offices, insurance carriers, food services, and nursing and community care facilities.

NASA GLENN RESEARCH CENTER: AN OVERVIEW

- In FY 2016, NASA Glenn's civil service employment totaled 1,572. Compared to FY 2015, the total Glenn employment increased by 9 employees. Over the past five years, the most notable change in the occupational structure at NASA Glenn has been the decrease in the number of clerical and technician positions.
- The NASA Glenn workforce is highly educated. In FY 2016, 85% of NASA Glenn's employees held at least a bachelor's degree. Looking at all NASA Glenn employees, 17% held doctoral degrees, 37% held master's degrees, and 31% held bachelor's degrees.[3] Though there was a slight decrease in the share of bachelor's degree or higher from FY 2015, the percentage of employees holding bachelor's degrees or higher was still 3% higher in FY 2016 than it was in FY 2012. NASA Glenn still aims to increase the share of its civil servant workforce dedicated to research and technology while reducing the cost of support personnel.
- Scientists and engineers represented 71% of the civil service employees at NASA Glenn in FY 2016, the largest occupational category. This is the highest percentage of representation for this category in the five-year study period, continuing an upward trend. The number of total scientists and engineers increased to 1,116 in FY 2016, up from 1,078 in FY 2015.
- Combining civil service employees and local contractors, the total number of employees at NASA Glenn was 3,197 in FY 2016. This was an increase of 72 total employees from FY 2015. Over the past 5 years, the highest total combined employment was 3,347 in FY 2012 and the lowest was 3,125 in FY 2015.
- NASA Glenn civil service employees received total compensation of $228.3 million in total compensation in FY 2016.[4] Total compensation includes both payroll, at $175.6 million, and employee benefits, at $52.7 million. Total compensation increased by $104,623, or less than 0.05%.[5] Compared to FY 2012, total compensation increased by $1.9 million, or 0.84%. The NASA Glenn FY 2016 payroll, $175.6 million, was $1.6 million less than the FY 2015 payroll, a 0.9% decrease from the previous year. The FY 2016 payroll was $8.6 million less than the FY 2012 payroll, a decrease of 4.7%. This decrease can be largely attributed to the reduction of 87 civil servant employees from FY 2012 to FY 2016.
- NASA Glenn's total revenue in FY 2016 was $664.1 million. This was the second lowest revenue total in the past five years, only ranking above the FY 2013 total of $655.1 million (in nominal dollars). Over the five-year period, NASA Glenn revenues ranged from $655.1 million to $687.7 million. Compared to FY 2015, the revenues decreased by $7.4 million, or 1.1%. NASA Glenn's total revenue has decreased by $23.5 million, or 3.4%, between FY 2012 and FY 2016.
- NASA Glenn's expenditures totaled $407 million in FY 2016. Vendors in 47 states, Washington, D.C., and eleven foreign countries received a portion of NASA Glenn expenditures. In nominal dollars, the FY 2016 total expenditures were $7.3 million higher than that in FY 2015 illustrating a 1.8% increase. Between FY 2012 and FY 2016, NASA Glenn total expenditures decreased by 6.4%, or $27.7 million. Adjusting for inflation, NASA Glenn expenditures increased by $7 million, or 1.7%, from FY 2015 to FY 2016.[6] Total expenditures decreased by $40 million from FY 2012 to FY 2016, a decrease of 9%.

[3] These counts do not include Student Trainees.

[4] All dollar value comparisons in this section are adjusted for inflation.

[5] Total nominal compensation increased by 0.13% ($289,303) between FY 2015 and FY 2016.

[6] Inflation was adjusted using Ohio IMPLAN model inflation coefficient.

- Ohio received the largest portion of Glenn's expenditures with $284.5 million. Compared to FY 2015, this was a nominal decrease of $5.7 million. Ohio's share decreased from 72.6% in FY 2015 to 69.9% in FY 2016. This is still higher, however, than the share Ohio had in FY 2012, which was 63.1%.
- Northeast Ohio received 97.5% of NASA Glenn's spending in the state of Ohio in FY 2016, a total of $277.4 million. The spending in Northeast Ohio accounted for 68.1% of NASA Glenn's total spending in FY 2016. Cuyahoga County received 67.5%, or $274.7 million, of NASA Glenn's total spending in FY 2016.
- After Ohio, the states that received the largest portions of NASA Glenn spending in FY 2016 were Maryland and California. Maryland received $26.4 million, 6.5% of total FY 2016 spending, and California received $14.9 million, 3.7% of totaling spending. These two states received the second and third largest portions of NASA Glenn spending in FY 2016. Between FY 2015 and FY 2016, spending in Maryland decreased by $519,914, or 1.9%, in nominal dollars. Over the same time, spending in California increased by $723,837, or 5.1%.
- NASA Glenn expenditures in foreign countries totaled $903,231 in FY 2016, a double increase over the FY 2015 total and a nominal increase of $448,581. Foreign expenditures represented 0.22% of NASA Glenn's total FY 2016 expenditures. The increase in spending was primarily due to increases in spending to Great Britain, with a $130,366 nominal increase, and Germany, with a $307,509 nominal increase.
- In FY 2016, NASA Glenn's funding to colleges and universities totaled $12.1 million. Institutions in 31 states, Washington, D.C., and two foreign countries, Great Britain and Iceland, received funding. In comparison to FY 2015, the total amount of funding to academic institutions increased by $2.6 million in FY 2016, an increase of 27.5% (comparing nominal dollars).
- Academic institutions in California received the largest share of NASA Glenn funding to academic institutions in FY 2016 with a total of $1.98 million, or 16.5% of total awards. Maryland and Illinois ranked second and third, and both received $1.3 million in funding to academic institutions, or 10.7% of total awards. Ohio's academic institutions received almost $1.1 million in FY 2016, or 8.75% of total funding, placing the state in fourth. Ohio colleges and universities received $117,001 more in awards in FY 2016 than in FY 2015, an increase of 12.5%. Pennsylvania ranked fifth with $0.7 million in funding, or 5.8%.
- Of the $1.1 million awarded to Ohio academic institutions in FY 2016, $0.62 million went to academic institutions in Northeast Ohio. Northeast Ohio received 58.9% of the total academic awards granted in the state of Ohio and 5.1% of all NASA Glenn academic awards. In comparison to FY 2015, Northeast Ohio's share of awards declined both at the state level (61.7% of total Ohio awards in FY 2015) and national level (5.9% of total awards in FY 2015).
- NASA Glenn continues to be an important institution influencing the economies of both Northeast Ohio and the state of Ohio. NASA Glenn's employees are part of the knowledge-intensive labor force that advances the nation, generates wealth in the region, and attracts other creative workers to reside in Ohio.

A. INTRODUCTION

This report presents an analysis of the economic impact of the National Aeronautics and Space Administration's John H. Glenn Research Center (NASA Glenn) during its fiscal year (FY) 2016. It uses an input-output model, which reflects the buy-sell relationships among industries, the household sector, and the government sector in a region, to estimate the effect of NASA Glenn's spending on the economies of both Northeast Ohio and the state of Ohio.[7]

This model assesses economic impact in terms of growth in total output (sales); value added (output less intermediary goods); household earnings, number of new and supported jobs, and taxes.[8]

The report also provides an overview of NASA Glenn and describes some of its research and development (R&D) activities. It looks at changes in NASA Glenn's employees in terms of payroll, occupation, and place of residence. The report further provides information on NASA Glenn's expenditures and revenues, awards to academic institutions, and taxes contributed by employees.

The analysis was conducted by the Center for Economic Development at Cleveland State University's Maxine Goodman Levin College of Urban Affairs. This FY 2016 report is an update to previous studies published in 1996, 2000, 2005, and annually from 2007 through 2016.[9]

[7] For purposes of this study, Northeast Ohio is defined as Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

[8] Output impact reflects the total value of all additional goods and services produced in the economy. For example, the output economic impact includes the total value of all professional scientific and technical services and all intermediary goods created to secure delivery of the scientific services. Value added impact reflects the value of only additional output produced in the region, which is calculated as total sales less intermediary goods not sold as final products. For example, the value added impact will account for the value of all professional scientific and technical services, excluding intermediary goods produced to deliver these services. Such intermediary goods include research supplies, utilities, research services of intermediary steps of research, etc.

[9] All previous studies can be found on the Center for Economic Development's website: http://urban.csuohio.edu/economicdevelopment/publications/

B. NASA GLENN RESEARCH CENTER: BACKGROUND

Located at Lewis Field (next to Cleveland Hopkins International Airport) and Plum Brook Station (Sandusky, Ohio), the NASA Glenn Research Center performs research, engineering development and test to advance aviation, enable exploration of the universe, and improve life on Earth. Its scientists and engineers deliver advanced technology and flight systems for spacecraft and improve efficiency in aircraft, often in partnership with U.S. companies, universities, and other government institutions. The center's core capabilities concentrate on air-breathing and in-space propulsion, power systems, aerospace communications, materials for extreme environments, biomedical technologies and high-value space experiments in the physical sciences--all focused on solving important, practical aerospace problems and opening new frontiers (scientific, technological, and economical) for our nation.[10]

B.1. NASA GLENN TEST FACILITIES

NASA Glenn's campus includes more than 150 buildings that contain a unique collection of world-class laboratories and test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $930 million has been invested in the construction of NASA Glenn's campus. The estimated current replacement value of Lewis Field and Plum Brook Station is over $3.5 billion.

Glenn's main campus, Lewis Field, is situated on 350 acres of land and contains more than 150 buildings. Lewis Field has a large inventory of facilities that supports research, development, testing, and evaluation activities. There are approximately 450 research and test facilities located at the Lewis Field site including 24 major test facilities and over 100 research and development laboratories. The world-class facilities at Lewis Field include large and unique aero-propulsion wind tunnels, micro-gravity and zero gravity research facilities, engine test cells, flight research facilities, space environment chambers, vacuum chambers and a host of additional research and development laboratories and test stands.

Glenn's Plum Brook Station is located 50 miles west of Cleveland in Sandusky, Ohio, on 6,400 acres of land. Plum Brook Station has large, unique facilities that simulate the environment of space. Most of these capabilities are world-unique, including the largest space simulation chamber, the largest mechanical vibration table, the most powerful reverberant acoustic test chamber, the largest electromagnetic test chamber, the largest space simulation chamber which can test in planetary dust, the largest liquid hydrogen-capable space simulation chamber, and the only cold soak start/restart rocket engine test facility.

Both locations enable NASA, other governmental agencies, and academic and industry partners from across the country to perform specialized research and testing to support the Agency's Aeronautics, Space and Science Missions as well as the country's interests in these areas.

[10] For further information, use the following link: http://www.nasa.gov/centers/glenn/home/index.html#.U7R0kpRdUwA

B.2. NASA GLENN MISSION AREAS SUPPORTING NASA THEMES

During the period covered in this report, NASA Glenn has had several leadership roles that are critical to programs and projects in all of NASA's missions: Exploration, Science, Space Operation, Space Technology, and Aeronautics Research.

Human Exploration & Operations (Human Spaceflight to the International Space Station (ISS), Moon and Beyond).

- Managing the European Service Module (ESM) and its integration within the Orion MPCV Program. The ESM provides power, propulsion, and communications for Orion's Crew Module (CM).
- Managing and developing next-generation Solar Electric Propulsion systems that support humans reaching farther into space.
- Managing contractual and technical development for the Universal Stage Adapter connecting the Upper Stage of the SLS to the Orion Crew and Service Module, and applying human spaceflight engineering and technical capabilities to perform a variety of analysis and integration tasks to support development of the Space Launch System (SLS) and the Orion Multi-Purpose Crew Vehicle.
- Conducting critical-path environmental testing of the integrated Orion spacecraft at Plum Brook Station.
- Contributing to the Human Research Program, which performs research and technology related to human health and medical devices.
- Leading the operation and utilization of new, advanced communications technology, including the SCaN Testbed - a demonstration already located and in service on the International Space Station for software-defined radios.
- Conducting high-value microgravity physical science research (specifically combustion science and fluid physics) on the International Space Station, from research objective definition to experiment equipment provision and operation.
- Developing next-generation systems that support humans in space via specific projects within NASA's Advanced Exploration Systems (AES) program. NASA Glenn is leading AES projects to make advancements in spacecraft fire safety, including developing and launching payloads to test and observe flames in a microgravity environment, advanced modular power systems, and power, avionics, software, and communication technologies for extra-vehicular activity applications.
- Managing several research and advanced technology development projects on the ISS and on Earth, in support of human exploration.
- Managing, overseeing the development of system upgrades for and supporting safe and reliable operation of the International Space Station's electrical power system.

Space Technology

- Leading the development of Solar Electric Propulsion technology for Technology Demonstration Missions, the Asteroid Redirect/Retrieval Mission, and other space-based exploration and scientific missions of the future.
- Leading development of technologies for cryogenic fluids transfer and storage, for both application to the Space Launch System and future transportation systems.
- Providing propulsion system analysis and testing of "green" fuels for satellite missions.

- Managing and developing kilo-watt class nuclear power systems for in-space and surface power.
- Testing small satellite infusion of propulsion and power generation technologies using micro-sats and Cube-sats.

Science

- Managing the Radioisotope Power Systems Program and developing associated power technologies. Radioisotope Power Systems enable scientific missions where conventional power systems such as solar power or batteries are impractical. The Advanced Stirling Converter (ASC) and Stirling Radioisotope Generators (SRGs) are examples of these technologies.
- Managing Department of Energy production of radioisotope materials and fuel for NASA space missions.
- Developing and promulgating NASA-wide strategy for nuclear power and propulsion systems.
- Developing with industry ion-grid solar electric propulsion thrusters and power processing units to be provided as NASA equipment to future Space Science Missions.
- Managing the In-Space Propulsion Technology (ISPT) Program and developing its associated technologies including propulsion systems (e.g. solar electric propulsion), spacecraft bus (e.g. power, extreme environments), sample return, and re-entry. Conducting system and mission studies to validate benefits.
- Developing new scientific instruments and mission concepts for planetary surfaces (e.g. Venus, Mars) and Earth science (e.g. fresh water).
- Supporting NASA Headquarters with assessments and panel membership for Planetary Science including high altitude balloon research, technology/tools coordination, and science advisory groups.

Aeronautics Research

- Managing the Advanced Air Transport Technology Project defining the most compelling technical challenges facing the air transport industry as envisioned for the 2030-2040-time horizon. The research explores and advances knowledge, technologies, and concepts to enable giant steps in energy efficiency and environmental compatibility resulting in less fuel burn and less direct impact with the atmosphere.
- Managing the hybrid electric propulsion investments and partnerships, and performing technical research, development and testing for hybrid electric elements and subsystems including high power density materials, high efficiency, high power density megawatt class electric machines, and more efficient, higher performing combustion and turbine systems.
- Managing and performing research and testing for propulsion/airframe integration advances to enable changes in air vehicle shapes resulting in significant improvements in fuel efficiency.
- Managing and performing engine icing research and testing in the only facility in the world capable of replicating conditions for ice formation at altitude internal to combustion engines, to understand the physics and to provide the capability to certify commercial engines for operations in icing conditions.
- Managing and overseeing development and performing testing of advanced air-breathing combustion subsystems and systems to achieve higher efficiencies and reduce system emissions due to combustion.

- Managing as Deputy the Revolutionary Vertical Lift Technologies Project, defining the most compelling technical challenges facing the rotorcraft and vertical lift communities, and performing research, development and testing of drive systems, transmissions, and turbomachinery for vertical lift vehicles.
- Managing as Deputy the Commercial Supersonic Technologies Project overseeing vehicle research, integration and testing in the development of tools, technologies and knowledge that will eliminate technical barriers preventing practical commercial supersonic flight. Performing research and development to design tools and innovative concepts for integrated supersonic propulsion systems that can meet airport noise regulations.
- Managing the Aeronautics Evaluation and Test Capabilities Project, combining research, analysis, and test capabilities necessary to achieve future air vehicle development and operations. Providing operations and maintenance oversight while also developing and implementing a construct to make future investment portfolio decisions for Aeronautics and Agency Aerosciences objectives.
- Developing radios through a cooperative agreement and demonstrating secure and reliable unmanned aerial systems controlled communication via large-scale simulations and flight testing to validate performance requirements for civil unmanned aerial systems.
- Managing the Convergent Aeronautics Solutions Project, pursuing short duration activities to establish early-stage concept and technology feasibility for high-potential solutions to major-system-level challenges that require NASA and the aviation community to think beyond current concepts, architectures and relationships. Performing technology developments include airframe structures accounting for power system elements and establishing voltage and power limits for hybrid electric aircraft options.
- Managing the Transformative Tools and Technology Project to develop new computer-based tools, models, and associated scientific knowledge that will provide first-of-a-kind capabilities to analyze, understand, and predict performance for a wide variety of aviation concepts. Performing research and technology development of ceramic matrix composite materials, advanced coatings and propulsion analysis and design tools for future aeronautics concepts.
- Providing requirements and systems engineering approach to embed cyber-security into the future air traffic management system, and developing communications architectures and potential future communications elements, sensors and autonomy solutions, with test and verification, for future airspace operations concepts.
- Managing as the Deputy the Hypersonics Project, and supporting vehicle studies, performing propulsion testing, and developing high temperature seals and analytic tool development to advance hypersonic technology for the nation.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents an economic overview of the NASA Glenn Research Center during FY 2016. Changes between FY 2012 and FY 2016 are illustrated with payroll, revenues, expenditures, awards to academic institutions, occupational distribution, number of employees, employee residence locations, and income taxes paid by NASA Glenn employees.

C.1. EMPLOYMENT AND OCCUPATIONS

The labor force at NASA Glenn Research Center is made up of two types of workers, civil service employees and local contractors. Contractors are commonly used by Federal agencies to perform specialized services. In contrast to civil service employees, employing contractors offers flexibility in terms of contract length, hiring process, and labor costs. The number of contracted employees is more fluid than civil service employment and could be adjusted based on project needs at NASA Glenn.

NASA Glenn's civil service employment distribution is made up of four occupational categories: scientists and engineers, administrative professionals, technicians, and clerical staff.

Table 1 shows the total number of NASA Glenn civil service employees and the shares of the four main occupational categories over time. There was a slight overall increase in the number of civil service employees in FY 2016, up to 1,572. This ends a previous three-year trend of decreasing number of employees. Compared to FY 2015, the total Glenn employment increased by 9 employees. Over the past five years, the most notable change in the occupational structure at NASA Glenn has been the decrease in the number of clerical and technician positions.

Table 1. NASA Glenn Civil Service Employment Distribution by Occupational Category, FY 2012-FY 2016

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2012	1,659	21%	4%	67%	9%
2013	1,664	21%	3%	68%	8%
2014	1,624	21%	3%	68%	8%
2015	1,563	23%	2%	69%	6%
2016	1,572	22%	2%	71%	5%

Note: Table does not include local contractors.[11]

[11] A detailed listing of NASA Glenn's local contractors can be found at http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm

Scientists and engineers represented 71% of the civil service employees at NASA Glenn in FY 2016, the largest occupational category. This is the highest percentage of representation for this category in the five-year study period, continuing an upward trend. The number of total scientists and engineers increased to 1,116 in FY 2016, up from 1,078 in FY 2015.

The second largest occupational category is administrative professionals, representing 22% of NASA Glenn employees in FY 2016. This was a slight decrease from 23% in FY 2015. The administrative professional category has maintained a relatively steady share of NASA Glenn employment over the last five years, ranging from 21% to 23% of total civil service employees.

Technicians accounted for 5% of NASA Glenn's civil service employees in FY 2016, a decrease from 6% in FY 2015. NASA Glenn employed 79 technicians in FY 2016. This is down 70 employees from the FY 2012's total of 149. This category of employment has been steadily decreasing for over a decade, down from representing 17% of the workforce in FY 2004.

The smallest civil service employment category at NASA Glenn is the clerical employees, which represented 2% of total employment in FY 2016. This percentage is the same as it was in FY 2015 and represents a 50% drop in the clerical employee share since FY 2012 when it was 4%.

The NASA Glenn workforce is highly educated. In FY 2016, 85% of NASA Glenn's employees held at least a bachelor's degree. Looking at all NASA Glenn employees, 17% held doctoral degrees, 37% held master's degrees, and 31% held bachelor's degrees.[12] Though there was a slight decrease in the share of bachelor's degree or higher from FY 2015, the percentage of employees holding bachelor's degrees or higher was still 3% higher in FY 2016 than it was in FY 2012.

NASA Glenn contracted work to 1,625 on- or near-site contractors in FY 2016 (Table 2). NASA Glenn contractor employment ranged from 1,562 to 1,688 over the five-year study period, with an average of 1,638 contractors used per year. For broader context, the range of contractor employment from the past 10 years was a low of 1,562 in FY 2015 and a high of 1,912 in FY 2010. The variability in contractor employment over this period is much higher than civil service employee variability, demonstrating the value and flexibility contractors provide to help meet varying project demands.

Combining civil service employees and local contractors, the total number of employees at NASA Glenn was 3,197 in FY 2016. This was an increase of 72 total employees from FY 2015. Over the past 5 years, the highest total combined employment was 3,347 in FY 2012 and the lowest was 3,125 in FY 2015.

[12] These counts do not include Student Trainees.

Table 2. NASA Glenn On- or Near-Site Contractors Employment, FY 2012-FY 2016

Fiscal Year	Employment of On- or Near-Site Contractors
2012	1,688
2013	1,643
2014	1,673
2015	1,562
2016	1,625

C.2. PLACE OF RESIDENCE FOR GLENN EMPLOYEES

NASA Glenn Research Center is located in Cleveland, Ohio, adjacent to Cleveland Hopkins International Airport in Cuyahoga County. NASA Glenn also operates Plum Brook Station, located near Sandusky, Ohio, in Erie County to the west of Cleveland. Most civil service employees working at NASA Glenn live in Cuyahoga County or the surrounding counties that comprise Northeast Ohio.[13] Figure 1 shows the breakdown of employees' postal addresses by geographic region. In FY 2016, 93.2% of NASA Glenn employees lived in Northeast Ohio.

Of the 1,572 civil servants working at NASA Glenn, 59.6%, or 936, lived in Cuyahoga County in FY 2016. The next largest counties of residence for civil service employees were Lorain County (14.7%; 230 employees), Medina County (11.7%; 184 employees), and Summit County (4.1%; 64 employees). The other Northeast Ohio counties accounted for 3.2% of NASA Glenn employee places of residence, and another 3.2% lived in Ohio counties outside of Northeast Ohio. Only 3.6% of NASA Glenn employees resided outside Ohio.

In comparison to FY 2015, there was a 1% decrease in the percentage of NASA Glenn employees residing in Northeast Ohio, going from 94.2% in FY 2015 to 93.2% in FY 2016. This decrease coincided with a 0.5% increase in the number of employees living in Ohio outside the Northeastern counties and a 0.5% increase in the number of employees residing outside of the state. The percentage of NASA Glenn employees residing outside of Ohio has grown in recent years, largely driven by scientists and engineers living out of state.

[13] Northeast Ohio includes Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

Figure 1. NASA Glenn Civil Service Employees by Place of Residence, FY 2016

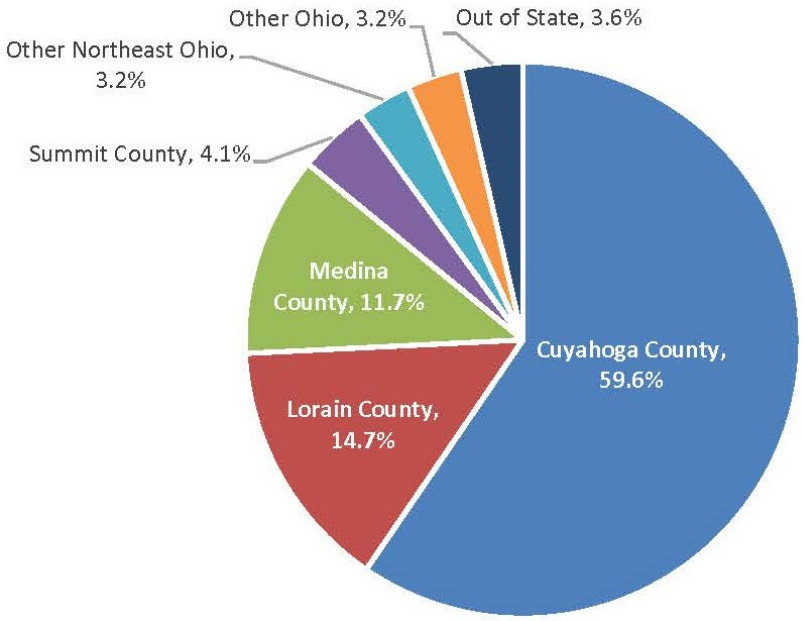


Table 3 shows the distribution NASA Glenn civil service employees by occupation and place of residence. In FY 2016, 93.2% of NASA Glenn employees lived in Northeast Ohio, with 59.6% living in Cuyahoga County. Technicians and clerical employees were the most likely to reside in Northeast Ohio, at 96.5% and 96.2% respectively. Scientists and engineers were the most likely occupational category to live outside Northeast Ohio, at 7.1%, and the most likely to reside outside Ohio, at 4.5%. Administrative professionals were the next most likely to live outside Northeast Ohio, at 6.2%, with 1.8% living out of state.

Table 3. NASA Glenn Civil Service Employees by Occupation and Place of Residence, FY 2016

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	93.8%	96.2%	92.9%	96.5%	93.2%
Cuyahoga County	59.2%	69.2%	60.0%	53.5%	59.6%
Lorain County	16.3%	19.2%	13.9%	16.3%	14.7%
Medina County	11.0%	3.9%	11.6%	18.6%	11.7%
Summit County	5.3%	0.0%	4.0%	2.3%	4.1%
Lake County	0.6%	3.9%	1.3%	2.3%	1.2%
Geauga County	0.3%	0.0%	1.3%	1.2%	1.0%
Portage County	1.2%	0.0%	0.9%	1.1%	0.9%
Ashtabula County	0.0%	0.0%	0.0%	1.2%	0.1%
Other Ohio	4.4%	3.8%	2.6%	3.5%	3.2%
Out of State	1.8%	0.0%	4.5%	0.0%	3.6%

Note: Northeast Ohio component counties sorted by total.

C.3. PAYROLL

NASA Glenn civil service employees received $228.3 million in total compensation in FY 2016.[14] Total compensation includes both payroll, at $175.6 million, and employee benefits, at $52.7 million. Total compensation increased by $104,623, or less than 0.05%.[15] Compared to FY 2012, total compensation increased by $1.9 million, or 0.84%.

The NASA Glenn FY 2016 payroll, $175.6 million, was $1.6 million less than the FY 2015 payroll, a 0.9% decrease from the previous year.[16] The FY 2016 payroll was $8.6 million less than the FY 2012 payroll, a decrease of 4.7%.[17] This decrease can be largely attributed to the reduction of 87 civil servant employees from FY 2012 to FY 2016.

Employee benefits increased from FY 2015 to FY 2016. The increase in benefits compensation was enough to counteract the slight decrease in payroll compensation and led to a net gain in total compensation for from FY 2015 to FY 2016. Benefits increased 8.7%, or $4.2 million, between FY 2012 and FY 2016.[18] In FY 2012, payroll was 79.2% of total compensation, while in FY 2016 payroll was down to 76.9% of total compensation.

Between FY 2015 and FY 2016, the average wage per civil service employee decreased from $113,389 to $111,726, a 1.5% drop. Between FY 2012 and FY 2016, there was a slight increase of 0.6% in the total average wage per civil service employee.[19]

[14] All dollar value comparisons in this section are adjusted for inflation.

[15] Total nominal compensation increased by 0.13% ($289,303) between FY 2015 and FY 2016.

[16] Total nominal payroll decreased by 0.8% ($1.5 million) between FY 2015 and FY 2016.

[17] Total nominal payroll decreased by $3.5 million, or 1.9%, between FY 2012 and FY 2016.

[18] Total nominal benefits increased by $5.6 million, or 11.8%, between FY 2012 and FY 2016.

[19] The average wage per employee in nominal terms increased 3.5%, or $3,762, between FY 2012 and FY 2016.

C.4. NASA GLENN EXPENDITURES, FY 2016

NASA Glenn's expenditures totaled $407 million in FY 2016. Vendors in 47 states, Washington, D.C., and eleven foreign countries received a portion of NASA Glenn expenditures. In nominal dollars, the FY 2016 total expenditures were $7.3 million higher than that in FY 2015 illustrating a 1.8% increase. Between FY 2012 and FY 2016, NASA Glenn total expenditures decreased by 6.4%, or $27.7 million. Adjusting for inflation, NASA Glenn expenditures increased by $7 million, or 1.7%, from FY 2015 to FY 2016.[20] Total expenditures decreased by $40 million from FY 2012 to FY 2016, a decrease of 9%.

Figure 2 shows the geographic distribution of NASA Glenn's spending during FY 2016. Ohio received the largest portion of NASA Glenn expenditures with $284.5 million. Compared to FY 2015, this was a nominal decrease of $5.7 million. Ohio's share of grand total expenditures decreased from 72.6% in FY 2015 to 69.9% in FY 2016. This is still higher, however, than the share Ohio had in FY 2012, which was 63.1%.

Northeast Ohio received 97.5% of NASA Glenn's spending in the state of Ohio in FY 2016, a total of $277.4 million. The spending in Northeast Ohio accounted for 68.1% of NASA Glenn's total spending in FY 2016. Cuyahoga County received 67.5%, or $274.7 million, of NASA Glenn's total spending in FY 2016.

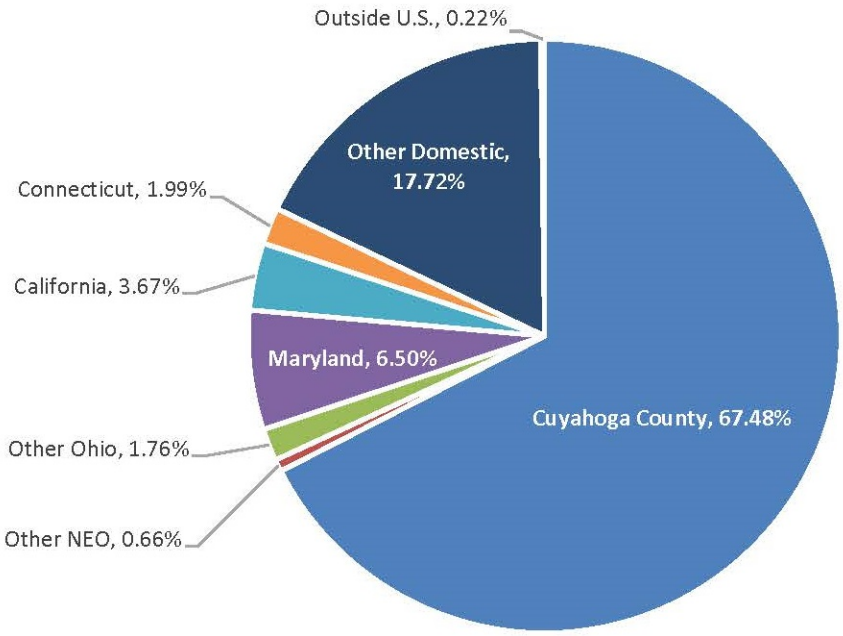
After Ohio, the states that received the largest portions of NASA Glenn spending in FY 2016 were Maryland and California. Maryland received $26.4 million, 6.5% of total FY 2016 spending, and California received $14.9 million, 3.7% of total spending. These two states received the second and third largest portions of NASA Glenn spending in FY 2016. Between FY 2015 and FY 2016, spending in Maryland decreased by $519,914, or 1.9%, in nominal dollars. Over the same time, spending in California increased by $723,837, or 5.1%.

Of all the states that received NASA Glenn spending, Tennessee had the largest increase in spending from FY 2015 to FY 2016 with a nominal increase of $5 million. In addition to Tennessee, Virginia, Washington, Texas, Indiana, Missouri, and New Mexico all saw an increase in NASA Glenn spending totaling more than $1 million between FY 2015 and FY 2016. Outside of Ohio, three states, Connecticut, Florida, and Oregon, had decreases in NASA Glenn spending of more than $1 million between FY 2015 and FY 2016. In FY 2016, 22 states received at least $1 million in NASA Glenn spending, which was two fewer than in FY 2015, where 24 states received at least $1 million in NASA Glenn spending. (See Appendix Table A.1 for more information on NASA Glenn spending by state).

NASA Glenn expenditures in foreign countries totaled $903,231 in FY 2016, a 100% increase over the FY 2015 total and a nominal increase of $448,581. Foreign expenditures represented 0.22% of NASA Glenn's total FY 2016 expenditures. This was primarily due to increased spending in Great Britain, with a $130,366 nominal increase, and Germany, with a $307,509 nominal increase. (See Appendix Table A.1 for more information on NASA Glenn out of country expenditures).

[20] Inflation was adjusted using Ohio IMPLAN inflation coefficient.

Figure 2. NASA Glenn Spending in Selected Regions, FY 2016



Total Expenditure: $ 407 million

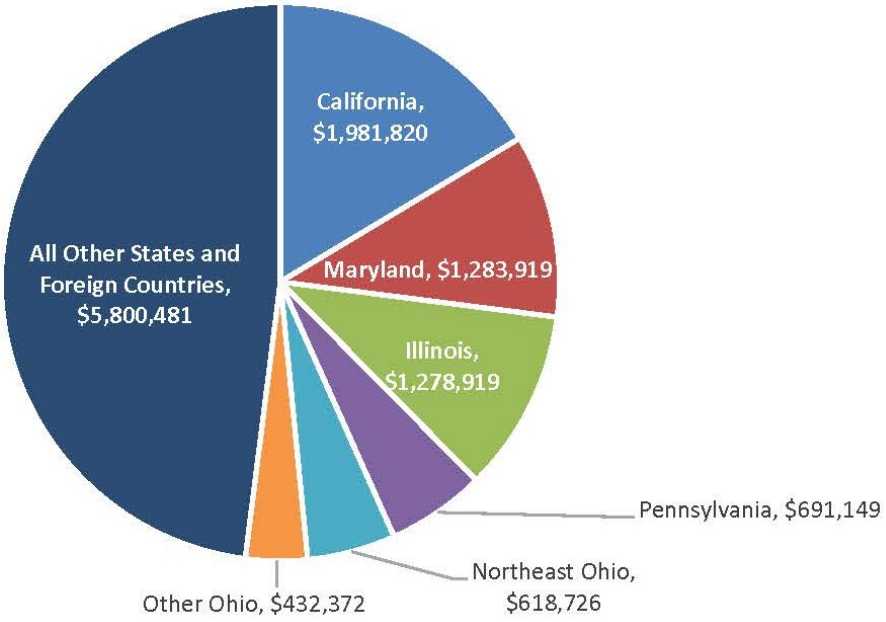
C.5. NASA Glenn Awards to Academic and Other Institutions

NASA Glenn Research Center provides funding to colleges, universities, and other nonprofit institutions through R&D contracts and grants for assisting NASA in R&D projects. Funding to academic institutions is dependent upon NASA Glenn's year to year goals and mission.

In FY 2016, NASA Glenn's funding to colleges and universities totaled $12.1 million. Institutions in 31 states, Washington, D.C., and two foreign countries, Great Britain and Iceland, received funding. In comparison to FY 2015, the total amount of funding to academic institutions increased by $2.6 million in FY 2016, an increase of 27.5% (comparing nominal dollars).

Figure 3 displays the distribution of funding to academic institutions by state and country. States that received a larger share of the funding are emphasized. The five states that received the most in academic awards in FY 2016, California, Maryland, Ohio, Illinois, and Pennsylvania, accounted for 52% of the total funding awarded to academic institutions. (See Appendix Table A.2. for more information).

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2016



Total Academic Awards: $12.1 million

Notes:
Figures in nominal dollars
"Other Ohio" refers to colleges and universities located outside the 8-county definition of Northeast Ohio used in this report

Academic institutions in California received the largest share of NASA Glenn funding to academic institutions in FY 2016 with a total of $1.98 million, or 16.5% of total awards. Maryland and Illinois ranked second and third, and both received $1.3 million in funding to academic institutions, or 10.7% of total awards. Ohio's academic institutions received almost $1.1 million in FY 2016, or 8.75% of total funding, placing the state in fourth. Ohio colleges and universities received $117,001 more in awards in FY 2016 than in FY 2015, an increase of 12.5%. Pennsylvania ranked fifth with $0.7 million in funding, or 5.8%.

Of the $1.1 million awarded to Ohio academic institutions in FY 2016, $0.62 million went to academic institutions in Northeast Ohio. Northeast Ohio received 58.9% of the total academic awards granted in the state of Ohio and 5.1% of all NASA Glenn academic awards. In comparison to FY 2015, Northeast Ohio's share of awards declined both at the state level (61.7% of total Ohio awards in FY 2015) and national level (5.9% of total awards in FY 2015).

Table 4 shows the distribution of NASA Glenn awards to academic institutions in the state of Ohio from FY 2012 to FY 2016 (inflated to 2016 dollars). Between FY 2012 and FY 2016, the total amount of funding to Ohio academic institutions decreased by 79.3%, going from $5.1 million in FY 2012 to $1.1 million in FY 2016. The increase in awards to Ohio institutions between FY 2015 and FY 2016 broke a 10-year trend of decreasing NASA Glenn funding to Ohio academic institutions.

Case Western Reserve University and Ohio State University received most funding to Ohio academic institutions. Case Western Reserve University received $.38 million and Ohio State University received $.35 million. Combined, the two universities accounted for 69.6% of NASA Glenn awards to Ohio academic institutions in FY 2016. For Case Western Reserve University, this was a $44,979 increase in funding over FY 2015, a 13.5% increase. For Ohio State University, this was an $86,193 increase over FY 2015, a 32.1% increase.

Cuyahoga Community College received $158,014 in FY 2016 after not receiving funding in FY 2015. The remainder of the FY 2016 awards from NASA Glenn to Ohio academic institutions went to Ohio University ($77,859), Kent State University ($39,749), Cleveland State University ($19,144), The University of Akron ($15,002), Baldwin Wallace University ($5,370), and University of Akron Research Foundation ($4,000). For the University Akron, the FY 2016 award total was $204,372 less than it was in FY 2015.

Table 4. NASA Glenn Educational Grants in Ohio by Academic Institution, FY 2012-FY 2016

Ohio Colleges and Universities	FY2012	FY2013	FY2014	FY2015	FY2016	FY2016 Share
Case Western Reserve University	$698,718	$306,632	$500,829	$332,737	$377,447	35.9%
Ohio State University	$386,622	$57,609	$18,010	$268,537	$354,513	33.7%
Cuyahoga Community College	$0	$0	$0	$0	$158,014	15.0%
Ohio University	$177,573	$92,718	$69,035	$59,391	$77,859	7.4%
Kent State University	$0	$0	$0	$20,196	$39,749	3.8%
Cleveland State University	$549,163	$382,240	$100,996	$9,473	$19,144	1.8%
University of Akron	$1,554,938	$1,868,153	$614,630	$219,552	$15,002	1.4%
Baldwin Wallace	$0	$0	$0	$0	$5,370	0.5%
University of Akron Research Foundation	$0	$0	$0	$0	$4,000	0.4%
University of Dayton	$0	$0	$0	$23,967	$0	0.0%
University of Toledo	$1,589,143	$1,619,271	$35,192	$1,001	$0	0.0%
University of Cincinnati	$132,902	$42,338	$0	$0	$0	0.0%
Wright State University	$0	$0	$2,001	$0	$0	0.0%
TOTAL	**$5,089,060**	**$4,368,960**	**$1,340,692**	**$934,854**	**$1,051,098**	**100.0%**

Notes:
Table is sorted by FY 2016 column.
FY2012 – FY 2015 data inflated to 2016 dollars.

C.6. NASA Glenn Revenues

NASA Glenn's total revenue in FY 2016 was $664.1 million. This was the second lowest revenue total in the past five years, only ranking above the FY 2013 total of $655.1 million (in nominal dollars). Over the five-year period, NASA Glenn revenues ranged from $655.1 million to $687.7 million. Compared to FY 2015, the revenues decreased by $7.4 million, or 1.1%. NASA Glenn's total revenue has decreased by $23.5 million, or 3.4%, between FY 2012 and FY 2016.

Table 5 displays NASA Glenn's revenues between FY 2012 and FY 2016. NASA Glenn generates revenue through two sources: NASA direct authority and reimbursable commitments. In FY 2016, NASA Glenn received $623.4 million of revenue directly from NASA and an additional $40.7 million from reimbursable commitments. NASA's direct authority revenue has remained steady over the past three years, with totals ranging between $618.8 million and $624.6 million.

Over the same three-year period from FY 2014 to FY 2016, reimbursable commitments declined from $59.1 million in FY 2014 to $40.7 million in FY 2016. Accordingly, the percentage of the budget supplied by NASA directly has increased over the same three-year period, going from 91.3% in FY 2014 to 93.90% in FY 2016. This is close to the total percentage of the budget provided by NASA in FY 2012, which was 94.1%.

In FY 2016, 82.3%, or $33.5 million, of NASA Glenn revenue from reimbursable commitments came from federal sources. NASA Glenn's revenues from reimbursable commitments decreased by $6.2 million, or 13.2%, from FY 2015 to FY 2016. There was an $8.8 million decline in revenue from domestic, non-federal government sources and a $9.1 million decline in federal spending from sources outside the Department of Defense. However, there was an $11.8 million increase in Department of Defense spending.

Table 5. NASA Glenn Revenues, FY 2012-FY 2016

Description	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
NASA Direct Authority	$647,256	$608,600	$618,825	$624,619	$623,412
Total Reimbursable Commitments	$40,402	$46,457	$59,112	$46,879	$40,706
Total FY Authority	$687,657	$655,057	$677,937	$671,498	$664,118
NASA Budget %	94.1%	92.9%	91.3%	93.0%	93.90%

Note: Data in thousands of nominal dollars.

C.7. Taxes Paid by NASA Glenn Employees

The taxes paid by NASA Glenn employees directly to local and state governments contribute substantially to the Northeast Ohio regional economy and the economy of the state. Since NASA Glenn's facilities are primarily located in the cities of Brook Park, Fairview Park, and Cleveland, it affects the distribution of income tax paid by Glenn employees.

Table 6 shows the amount of income taxes NASA Glenn employees paid at the local, state, and federal levels. The table does not include taxes paid by NASA Glenn employees to local governments based on their place of residence. Total income tax paid by NASA Glenn employees in FY 2016 amounted to $32.9 million, a slight decrease of 0.5% from the FY 2015 total (in a nominal dollar comparison).

In FY 2016, NASA Glenn employees paid $8.8 million in income taxes at the state and local levels, a decrease of 2.1% from the FY 2015 total. The amount of taxes paid to local and state governments has decreased slightly every year since 2012, going from $9.7 million in FY 2012 to $8.8 million in FY 2016.

Of the taxes paid at the state and local level, the clear majority (99.6%) went to the city of Brook Park and the state of Ohio in FY 2016. The state of Ohio received 62.2% of the income taxes at the state and local level in FY 2016 with a total of $5.5 million. On average, NASA Glenn employees have contributed $5.9 million per year in state and local income taxes over the five-year study period.

At the local level, the city of Brook Park received 98.9% of income taxes paid to the three listed cities by NASA Glenn employees in FY 2016, a total of $3.3 million. The taxes received by the city of Brook Park declined 2% between FY 2012 and FY 2016. The cities of Fairview Park and Cleveland receive a much smaller portion of the income tax generated from NASA Glenn employees. Fairview Park received $26,636 in FY 2016 and Cleveland received $10,107. This was a slight decrease for Fairview Park and a slight increase for Cleveland compared to FY 2015.

Table 6. Income Taxes Paid by NASA Glenn Employees

Year	City of Brook Park	City of Cleveland	City of Fairview Park	State of Ohio	Federal	Total
2012	$3,370,391	$14,205	$26,008	$6,309,804	-	**$9,720,408**
2013	$3,317,434	$13,492	$28,048	$6,091,867	-	**$9,450,841**
2014	$3,339,884	$7,009	$25,180	$5,731,492	$23,964,173	**$33,067,738**
2015	$3,323,048	$9,706	$27,596	$5,671,062	$24,038,165	**$33,069,577**
2016	$3,303,850	$10,107	$26,636	$5,498,587	$24,070,576	**$32,909,756**
5-Year Total	**$16,654,607**	**$54,519**	**$133,468**	**$29,302,812**	**$72,072,914**	**$118,218,320**

Note: Data in nominal dollars. Federal taxes in FY2012 and FY 2013 were not reported.

D. ECONOMIC IMPACT OF NASA GLENN

This section focuses on the methodology and results of research on the economic impact NASA Glenn had on Northeast Ohio and the state of Ohio in FY 2016.[21] Economic impact is measured in terms of output (sales); employment; value added; household earnings; and taxes contributed to local, state, and federal governments.

Each of the economic impact categories is estimated as the sum of three types of impact: direct, indirect, and induced.[22] NASA Glenn's total impact on Northeast Ohio and the state of Ohio are presented as separate estimates.

[21] For this analysis, Northeast Ohio is delineated by eight counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit.

[22] The change in final demand is the direct economic impact created by NASA Glenn in Northeast Ohio and Ohio.

D.1. METHODOLOGY

Estimates of NASA Glenn's economic impact are based on the assumption that NASA Glenn established its operations in the region at the beginning of FY 2016 and generated a demand by purchasing goods and services for its organization across a number of different supply industries.

This new demand for goods and services is called "change in final demand," which represents the direct impact NASA Glenn spending has on the economy. [23] The increase in demand from NASA's expenditures (i.e. change in final demand) in the region results in economic impacts on both Northeast Ohio and Ohio. This study uses an input-output model that reflects the buy-sell relationships among all industry sectors within the region of study.

NASA Glenn purchases goods and services as intermediate inputs in the process of its research and development activities. Additionally, economic impact is assessed from the wages NASA Glenn employees use to buy goods and services for themselves and their households. Assessment of intermediate goods purchasing is represented in the indirect portion of the economic impact, while the spending patterns of both NASA Glenn employees and employees of NASA Glenn's suppliers are reflected in the induced effects portion of the assessment.

Indirect impact measures the value of labor, capital, and other inputs of production needed to produce the goods and services that serve as the supplies required by NASA Glenn for its operation. Induced impact measures local households' change in spending due to earnings by NASA Glenn employees and increased earnings of employees in local industries who produce goods and services for NASA Glenn and its suppliers.

To calculate direct value added, NASA Glenn is treated as a research and development institution, which assumes that NASA Glenn's intermediate expenditure pattern conforms to that of other, comparable research institutions in the area.

Economic impact analysis accounts for inter-industry buy-sell relationships within the respective economy of the research area (NEO or Ohio). These relationships determine how the economy responds to changes in buying and selling patterns among firms and industries. Input-output (I-O) models estimate inter-industry relationships at the county, regional, state, or country level by measuring the distribution of inputs purchased and outputs sold by each industry, the government sector, and the household sector. By using I-O models' multipliers, it is possible to estimate the specific impact of one additional dollar spent by or one additional employee hired for NASA Glenn. This impact continues, creating additional expenditures and jobs. The economic multiplier measures the extent to which an initial expenditure affects the regional economy.[24]

[23] Change in final demand, or direct impact, is defined as the total purchases of goods and services for NASA Glenn's overall operations.

[24] For example, suppose that Company "A" reports sales of $1 million. From the revenues, the company pays its suppliers and workers, covers production costs, and takes a profit. Once the suppliers and employees receive their payments, they will spend a portion of their money in the local economy purchasing goods and services, while another portion of the monies will be spent outside the local economy (leakage). By evaluating the chain of local purchases that result from the initial infusion of $1 million, it is possible to estimate a regional economic multiplier.

This study utilizes regional I-O multipliers from the IMPLAN Professional model.[25] Specifically, SAM multipliers are used to estimate the ripple effect that an initial expenditure made by NASA Glenn has on the regional economy.[26] For this study, we use the "bill of goods" method and applied it to industry change. We match each category of NASA Glenn's expenditures to the industry it purchases products from. This technique enables the research to match goods and services purchased by NASA Glenn to goods and services produced by different industries in the region in question.

When estimating regional economic impact three factors need to be addressed: (1) the exclusion of purchases from companies located outside of the study's region, (2) how the commuting patterns of NASA Glenn employees living outside the study area affect total payroll accounting, and (3) what amount of revenues are received from local sources. For this analysis, NASA Glenn's economic impact on the Northeast Ohio economy is exclusively generated from purchases of goods produced by companies located in Northeast Ohio. Following the same methodology, the economic impact on the state of Ohio is assessed from NASA Glenn purchases of goods and services produced only by companies located in Ohio. Therefore, when estimating the impact on Northeast Ohio, the model excluded goods and services purchased from businesses and other entities located outside of the 8-county region. Likewise, all goods and services purchased from businesses and entities located outside of the state were excluded when estimating the statewide impact of NASA Glenn.

Adjustments by commuting pattern were made to total payroll amounts to account for local spending by employees residing outside of the 8-county region and outside of the state for the Northeast Ohio and Ohio portions of the economic impact, respectively. IMPLAN considers the difference between the average regional share of commuting employees and the institution's share of employees living outside of the region. The model adjusts the total payroll by this difference, assuming that the commuting employees still spend a portion of their income near their employer. Because all of NASA Glenn's revenues came from federal sources (from outside of the study area), no further adjustments were required.

IMPLAN measures economic impact using five variables: employment, labor income, value added, output, and taxes:

- Employment impact measures the number of jobs created in the region as a result of NASA Glenn expenditures.
- Labor income impact measures the additional labor earnings created in the region due to NASA Glenn expenditures.
- Value added impact measures the additional value added created in the region as a result of NASA Glenn expenditures. Value added is calculated as output less the value of intermediary goods.[27]

[25] IMPLAN (IMpact analysis for PLANning) was originally developed by two federal agencies, the Department of Agriculture and the Department of the Interior, to assist in land and resource management planning. The Minnesota IMPLAN Group Inc. later commercialized the model as a software package. The company was then sold and rebranded as IMPLAN Group LLC.

[26] IMPLAN type SAM (Social Accounting Matrices) multipliers are used in this study. SAM multipliers are based on information in a social account matrix that considers commuting, institutional savings, inter-institutional transfers, and social security and income tax leakages.

[27] Intermediary goods and services—such as energy, materials, and purchased services—are purchased for the production of other goods and services rather than for final consumption.

- Output impact measures the additional value of all goods and services produced in the region as a result of NASA Glenn expenditures.

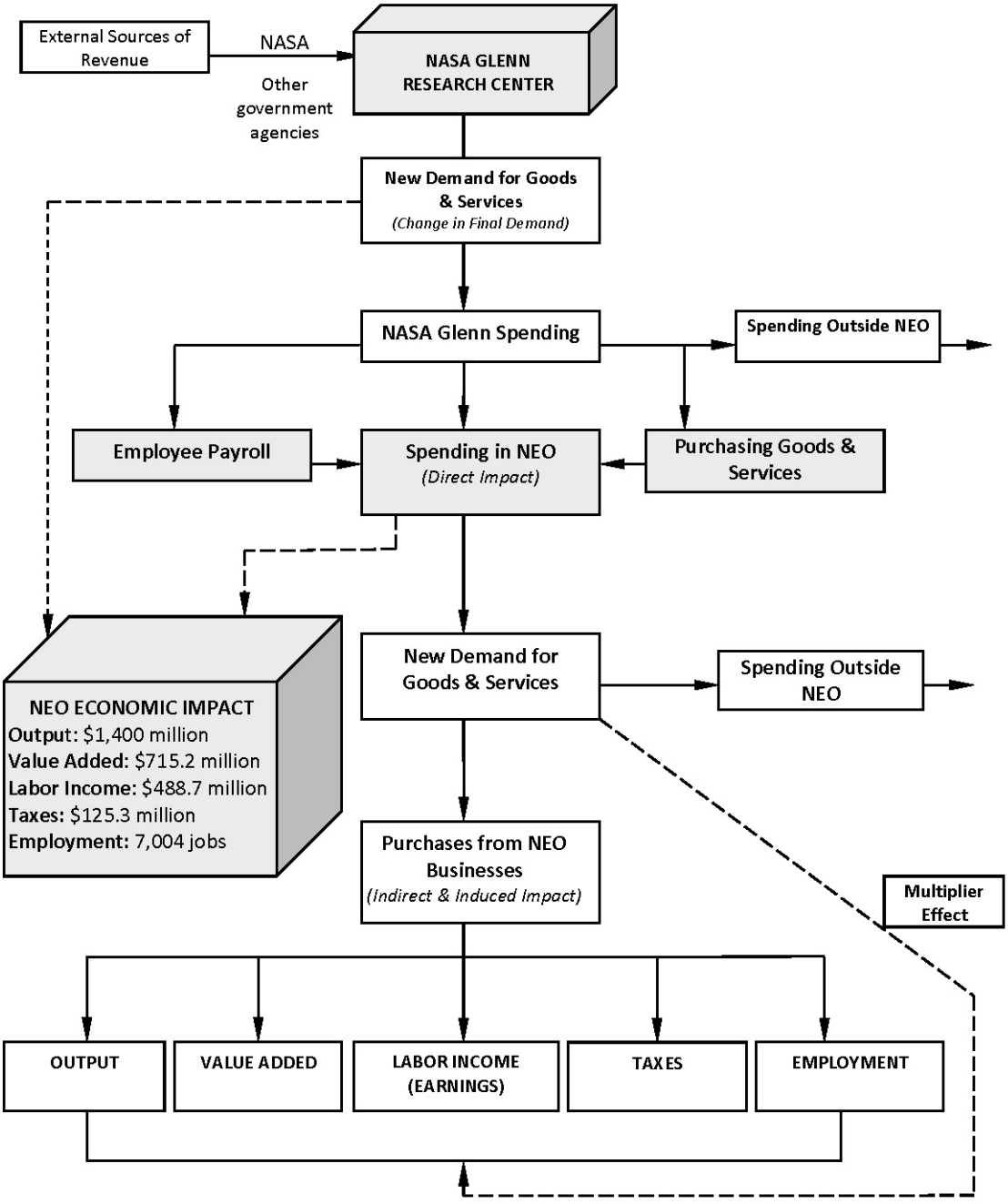
- Tax impact measures the additional federal and state and local tax revenues collected in the region as a result of NASA Glenn expenditures.

The employment, labor income, value added impact, and output impact are each a summation of three components: direct impact, indirect impact, and induced impact.[28] Figure 4 illustrates the process by which NASA Glenn impacted Northeast Ohio's economy through its spending in the region in FY 2016.

Through its attraction of federal dollars, NASA Glenn created new demand for goods and services (change in final demand, which is also treated as a direct impact). Some of this demand was generated for goods and services provided by vendors outside Northeast Ohio and Ohio, resulting in dollars leaving the regional and state economies. However, most goods and services necessary for NASA Glenn operations were purchased locally.

[28] The summation of direct, indirect, and induced impacts across industries in the impact tables (Tables 7-14) and following figures may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling. According to IMPLAN, discrepancies of up to 3% are due to rounding during multiple iterations of data calculations in the model.

Figure 4. Economic Impact of NASA Glenn Research Center on Northeast Ohio, FY 2016



D.2. Economic Impact on Northeast Ohio, FY 2016

This section details the effects NASA Glenn had on the economy of Northeast Ohio in FY 2016. These effects are encompassed by the changes in output (sales), employment, labor income (earnings), value added, and federal, state, and local tax revenues paid and generated by NASA Glenn.

D.2.1. Output Impact on Northeast Ohio, FY 2016

To calculate an output income, NASA Glenn's expenditures were split into two brackets of spending: (1) goods and services purchased from companies and institutions located in Northeast Ohio and (2) spending for goods and services from businesses and other institutions located outside Northeast Ohio. The first group of spending creates an economic impact on the economy of Northeast Ohio, while the second is considered a regional "leakage" (loss); therefore, these expenditures are not included in the impact calculations for Northeast Ohio. Local spending is then categorized by products purchased from different industries in the regional economy. Based on an IMPLAN classification system of industries, the spending is coded across 536 IMPLAN sectors.[29] IMPLAN industry sectors are similar to the description of industries used in the North American Industry Classification System (NAICS) but do not fully correspond to the NAICS system. Appendix Table A.3. illustrates detailed NASA Glenn expenditures in Northeast Ohio by NAICS industry.

About 44% of NASA Glenn total expenditures in Northeast Ohio went towards employee compensation. NASA Glenn's largest expenditures on goods and services in Northeast Ohio in FY 2016 were made on professional, scientific and technical services (31.1%), including about 21.5% of total expenditures on scientific research and development. NASA Glenn's spending in Northeast Ohio has a significant regional economic impact.

Table 7 presents the total output impact of NASA Glenn on the economy of Northeast Ohio, disaggregated into direct, indirect, and induced impacts. NASA Glenn's total operational expenditures represent the direct output impact for Northeast Ohio. This impact includes the regional portion of purchases from the retail industry. Indirect impact is estimated as all direct purchases of goods and services made from industries in Northeast Ohio and the contributions of individual industries acting as suppliers for the producers of the goods and services consumed by NASA Glenn. Finally, induced impact is derived from the spending of employees of both NASA Glenn and its suppliers.

[29] In 2014, the IMPLAN data sectors were expanded from 440 to 536 sectors to better describe the type of expenditures and therefore better measure the economic impact. The main changes of sector representation occurred in energy-related industries, construction and some manufacturing.

Table 7. Output Impact in Northeast Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$66,425	$209,846	$276,271
Mining		$916,773	$596,960	$1,513,733
Utilities		$26,207,072	$8,038,505	$34,245,577
Construction		$37,793,236	$4,300,803	$42,094,039
Manufacturing		$6,013,297	$7,438,198	$13,451,495
Wholesale Trade		$5,196,883	$16,385,325	$21,582,208
Retail Trade		$5,205,427	$31,587,985	$36,793,412
Transportation and Warehousing		$5,128,531	$10,218,629	$15,347,160
Information		$6,454,275	$14,275,702	$20,729,977
Finance and Insurance		$11,100,911	$42,513,114	$53,614,025
Real Estate and Rental		$23,742,292	$66,766,495	$90,508,786
Professional, Scientific, and Tech Services		$197,001,457	$15,109,271	$212,110,728
Management of Companies		$4,561,585	$4,326,372	$8,887,957
Administrative and Waste Services		$76,575,087	$9,924,070	$86,499,157
Educational Services		$7,545,194	$6,193,320	$13,738,514
Health and Social Services		$133,314	$53,969,797	$54,103,111
Arts, Entertainment, and Recreation		$1,599,455	$6,848,251	$8,447,706
Accommodation and Food Services		$2,572,756	$17,545,201	$20,117,957
Other Services		$5,017,914	$17,734,222	$22,752,136
Government & non-NAICs	$639,338,269	$882,468	$2,931,724	$643,152,462
Total Output	**$639,338,269**	**$423,714,352**	**$336,913,792**	**$1,399,966,413**

For output impact, the change in final demand or direct impact ($639,338,269) equals the total spending of NASA Glenn for goods and services in- and outside of Northeast Ohio, including wages and benefits with minor discrepancies due to IMPLAN rounding errors. The amount of $635,360,564 in 2016 dollars equates to $639,338,269 while adjusted for inflation and shown in the table in 2017 dollars (Inflation is based on NEO IMPLAN model inflation coefficient).

The total output impact of NASA Glenn on Northeast Ohio was $1.4 billion in FY 2016. NASA Glenn's $639.3 million worth of expenditures resulted in an output (sales) change of $1.4 billion across all industry sectors (Table 7). For example, NASA Glenn's spending caused a $212.1 million increase in total sales by the Professional, Scientific, and Technical services industry and a $42.1 million increase in sales -- direct, indirect, and induced -- by the Construction industry. If NASA Glenn did not exist in Northeast Ohio, the regional output in the Administrative and Waste Services industry would drop by $86.5 million. These examples illustrate the idea that the regional impact of NASA Glenn's operation can be best described as the increase in output of affected industries in comparison to the *hypothetical* absence of NASA Glenn in Northeast Ohio.

Of the total output impact, 45.7% ($639.3 million in 2017 dollars) is accounted for by NASA Glenn's direct spending, which constitutes the direct economic impact to Northeast Ohio. The remaining output impact of $760.6 million (54.3%) can be attributed to the indirect and induced impact from NASA Glenn purchases rippling through the regional economy.

A detailed analysis of the IMPLAN modeling results indicates that the indirect and induced portions can be further divided into three broad categories: NASA Glenn-driven industries, consumer-driven industries, and other industries.

NASA Glenn-driven industries see increases in sales, employment, and earnings primarily due to NASA Glenn's operations. They include: utilities; construction; information, professional and scientific services; administrative and support services; and education. The increase in output due to indirect and induced economic impacts from the aforementioned industries in FY 2016 was $409.4 million, or 53.8% of NASA Glenn's overall indirect and induced impact on Northeast Ohio.

Consumer-driven industries are those that increase sales, employment, and earnings primarily due to spending by NASA Glenn employees and other workers who produce goods and services for NASA Glenn and their suppliers. These industries include: retail; healthcare; real estate; other services (see below); owner-occupied buildings; finance and insurance; and entertainment and food.[30] The FY 2016 increase in output due to indirect and induced economic impacts for these seven industries totaled $271.3 million, or 35.6%, of the total impact.

Other industries are driven by both NASA Glenn and consumer spending, but due to their impact being split between NASA Glenn and other area businesses, they should not be attributed to NASA Glenn operations only. These industries include: mining, manufacturing, agriculture, government enterprises, wholesale trade, and transportation and warehousing. The total increase in output due to indirect and induced economic impacts for these industries in FY 2016 amounted to $80.5 million or 10.6% of the total impact.

Output portions for select NASA Glenn-driven industries and consumer-driven industries are shown in Figure 5 and Figure

[30] An *owner-occupied dwelling* is a special industry sector developed by the Bureau of Economic Analysis. It estimates what owner/occupants would pay in rent if they rented rather than owned their homes. This sector creates an industry out of owning a home. Its sole product (or output) is ownership, purchased entirely by personal consumption expenditures. Owner-occupied dwellings capture the expenses of home ownership such as repair and maintenance construction, various closing costs, and other expenditures related to the upkeep of the space in the same way expenses are captured for rental properties.

6, respectively. Each of the industries presented in Figure 5 had additional sales of at least $11 million in FY 2016. Each of the industries presented in Figure 6 had additional sales of at least $9 million in FY 2016.

The largest output was generated by the scientific research and development industry, increasing by $113.4 million in FY 2016 due to NASA Glenn's operations (Figure 5). This amount is the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on research services. The increase of $113.4 million accounted for 27.7% of the $409.4 million increase in output for all NASA Glenn-driven industries.

Other industries shown in Figure 5 can be interpreted in the same manner.

Figure 6 presents consumer-driven industries of the economy that saw large increases in sales. The real estate industry generated the largest output impact; it increased by $44.6 million in FY 2016 due to NASA Glenn's operations in Northeast Ohio. This amount is the summation of the indirect and induced impacts generated primarily by NASA Glenn employees and other workers for rental activities. The increase of $44.6 million accounted for 16.4% of the $271.3 million increase in output for all industries within the consumer-driven sector.

Figure 5. Increase in Sales for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2016

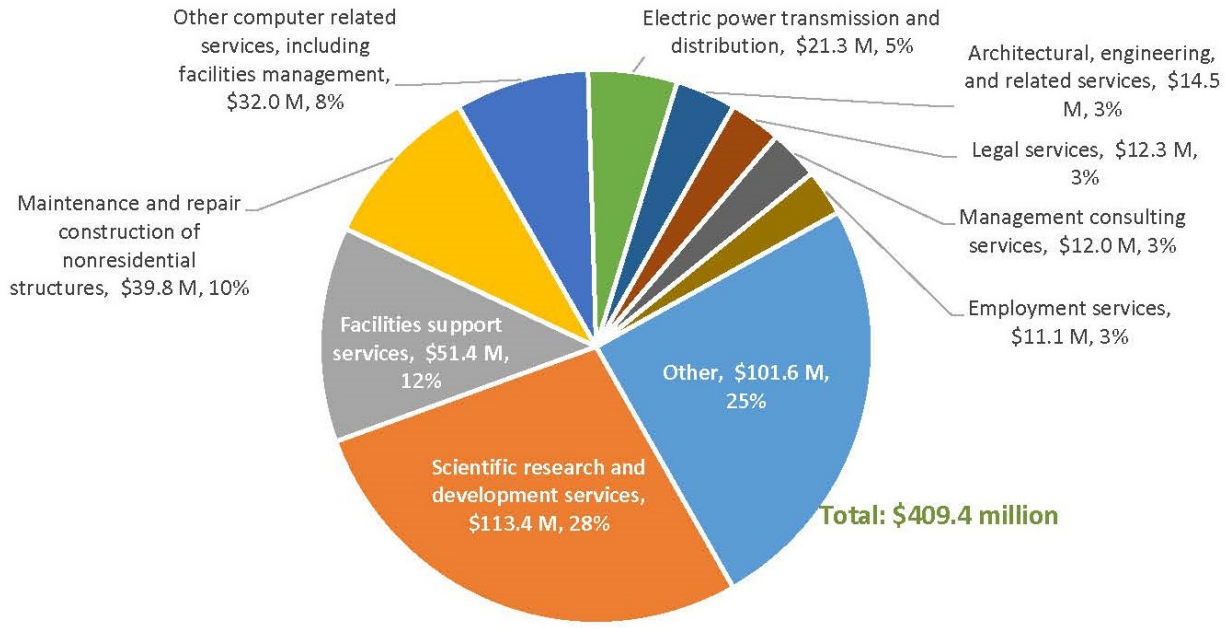
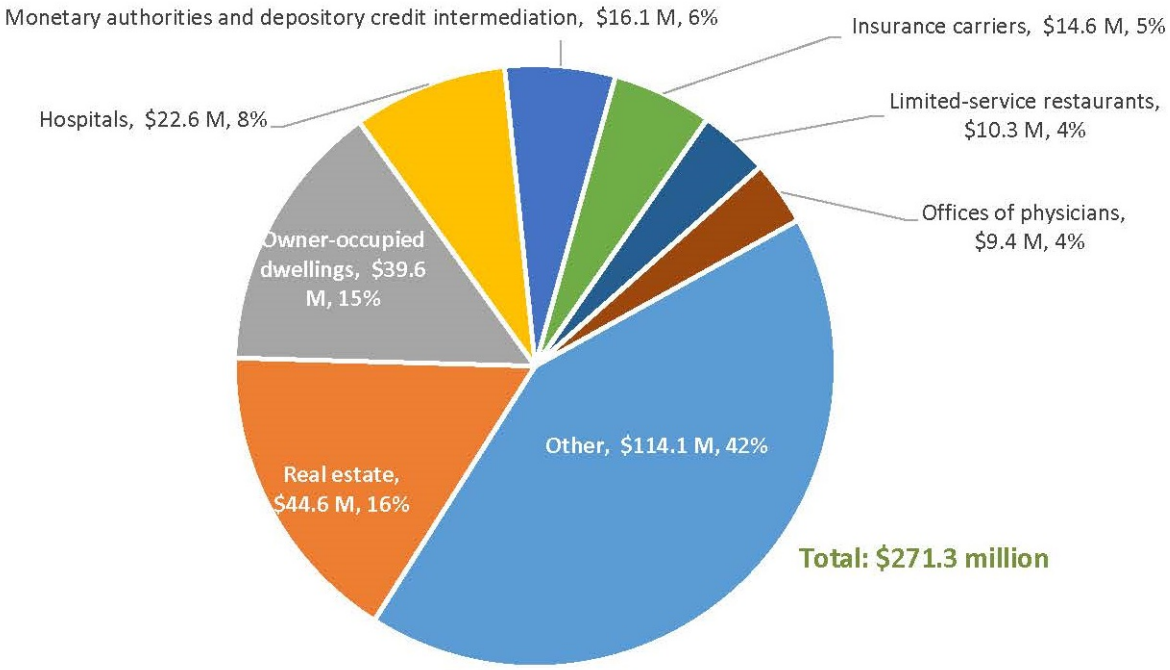


Figure 6. Increase in Sales for Select Consumer-Driven Industries in Northeast Ohio, FY 2016



D.2.2. Employment Impact on Northeast Ohio, FY 2016

NASA Glenn's presence in Northeast Ohio supported existing jobs and created new full-time and part-time jobs elsewhere, in addition to its own employment (change in final demand or direct impact). NASA Glenn's spending generated increased employment in its supplier industries (indirect impact).

In addition, money spent by employees of NASA Glenn, employees of the businesses from which NASA Glenn buys goods and services, and employees of the companies in the supply chain generate indirect and induced employment effect on the regional economy. The total employment impact equals the sum of NASA Glenn's own employment numbers (direct impact) and the indirect and induced impacts discussed. Table 8 shows the number of new and supported jobs by industry sector.

Table 8. Employment Impact in Northeast Ohio, FY 2016

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		1	4	5
Mining		4	3	7
Utilities		27	7	33
Construction		289	27	315
Manufacturing		19	17	35
Wholesale Trade		21	67	88
Retail Trade		98	393	491
Transportation and Warehousing		35	73	108
Information		18	34	52
Finance and Insurance		35	159	194
Real Estate and Rental		86	105	191
Professional, Scientific, and Tech Services		1,140	108	1,248
Management of Companies		19	18	37
Administrative and Waste Services		813	147	961
Educational Services		264	95	359
Health and Social Services		1	526	527
Arts, Entertainment, and Recreation		24	78	102
Accommodation and Food Services		49	314	363
Other Services		56	247	303
Government & non-NAICs		3	10	13
Total Employment	**1,572**	**3,002**	**2,430**	**7,004**

Notes:
For employment impact, the change in final demand (direct impact) equals the number of employees working for NASA Glenn.

The total employment impact of NASA Glenn on the Northeast Ohio economy in FY 2016 was 7,004 jobs. Of these 7,004 jobs, 1,572 (22.4%) were directly employed at NASA Glenn Research Center. As a result of Glenn's spending on goods and services, an additional 3,002 full-time and part-time jobs (42.9%) were supported and created in the region as indirect economic impact. The rest of the employment impact, 2,430 jobs (34.7%), was created as induced impact due to purchases made by NASA Glenn and suppliers' employees. These industries produce products that are typically within a consumer purchasing pattern of the region.

Of the 5,432 jobs created and supported in Northeast Ohio due to the indirect and induced impacts, 2,967 (54.6%) were in NASA Glenn-driven industries, 1,945 (35.8%) were in consumer-driven industries, and 520 (9.6%) were in other industries.[31] The job distribution for select NASA Glenn- and consumer-driven industries are shown in Figures 7 and 8, respectively. The industries presented in Figures 7 and 8 are the leading industries in terms of most created and supported employment (a minimum of 160 and 50 employees per industry, respectively).

The scientific research and development industry generated the highest number of additional jobs. Companies engaged in scientific R&D (professional, scientific, and technical services sector) saw an increase of 522 jobs in FY 2016 due to NASA Glenn's operation in Northeast Ohio (Figure 7). These jobs are the summation of the indirect and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's spending on R&D contractors in Northeast Ohio. The 522 jobs accounted almost for 18% of the 2,967 jobs that were created in all industries within the NASA Glenn-driven industries. Other industries shown in Figure 7 can be interpreted similarly.

The real estate industry saw the largest increase among consumer-driven industries; the increase of 172 jobs in FY 2016 was due to NASA Glenn's spending generating labor income in regional supply industries (Figure 8). These jobs equal to the total of the direct, indirect, and induced employment impacts generated primarily by NASA Glenn employees and other workers participating in Northeast Ohio's real estate sector. The 172 jobs accounted for 9% of the 1,945 jobs created across all consumer-driven industries.

[31] NASA Glenn-driven industries include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven industries include retail, healthcare, real estate, other services, owner-occupied buildings, and finance and insurance.

Figure 7. Increase in Jobs for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2016

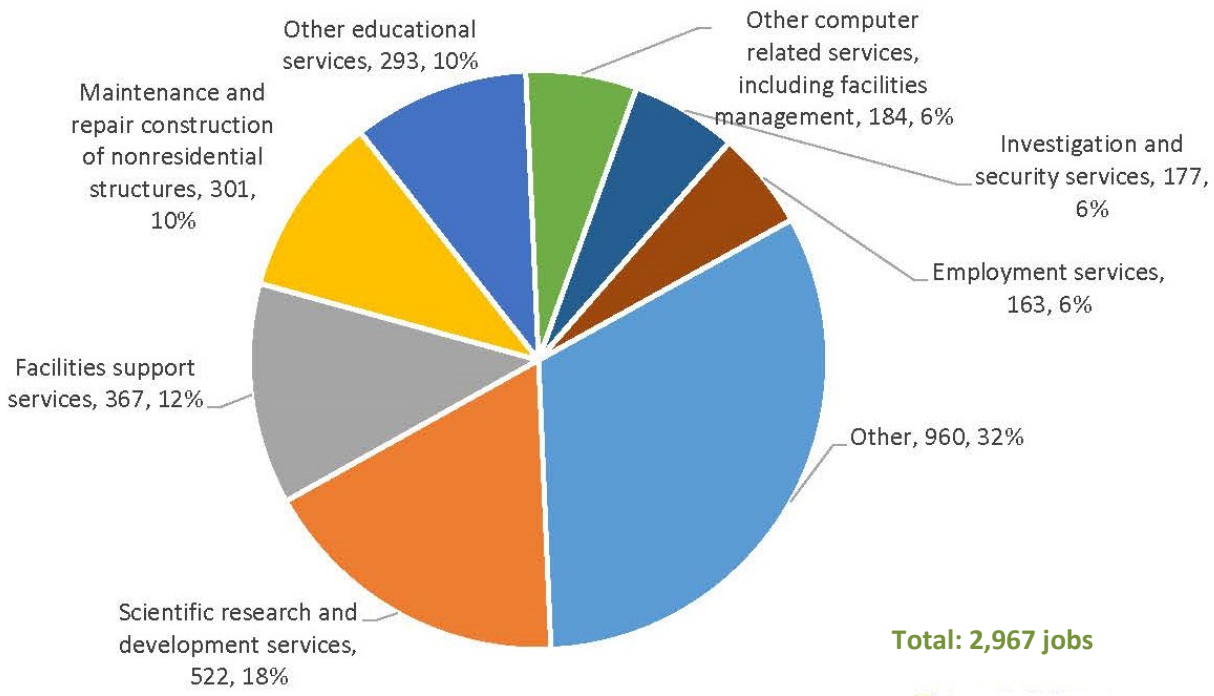
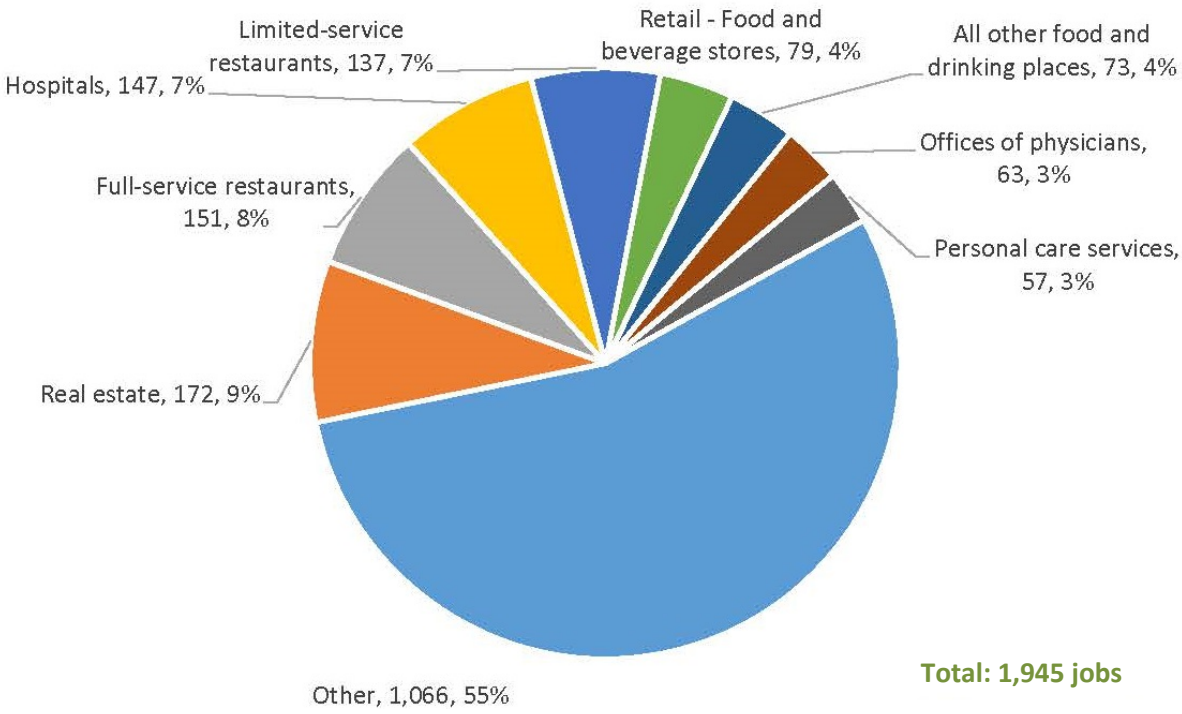


Figure 8. Increase in Jobs for Select Consumer-Driven Industries in Northeast Ohio, FY 2016



D.2.3. LABOR INCOME IMPACT ON NORTHEAST OHIO, FY 2016

Labor income impact is the estimated total change in labor income paid to employees of local businesses due to spending by NASA Glenn for goods and services purchased in Northeast Ohio and the money paid to employees of NASA Glenn. The total wages and benefits paid to NASA Glenn employees account for the employment base of NASA Glenn located within Northeast Ohio. It also accounts for a portion of the income spent within the region by employees who live outside of Northeast Ohio and commute to work.

The direct economic impact represents the total compensation NASA Glenn pays its employees in and outside the region. Indirect impact is estimated by summing the money paid to people working for companies that provide either products and services purchased by NASA Glenn or inputs to the producers of goods and services ultimately consumed by NASA Glenn.

Induced impact represents money paid to workers in all industries who are employed as a result of purchases by people whose income is affected by the demand for products and services created by NASA Glenn. The total earnings impact includes the wages and benefits received by NASA Glenn employees (change in final demand or the direct effect), indirect, and induced impacts. Table 9 shows the earnings impact by industry sector.

Table 9. Labor Income Impact in Northeast Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$31,929	$74,762	$106,691
Mining		$304,197	$201,408	$505,605
Utilities		$2,482,082	$754,424	$3,236,506
Construction		$13,629,632	$1,430,838	$15,060,470
Manufacturing		$1,242,405	$1,091,915	$2,334,321
Wholesale Trade		$1,833,963	$5,759,152	$7,593,114
Retail Trade		$2,460,455	$12,618,238	$15,078,693
Transportation and Warehousing		$1,961,750	$3,909,821	$5,871,571
Information		$1,253,224	$2,396,231	$3,649,455
Finance and Insurance		$2,529,584	$9,663,170	$12,192,754
Real Estate and Rental		$3,901,091	$4,700,342	$8,601,433
Professional, Scientific, and Tech Services		$85,407,479	$8,089,886	$93,497,364
Management of Companies		$2,327,263	$2,207,260	$4,534,523
Administrative and Waste Services		$26,978,099	$5,169,535	$32,147,634
Educational Services		$4,680,566	$3,589,715	$8,270,281
Health and Social Services		$69,909	$30,748,743	$30,818,651
Arts, Entertainment, and Recreation		$783,017	$2,477,658	$3,260,675
Accommodation and Food Services		$1,092,348	$6,799,127	$7,891,476
Other Services		$2,555,758	$7,737,348	$10,293,106
Government & non-NAICs	$222,493,854	$292,000	$969,939	$223,755,793
Total Labor Income	**$222,493,854**	**$155,816,752**	**$110,389,512**	**$488,700,117**

Notes:
Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy. The direct labor income is adjusted for commuters' compensation and inflation and shown in the table in 2017 dollars (Inflation based on NEO IMPLAN model).

Total labor income in Northeast Ohio increased by $488.7 million as a result of NASA operation in FY 2016. Of the $488.7 million of the total labor income, $222.5 million (45.5%) constituted wages and benefits paid directly to NASA Glenn employees (i.e., change in final demand or direct effect measured in 2017 dollars). Of the total impact, $155.8 million (31.9%) represented indirect impact, or the money paid to employees of companies in Northeast Ohio that supply goods and services to NASA Glenn. The remaining earnings constitute an induced effect of $110.4 million (22.6%); occurring as the effects of NASA Glenn's spending rippled through the Northeast Ohio economy via spending derived from labor income.

Of the $266.2 million increase in labor income generated across Northeast Ohio due to the indirect and induced impacts, $155.9 million (58.5%) was generated in NASA Glenn-driven industries, $82.9 million (31.1%) was reported in consumer-driven industries, and $27.5 million (10.3%) occurred in other industries.[32]

The labor income distribution for select NASA Glenn-driven industries is shown in Figure 9. The labor income distribution for select consumer-driven industries is shown in Figure 10. These industries shown in Figures 9 and 10 added over $5 million and $2 million, respectively.

In the NASA Glenn-driven industries, people who engaged in scientific research and development services saw their labor income increase by $39.4 million in FY 2016 (Figure 9). These earnings are the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn using scientific research and development services in Northeast Ohio. The $39.4 million spent on scientific research and development accounted for 25.3% of the $155.9 million increase in labor income reported by all the NASA Glenn-driven industries.

Private hospitals, part of the consumer-driven industries, saw their labor income increase by $11.66 million in FY 2016 (Figure 10). These earnings are the summation of the indirect and induced impacts generated by consumer spending for doctors' services. This $11.66 million accounted for 14% of the $82.91 million labor income increase that occurred in all consumer-driven industries.

[32] See section D.2.1. Output Impact on Northeast Ohio for definitions of Glenn-driven, consumer-driven, and other industries.

Figure 9. Increase in Labor Income for NASA Glenn-Driven Industries in Northeast Ohio, FY 2016

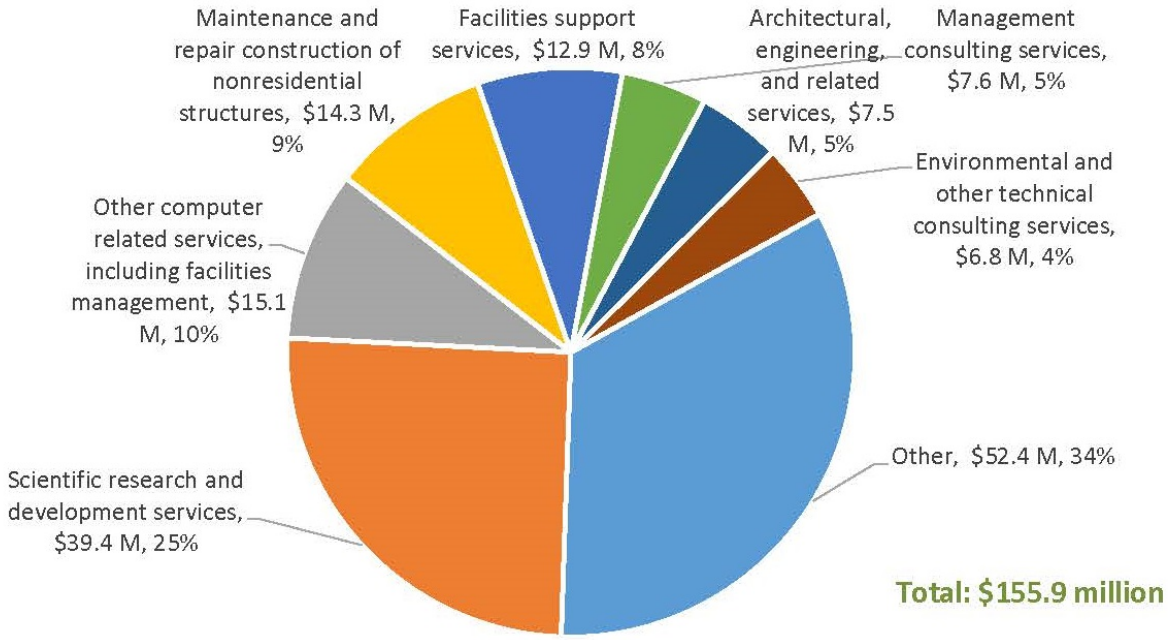
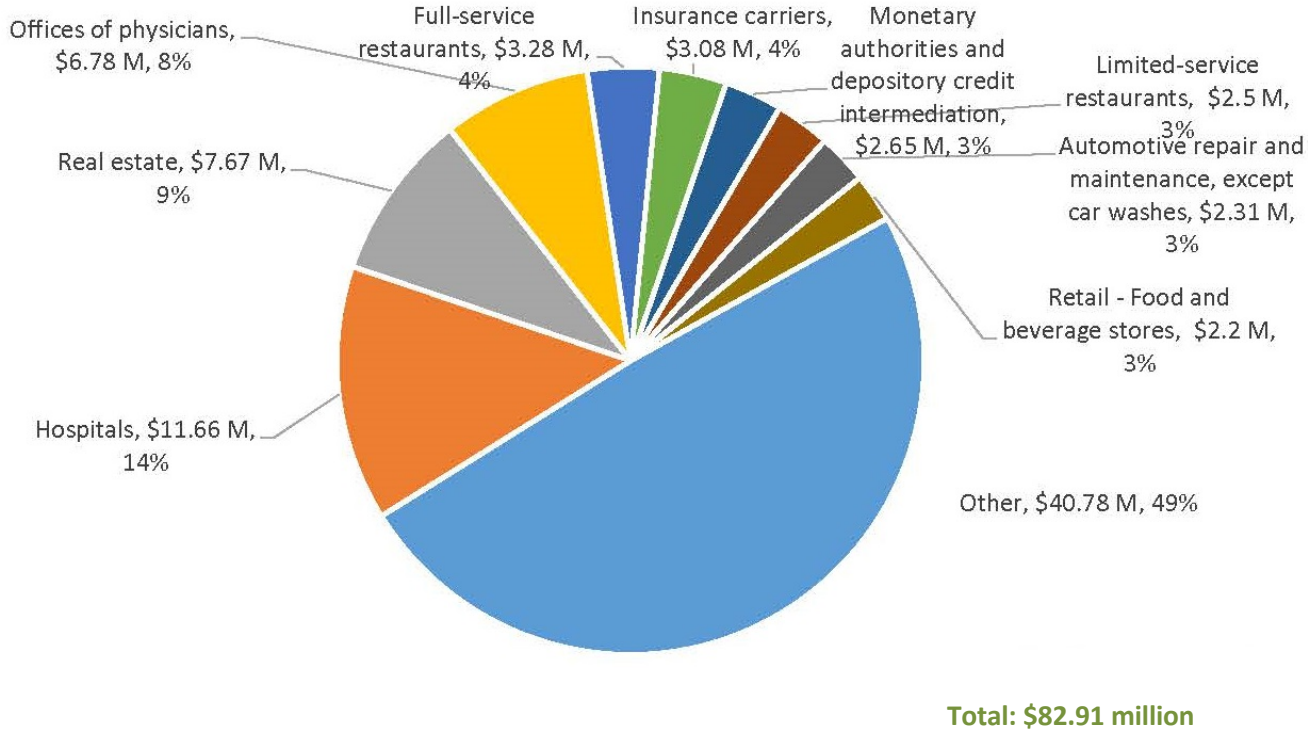


Figure 10. Increase in Labor Income for Consumer-Driven Industries in Northeast Ohio, FY 2016



D.2.4. Value Added Impact on Northeast Ohio, FY 2016

The total value added impact[33] in Northeast Ohio was $715.2 million, which resulted from NASA Glenn's regional spending on goods and services. NASA Glenn's spending led to a $715.2 million increase in sales (direct, indirect, and induced impacts) by all industries, excluding intermediary goods and services. The total output less intermediate expenditures constituted the change in final demand (or direct impact) for value added, $287.7 million. The sales from companies and other suppliers of goods and services to NASA Glenn, excluding the value of intermediary goods and services, represented the indirect value added impact. Induced impact represents sales, excluding intermediary goods and services, in all industries that produced products for industries in which income was affected by the demand for products and services created by NASA Glenn. The total value added impact was found by adding the direct, indirect, and induced impacts. Table 10 shows the value added impact by industry sector.

[33] "Value added" measures the economic impact of all goods and services produced in Northeast Ohio because of the operation of NASA Glenn, excluding intermediary goods which are goods used in the production of other goods and not for final consumption.

Table 10. Value Added Impact in Northeast Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$41,062	$134,819	$175,881
Mining		$420,420	$273,035	$693,454
Utilities		$13,340,086	$3,899,931	$17,240,017
Construction		$17,493,200	$1,822,609	$19,315,809
Manufacturing		$2,250,023	$2,466,423	$4,716,446
Wholesale Trade		$3,269,873	$10,268,311	$13,538,184
Retail Trade		$3,296,030	$20,867,770	$24,163,800
Transportation and Warehousing		$2,336,255	$4,561,851	$6,898,106
Information		$2,606,382	$6,336,420	$8,942,802
Finance and Insurance		$7,266,173	$22,569,927	$29,836,100
Real Estate and Rental		$18,086,246	$47,571,756	$65,658,001
Professional, Scientific, and Tech Services		$101,093,906	$9,823,371	$110,917,277
Management of Companies		$2,852,305	$2,705,230	$5,557,535
Administrative and Waste Services		$41,631,120	$6,680,159	$48,311,279
Educational Services		$4,628,443	$3,773,622	$8,402,065
Health and Social Services		$77,813	$33,849,512	$33,927,325
Arts, Entertainment, and Recreation		$859,053	$3,994,209	$4,853,262
Accommodation and Food Services		$1,352,461	$9,287,844	$10,640,305
Other Services		$3,191,451	$8,691,235	$11,882,686
Government & non-NAICs	$287,702,221	$429,490	$1,415,851	$289,547,562
Total Value Added	**$287,702,221**	**$226,521,792**	**$200,993,884**	**$715,217,897**

Notes:
For value added impact, the change in final demand or direct impact equals the total output less intermediate expenditures. For this study, we treated NASA Glenn as any other research and development institution, assuming that NASA Glenn's intermediate expenditure pattern is the same as that of any other research institution in the Northeast Ohio. For an average research institution in Northeast Ohio, the intermediate expenditures accounted for 54% of total output.

Total value added in Northeast Ohio increased by $715.2 million in FY 2016 as a result of NASA Glenn's spending on goods and services. Of this total amount, $287.7 million (40.2%) accounts for the change in final demand or direct impact, calculated as total output less intermediate expenditures, or the large portion of the value added in the wages and salaries paid to NASA Glenn employees. Another $226.5 million (31.7%) represented the value of goods and services, less intermediary goods, of companies in Northeast Ohio that supply NASA Glenn (i.e., indirect impact). The remaining value added impact (the induced component) was estimated at $201.0 million (28.1%). This was the result of the ripple effects NASA Glenn's spending had on Northeast Ohio's economy.

Of the $427.5 million increase in value added generated across Northeast Ohio due to the indirect ($226.5 million) and induced impacts ($201.0 million), $213.1 million (49.9%) was reported in NASA Glenn-driven industries, $171.4 million (40.0%) was generated in consumer-driven industries, and $43.2 million (10.1%) was reported in other industries.[34]

The value added distribution for select NASA Glenn-driven industries is shown in Figure 11. The value added distribution for select consumer-driven industries is shown in Figure 12. Each of the select industries shown in Figures 11 and 12 added at least $8.5 million and $3 million each, respectively.

The scientific research and development services industry, the largest NASA Glenn-driven industry, saw value added increase $51.5 million in FY 2016 (Figure 11). This increase in value added is a result of the indirect and induced impacts' summation, generated primarily, but not exclusively, by NASA Glenn use of scientific research and development services in Northeast Ohio. The $51.5 million accounted for 24% of the $213.1 million value added increase that was reported by all NASA Glenn-driven industries.

People working in the real estate industry saw their value added grow by $35.5 million in FY 2016 (Figure 12). This value added increase is a result of the summation of the indirect and induced impacts generated by consumer spending at real estate establishments. The $35.5 million accounted for 21% of the $171.4 million value added increase that occurred in all consumer-driven industries.

[34] See section D.2.1. Output Impact on Northeast Ohio for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 11. Increase in Value Added for NASA Glenn-Driven Industries in Northeast Ohio, FY 2016

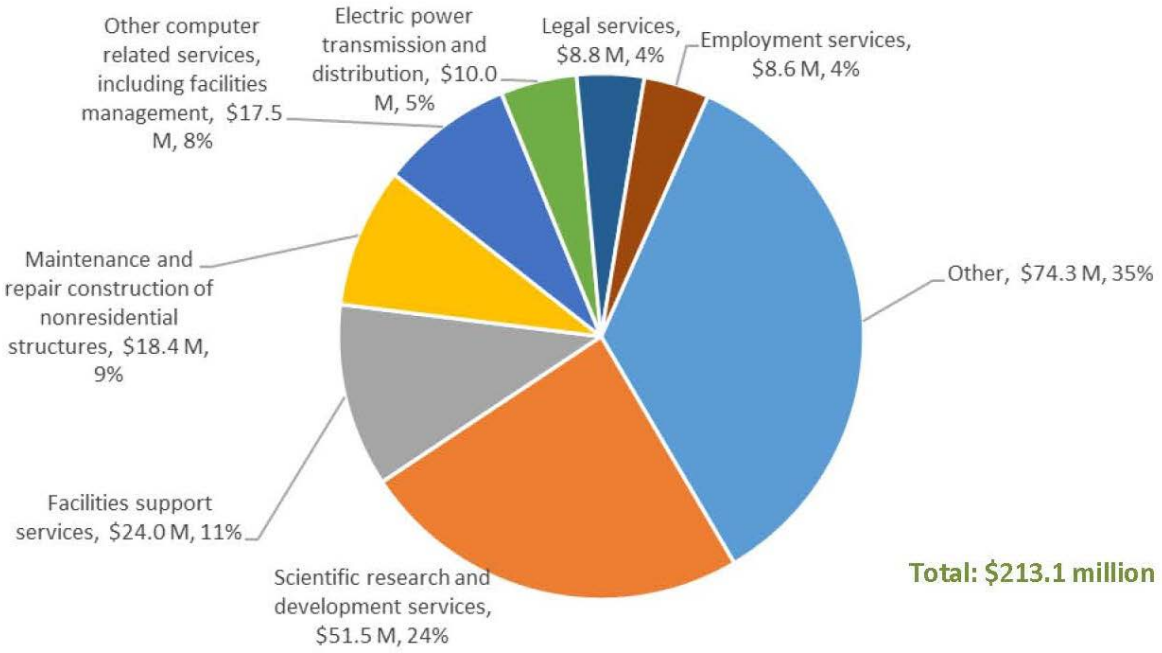
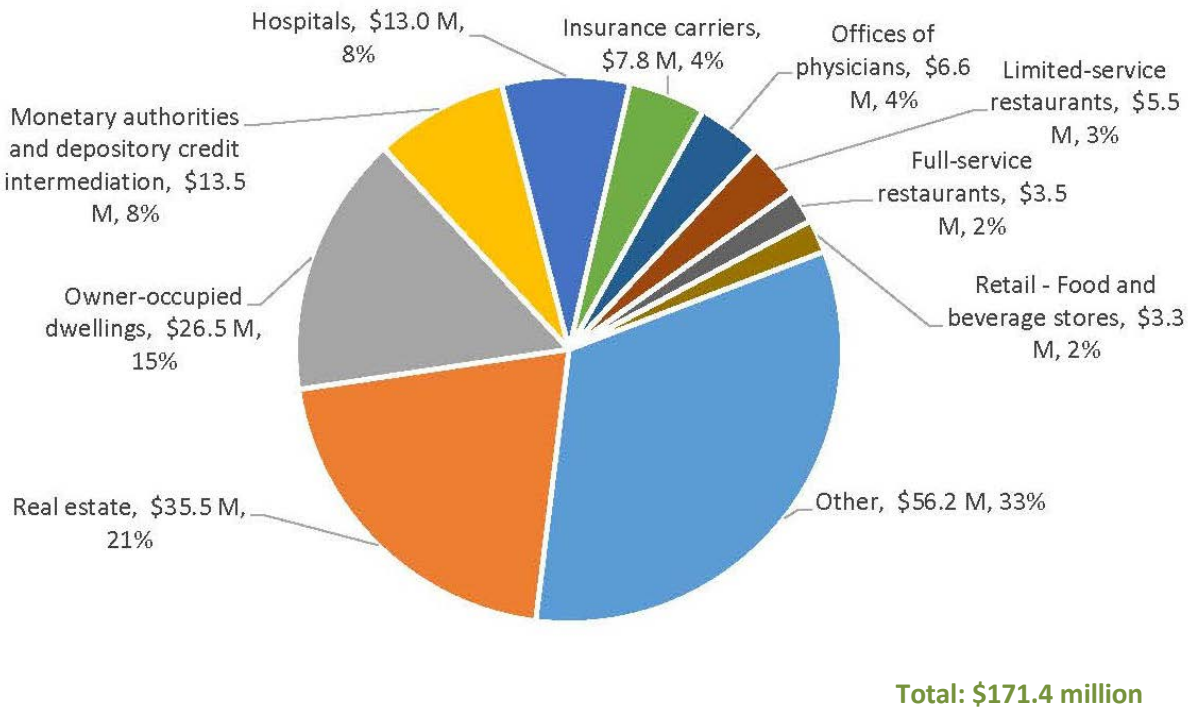


Figure 12. Increase in Value Added for Consumer-Driven Industries in Northeast Ohio, FY 2016



D.2.5. Tax Impact on Northeast Ohio, FY 2016

NASA Glenn's operation in Northeast Ohio generated a total of $125.3 million in tax revenues in FY 2016 (in 2017 dollars). The direct tax impact paid by NASA Glenn's employees in 2017 dollars was $33.1 million, $46.1 million was indirect tax impact, and $46.2 came from induced tax impact.

D.2.6. FY 2016 Northeast Ohio Impact Summary

Economic activity conducted by NASA Glenn generated the following total economic impact on Northeast Ohio (in 2017 dollars):

- Total Output Impact: $1,400.0 M
- Total Employment Impact: 7,004 jobs
- Total Labor Income Impact: $488.7 M
- Total Value Added Impact: $715.2 M
- Total Tax Impact: $125.3 M

The economic impact of NASA Glenn Research Center's activities on Northeast Ohio reflects the benefits of total expenditures of $495.7 million. These expenditures include a total amount of $277.4 million spent on purchases in Northeast Ohio in FY 2016 and expenditures on labor income paid to employees living in or commuting to Northeast Ohio in the amount of $218.4 million (in 2016 dollars).

Excluding expenditures on labor income, 55.6% (over $155 million) of NASA Glenn's expenditures were allocated to professional, scientific and technical services; 21.5% ($59.9 million) was spent on administrative and support services; and 12.7% ($35.5 million) was spent on construction – the three largest groups of NASA Glenn expenditures in Northeast Ohio.[35] These three sectors constituted the largest categories of NASA Glenn spending in Northeast Ohio and, together, accounted for $250.6 million or almost 90% of all NASA Glenn's FY 2016 expenditures in Northeast Ohio, excluding labor income. Among other expenditures, utilities accounted for 6.0%; education 2.1% and educational services 2.7%. Other sectors' expenditures were less than 1%.

Businesses across many industries benefited from spending by NASA Glenn personnel and other workers. Labor income received by NASA Glenn personnel and other workers was spent following typical consumer spending patterns. This pattern includes expenditures on food service, accounting services, commerce al banks, miscellaneous retailers, real estate companies, motor vehicle dealers, and hospitals and healthcare services.

[35] Amounts in parentheses detailing percentage numbers are presented in 2016 dollars and correspond to Appendix Table A.3.

D.3. ECONOMIC IMPACT ON THE STATE OF OHIO, FY 2016

The methodology used to assess NASA Glenn's economic impact on the state of Ohio was similar to that used for Section D.2., Economic Impact on Northeast Ohio, FY 2016. The main difference was that the model accounted for all purchases NASA Glenn made from companies in Ohio as opposed to only companies located in Northeast Ohio.

D.3.1. Output Impact on the State of Ohio, FY 2016

The economic impact is assessed with IMPLAN multipliers identifying buy-sell relationships between industries in Ohio. The multipliers applied to spending in Ohio are normally larger than the multipliers applied to expenditures in Northeast Ohio due to a larger geographic area allowing for capturing more purchases within the region. It also enables more purchases from the state economy suppliers and, therefore, less leakage from the economy.

NASA Glenn's expenditures were divided into two categories: (1) spending on goods and services purchased from companies and other institutions located in the state of Ohio (local) and (2) spending on goods and services from businesses located outside Ohio. Local spending is then categorized by products and services made in and provided by the local economy, based on an IMPLAN classification system of industries that produced the products and services. Then, the spending is assigned to 536 IMPLAN sectors similar to the NAICS code industrial classification. Table A.4 in Appendix A provides a detailed list of NASA Glenn's expenditures by industry in the state of Ohio.

Table 11 presents the total output impact. The total purchases for all NASA Glenn operations represented the direct output impact (change in final demand). Regional expenditures and the contributions of individual industries that provided inputs to the producers of goods and services ultimately consumed by NASA Glenn represented indirect impact. Induced impact was estimated by measuring the spending of workers who were employed at NASA Glenn and supplying industries as a result of Glenn's increased demand for products and services. Total output impact is the sum of these three components. Table 11 reports output impacts by industry sector, illustrating how NASA Glenn's spending across Ohio affects sectors of the state economy differently.

Table 11. Output Impact in the State of Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$161,476	$1,084,096	$1,245,572
Mining		$1,200,526	$814,491	$2,015,017
Utilities		$27,258,807	$9,663,359	$36,922,166
Construction		$37,731,827	$4,795,987	$42,527,814
Manufacturing		$10,451,666	$20,434,761	$30,886,427
Wholesale Trade		$4,845,373	$15,684,532	$20,529,905
Retail Trade		$5,467,996	$34,037,920	$39,505,916
Transportation and Warehousing		$5,499,159	$11,744,555	$17,243,714
Information		$6,404,385	$14,674,450	$21,078,835
Finance and Insurance		$11,000,657	$43,017,469	$54,018,126
Real Estate and Rental		$19,537,432	$66,088,174	$85,625,606
Professional, Scientific, and Tech Services		$196,453,899	$13,287,980	$209,741,880
Management of Companies		$4,530,681	$4,935,783	$9,466,464
Administrative and Waste Services		$76,280,343	$10,330,653	$86,610,996
Educational Services		$7,977,265	$5,794,318	$13,771,584
Health and Social Services		$133,726	$56,570,787	$56,704,513
Arts, Entertainment, and Recreation		$1,444,862	$6,209,879	$7,654,741
Accommodation and Food Services		$2,628,395	$19,196,142	$21,824,536
Other Services		$4,774,463	$21,499,146	$26,273,609
Government & non-NAICs	$639,338,269	$819,390	$2,776,673	$642,934,332
Total Output	**$639,338,269**	**$424,602,329**	**$362,641,154**	**$1,426,581,752**

Notes:

Direct impact of NASA Glenn is a change in final demand that is applied to a sector of NASA Glenn's industry, NAICS 9271 – Space Research and Technology, which is a part of a larger industry sector NAICS 92 – Public Administration (Government & non-NAICs).

For output impact, the change in final demand or direct impact equals the spending of NASA Glenn for goods and services within and outside Ohio, including wages and benefits. The direct output is adjusted for inflation and shown in the table in 2017 dollars (Inflation coefficient is based on Ohio IMPLAN model).

The total output impact of NASA Glenn Research Center's spending of goods and services on the state of Ohio was $1,426.6 million in FY 2016. Glenn's expenditures of $639.3 million resulted in an increase of $1,426.6 million in output (sales) across all industry sectors (Table 11). For example, in Ohio's two largest sectors in terms of output-professional, scientific, and technical services and administrative and waste services, NASA Glenn's spending created $209.7 million and $86.6 million increases in sales, respectively.

Of the total output impact, 44.8% ($639.3 million) was accounted for by the change in final demand or direct impact due to NASA Glenn's actions bringing resources into Ohio. Approximately $424.6 million (29.8%) of the total output impact was a result of indirect spending by NASA Glenn on goods and services purchased within the state of Ohio. The remaining output impact of $362.6 million (25.4%) was due to the induced impact of NASA Glenn's spending throughout the state.[36]

An analysis of the IMPLAN model shows that the $787.2 million increase in sales generated by the indirect and induced impacts can be divided into the same broad categories that were identified for Northeast Ohio: NASA Glenn-driven ($410.3 million, 52.1%), consumer-driven ($274.4 million, 34.9%), and other industries ($102.6 million, 13.0%).[37]

The output distributions for select NASA Glenn- and consumer-driven industries are shown in Figures 13 and 14, respectively. The select industries shown in Figures 13 and 14 each added over $11 and $7 million, respectively.

The scientific research and development services industry in the state of Ohio saw an increase in revenue of $117.6 million in FY 2016 (Figure 13). This amount is the summation of the indirect and induced impacts generated by NASA Glenn's spending. This increase of $117.6 million accounted for a 28.7% share of the $410.3 million increase in output value for all NASA Glenn-driven industries. Other industries shown in Figure 13 can be interpreted similarly.

The real estate industry experienced an increase of $38.0 million in FY 2016 (Figure 14). This amount is the summation of the indirect and induced impact components generated primarily by NASA Glenn employees and other workers. This increase of $38.0 million represented a 13.9% share of the $274.4 million increase in output for all consumer-driven industries. Other industries shown in Figure 14 can be interpreted similarly.

[36] All figures are reported in 2017 dollars.

[37] NASA Glenn-driven sectors include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven sectors include retail, healthcare, real estate, other services, owner-occupied buildings, finance and insurance, and entertainment and food.

Figure 13. Increase in Sales for Select NASA Glenn-Driven Industries in Ohio, FY 2016

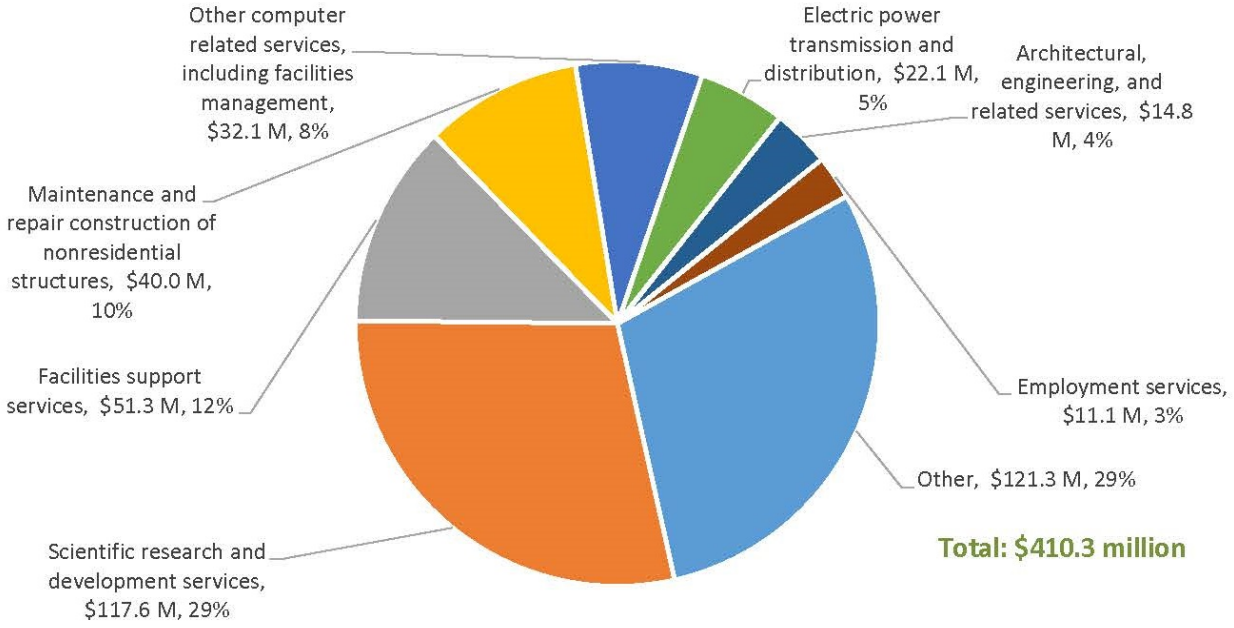
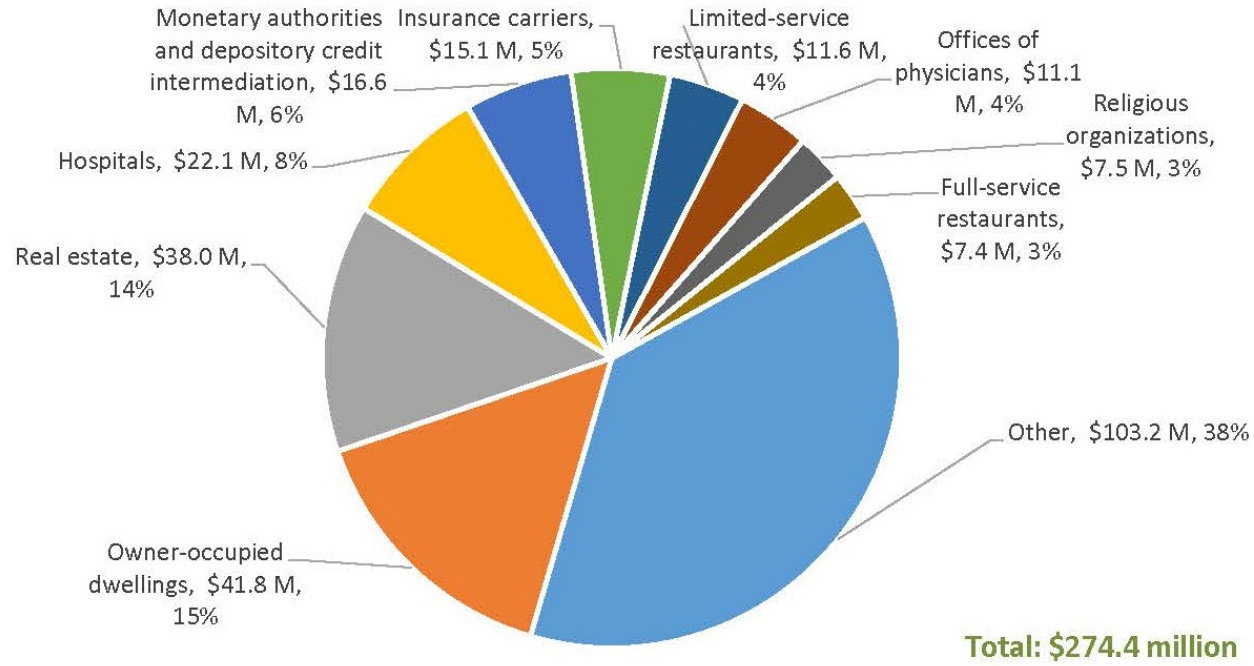


Figure 14. Increase in Sales for Select Consumer-Driven Industries in Ohio, FY 2016



D.3.2. Employment Impact on the State of Ohio, FY 2016

NASA Glenn's spending activities supported existing employment and the creation of new part- and full-time jobs in addition to their own employment (change in final demand or direct impact). NASA Glenn's spending created employment in the supply-chain industries from which it purchases goods and services (indirect impact) across Ohio.

In addition, money spent by NASA Glenn employees and employees of supply companies created jobs in various other industries that sell them products and services (induced impact). The total employment impact equals the sum of NASA Glenn's employment (direct impact) and the indirect and induced components. Table 12 shows the number of jobs supported and created by industry sector.

Table 12. Employment Impact in the State of Ohio, FY 2016

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		3	12	14
Mining		6	5	10
Utilities		25	7	32
Construction		288	30	318
Manufacturing		30	35	65
Wholesale Trade		21	66	87
Retail Trade		107	430	537
Transportation and Warehousing		37	82	119
Information		17	36	53
Finance and Insurance		37	162	199
Real Estate and Rental		81	108	189
Professional, Scientific, and Tech Services		1,153	105	1,258
Management of Companies		19	21	40
Administrative and Waste Services		784	151	934
Educational Services		271	94	366
Health and Social Services		1	565	566
Arts, Entertainment, and Recreation		23	79	103
Accommodation and Food Services		50	342	392
Other Services		50	268	317
Government & non-NAICs		4	10	13
Total Employment	**1,572**	**3,006**	**2,606**	**7,184**

Notes:
For employment impact, the change in final demand (direct impact) equals the number of NASA Glenn employees.

Employment increased by 7,184 jobs in Ohio in FY 2016 due to NASA Glenn's spending in the state. Of these 7,184 jobs, 1,572 people (21.9%) were directly employed at NASA Glenn. As a result of NASA Glenn's direct spending for goods and services purchased in Ohio through their supply industries, 3,006 jobs (41.9%) were supported and created (indirect effect). The remaining 2,606 jobs (36.2%) was the induced impact resulting from spending wages and salaries of NASA Glenn's workers and supply companies' employees through the state's economy.

Of the 5,612 jobs created in Ohio due to the indirect and induced effects, 2,960 (52.7%) were in NASA Glenn-driven sectors, 2,040 (36.4%) were in consumer-driven sectors, and 612 (10.9%) were created in other sectors.[38]

The job distribution for select NASA Glenn-driven industries is shown in Figure 15. The job distribution for select consumer-driven industries is shown in Figure 16. Each of the selected industries shown in Figures 15 and 16 supported or added over 130 and 50 jobs, respectively.

Because of NASA Glenn's spending in Ohio, 345 jobs were added to the facilities services industry during FY 2016 (Figure 15). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's need for facilities support services. The 345 jobs accounted for a 12% share of the 2,960 jobs that were created across all NASA Glenn-driven industries.

The full-service restaurants industry experienced an increase of 165 jobs in FY 2016 (Figure 16). The 165 jobs were supported or created due to NASA Glenn employees and employees of Glenn's supply industries dining out at full-service restaurants in Ohio. These jobs accounted for an 8% share of the 2,040 jobs that were created in all consumer-driven industries in the state.

[38] Glenn-driven industries include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven industries include retail, healthcare, real estate, other services, owner-occupied buildings, finance and insurance, and entertainment and food.

Figure 15. Increase in Jobs for Select NASA Glenn-Driven Industries in Ohio, FY 2016

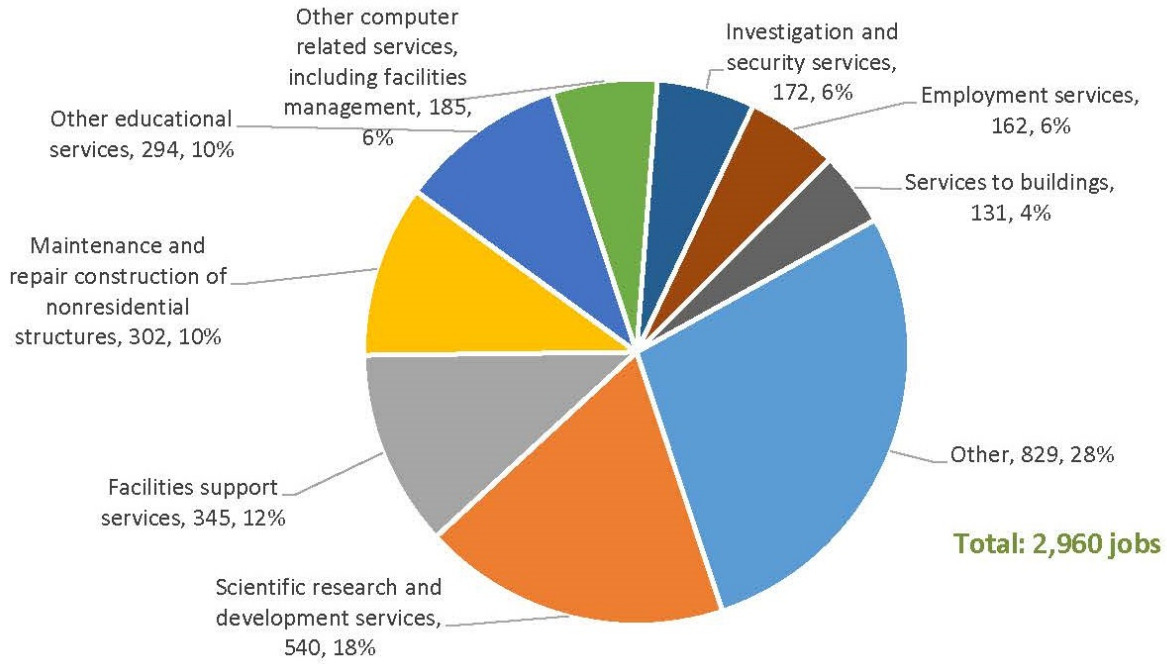
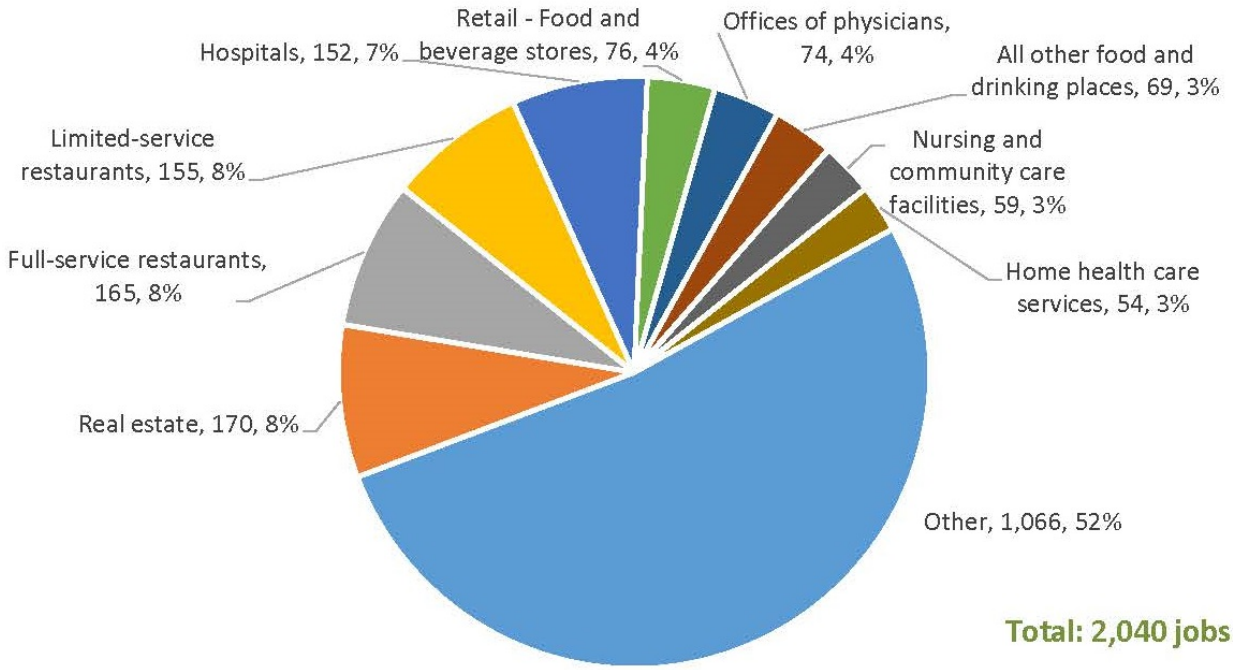


Figure 16. Increase in Jobs for Select Consumer-Driven Industries in Ohio, FY 2016



D.3.3 Labor Income Impact on the State of Ohio, FY 2016

Labor income is assessed as the estimated earnings received by NASA Glenn employees and the change in the earnings of employees of its supply companies in the state of Ohio due to NASA Glenn's spending on goods and services in the state. Wages and benefits paid to all NASA Glenn employees constituted the change in final demand or direct impact of NASA Glenn in Ohio measured in labor Income.

Money paid to the employees of both the companies from which NASA Glenn buys its supplies and these companies' suppliers represented the indirect earnings impact. Induced impact was generated through the spending of workers in all industries who were employed as a result of the increased demand for products and services created by NASA Glenn. The total labor income impact of NASA Glenn can be determined by adding these three impacts. Table 13 shows the labor income impact by industry sector.

Table 13. Labor Income Impact in the State of Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$67,235	$324,555	$391,790
Mining		$342,561	$214,035	$556,596
Utilities		$2,777,090	$957,190	$3,734,280
Construction		$13,691,338	$1,604,107	$15,295,445
Manufacturing		$1,912,867	$2,316,735	$4,229,602
Wholesale Trade		$1,656,837	$5,332,469	$6,989,306
Retail Trade		$2,544,283	$13,303,158	$15,847,442
Transportation and Warehousing		$2,211,635	$4,742,563	$6,954,198
Information		$1,349,601	$2,661,955	$4,011,556
Finance and Insurance		$2,450,336	$9,752,846	$12,203,182
Real Estate and Rental		$3,147,170	$4,150,585	$7,297,755
Professional, Scientific, and Tech Services		$83,256,635	$6,804,031	$90,060,666
Management of Companies		$2,282,104	$2,486,154	$4,768,257
Administrative and Waste Services		$27,826,903	$5,369,221	$33,196,124
Educational Services		$4,868,236	$3,243,609	$8,111,844
Health and Social Services		$67,278	$31,802,285	$31,869,563
Arts, Entertainment, and Recreation		$646,254	$2,116,106	$2,762,360
Accommodation and Food Services		$1,073,279	$7,135,512	$8,208,791
Other Services		$2,475,171	$8,445,236	$10,920,408
Government & non-NAICs	$225,474,374	$302,362	$911,141	$226,687,877
Total Labor Income	**$225,474,374**	**$154,949,176**	**$113,673,491**	**$494,097,042**

Notes:
For labor income impact, the change in final demand or direct impact equals the wages and benefits paid to NASA Glenn employees. The direct labor income is adjusted for commuters' compensation and inflation, and it is shown in the table in 2017 dollars (Inflation based on NEO IMPLAN model).

Total labor income in the state of Ohio increased by $494.1 million as a result of NASA Glenn's spending on goods and services in FY 2016. Of this amount, $225.5 million (45.6%) included wages and benefits paid to NASA Glenn employees (change in final demand or direct impact). Income received by employees of companies across the state from which NASA Glenn buys its supplies and suppliers of those companies (indirect impact) represented $155.0 million (31.3%). The remaining earnings impact (induced component), $113.7 million (23.0%), was the result of NASA Glenn's employees and its suppliers' employees' spending rippling through the Ohio economy.

Of the $268.6 million increase in labor income attributed to the indirect and induced impacts, $154.3 million (57.5%) was observed in Glenn-driven industries, $83.3 million (31.0%) occurred in consumer-driven industries, and $31.0 million (11.5%) was reported in other industries.[39]

The labor income distribution for select NASA Glenn-driven industries is shown in Figure 17. The labor income distribution for select consumer-driven industries is shown in Figure 18. The selected industries shown in these figures experienced the most gains in earnings (over $6.5 million and $2.5 million each in Figures 17 and 18, respectively).

In the NASA Glenn-driven industries, employees in scientific research and development services across the state of Ohio saw their labor income increase by $40.8 million in FY 2016 (Figure 17). These earnings are the summation of the indirect and induced impacts generated by NASA Glenn's purchases of computer-related services. The $40.8 million represented a 26.4% of the $154.3 million earnings increase that occurred in all NASA Glenn-driven industries.

In the consumer-driven industries, employees working for offices of physicians industry experienced an increase in labor income of $8.0 million in FY 2016 (Figure 18). This amount is the summation of the indirect and induced impacts generated primarily by the spending of NASA Glenn employees and other workers for insurance. The $8.0 million accounted for a 9.6% share of the $83.3 million earnings increase that was reported by all consumer-driven industries.

[39] See section D.2.1. Output Impact on Northeast Ohio, FY 2016 for detailed definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 17. Increase in Labor Income for Select NASA Glenn-Driven Industries in Ohio, FY 2016

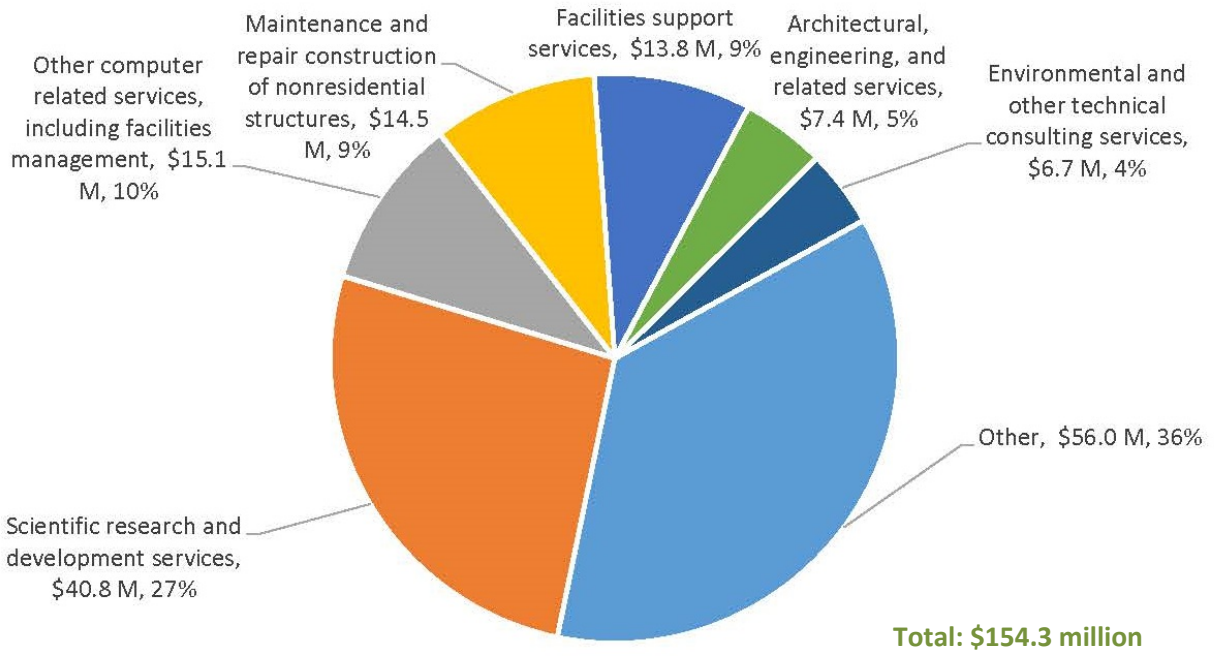
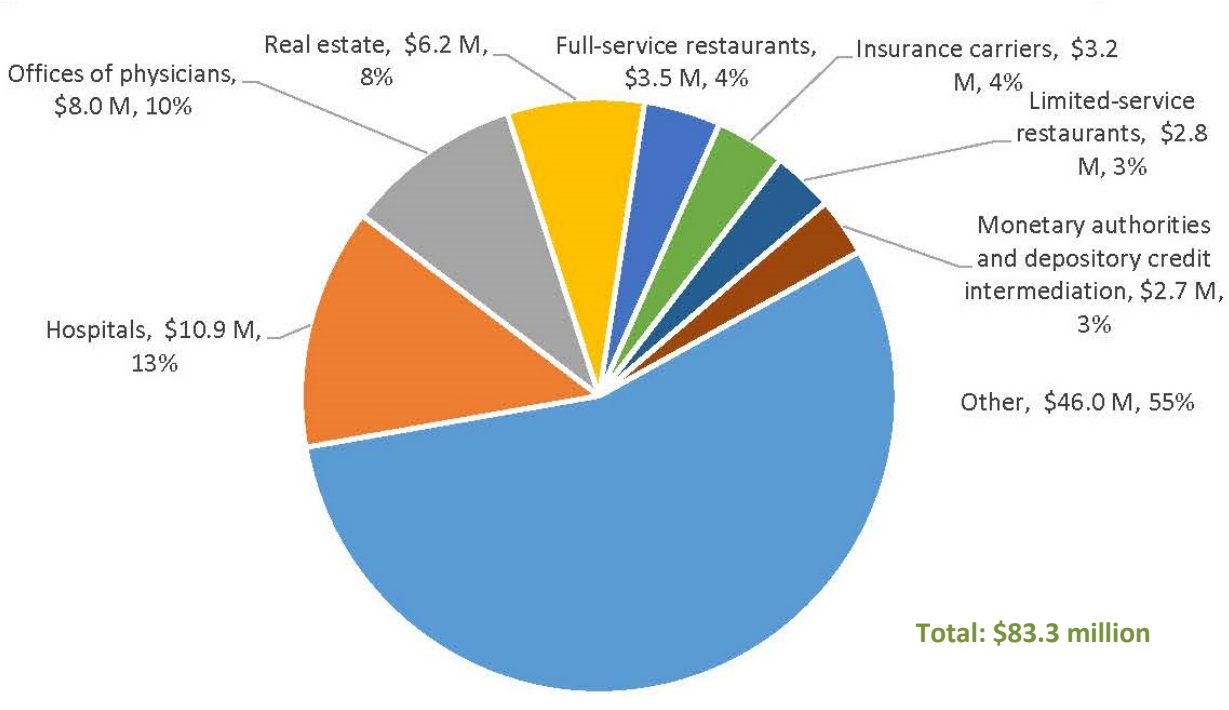


Figure 18. Increase in Labor Income for Select Consumer-Driven Industries in Ohio, FY 2016



D.3.4. Value Added Impact on the State of Ohio, FY 2016

NASA Glenn's spending created an increase of $719.5 million in value added for all industries in Ohio.[40] Of this, $287.7 million (40.0%) was the change in final demand or direct impact calculated as total output less intermediate expenditures made in the state.

The largest portion of the value added was the wages and salaries paid to NASA Glenn employees. Another $223.4 million (31.1%) represented the value of goods and services, less intermediary goods, of companies in Ohio that supply NASA Glenn (i.e., indirect impact).

The remaining value added impact (induced component) was estimated at $208.4 million (29.0%). It occurred as a result of NASA Glenn's spending rippling through the Ohio economy. The total value added impact is a summation of the direct, indirect, and induced impacts.[41]

[40] "Value added" measures the economic impact of all goods and services produced in the state of Ohio due to NASA Glenn's operation (excluding intermediary goods).

[41] For value added impact, the change in final demand (direct impact) equals total output less the intermediate expenditures. For this study, we treated NASA Glenn as any other research and development institution, assuming that NASA Glenn's intermediate expenditure pattern is the same as that of any other research institution in Ohio. For an average research institution in Ohio, the intermediate expenditures accounted for 54% of total output. Negative values in Value Added effect suggest that costs of creating products and providing services in this sector are greater than revenues. Value added consists of employee compensation, proprietor income, other property type income and taxes on production and imports. Any of these values could be negative.

Table 14. Value Added Impact in the State of Ohio, FY 2016 (in 2017 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting		$86,943	$484,443	$571,386
Mining		$640,757	$390,805	$1,031,562
Utilities		$13,592,794	$4,608,480	$18,201,273
Construction		$17,498,868	$2,035,518	$19,534,386
Manufacturing		$3,916,351	$6,636,855	$10,553,206
Wholesale Trade		$2,988,733	$9,619,123	$12,607,856
Retail Trade		$3,404,993	$22,275,663	$25,680,656
Transportation and Warehousing		$2,682,009	$5,642,171	$8,324,180
Information		$2,687,461	$6,885,587	$9,573,048
Finance and Insurance		$7,066,853	$22,949,439	$30,016,292
Real Estate and Rental		$14,323,990	$46,111,189	$60,435,179
Professional, Scientific, and Tech Services		$98,700,590	$8,134,888	$106,835,478
Management of Companies		$2,799,071	$3,049,344	$5,848,415
Administrative and Waste Services		$42,952,807	$6,944,042	$49,896,848
Educational Services		$4,850,349	$3,402,877	$8,253,225
Health and Social Services		$74,924	$34,961,135	$35,036,059
Arts, Entertainment, and Recreation		$702,270	$3,390,303	$4,092,573
Accommodation and Food Services		$1,367,032	$10,077,822	$11,444,854
Other Services		$3,084,443	$9,547,826	$12,632,269
Government & non-NAICs	$287,702,221	-$41,218	$1,257,731	$288,918,734
Total Value Added	**$287,702,221**	**$223,380,020**	**$208,405,240**	**$719,487,482**

Total value added in the state of Ohio increased by $719.5 million as a result of NASA Glenn's spending on goods and services in FY 2016. Of this total amount, $287.7 million (40.0%) included the wages and benefits paid directly to NASA Glenn employees and other added value (change in final demand or direct impact). Another $223.4 million (31.1%) represented the value of goods and services (less intermediary goods) created by companies in Ohio due to operations of NASA Glenn (indirect impact). The remaining value added impact (induced component), assessed at $208.4 million (29.0%), occurred as the effects of NASA Glenn's spending rippled through the Ohio economy.

Of the $431.8 million increase in value added generated by induced and indirect impacts in Ohio, $212.1 million (49.1%) was observed in NASA Glenn-driven industries, $168.5 (39.0%) was generated in consumer-driven industries, and $51.1 million (11.8%) was reported in other industries.[42]

[42] See section D.2.1 Output Impact on Northeast Ohio, FY 2015 for definitions of NASA Glenn-driven, consumer-driven, and other industries.

The value added distribution for select NASA Glenn-driven industries is shown in Figure 19. The value added distribution for select consumer-driven industries is shown in Figure 20. Selected industries in Figure 19 and Figure 20 each added over $7 and $6 million, respectively.

Within the NASA Glenn-driven industries, the facilities support services sector's value added increased by $25.5 million in FY 2016 (Figure 19). This increase is a result of the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on facilities support services. The $25.5 million accounted for 12.0% of the $212.1 million value added increase that was reported by all NASA Glenn-driven industries.

In the consumer-driven industries, employees of the real estate industry saw the sector's value added increase by $29.0 million in FY 2016 (Figure 20). This increase is a result of the summation of the indirect and induced impacts generated by consumer spending within the industry. The increase of $29.0 million accounted for 17.2% of the $168.5 million value added increase that occurred in all consumer-driven industries.

Figure 19. Increase in Value Added for NASA Glenn-Driven Industries in Ohio, FY 2016

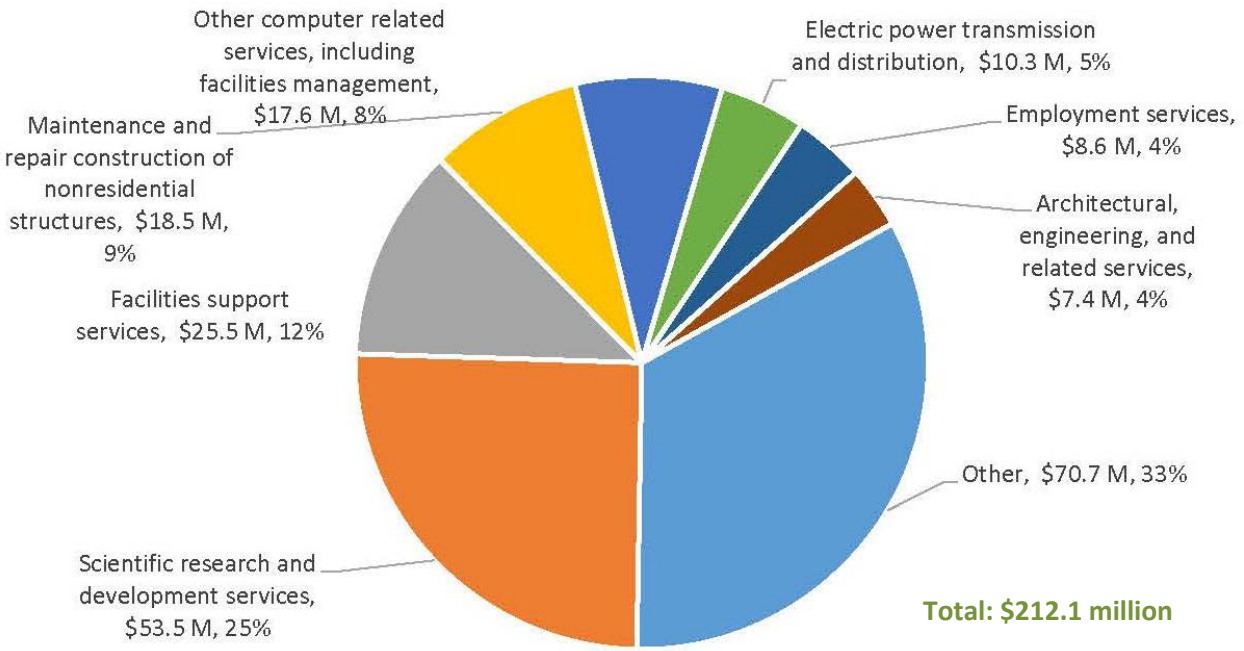
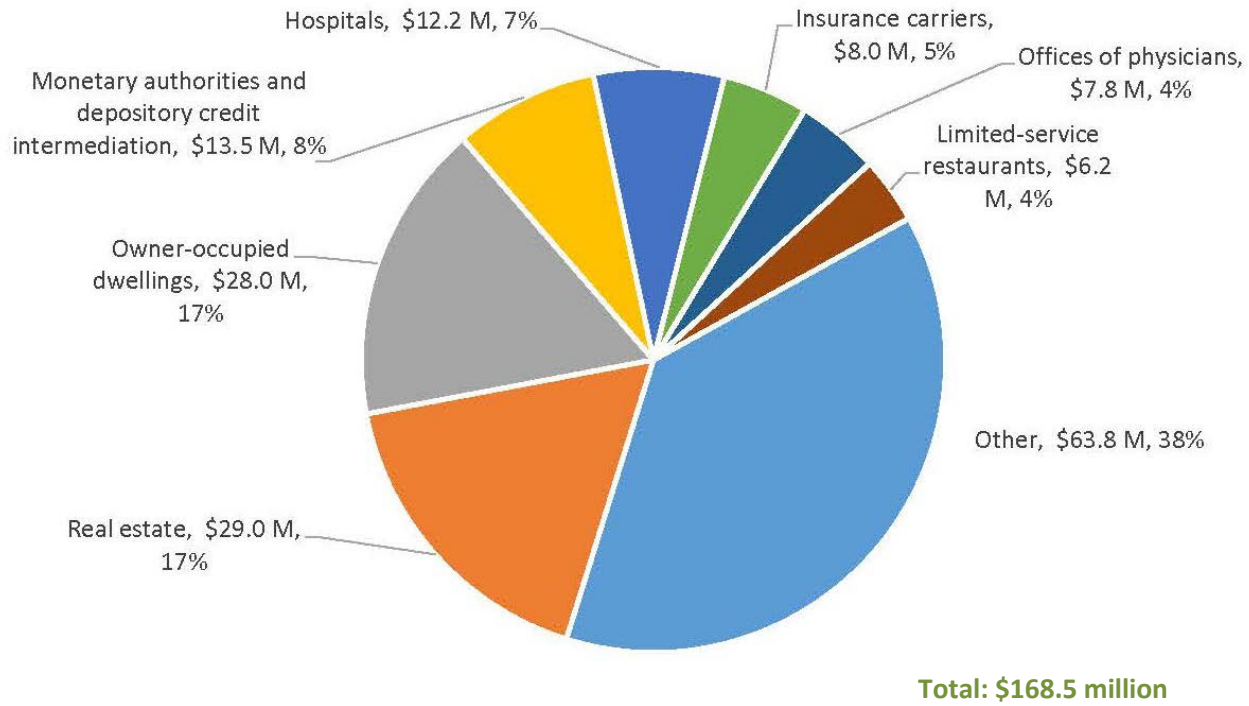


Figure 20. Increase in Value Added for Consumer-Driven Industries in Ohio, FY 2016



D.3.5. Tax Impact on the State of Ohio, FY 2016

NASA Glenn's operation and economic impact on the state of Ohio in FY 2016 increased tax revenues by a total of $126.2 million. Of that amount, direct tax impact in 2017 dollars was $33.1 million in Glenn's employee taxes on wages, $45.0 million indirect tax impact, and $48.1 million induced tax impact.

D.3.6. FY 2016 Ohio Impact Summary

The economic activity of NASA Glenn in the state of Ohio generated the following total economic impact (in 2017 dollars):

- Total Output Impact: $1,427.6 M
- Total Employment Impact: 7,184 jobs
- Total Labor Income Impact: $494.1 M
- Total Value Added Impact: $719.5 M
- Total Tax Impact: $126.2 M

The impact of NASA Glenn's expenditures on the state of Ohio is slightly higher than the impact on Northeast Ohio because the Ohio models capture more buy-sell relationships in the larger geographic area. However, a significant majority of NASA Glenn's spending in Ohio occurred in Northeast Ohio.

In FY 2016, NASA Glenn's expenditures in the state of Ohio totaled $508.4 million, including labor income (adjusted for commuter spending). The total expenditures in all of Ohio were $12.7 million more than in the total expenditures in Northeast Ohio (in 2016 dollars).

Compared to the expenditures made in Northeast Ohio in FY 2016, the largest share of the total payments, excluding labor income, was spent on professional, scientific, and technical services in Ohio (60.0% in Ohio, compared to 55.5% in Northeast Ohio). More than 95.2% of NASA Glenn spending in Ohio ($272.7 million), excluding labor income, went to the following industry sectors: professional, scientific and technical services ($160.4 million); administrative and support services ($59.9 million); construction ($35.6 million); and utilities ($16.9 million).[43] Additionally, 2.4% ($7.9 million) went toward the education sector and 1.4% ($3.0 million) for wholesale and retail trade.

NASA Glenn's statewide expenditure pattern is similar to the expenditures in Northeast Ohio. A large institution employing highly qualified and well paid labor, NASA Glenn is accountable for a large part of the economic impact through the spending of its employees. The businesses that benefited the most from spending by NASA Glenn personnel and other workers whose earnings were due in part to NASA Glenn's expenditures are typical, considering consumer spending patterns. These businesses include the following industries: food services, accounting services, commercial banks, miscellaneous retailers, real estate companies, motor vehicle dealers, educational institutions and hospitals and other healthcare services.

[43] Amounts in parentheses detailing percentage numbers are presented in 2016 dollars and correspond to Appendix table A.4.

APPENDIX A: DATA TABLES

Table A.1. NASA Glenn Spending by State, Excluding Payroll, FY 2016

State	Spending	Share
Ohio	$284,533,038.86	69.90%
Maryland	$26,447,960.87	6.50%
California	$14,930,278.57	3.67%
Connecticut	$8,088,930.55	1.99%
Virginia	$7,095,402.15	1.74%
Washington	$6,986,894.00	1.72%
Texas	$6,503,991.52	1.60%
Pennsylvania	$5,596,685.32	1.37%
Tennessee	$5,182,734.76	1.27%
Georgia	$3,846,186.57	0.94%
Indiana	$3,394,301.55	0.83%
Florida	$3,215,627.96	0.79%
Missouri	$2,722,187.57	0.67%
Massachusetts	$2,606,579.80	0.64%
Illinois	$2,478,030.95	0.61%
New Mexico	$2,412,620.28	0.59%
Michigan	$2,369,552.67	0.58%
New Hampshire	$2,311,972.54	0.57%
New Jersey	$2,249,716.30	0.55%
New York	$2,223,648.16	0.55%
Arizona	$2,205,781.61	0.54%
Colorado	$1,589,343.39	0.39%
Utah	$845,324.72	0.21%
North Carolina	$797,169.97	0.20%
Minnesota	$745,570.77	0.18%
Oregon	$607,322.30	0.15%
Iowa	$602,323.53	0.15%
Wisconsin	$566,287.10	0.14%
Delaware	$556,840.65	0.14%
Alabama	$474,750.13	0.12%
South Carolina	$472,586.95	0.12%
District of Columbia	$442,476.53	0.11%

State	Spending	Share
Oklahoma	$249,472.26	0.06%
Rhode Island	$207,475.92	0.05%
Kansas	$139,364.25	0.03%
South Dakota	$101,800.79	0.03%
Montana	$91,671.45	0.02%
Kentucky	$65,264.67	0.02%
Nevada	$65,194.94	0.02%
Vermont	$37,965.25	0.01%
Mississippi	$27,276.69	0.01%
Wyoming	$16,552.00	0.00%
Hawaii	$11,648.48	0.00%
Nebraska	$9,052.00	0.00%
Idaho	$5,675.52	0.00%
Maine	$609.39	0.00%
Alaska	$356.02	0.00%
West Virginia	-$142.39	0.00%
U.S. Total	**$406,131,355.82**	**99.78%**
Canada	$112,929.41	0.03%
France	$3,187.00	0.00%
Germany	$413,663.22	0.10%
Great Britain	$231,079.48	0.06%
Iceland	$2,450.00	0.00%
Israel	$45,700.00	0.01%
Netherlands	$647.39	0.00%
Norway	$9,357.00	0.00%
Portugal	$2,157.44	0.00%
Spain	$62,400.00	0.02%
Foreign Total	**$903,230.52**	**0.22%**
Total	**$407,034,586.34**	**100.00%**

Table A.2. NASA Glenn Funding Allocated to Academic Institutions by State, FY 2016

State	Amount	Share
California	$1,981,820.24	16.40%
Maryland	$1,283,918.93	10.62%
Illinois	$1,278,919.47	10.58%
Ohio	$1,051,098.23	8.70%
Pennsylvania	$691,148.54	5.72%
Michigan	$596,256.40	4.93%
Texas	$571,846.50	4.73%
Massachusetts	$527,065.74	4.36%
New Jersey	$414,860.41	3.43%
Arizona	$412,121.83	3.41%
Colorado	$377,242.21	3.12%
Connecticut	$373,750.08	3.09%
Indiana	$361,374.79	2.99%
Georgia	$298,215.18	2.47%
Delaware	$278,401.23	2.30%
Iowa	$215,913.89	1.79%
North Carolina	$208,137.62	1.72%
New York	$200,517.54	1.66%
South Carolina	$120,107.83	0.99%
Virginia	$119,445.26	0.99%
Florida	$86,599.36	0.72%
New Mexico	$80,387.49	0.67%
Oregon	$78,101.37	0.65%
South Dakota	$65,983.47	0.55%
Missouri	$65,919.69	0.55%
Kansas	$61,564.00	0.51%
Washington	$59,092.23	0.49%
Alabama	$57,384.84	0.47%
Kentucky	$48,110.29	0.40%
Mississippi	$27,276.69	0.23%
Hawaii	$11,648.48	0.10%
District of Columbia	$2,820.00	0.02%
Outside US	$80,336.48	0.66%
Great Britain Total	$77,886.48	0.64%
Iceland Total	$2,450.00	0.02%
Total	**$12,087,386.31**	**100.00%**

Note: Nineteen states did not have Academic Institutions that received NASA Glenn grants in 2016.

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2016

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$16,581,363.22**
	Electric power transmission and distribution	49	$14,802,432.41
	Natural gas distribution	50	$529,263.38
	Water, sewage and other systems	51	$1,249,667.43
Construction			**$35,174,253.41**
	Maintenance and repair construction of nonresidential structures	62	$35,174,253.41
Manufacturing			**$1,025,713.41**
	Printing	154	$2,009.38
	Industrial gas manufacturing	162	$28,042.18
	Iron and steel mills and ferroalloy manufacturing	217	$85.00
	Fabricated structural metal manufacturing	238	$15,158.00
	Sheet metal work manufacturing	241	$24,822.00
	Machine shops	249	$297,246.52
	Turned product and screw, nut, and bolt manufacturing	250	$32,840.00
	Metal heat treating	251	$7,100.00
	Metal coating and nonprecious engraving	252	$4,740.00
	Valve and fittings, other than plumbing, manufacturing	254	$61,590.30
	Other fabricated metal manufacturing	261	$121,106.75
	Industrial mold manufacturing	278	$13,096.42
	Machine tool manufacturing	281	$152,274.00
	Industrial process furnace and oven manufacturing	297	$9,395.00
	Broadcast and wireless communications equipment manufacturing	305	$14,915.00
	Audio and video equipment manufacturing	307	$56,857.35
	Industrial process variable instruments manufacturing	317	$40,955.50
	Electricity and signal testing instruments manufacturing	319	$92,752.62
	Watch, clock, and other measuring and controlling device manufacturing	322	$10,640.56
	Showcase, partition, shelving, and locker manufacturing	376	$6,524.37
	Office supplies (except paper) manufacturing	387	$13,087.46

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	All other miscellaneous manufacturing	394	$20,475.00
Wholesale & Retail Trade			**$2,562,270.44**
	Wholesale trade	395	$419,050.86
	Retail - Motor vehicle and parts dealers	396	$9,773.20
	Retail - Electronics and appliance stores	398	$31,590.00
	Retail - Miscellaneous store retailers	406	$2,093,396.38
	Retail - Nonstore retailers	407	$8,460.00
Transportation			**$13,803.62**
	Truck transportation	411	$4,911.16
	Transit and ground passenger transportation	412	$8,892.46
Information and Telecommunication			**$44,650.00**
	Book publishers	419	$1,550.00
	Satellite, telecommunications resellers, and all other telecommunications	429	$43,100.00
Real Estate and Rental & Leasing			**$36,138.90**
	Commercial and industrial machinery and equipment rental and leasing	445	$36,138.90
Professional, Scientific, & Technical Services			**$154,282,244.14**
	Legal services	447	$39,450.00
	Accounting, tax preparation, bookkeeping, and payroll services	448	$3,791,902.23
	Architectural, engineering, and related services	449	$5,322,522.10
	Other computer related services, including facilities management	453	$30,241,700.53
	Management consulting services	454	$207,098.91
	Environmental and other technical consulting services	455	$7,921,282.35
	Scientific research and development services	456	$106,584,516.85
	Marketing research and all other miscellaneous professional, scientific, and technical services	460	$173,771.17
Administrative & Support and Waste Management Services			**$59,415,777.77**
	Facilities support services	463	$50,497,491.09
	Investigation and security services	467	$6,503,639.61
	Services to buildings	468	$2,241,727.58
	Waste management and remediation services	471	$172,919.49
Education			**$7,337,166.00**

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Junior colleges, colleges, universities, and professional schools	473	$614,726.38
	Other educational services	474	$6,722,439.62
General Medical and Surgical Hospitals			**$130,500.00**
	Hospitals	482	$130,500.00
Arts, Entertainment, & Recreation			**$725,484.25**
	Museums, historical sites, zoos, and parks	493	$711,130.81
	Hotels and motels, including casino hotels	499	$14,353.44
Other Services, Except Public Administration			**$23,527.79**
	Electronic and precision equipment repair and maintenance	506	$10,491.04
	Commercial and industrial machinery and equipment repair and maintenance	507	$1,886.75
	Business and professional associations	515	$3,750.00
	Other local government enterprises	526	$7,400.00
Labor Income			**$218,373,855.24**
	Employee Compensation (c)		$218,373,855.24
TOTAL EXPENDITURES IN NEO			**$495,726,748.19**

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.
b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2016. Values shown in Table A-3 are limited to expenditures made in Northeast Ohio.
c. Labor Income: Labor income includes wages and benefits of Glenn employees living in Northeast Ohio and accounts for commuters' local spending.

All expenditures in this table are presented in 2016 dollars.

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2016

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$16,740,351.16**
	Electric power transmission and distribution	49	$14,802,432.41
	Natural gas distribution	50	$561,763.38
	Water, sewage and other systems	51	$1,376,155.37
Construction			**$35,230,449.40**
	Maintenance and repair construction of nonresidential structures	62	$35,230,449.41
	Maintenance and repair construction of highways, streets, bridges, and tunnels	64	-$0.01
Manufacturing			**$1,988,286.26**
	Printing	154	$2,009.38
	Industrial gas manufacturing	162	$28,042.18
	Polystyrene foam product manufacturing	192	$13,827.00
	Miscellaneous nonmetallic mineral products manufacturing	216	$1,295.00
	Iron and steel mills and ferroalloy manufacturing	217	$85.00
	Fabricated structural metal manufacturing	238	$15,158.00
	Plate work manufacturing	239	$24,822.00
	Sheet metal work manufacturing	241	$148,468.00
	Metal tank (heavy gauge) manufacturing	244	$44.78
	Machine shops	249	$348,955.21
	Turned product and screw, nut, and bolt manufacturing	250	$32,840.00
	Metal heat treating	251	$11,699.65
	Metal coating and nonprecious engraving	252	$4,740.00
	Valve and fittings, other than plumbing, manufacturing	254	$61,171.01
	Other fabricated metal manufacturing	261	$121,106.75
	Industrial mold manufacturing	278	$13,096.42
	Machine tool manufacturing	281	$178,274.00
	Overhead cranes, hoists, and monorail systems manufacturing	292	$4,959.35
	Industrial process furnace and oven manufacturing	297	$315,972.09
	Scales, balances, and miscellaneous general purpose machinery manufacturing	300	$33,707.27

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Electronic computer manufacturing	301	$12,669.00
	Broadcast and wireless communications equipment manufacturing	305	$54,058.50
	Audio and video equipment manufacturing	307	$56,857.35
	Industrial process variable instruments manufacturing	317	$40,955.50
	Electricity and signal testing instruments manufacturing	319	$154,277.62
	Analytical laboratory instrument manufacturing	320	$223,895.44
	Watch, clock, and other measuring and controlling device manufacturing	322	$10,679.49
	Motor and generator manufacturing	333	$2,044.44
	Aircraft engine and engine parts manufacturing	358	$32,244.00
	Showcase, partition, shelving, and locker manufacturing	376	$6,524.37
	Office supplies (except paper) manufacturing	387	$13,332.46
	All other miscellaneous manufacturing	394	$20,475.00
Wholesale & Retail Trade			**$2,829,063.12**
	Wholesale trade	395	$555,922.51
	Retail - Motor vehicle and parts dealers	396	$9,773.20
	Retail - Electronics and appliance stores	398	$31,590.00
	Retail - Building material and garden equipment and supplies stores	399	$15,000.00
	Retail - Miscellaneous store retailers	406	$2,208,317.41
	Retail - Nonstore retailers	407	$8,460.00
Transportation			**$13,996.31**
	Truck transportation	411	$5,103.85
	Transit and ground passenger transportation	412	$8,892.46
Information & Telecommunication			**$48,951.42**
	Book publishers	419	$1,550.00
	Wireless telecommunications carriers (except satellite)	428	$4,301.42
	Satellite, telecommunications resellers, and all other telecommunications	429	$43,100.00
Real Estate and Rental & Leasing			**$36,138.90**
	Commercial and industrial machinery and equipment rental and leasing	445	$36,138.90

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Professional, Scientific, & Technical Services			**$159,466,611.88**
	Legal services	447	$130,644.00
	Accounting, tax preparation, bookkeeping, and payroll services	448	$3,791,902.23
	Architectural, engineering, and related services	449	$6,527,684.20
	Custom computer programming services	451	$375.00
	Other computer related services, including facilities management	453	$30,257,950.53
	Management consulting services	454	$209,247.81
	Environmental and other technical consulting services	455	$7,921,282.35
	Scientific research and development services	456	$110,411,700.04
	Marketing research and all other miscellaneous professional, scientific, and technical services	460	$215,825.72
Administrative & Support and Waste Management Services			**$59,422,290.57**
	Facilities support services	463	$50,504,003.89
	Investigation and security services	467	$6,503,639.61
	Services to buildings	468	$2,241,727.58
	Waste management and remediation services	471	$172,919.49
Education			**$7,769,537.85**
	Junior colleges, colleges, universities, and professional schools	473	$1,047,098.23
	Other educational services	474	$6,722,439.62
General Medical and Surgical Hospitals			**$130,500.00**
	Hospitals	482	$130,500.00
Arts, Entertainment & Recreation			**$725,484.25**
	Museums, historical sites, zoos, and parks	493	$711,130.81
	Hotels and motels, including casino hotels	499	$14,353.44
Other Services, Except Public Administration			**$79,792.85**
	Electronic and precision equipment repair and maintenance	506	$18,541.04
	Commercial and industrial machinery and equipment repair and maintenance	507	$2,682.75
	Grantmaking, giving, and social advocacy organizations	514	$54,819.06
	Business and professional associations	515	$3,750.00

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Government Enterprise			**$51,584.88**
	Other federal government enterprises	520	$44,184.88
	Other local government enterprises	526	$7,400.00
Labor Income			**$223,916,291.95**
	Employee Compensation (c)		$223,916,291.95
TOTAL EXPENDITURES IN OHIO			**$508,449,330.80**

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.
b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2016. Values shown in Table A-4 are limited to expenditures made in Ohio.
c. Labor Income: Labor income includes wages and benefits of Glenn employees living in Ohio and accounts for commuters' local spending.

All expenditures in this table are presented in 2016 dollars.