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NASA GLENN RESEARCH CENTER

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**The NASA Glenn
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**An Economic
Impact Study
Fiscal Year 2014**

**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, power and energy storage, 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 physical plant 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 \$680 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately \$2.6 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 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 Space Launch System (SLS) and the Orion Multi-Purpose Crew Vehicle; 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 fundamental propulsion research in Acoustics, Combustion, Turbo-machinery, Electric Propulsion, power management, propulsion systems analysis, materials and Communications for subsonic, supersonic, and vertical lift aircraft systems, and through its program management efforts to support efficient, quiet, and reliable flight in any atmosphere at any speed, while enhancing aviation safety. A vast array of research and technology development projects in support of these attributes are performed by NASA Glenn.
- The report structure is as follows: Sections A and B provide an introduction and background for this report. Section C is 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 2014. This report is an update of several earlier studies in which NASA Glenn’s economic impact on Northeast Ohio and Ohio was estimated.

ECONOMIC IMPACT GENERATED BY NASA GLENN RESEARCH CENTER SPENDING

- Economic impact is an analytical approach used to estimate the economic benefits generated by an entity for an affected region. This study uses an input-output (I-O) model to estimate the effect of NASA Glenn’s spending on the economies of Northeast Ohio (NEO) and Ohio. This model measures economic impact in terms of growth in output (sales), value added (output less intermediary goods), number of new and supported jobs, the increase in labor income, and tax revenues. For this year study (FY 2014), the Center used a methodology to measure NASA Glenn’s impact on Northeast Ohio and Ohio similar

to the study completed for FY 2013. However, the model improvement compared to that used last year includes more detailed data tables developed by IMPLAN Group. Rather than classifying expenditures across 440 sectors in data files as was used in FY 2013, this year the expenditures were classified across 536 economic sectors. However, the results of this research are compared to last year’s report. The table below summarizes NASA Glenn’s economic impact on Northeast Ohio and the state of Ohio during FY 2014.

Economic Impact	Northeast Ohio	State of Ohio
Output	\$1,253 million	\$1,382 million
Value Added	\$667.2 million	\$721.9 million
Employment	6,589 jobs	7,468 jobs
Labor Income	\$474.4 million	\$514.6 million
Taxes	\$112.4 million	\$125.2 million

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

- NASA Glenn’s activities in Northeast Ohio in FY 2014, stimulated by \$612.5 million in direct spending originating primarily from outside of the region, generated an increased demand in output (sales) valued at \$1,253 million for goods and services produced in the region. In other words, value added output increased by \$667.2 million as a result of NASA Glenn’s activities. In addition, 6,589 jobs were created and supported in the region, and labor income in Northeast Ohio increased by \$474.4 million. NASA Glenn’s activities in Northeast Ohio also generated \$112.4 million in local, state, and federal taxes.
- NASA Glenn’s activities in Ohio in FY 2014, stimulated by \$612.5 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 \$1,382 million). Value added output increased by \$721.9 million as a result of NASA Glenn’s activities. In addition, 7,468 jobs were created and supported in Ohio and labor income across the state increased by \$514.6 million. NASA Glenn operations in Ohio also generated \$125.2 million in local, state, and federal taxes.

- Industries deriving the most benefit from direct NASA Glenn spending included education, manufacturing, power generation, facilities support services, administrative and support services, maintenance and repair construction, scientific research and development services, and other professional and technical services.
- Industries deriving the most benefit from spending by NASA Glenn personnel and other workers paralleled typical consumer spending patterns. These industries included food services, insurance services, commercial banks, miscellaneous retailers, real estate and rental services, and hospitals and healthcare offices.

NASA GLENN RESEARCH CENTER: AN OVERVIEW

- In FY 2014, NASA Glenn’s civil service employment totaled 1,624. During the past five years, Glenn civil service employment had a peak of 1,711 employees in 2011. Overall, during the past five fiscal years, NASA Glenn’s civil service employment has decreased by 2.1% (-34 employees).
- NASA Glenn employs highly educated and highly skilled civil service workers. In FY 2014, 85% of NASA Glenn’s employees possessed at least a bachelor’s degree, increasing from 69% in 2004.² Of all NASA Glenn’s civil service employees, 18% held doctoral degrees, 37% held master’s degrees, and 30% held bachelor’s degrees. Compared to FY 2013, the level of educational attainment of NASA Glenn’s civil service employees has increased slightly. The number of employees holding bachelor’s degrees or higher increased 2% between FY 2013 and FY 2014. The rising share of scientists and engineers employed at NASA Glenn between FY 2010 and FY 2014 is a contributing factor to the increasing share of highly educated workers, especially those possessing master’s degrees. NASA Glenn aims to increase the share of its civil servant workforce dedicated to research and technology while reducing the cost of support personnel.
- In FY 2014, scientists and engineers continue to be the largest occupational category, a trend that has continued since before FY 2010. In FY 2014, scientists and engineers accounted for 68% of the civil service employees. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2010 from 65% (1,078 employees) to 68% (1,097 employees) in 2014. This continues a long-term shift in the employment share of scientists and engineers over the last 10 years. Between FY 2004 and FY 2014, the share of scientists and engineers has increased from 57% to 68%.
- NASA Glenn civil service employees received total compensation of \$226.9 million in FY 2014. In this report, total compensation includes both payroll (\$177.9 million) and employee benefits (\$49.0 million). Between FY 2013 and FY 2014, total compensation dropped by \$499,116 (-0.2%).³ Additionally, between FY 2010 and FY 2014, total compensation fell by \$12.2 million (-5.1%) when adjusted for inflation, even as nominal spending increased.⁴ In FY 2014, NASA Glenn payroll stood at \$177.9 million, representing a decrease of \$1 million (-0.5%) since FY 2013.⁵ Between FY 2010 and FY 2014, payroll dropped by \$14.3 million (-7.4%), adjusting for inflation.⁶
- NASA Glenn’s total revenue in FY 2014 was \$677.9 million, increasing in FY 2014 by \$22.9 million (3.5%). Overall, NASA Glenn’s revenue decreased by \$58.3 million (-7.9%) from FY 2010 to FY 2014 (in nominal dollars); fortunately, the upturn in FY 2014 reverses the previous downward trend.⁷

² Total does not equal sum of components due to rounding.

³ Total nominal compensation increased by 1.2% (\$2.6 million) between FY 2013 and FY 2014.

⁴ Total nominal compensation increased by 2.3% (\$5.2 million) between FY 2010 and FY 2014.

⁵ Total nominal payroll increased by 0.9% (\$1.6 million) between FY 2013 and FY 2014.

⁶ Total nominal payroll decreased by 0.2% (\$0.3 million) between FY 2010 and FY 2014.

⁷ Nominal dollars refer to dollars that have not been adjusted for inflation.

- In FY 2014, NASA Glenn allocated its spending of \$388.7 million to vendors in 47 states, Washington, D.C., Puerto Rico, and six foreign countries. In FY 2014, NASA Glenn decreased its total expenditures by 1.8% compared to \$395.9 of expenditures in FY 2013 (a drop of \$7.2 million in nominal dollars). Total expenditures decreased by 29.7% (\$164 million) between FY 2010 and FY 2014.
- In FY 2014 Ohio was the largest beneficiary of expenditures, receiving \$275.5 million of NASA Glenn's total expenditures. With an \$866,520 increase (in nominal dollars) compared to FY 2013, the share of NASA Glenn's expenditures in Ohio increased from 69.4% in FY 2013 to 70.9% in FY 2014.
- Other than Ohio, three states (Maryland, California, and Connecticut) each received over \$12 million, or at least 3.2% of NASA Glenn's total expenditures during FY 2014. Maryland received \$24.6 million (6.3%), California \$17.3 million (4.4%), and Connecticut \$12.6 million (3.2%), making them the second-, third-, and fourth-largest beneficiaries of NASA Glenn spending. Maryland and Connecticut saw nominal increases in spending when compared to FY 2013: \$7.5 million and \$5.3 million, respectively. California saw a nominal decline of \$3.9 million in spending.
- In FY 2014, NASA Glenn decreased its expenditures in foreign countries compared to FY 2013, to \$0.7 million. This spending made up only 0.2% of NASA Glenn's total expenditures in FY 2014. The largest beneficiaries were the United Kingdom with \$0.5 million and Canada with \$0.2 million.
- Northeast Ohio received \$225.6 million of NASA Glenn's total expenditures in Ohio, accounting for 81.9% of total Ohio spending in FY 2014. Northeast Ohio also accounted for 58.1% of NASA Glenn's total spending in FY 2014. Cuyahoga County was by far the largest recipient of NASA Glenn spending in Northeast Ohio, accounting for 98.7% of said spending. Additionally, Cuyahoga County represented 80.8% of spending in Ohio, as well as 57.3% of total NASA Glenn spending in FY 2014.
- NASA Glenn Research Center awards funding to colleges, universities, and other nonprofit institutions in the form of R&D contracts and grants for assisting NASA in their research and development activities. NASA Glenn awarded \$10.5 million to colleges and universities in 32 states, the District of Columbia, Puerto Rico, and Great Britain in FY 2014. Compared to FY 2013, this represented a considerable reduction of academic grants from NASA Glenn totaling \$5.8 million (-35.4% in nominal dollars).
- Universities in four states—California, Ohio, Massachusetts, and Pennsylvania—each received over \$0.7 million in funding from NASA Glenn in FY 2014. The academic funding awarded in these four states collectively accounted for 44.4% of the total grants in FY 2014. Academic institutions in Ohio received \$1.3 million, which accounted for the second largest share (12.8%) of NASA Glenn's academic awards in FY 2014. NASA Glenn's academic awards to Ohio decreased substantially, by 68.9% (-\$3 million), between FY 2013 and FY 2014.

- Within the state of Ohio, academic institutions in Northeast Ohio received \$1.2 million in FY 2014. Northeast Ohio academic institutions accounted for both 11.6% of NASA Glenn's total academic awards and 90.7% of all academic grants given in Ohio. NASA Glenn reduced its awards to the universities and academic institutions in Northeast Ohio by 51.7% (-\$1.3 million) compared to FY 2013. NASA Glenn's funding to Ohio academic institutions located outside of Northeast Ohio's seven counties decreased by 93.1% (-\$1.7 million) compared to FY 2013.
- 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 labor to reside in Ohio.

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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 FY 2014. 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.⁸ This model assesses economic impact in terms of growth in total output (sales); value added (output less intermediary goods); household earnings, number of new jobs, and taxes.⁹

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 2014 report is an update to previous studies published in 1996, 2000, 2005, and annually from 2007 through 2014.¹⁰

⁸ For purposes of this study, Northeast Ohio is defined as Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

⁹ 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.

¹⁰ 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 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, power and energy storage, 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.¹¹

B.1. NASA GLENN TEST FACILITIES

NASA Glenn has two locations. Lewis Field is a 300-acre site adjacent to Cleveland Hopkins International Airport. Plum Brook Station is a 6,400 acre site, located in Sandusky, Ohio, which is 50 miles west of Cleveland.

In total, NASA Glenn's physical plant 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 \$680 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately \$2.6 billion.

Plum Brook and the Lewis Field site each host several large test facilities which use cryogenic fluids (gases frozen to their liquid state). Because working with large amounts of

cryogenic fluids is inherently dangerous, Plum Brook Station's large acreage uniquely allows for the safe testing of spacecraft and hypersonic vehicles in realistic operating conditions from launch to planetary operations. Most of these capabilities are world-unique, including the largest space simulation chamber, the largest mechanical vibration table, the most powerful resonant 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, the only cold soak start/restart rocket engine test facility, and the only clean air hypersonic tunnel. Since 2000, over \$567 million has been invested in Plum Brook station. The total replacement cost of all Plum Brook Station facilities is approximately \$4 billion.

¹¹ 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).
- Provide the Solar Electric Propulsion Module for the Asteroid Redirect/Retrieval Mission. Propose extension of this technology and vehicle for Human exploration cargo transfer vehicles.
- 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 space life and 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, 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.
- Supporting safe and reliable operation of the International Space Station's electrical power system.

Space Technology

- Leading the development of Solar Electric Propulsion technology, and the Solar Electric Propulsion Module, 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 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 Discovery 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

- Continuing to improve upon Glenn's world-renowned aeronautics' heritage by concentrating research and program management efforts on the mastery of the

principles of propulsion, flight in any atmosphere at any speed and the enhancement of aviation safety.

- Supporting the ARMD Research Thrusts in: Safe efficient growth in global operation, Transition to Low Carbon Propulsion, Innovation in Commercial Supersonic Aircraft, Real Time, System-wide Safety Assurance, Ultra-Efficient Commercial Vehicles, and Assured Autonomy for Aviation Transformation.

Advanced Air Vehicles Program

- Conducts fundamental research to improve aircraft performance and minimize environmental impacts from subsonic air vehicles.
- Develops and validates tools, technologies and concepts to overcome key barriers, including noise, efficiency, and safety for rotorcraft vehicles.
- Explores theoretical research for potential advanced capabilities and configurations for low boom supersonic aircraft.
- Conducts research to reduce the timeline for certification of composite structures for aviation.
- Ensures the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities to meet Agency and national aeronautics testing needs.
- Glenn provides technical project management leadership for the Advanced Air Vehicle Program, and conducts research for the following projects:

- **Advanced Air Transport Technology Project**

Will clearly define the most compelling technical challenges facing the air transport industry as envisioned for the "N+3" horizon. The research will explore and advance knowledge, technologies, and concepts to enable giant steps in energy efficiency and environmental compatibility resulting in

less fuel burned and less direct impact on the atmosphere. Potential new safety considerations associated with these advanced technologies and concepts will be identified.

– **Revolutionary Vertical Lift Technology (RVLT) Project**

Will clearly define the most compelling technical challenges facing the rotorcraft and vertical lift communities. The ability to leverage vertical flight and hover, with vastly improved noise, efficiency, and safety, has potential to lead to new missions and markets affecting human and cargo transportation and delivery, increased safety and security in constrained landscapes, and sustained and effective surveillance for natural and manmade disasters.

– **Advanced Composites (AC) Project**

Is addressing new test protocols and methods to reduce the development and certification timeline for composite materials and structures, moving away from practices primarily based on testing. Research will focus on the development and use of high fidelity and rigorous computational methods, improved test protocols, and standardized inspection techniques to shorten the timeline to bring innovative composite materials and structures to market.

– **Commercial Supersonic Technology (CST) Project**

Vehicle research includes tools, technologies, and knowledge that will help to eliminate today's technical barriers preventing practical, commercial supersonic flight. These barriers include: sonic boom; supersonic aircraft fuel efficiency; airport community noise; high altitude

emissions; prediction of vehicle control, operation and performance; and the ability to design future vehicles in an integrated, multidisciplinary manner.

– **Aeronautics Evaluation and Test Capabilities (AETC) Project**

Will combine the research, analysis, and test capabilities necessary to achieve future air vehicle development and operations as described above. This integrated approach will require the efficient and effective investment, use, and management of complementary high-end computing capabilities necessary for advanced analyses, wind tunnels, propulsion test facilities, and other NASA-unique test facilities and ground testing capabilities.

Integrated Aviation Systems Program

- Conducts research on promising concepts and technologies at an integrated system level.
- Explores, assesses, and demonstrates the benefits of promising technologies in a relevant environment.
- Conducts research into environmentally responsible aviation and unmanned system integration into the national airspace.
- Supports flight research needs across the ARMD strategic thrusts, programs and projects.
- Glenn provides technical project management leadership for the Integrated Aviation Systems Program, and conducts research for the following projects:

– **Low Boom Flight Demonstrator Project**

ARMD will conduct focused planning of a new project to develop a Low Boom Flight Demonstrator. The objective of this project will be to mature key low boom technologies that have been developed in the Fundamental Aeronautics Program through demonstration of associated benefits in

a realistic flight environment. This will be accomplished by flight validation of design tools and technologies of an aircraft with sonic boom levels acceptable for civil supersonic overland flight.

– **Flight Demonstrations and Capabilities (FDC) Project**

ARMD is increasing the emphasis on flight related research, and the Integrated Aviation Systems Program (IASP) will reflect this emphasis by combining the flight test portion of the former Aeronautics Test Program with flight research and demonstrations from ARMD in the Flight Demonstrations and Capabilities (FDC) Project. This will consist of two distinct components; Flight Capabilities and Flight Demonstrations. The underlying philosophy of this project will be to foster a focus on innovation and flexibility through embracing key attributes of the best practices of the flight research community (e.g. NASA X-planes, Boeing’s ecoDemonstrator with frequent flight demonstrations and disciplined schedules).

– **For FY15:**

The completion of the Environmental Responsible Aircraft (ERA) project: Propulsion Technology Sub-element focused on developing and demonstrating, in collaboration with industry and other government agencies, integrated systems technologies that enable industry to meet the NASA goals for reduction in aircraft emissions, noise, and fuel burn for the 2025 timeframe.

– **For FY15 - FY16:**

Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS): contributes capabilities

that reduce the technical barriers related to the safety and operational challenges associated with enabling routine UAS to the NAS. NASA Glenn has primary responsibility for the communication technology sub-element for the UAS in the NAS.

Transformative Aeronautics Concepts Program (New FY 15)

- Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation.
- Knocks down technical barriers and infuses internally and externally originated concepts into all six strategic thrusts identified by ARMD, creating innovation for tomorrow in the aviation system.
- Provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.
- Glenn provides technical project management leadership for the Transformative Aeronautics Concepts Program, and conducts research for the following projects:

– **Convergent Aeronautics Solutions (CAS) Project (New in FY 15)**

Will use short-duration activities to establish early-stage concept and technology feasibility for high-potential solutions to thrust-aligned major system-level challenges that require NASA and the aviation community to think beyond current concepts, architectures and relationships. The focus of CAS will be on merging traditional aeronautics disciplines with advancements driven by the non-aeronautics world to advance innovative solutions to these barriers to open and enable new capabilities in commercial aviation.

– **Transformative Tools and Technology (TTT) Project (New in FY 15)**

Will 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. These revolutionary tools will be applied to accelerate NASA's research and the community's design and introduction of advanced concepts. TTT will also perform fundamental development of technologies, applicable across ARMD mission programs, such as the understanding of new types of strong and lightweight materials that are vital to aviation.

– **Leading Edge Aeronautics Research for NASA (LEARN) Fund for Non-NASA Researchers (New in FY 15)**

The LEARN Fund annually provides opportunities for innovators from outside NASA to perform research, analysis, and proof-of-concept development of their novel ideas that have the potential to meet national aeronautics needs. The Fund provides resources for early-stage efforts not currently supported by ARMD Programs and Projects, with the goal of infusing promising concepts into the ARMD research portfolio or into NASA's Small Business Innovation Research (SBIR) program for further development. It is open to all domestic researchers. International partners may collaborate with LEARN research teams, but are not eligible to receive funding. NASA civil servants have a similar opportunity through the ARMD Seedling Fund, and are explicitly prohibited from competing for LEARN funding.

Airspace Operations and Safety Program (New in FY 15):

- Develops and explores fundamental concepts, algorithms, and technologies to increase throughput and efficiency of the National Airspace System safely.
- Provides knowledge, concepts, and methods to the aviation community to manage increasing complexity in the design and operation of vehicles and the air transportation system.
- Glenn provides technical project management leadership for the Airspace Operations and Safety Program, and conducts research for the following projects:

– **Airspace Technology Demonstrations (ATD) Project (New in FY 15)**

Provide a strong focus from the current Airspace Systems Program technical content delivering a limited, yet impactful set of transition-able benefits for NextGen covering gate-to-gate elements. This project contributes to the Safe and Efficient Growth in Global Aviation strategic thrust.

– **Technologies for Assuring Safe Energy and Attitude State activities (New in FY 15)**

Will deliver specific R&D products to industry as defined through community planning (Commercial Aviation Safety Team).

- **SMART-NAS Test-Bed for Safe, Trajectory-Based Operations (SMART-NAS) Project (New in FY 15)**
A strong focus will be placed on the SMART-NAS Project to deliver an evaluation capability, critical to the Air Traffic Management community, allowing full NextGen and beyond NextGen concepts to be assessed and developed.

- **Safe, Autonomous Systems Operations (SASO) Project (New in FY 15)**
Will develop autonomous capability in support of the Enable Assured Machine Autonomy for Aviation strategic thrust. Project deliverables will focus initially on development of concepts, requirements, and architectures to accept the broadest set of innovative concepts.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents an economic overview of the NASA Glenn Research Center during FY 2014. Changes between FY 2010 and FY 2014 are described in terms of payroll, revenues, expenditures, academic awards,

occupational distribution, number of employees, employee residence locations, and income taxes paid by NASA Glenn employees.

C.1. EMPLOYMENT AND OCCUPATIONS

The total labor force of NASA Glenn Research Center has two parts, civil service employees and local contractors. Federal laboratories commonly contract companies and individuals for specific tasks and services, which allows for more flexibility in performance and their labor costs. The number of contracted employees can be adjusted quickly to align with the varying amount and nature of the Glenn's scope of work and new projects.

In contrast, the NASA civil service employment has been relatively constant in order to retain workers with long-term core expertise, which is especially important for efficient and effective execution of aerospace projects that often last many years from conception through completion. Over the last five years, from

FY 2010 to FY 2014, NASA Glenn has averaged 1,663 civil service employees yearly.

Table 1 shows the total number of NASA Glenn's civil service employees and the shares of four main occupational categories over time. In FY 2014, NASA Glenn's civil service employment totaled 1,624. During the past five years, Glenn civil service employment had a peak of 1,711 employees in 2011. Between FY 2010 and FY 2011, NASA Glenn's employment increased by 3.2%, however it has since decreased by 5.1% through FY 2014. Overall, during the past five fiscal years, NASA Glenn's civil service employment has decreased by 2.1% (-34 employees). Compared to FY 2013, total Glenn employment decreased by 40 employees or 2.4% in FY 2014.

Table 1. NASA Glenn Civil Service Employment Distribution by Occupational Category, FY 2010-FY 2014

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2010	1,658	20%	4%	65%	11%
2011	1,711	20%	4%	65%	10%
2012	1,659	21%	4%	67%	9%
2013	1,664	21%	3%	68%	8%
2014	1,624	21%	3%	68%	8%

Note: Table does not include local contractors.¹²

¹² A detailed listing of NASA Glenn's local contractors can be found at <http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm>

NASA Glenn's civil service employment consists of four main occupational categories: clerical, technicians, administrative professionals, and scientists and engineers. The occupational structure of NASA Glenn has remained almost unchanged during the past five years.

In FY 2014, scientists and engineers continue to be the largest occupational category, a trend that has continued since before FY 2010. In FY 2014, scientists and engineers accounted for 68% of the civil service employees. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2010 from 65% (1,078 employees) to 68% (1,097 employees) in FY 2014. Although the net growth in this occupational category was 19 employees, a significant increase of the share (3%) is due to overall decreased NASA Glenn employment. However, even this small change is consistent with the long-term shift in the employment share of scientists and engineers over the last 10 years. Between FY 2004 and FY 2014, the share of scientists and engineers has increased from 57% to 68%.

The administrative professional category remains the second-largest occupational group after scientists and engineers, a position which has been held in all prior study years. The administrative professional category's share of total civil service employment has hovered around 20% since before FY 2010. Between FY 2011 and FY 2012, the share of the administrative professional group increased slightly from 20% to 21% and has remained at that level through FY 2014.

The number in clerical occupations accounted for 4% of the total civil service employees between FY 2010 and FY 2012, dropping to 3% in FY 2013, and remaining at that level for FY 2014. Overall, the clerical staff category has seen a decrease of 11 employees since FY 2010.

Over the last five years, the number of technicians employed by NASA Glenn has decreased by 46 employees, from 182 in FY 2010 to 136 in FY 2014. The technician group

accounted for 8% of NASA Glenn's civil service employment in FY 2014. The decrease in employment of technicians between FY 2010 and FY 2014 (dropping from 11% to 8% of total employment) reversely corresponds to the increase in employment of scientists and engineers. Looking back further, this downward trend continues over the long-term with technicians accounting for 17% of the workforce in FY 2004.

NASA Glenn employs highly educated and highly skilled civil service workers; 85% of NASA Glenn's employees had at least a bachelor's degree in FY 2014, increasing from 69% in 2004. Of all NASA Glenn's civil service employees, 18% held doctoral degrees, 37% held master's degrees, and 30% held bachelor's degrees. Compared to FY 2010, the level of educational attainment of NASA Glenn's civil service employees has increased, as the number of employees holding bachelor's degrees or higher increased 4% between FY 2010 and FY 2014. The rising share of scientists and engineers employed at NASA Glenn between FY 2010 and FY 2014 is a contributing factor to the increasing share of highly educated workers, especially those possessing master's degrees.

In addition to its own employment, NASA Glenn engaged 1,673 on- or near-site contractors in FY 2014 (Table 2). During the past five years, NASA Glenn's servicing of local contractors peaked in FY 2010 at 1,912. Since FY 2010, employment dropped by 14% through FY 2013, with the largest drop-off occurring between FY 2011 and FY 2012. However, between FY 2013 and FY 2014 engagement of contractors increased by 30, from 1,643 to 1,673. Yet, between FY 2010 and FY 2014 total on- or near-site contractor employment has decreased by 239 or 12.5%.

The total number of NASA Glenn employees, including both civil service employees and local contractors, was 3,297 in FY 2014. The total labor force peaked in FY 2010 with 3,570 employees, and has since declined to 3,297

(7.6% decrease) by FY 2014. NASA Glenn lost a net 34 civil service employees and lost 239 on- or near-site local contractors between FY 2010 and FY 2014.

Table 2. NASA Glenn On- or Near-Site Contractors Employment, FY 2010-FY 2014

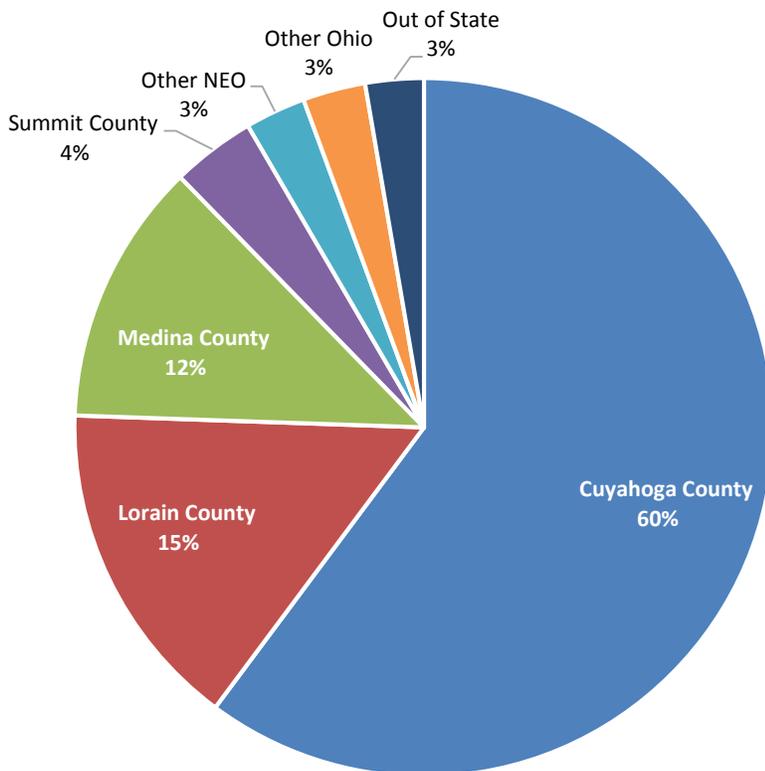
Fiscal Year	Employment of On- or Near-Site Contractors
2010	1,912
2011	1,858
2012	1,688
2013	1,643
2014	1,673

C.2. PLACE OF RESIDENCE FOR GLENN EMPLOYEES

Regarding the regions of study, NASA Glenn Research Center is located in Cuyahoga County, the heart of Northeast Ohio. The geographic site of NASA Glenn is located near Cleveland Hopkins International Airport in the Greater Cleveland Area. NASA Glenn also includes Plum Brook Station, located near Sandusky, Ohio, west of the main facility. Most civil service employees working at NASA Glenn live in Cuyahoga County or the other surrounding counties that comprise Northeast Ohio. Figure 1 shows the breakdown of employees' postal addresses by geographic region. During FY 2014, almost all of NASA Glenn's civil service employees (1,533 employees or 94.4% of the total employment base) resided in Northeast Ohio.

Specifically, 60.2% of civil servants (977 employees) lived in the same county as NASA Glenn. NASA Glenn employees also lived in Lorain (249 employees; 15.4%), Medina (197 employees; 12.2%), and Summit Counties (63 employees; 3.9%), with a small number in other surrounding Northeast Ohio counties. 47 of the total 1,624 employees (2.9%) lived in other than Northeast Ohio locales within Ohio, while 44 employees (2.7%) list a postal address in another state. Compared to FY 2013, the number of NASA Glenn employees who reside in Cuyahoga County has decreased by 28 (-2.8%). Those classified as living out of state, however, increased by 10% (4 employees) between FY 2013 and FY 2014.

Figure 1. NASA Glenn Civil Service Employees by Location of Residence, FY 2014



NASA Glenn’s civil service employees’ places of residence are shown by occupation in Table 3. More than 59.1% of NASA Glenn’s scientists and engineers, administrative professionals, and clerical employees lived in Cuyahoga County in FY 2014, the place of residence of the highest share of employees in each occupational category. Technicians, however, were the least likely to live in Cuyahoga County, with only 52.5% residing there, while scientists and engineers were the most likely, with 61.2% in the county.

Between 4% and 7% of NASA Glenn’s technicians, administrative professionals, and scientists and engineers have postal addresses outside of Northeast Ohio. Clerical employees were most likely to live in Northeast Ohio, with only 2.9% living outside of the region, and none living outside Ohio. Administrative professionals were the least likely to live in Northeast Ohio (6.3%). While scientists & engineers were the most likely to live in Cuyahoga County, they were also the most likely to reside outside Ohio (3.5%).

Table 3. NASA Glenn Civil Service Employees by Occupation and Place of Residence, FY 2014

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	93.7%	97.1%	94.4%	95.9%	94.4%
Cuyahoga County	59.1%	60.0%	61.2%	52.5%	60.2%
Lorain County	18.4%	20.0%	14.2%	16.2%	15.4%
Medina County	10.4%	11.4%	12.2%	18.2%	12.2%
Summit County	4.6%	0.0%	3.9%	3.0%	3.9%
Geauga County	0.3%	5.7%	1.1%	3.0%	1.1%
Portage County	0.9%	0.0%	1.0%	1.0%	0.9%
Lake County	0.0%	0.0%	0.9%	1.0%	0.7%
Ashtabula County	0.0%	0.0%	0.0%	1.0%	0.1%
Remainder of Ohio	4.9%	2.9%	2.1%	4.1%	2.9%
Out of State	1.4%	0.0%	3.5%	0.0%	2.7%

Note: Northeast Ohio component counties sorted by total.

C.3. PAYROLL

NASA Glenn civil service employees received total compensation of \$226.9 million in FY 2014.¹³ In this report, total compensation includes both payroll (\$177.9 million) and employee benefits (\$49.0 million). Between FY 2013 and FY 2014, total compensation slightly decreased, by \$499,116 (-0.2%).¹⁴ Additionally, between FY 2010 and FY 2014, total compensation fell by \$12.2 million (-5.1%). However, nominal spending increased during that same period.¹⁵

In FY 2014, NASA Glenn payroll stood at \$177.9 million, representing a decrease of \$1 million (-0.5%) since FY 2013.¹⁶ Between FY 2010 and FY 2014, payroll dropped by \$14.3 million, for a decrease of 7.4%.¹⁷

Between FY 2010 and FY 2014, the change in total compensation and the change in payroll demonstrate that employee benefits have increased at a rate that partially offsets the declining real value of payroll. In 2010, payroll made up 80.4% of total compensation. By 2014, however, this had dropped to 78.4%.

The declining value of payroll as a component of total compensation can also be seen in the gradual changes in the average wage per employee. This calculation takes into account only the labor component of compensation, excluding benefits. Between FY 2010 and FY 2014 the average wage per civil service employee, after adjusting for inflation, dropped from \$115,887 to \$109,514, a decrease of 5.5%.¹⁸ The average wage per civil service employee, however, increased by 1.9% from \$107,466 in FY 2013 to \$109,514 in FY 2014.¹⁹

¹³ All dollar value comparisons in this section are adjusted for inflation.

¹⁴ Total nominal compensation *increased* by 1.2% (\$2.8 million) between FY 2013 and FY 2014.

¹⁵ Total nominal compensation *increased* by 2.3% (\$5.2 million) between FY 2010 and FY 2014.

¹⁶ Total nominal payroll *increased* by 0.9% (\$1.6 million) between FY 2013 and FY 2014.

¹⁷ Total nominal payroll decreased by 0.2% (\$0.3 million) between FY 2010 and FY 2014.

¹⁸ The average wage per employee in nominal terms *increased* 2.2% (\$2,059) between FY 2010 and FY 2014.

¹⁹ The average wage per employee in nominal terms *increased* 3.4% (\$3,587) between FY 2013 and FY 2014.

C.4. NASA GLENN EXPENDITURES, FY 2014

In FY 2014, NASA Glenn allocated its spending of \$388.7 million to vendors in 47 states, Washington, D.C., Puerto Rico, and six foreign countries. In FY 2014, NASA Glenn decreased its total expenditures by 1.8% compared to \$395.9 of expenditures in FY 2013 (a drop of \$7.2 million in nominal dollars). Total expenditures decreased by 29.7% (\$164 million) between FY 2010 and FY 2014.

When adjusted for inflation to 2013 dollars, the drop in expenditures is larger.²⁰ Between FY 2013 and FY 2014, expenditures dropped by 3.4% (\$13.6 million). Compared to FY 2010, expenditures for FY 2014 dropped by more than 35%, representing a reduction of \$211.6 million in constant 2014 dollars.²¹

Figure 2 shows the geographic distribution of NASA Glenn's spending during FY 2014. Ohio was the largest beneficiary of expenditures, receiving \$275.5 million of NASA Glenn's total expenditures. With an \$866,520 increase (in nominal dollars) compared to FY 2013, the share of NASA Glenn's expenditures in Ohio increased from 69.4% in FY 2013 to 70.9% in FY 2014.

Northeast Ohio received \$225.6 million of NASA Glenn's total expenditures in Ohio, accounting for 81.9% of total Ohio spending in FY 2014. Northeast Ohio accounted for 58.1% of NASA Glenn's total spending in FY 2014. Cuyahoga County was by far the largest recipient of NASA Glenn spending in Northeast Ohio, accounting for 98.7% of said spending. Additionally, Cuyahoga County represented 80.8% of spending in Ohio as well as 57.3% of total NASA Glenn spending in FY 2014.

Other than Ohio, three states (Maryland, California, and Connecticut) each received over \$12 million or at least 3.2% of NASA Glenn's total expenditures during FY 2014. Maryland received \$24.6 million (6.3%), California \$17.3 million (4.4%), and Connecticut \$12.6 million (3.2%), making them the second-, third-, and fourth-largest beneficiaries of NASA Glenn spending. Maryland and Connecticut saw nominal increases in spending when compared to FY 2013, \$7.5 million and \$5.3 million, respectively. California saw a nominal decline of \$3.9 million in spending compared to FY 2013.

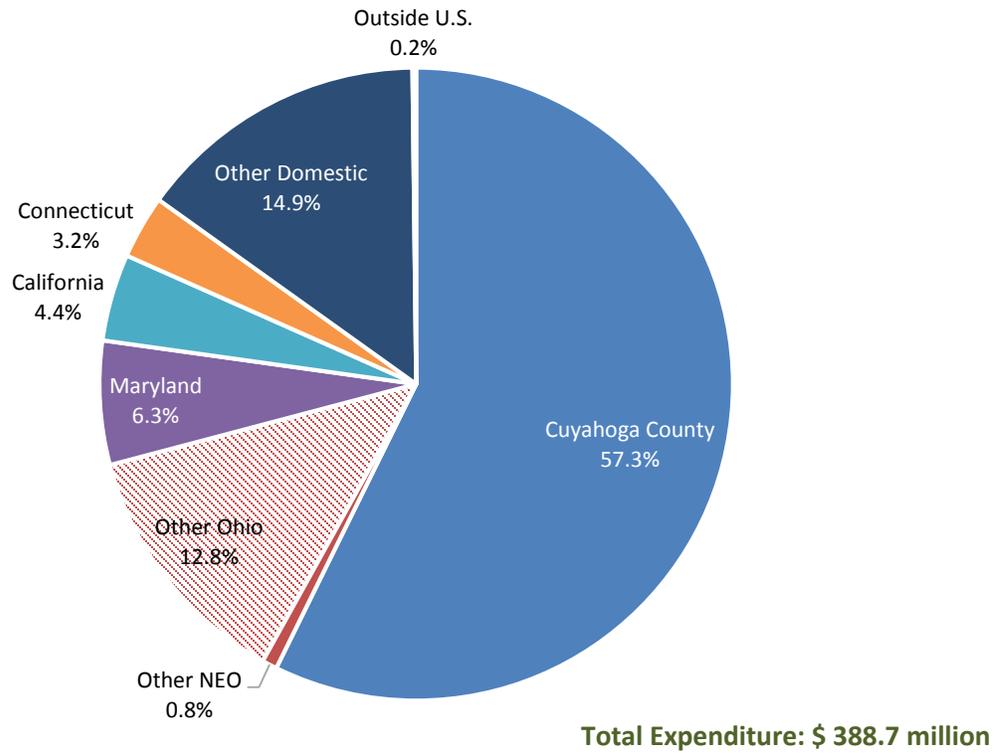
Aside from the three states listed above, Massachusetts saw the largest nominal dollar decline in expenditures at \$3.0 million. Two other states with large declines included New York (\$2.5 million) and New Jersey (\$2.4 million). Wyoming represented the highest percent decline in spending with a drop of 95.6% from FY 2013. In addition to receiving the second highest amount of NASA Glenn's total expenditures, Maryland was also the largest beneficiary of new spending in FY 2014, seeing an increase of \$7.5 million when compared to FY 2013. (See Appendix Table A.1. for more information.)

In FY 2014, NASA Glenn decreased its expenditures in foreign countries by 3.0% compared to FY 2013, to \$734,480. This spending made up only 0.2% of NASA Glenn's total expenditures in FY 2014. The largest recipients were the United Kingdom with \$0.5 million and Canada with \$0.2 million. (See Appendix Table A.1. for more information.)

²⁰ Inflation was adjusted using CPI-U for the Cleveland MSA.

²¹ Constant or real dollar is an adjusted for inflation value of currency used to compare dollar values from one period to another.

Figure 2. NASA Glenn Spending in Selected Regions, FY 2014



C.5. NASA GLENN AWARDS TO ACADEMIC AND OTHER INSTITUTIONS

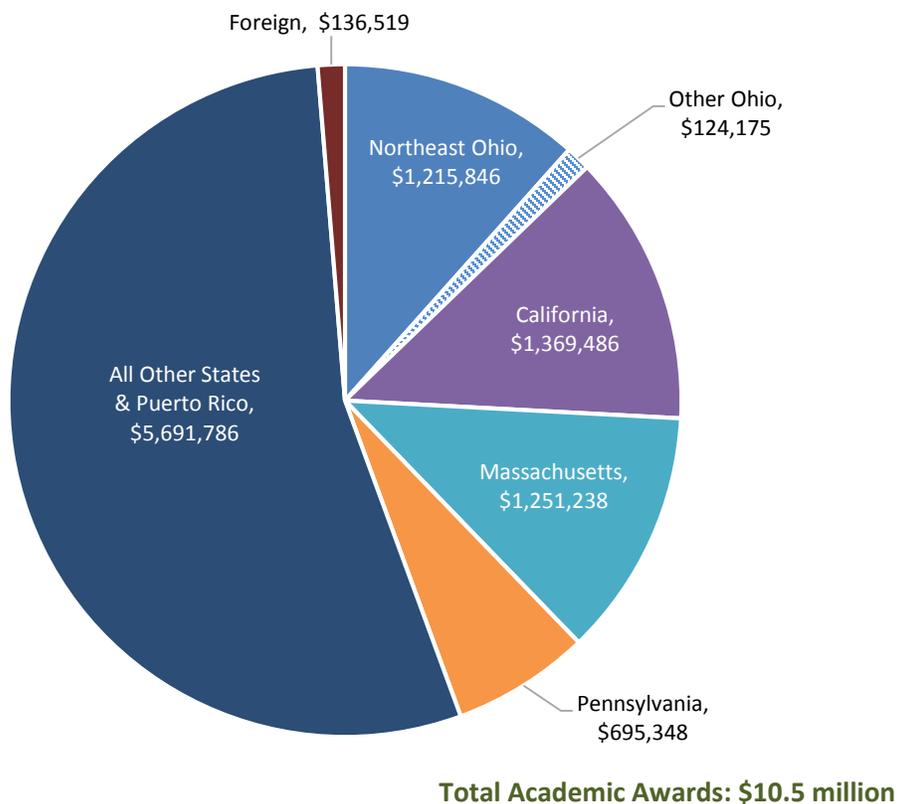
NASA Glenn Research Center awards funding to colleges, universities, and other nonprofit institutions in the form of R&D contracts and grants for assisting NASA in their R&D activities. The amount of NASA Glenn’s funding to academic and major institutions is driven by NASA Glenn’s goals and mission for each year.

NASA Glenn awarded \$10.5 million to colleges and universities in 32 states, Washington, D.C., Puerto Rico, and Great Britain in FY 2014. Compared to FY 2013, this represented a large

reduction of academic grants from NASA Glenn totaling \$5.8 million (-35.4% in nominal dollars).

Figure 3 shows the distribution of funding awarded to colleges and universities with emphasis on select states. The academic funding awarded in the top four states in FY 2014 collectively accounted for 44.4% of the total grants, compared to the top four states representing 56.1% of total grants during FY 2013. (See Appendix Table A.2. for more information.)

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2014



Notes:
 Figures in nominal dollars
 “Other Ohio” refers to colleges and universities located outside the 7-county definition of Northeast Ohio used in this report.

Academic institutions in Ohio received \$1.3 million of NASA Glenn's academic awards in FY 2014, which accounted for the second largest share (12.8%), after California (13.1%). NASA Glenn's academic awards to Ohio decreased substantially, by 68.9% (-\$3.0 million), between FY 2013 and FY 2014.

Within the state of Ohio, academic institutions in Northeast Ohio received \$1.2 million in FY 2014. Northeast Ohio academic institutions accounted for both 11.6% of NASA Glenn's total academic awards and 90.7% of all academic grants given in Ohio. Compared to FY 2013, NASA Glenn reduced its awards to the universities and academic institutions in Northeast Ohio by 51.7% (-\$1.3 million). NASA Glenn's funding to Ohio academic institutions located outside of Northeast Ohio's eight counties decreased by 93.1% (-\$1.7 million) compared to FY 2013.

In FY 2014, the state of California received \$1.4 million, Massachusetts received \$1.3 million, and Pennsylvania received \$0.7 million in academic grants from NASA Glenn. (See Appendix Table A.2. for more details/information.)

Table 4 shows the distribution of NASA Glenn awards to colleges and universities in Ohio from FY 2010 to FY 2014 (inflated to 2014 dollars). Total academic grants awarded in Ohio decreased by 50%, from \$7.8 million in FY 2010 to \$1.3 million in FY 2014. In keeping with the downward trend of NASA Glenn's academic awards, between FY 2013 and FY 2014 NASA Glenn reduced its academic funding to Ohio universities and colleges by 69.4% or \$3.0 million (adjusted to 2014 dollars).

The University of Akron and Case Western Reserve University each received more than \$0.5 million from NASA Glenn in FY 2014. The University of Akron received the highest

amount of funding in FY 2014, a position it has held since FY 2013. The University of Akron, with funding in the amount of \$0.6 million, accounted for 45.8% of total awards to colleges and universities in Ohio in FY 2014. Academic awards to the University of Akron decreased by 67.1% (\$1.3 million) between FY 2013 and FY 2014. On the other hand, NASA Glenn's academic funding to Case Western Reserve University increased by 63.3% (\$0.2 million) from FY 2013 to FY 2014. Case Western educational grants represented 37.4% of total awards to colleges and universities in Ohio.

In FY 2014, Cleveland State University received \$0.1 million, Ohio University received \$69,000, and the University of Toledo received \$35,174. The University of Toledo, who until FY 2012 received the largest share of funding of academic institutions in Ohio, was awarded considerably less in FY 2014 compared to FY 2013 (\$35,174 compared to \$1.6 million, a 97.8% decrease).

Table 4. NASA Glenn Educational Grants in Ohio by Academic Institution, FY 2010-FY 2014

OHIO COLLEGES & UNIVERSITIES	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2014 Share
University of Akron	\$3,009,697	\$1,446,031	\$1,554,160	\$1,867,218	\$614,322	45.8%
Case Western Reserve University	\$904,296	\$840,309	\$698,369	\$306,478	\$500,578	37.4%
Cleveland State University	\$1,110,429	\$741,782	\$548,888	\$382,049	\$100,946	7.5%
Ohio University	\$211,006	\$190,309	\$177,484	\$92,672	\$69,000	5.1%
University of Toledo	\$686,478	\$2,140,719	\$1,588,347	\$1,618,461	\$35,174	2.6%
Ohio State University	\$1,575,699	\$555,284	\$386,429	\$57,580	\$18,001	1.3%
Wright State University	\$18,367	\$34,449	\$0	\$0	\$2,000	0.1%
University of Cincinnati	\$293,760	\$183,449	\$132,836	\$42,316	\$0	0%
Kent State University	\$379	\$19,439	\$0	\$5,707	\$0	0%
Total	\$7,810,111	\$6,151,771	\$5,086,513	\$4,372,481	\$1,340,021	

Notes:

Table is sorted by FY 2014 column.
Data inflated to 2014 dollars.

C.6. NASA GLENN REVENUES

NASA Glenn’s total revenue in FY 2014 was \$677.9 million. Of the past five years, NASA Glenn’s total revenue was lowest in FY 2013 but increased slightly in FY 2014. Revenues increased in FY 2014 by \$22.9 million (3.5%) from the previous year. However, NASA Glenn’s overall revenue has decreased by \$58.3 million (-7.9%) from FY 2010 to FY 2014 (in nominal dollars).

Table 5 shows NASA Glenn’s revenue by source from FY 2010 to FY 2014. NASA Glenn’s revenue consists of two sources: NASA direct authority and reimbursable commitments. The share of revenue from NASA’s direct authority has steadily declined between FY 2010 and FY 2014, dropping from 95.8% to 91.3%. In FY 2014, NASA Glenn received \$618.8 million of revenue directly from NASA and an additional \$59.1 million from reimbursable commitments.

As shown in Table 5 below, the growth in reimbursable funding is significant—representing more than 92% growth from the FY 2010 level and reflecting a growing diversity

of non-NASA customers doing business with NASA Glenn in recent years. Within the past year, Glenn’s revenues from reimbursable commitments have increased by 27.2% (\$12.7 million in nominal dollars) from FY 2013 to FY 2014. Increases in commercial investments in NASA Glenn have spurred this growth in reimbursable commitments, which have more than doubled over the past five years, with 17.9% growth between FY 2013 and FY 2014.

Federal sources remain the largest source of revenue for reimbursable commitments, however, accounting for 67% or \$39.5 million. From FY 2013 to FY 2014, reimbursable commitments from the Department of Defense showed a 49.2% increase, driven largely by the U.S. Air Force, which had a \$11.2 million (127%) increase. In FY 2014, the Department of Defense accounted for the largest share of total reimbursable commitments (34.7%), with other federal agencies (32.1%) and domestic and non-federal entities (33.2%) accounting for the balance.

Table 5. NASA Glenn Revenues, FY 2010-FY 2014

Revenue Source	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
NASA Direct Authority	\$705,550	\$696,917	\$647,256	\$608,600	\$618,825
Reimbursable Commitments	\$30,682	\$41,680	\$40,402	\$46,457	\$59,112
Total FY Authority	\$736,232	\$738,597	\$687,657	\$655,057	\$677,937
Revenue from NASA	95.8%	94.4%	94.1%	92.9%	91.3%

Note: Data in thousands of nominal dollars.

C.7. TAXES PAID BY NASA GLENN EMPLOYEES

Income taxes paid directly to state and local governments by NASA Glenn employees play an important role in the regional economies of Northeast Ohio and the state of Ohio. NASA Glenn is located in the cities of Brook Park, Fairview Park, and Cleveland, which affects the distribution of income tax paid by Glenn employees.

Table 6 shows the amount of income taxes withheld from the paychecks of NASA Glenn employees and sent directly to federal, state, and local governments. These taxes exclude those paid by Glenn employees to local governments based on their place of residence. The total income tax paid by NASA Glenn's employees was substantially higher in FY 2014 than in previous years, due to the inclusion of federal taxes (\$24.0 million in FY 2014).

Excluding federal taxes, in FY 2014 NASA Glenn's employees paid \$9.1 million in income taxes. This represented a decrease of 3.7% from FY 2013, a drop of nearly \$350,000 (in nominal dollars). Compared to FY 2010, NASA Glenn employees paid \$679,531 less in income taxes in FY 2014 (in nominal dollars).

Accounting for 99.6% of the total state and local income taxes paid in FY 2014, the state of Ohio and the city of Brook Park were the two largest recipients of income taxes paid by NASA Glenn's employees. The state of Ohio's share of income tax in FY 2014, excluding federal taxes, was 63.0% (\$5.7 million). Over the past five years, NASA Glenn employees paid annually an average of more than \$6.1 million in income taxes to the state of Ohio. The city of Brook Park received \$3.3 million in income tax from NASA Glenn employees in FY 2014, a slight decrease (0.7%) compared to FY 2013.

NASA Glenn employees paid \$25,180 in income tax to the city of Fairview Park in FY 2014. This represented an 84.4% decrease in income tax paid by NASA Glenn workers to the city of Fairview Park between FY 2010 and FY 2014. This large decrease in taxes occurred due to the relocation of civil servants from facilities in Fairview Park to the main campus in 2010. In addition, income tax paid to the city of Cleveland remained very low, peaking in FY 2012 at \$14,205. In FY 2014, NASA Glenn employees paid \$7,009 in income taxes to the city of Cleveland, a decrease of almost 50% when compared to FY 2013.

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
2010	\$3,264,189	\$11,465	\$160,915	\$6,346,527		\$9,783,096
2011	\$3,421,825	\$12,755	\$26,097	\$6,384,735		\$9,845,412
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

Note: Data in nominal dollars.

D. ECONOMIC IMPACT OF NASA GLENN

This section discusses the methodology and results of research on the economic impact of NASA Glenn on Northeast Ohio and the state of Ohio in FY 2014²². Total impact is measured in terms of output (sales); employment; value added; household earnings; and taxes contributed to local, state, and federal governments. In FY 2014, data became available on the federal taxes paid by NASA Glenn employees. This figure

was added to the total tax impact created by NASA Glenn in FY 2014.

Each of these categories is estimated as the sum of three components: direct impact, indirect impact, and induced impact.²³ NASA Glenn's total impact on Northeast Ohio and the state of Ohio are estimated separately.

D.1. METHODOLOGY

The estimate of NASA Glenn's economic impact is based on the assumption that NASA Glenn established its operations in the region at the beginning of FY 2014 and generated a demand for its operation by purchasing goods and services from the supply companies across a number of industries.

households. Assessment of the intermediate goods purchases is reflected in the indirect economic impact and the spending pattern of NASA Glenn employees and employees of their suppliers is reflected through the assessment on induced effects.

This new demand is called "change in final demand," which represents the direct impact of NASA Glenn spending.²⁴ The increase in demand from NASA's expenditures (i.e. change in final demand) in the region generates an economic impact on Northeast Ohio and Ohio. The study is using an input-output model reflecting the buy-sell relationships among all industry sectors within the region of study.

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

In order for NASA Glenn to perform research and development services, it needs to buy supplies (goods and services) as intermediate inputs. Additional impact on the economy is assessed from other purchases occurred from income received by NASA Glenn employees who buy goods and services for their

For the calculation of direct value added impact, we treated NASA Glenn as a research and development institution, assuming that NASA Glenn's intermediate expenditure pattern is similar to other research institution in the research area.

²² For this analysis, Northeast Ohio is limited to eight counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit.

²³ The change in final demand is the direct economic impact created by NASA Glenn on Northeast Ohio and Ohio.

²⁴ Change in final demand or direct impact, is defined as the total purchases of goods and services for NASA Glenn's overall operations.

Economic impact analysis takes into account inter-industry buy-sell relationships within the respective economy in the research area (NEO or Ohio). These relationships determine how the economy responds to changes in economic activity. Input-output (I-O) models estimate inter-industry relationships in a county, region, 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 how the impact of one additional dollar or one additional job required for NASA Glenn operation ripples through the target economies, creating additional expenditures and jobs. The economic multiplier measures the extent of the ripple effect that an initial expenditure has on the regional economy.²⁵

This study utilizes regional I-O multipliers from the IMPLAN Professional model.²⁶ Specifically, SAM multipliers are used to estimate the ripple effect that an initial expenditure made by NASA Glenn has on the regional economy.²⁷ For this study, we used the method called "bill of goods" and applied it to industry change. We matched each category of NASA Glenn's expenditures to the industry from which it buys products. This technique enables the research to match goods that NASA Glenn bought to goods and services produced by different industries in the targeted region.

²⁵ 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.

Three factors need to be addressed when estimating economic impact: (1) purchases from companies located outside of the study's region need to be excluded, (2) total payroll accounting for the commuting pattern of NASA Glenn employees who live outside the study area needs to be adjusted, and (3) the share of revenues received from local sources needs to be considered. For this analysis, NASA Glenn's economic impact on the Northeast Ohio economy is generated only by purchases of goods produced from 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 from companies located in Ohio. Therefore, when estimating the impact on Northeast Ohio, goods and services purchased from businesses and other entities located outside of the 8-county region were excluded from the model. Likewise, all goods and services purchased from businesses and entities located outside of the state were excluded when estimating the impact on the state of Ohio.

The local spending of employees residing outside of the 8-county region for the Northeast Ohio economic impact and outside of the state of Ohio for Ohio economic impact were included via adjustments of total payroll by commuting pattern. IMPLAN takes into account 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

²⁶ 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.

²⁷ 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.

total payroll by this difference, assuming that the commuting employees still spend part of their income in the area where they work. Because all of NASA Glenn's revenues were received from federal sources (from outside of the study area), no further adjustments were required.

The economic impact is measured in terms of five variables: employment, labor income, value added, output, and taxes:

- Employment impact measures the number of additional 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 output created in the region as a result of NASA Glenn expenditures. Value added is calculated as output less the value of intermediary goods.²⁸
- 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.²⁹ Figure 4 illustrates the process by which NASA Glenn impacted Northeast Ohio economy through its spending in the region in FY 2014.

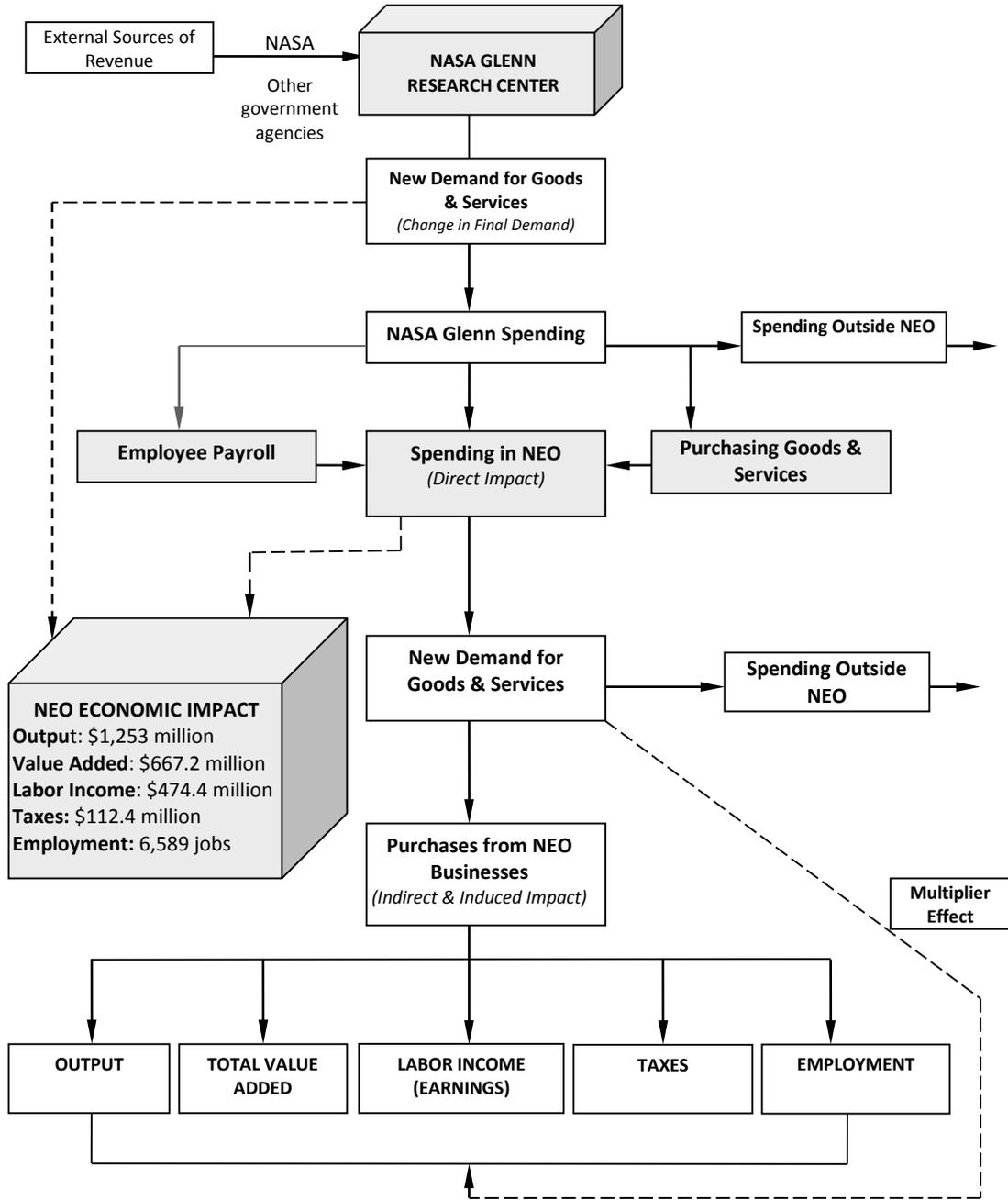
Through its attraction of federal dollars, NASA Glenn created new demand for goods and services (change in final demand, which is also treated as a direct impact). Some of this demand was generated for goods and services provided by vendors outside Northeast Ohio and Ohio, resulting in dollars leaking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

²⁸ 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.

²⁹ The summation of direct, indirect, and induced impacts across industries in the impact tables (Tables

7-14) may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling. According to IMPLAN, the 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 2014



D.2. ECONOMIC IMPACT ON NORTHEAST OHIO, FY 2014

This section describes the economic impact that NASA Glenn created on Northeast Ohio's economy in FY 2014. The analysis includes a detailed overview of the changes in output (sales), employment, labor income (earnings), value added, and taxes generated by NASA Glenn's services in Northeast Ohio.

D.2.1. Output Impact on Northeast Ohio, FY 2014

To calculate an output income, NASA Glenn's expenditures were divided into two groups 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. The second group is considered as a leakage from this region; therefore, these expenditures are not included in the calculations of the output impact on 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. 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. 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. Table A.3., found in Appendix A, provides detailed NASA Glenn expenditures in Northeast Ohio by NAICS industry.

Almost 50% of NASA Glenn spending in Northeast Ohio was for employee compensation. NASA Glenn's largest expenditures on goods and services in Northeast Ohio in FY 2014 were made on scientific research and development services (12.5%), including equipment, supplies and materials, grants, and professional services. The spending that takes place in Northeast Ohio produces significant economic impact on the regional economy.

Table 7 presents the total output impact of NASA Glenn of the economy of Northeast Ohio, comprised of direct impacts, indirect impacts, and induced impacts. NASA Glenn's total expenditures for operations represent the direct output impact for Northeast Ohio. This impact includes the regional margin 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 that supply the producers of the goods and services consumed by NASA Glenn. Lastly, induced impact is estimated from the spending of employees of Glenn and its suppliers.

Table 7. Output Impact in Northeast Ohio, FY 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 37,903	\$ 174,168	\$ 212,071
Mining	\$ -	\$ 432,276	\$ 519,619	\$ 951,895
Utilities	\$ -	\$ 20,061,227	\$ 7,087,639	\$ 27,148,866
Construction	\$ -	\$ 31,983,967	\$ 4,172,764	\$ 36,156,731
Manufacturing	\$ -	\$ 5,069,910	\$ 7,140,309	\$ 12,210,219
Wholesale Trade	\$ -	\$ 3,801,087	\$ 12,542,261	\$ 16,343,348
Retail Trade	\$ -	\$ 7,386,720	\$ 26,439,323	\$ 33,826,042
Transportation and Warehousing	\$ -	\$ 3,718,898	\$ 8,129,618	\$ 11,848,515
Information	\$ -	\$ 5,246,333	\$ 12,921,636	\$ 18,167,969
Finance and Insurance	\$ -	\$ 8,855,805	\$ 35,595,192	\$ 44,450,997
Real Estate and Rental	\$ -	\$ 16,337,161	\$ 59,671,712	\$ 76,008,873
Professional, Scientific, and Tech Services	\$ -	\$ 143,198,149	\$ 12,862,803	\$ 156,060,951
Management of Companies	\$ -	\$ 3,652,624	\$ 4,031,983	\$ 7,684,607
Administrative and Waste Services	\$ -	\$ 73,334,252	\$ 8,301,442	\$ 81,635,694
Educational Services	\$ -	\$ 8,288,486	\$ 5,916,551	\$ 14,205,037
Health and Social Services	\$ -	\$ 737	\$ 51,857,394	\$ 51,858,131
Arts, Entertainment, and Recreation	\$ -	\$ 1,137,188	\$ 5,778,779	\$ 6,915,967
Accommodation and Food Services	\$ -	\$ 2,668,857	\$ 18,038,130	\$ 20,706,987
Other Services	\$ -	\$ 4,115,660	\$ 14,384,116	\$ 18,499,776
Government & non-NAICs	\$ 612,476,382	\$ 1,636,450	\$ 4,357,350	\$ 618,470,182
Total Output	\$ 612,476,382	\$ 340,963,688	\$ 299,922,788	\$ 1,253,362,858

For output impact, the change in final demand or direct impact (\$612,476,382) 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 \$615,510,534 in 2014 dollars equates to \$612,476,382 while adjusted for inflation and shown in the table in 2015 dollars (Inflation based on CPI U for the Cleveland MSA as of Q1 2015 is running at -0.51%).

The total output impact of NASA Glenn on Northeast Ohio was \$1.253 billion in FY 2014. NASA Glenn's \$612 million worth of expenditures resulted in an output (sales) change of \$1.253 billion across all industry sectors (Table 7). For example, NASA Glenn's spending caused a \$156.1 million increase in total sales by all professional, scientific, and technical services industries and a \$36.2 million increase in sales (direct, indirect, and induced impacts) by the construction industry. Furthermore, if NASA Glenn did not exist in Northeast Ohio, the regional economy would suffer an \$81.6 million decrease in output in the Administrative and Waste Services industry. Thus, the impact of NASA Glenn's presence in the area is represented 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, 48.9% (\$612.5 million in 2015 dollars) is accounted for by NASA Glenn's direct spending, which constitutes the direct economic impact to Northeast Ohio. The remaining output impact of \$640.9 million (51.1%) is due to the indirect and induced components as NASA Glenn purchases directly from companies and first-round suppliers ripple through the economy.

A detailed analysis of the IMPLAN models' results indicates that the \$640.9 million change in output (sales) due to indirect and induced economic impacts can be divided into three broad categories: NASA Glenn-driven industries, consumer-driven industries, and other industries. NASA Glenn-driven industries are industries that increase sales, employment, and earnings

primarily due to NASA Glenn's operations. Among these industries are utilities, construction, information, professional and scientific services, administrative and support services, and education. The increase in output due to indirect and induced economic impacts for these industries in FY 2014 was \$333.4 million or 54.4% of NASA Glenn's overall indirect and induced impact on Northeast Ohio.

The 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 increase in output due to indirect and induced economic impacts for these industries in FY 2014 was \$238.8 million, or 39%, of the total impact.

Other industries are those that are driven by both NASA Glenn and consumer spending, but their impact is split between NASA Glenn and other businesses in the region and cannot 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 2014 was \$39.8 million or 6.5% of the total impact.

The output distributions for select NASA Glenn-driven industries and consumer-driven industries are shown in Figure 5 and

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.

Figure 6, respectively. Each of the industries presented in Figure 5 had additional sales of at least \$15 million in FY 2014. Each of the industries presented in Figure 6 had additional sales of at least \$8 million in FY 2014.

The scientific research and development industry generated the largest output impact; it increased by \$74.9 million in FY 2014 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 \$74.9 million accounted for 22% of the \$333.4 million increase in output for all NASA Glenn-driven industries. Other industries shown in Figure 5 can be interpreted similarly.

Figure 6 presents consumer-driven industries of the economy that saw large increases in sales. The imputed rental activity industry generated the largest output impact; it increased by \$36.3 million in FY 2014 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 \$36.3 million accounted for 15% of the \$238.8 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 2014

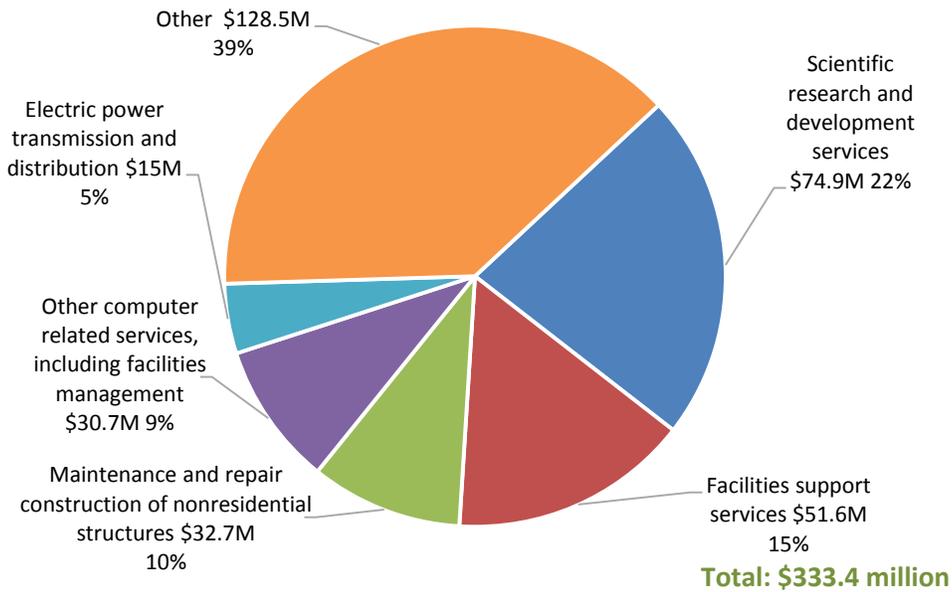
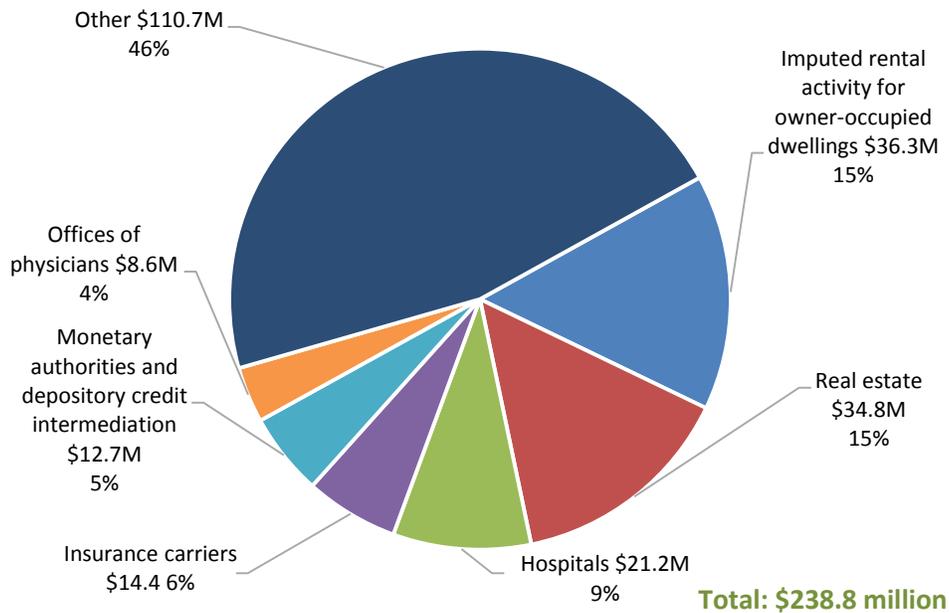


Figure 6. Increase in Sales for Select Consumer-Driven Industries in Northeast Ohio, FY 2014



D.2.2. Employment Impact on Northeast Ohio, FY 2014

NASA Glenn’s operation in Northeast Ohio supported existing jobs and created new full-time and part-time jobs in addition to its own employment (change in final demand or direct impact). NASA Glenn’s spending triggered increased employment in industries which provide supplies to NASA Glenn operations (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 employment (direct impact), indirect impact, and induced impact. Table 8 shows the number of new and supported jobs by industry sector.

Table 8. Employment Impact in Northeast Ohio, FY 2014

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	0	1	4	5
Mining	0	1	1	1
Utilities	0	22	6	27
Construction	0	211	22	234
Manufacturing	0	17	17	33
Wholesale Trade	0	17	55	72
Retail Trade	0	123	343	466
Transportation and Warehousing	0	26	55	81
Information	0	16	37	53
Finance and Insurance	0	41	169	210
Real Estate and Rental	0	71	111	182
Professional, Scientific, and Tech Services	0	930	95	1,025
Management of Companies	0	15	17	32
Administrative and Waste Services	0	831	129	960
Educational Services	0	208	92	301
Health and Social Services	0	0	530	530
Arts, Entertainment, and Recreation	0	16	74	89
Accommodation and Food Services	0	46	311	356
Other Services	0	36	241	277
Government & non-NAICs	1,624	9	21	1,654
Total Employment	1,624	2,635	2,330	6,589

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 2014 was 6,589 jobs. Of these 6,589 jobs, 1,624 (24.6%) were directly employed at NASA Glenn Research Center. As a result of Glenn's direct spending on goods and services, an additional 2,635 full-time and part-time jobs (40%) were supported and created in the region as indirect economic impact. The rest of the employment impact, 2,330 jobs (35.4%), was created as induced impact due to spending of NASA Glenn and suppliers' employees made through industries in the regional economy. These industries produce products that are typically within a consumer purchasing pattern of the region.

Of the 4,965 jobs created in Northeast Ohio due to the indirect and induced impacts, 2,600 (52.4%) were in NASA Glenn-driven industries, 1,895 (38.2%) were in consumer-driven industries, and 470 (9.5%) were in other industries.³¹ The job distribution for select NASA Glenn-driven industries is shown in Figure 7. The job distribution for select consumer-driven industries is shown in Figure 8. The industries presented in Figures 7 and 8 are the leading industries in terms of most created and supported employment (a minimum of 180 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 396 jobs in FY 2014 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 396 jobs accounted for 15% of the 2,600 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 164 jobs in FY 2014 was due to NASA Glenn's spending that generates labor income in regional supply industries (Figure 8). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily by NASA Glenn employees and other workers participating in the real estate industry in Northeast Ohio. The 164 jobs accounted for 9% of the 1,895 jobs that were created in 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 2014

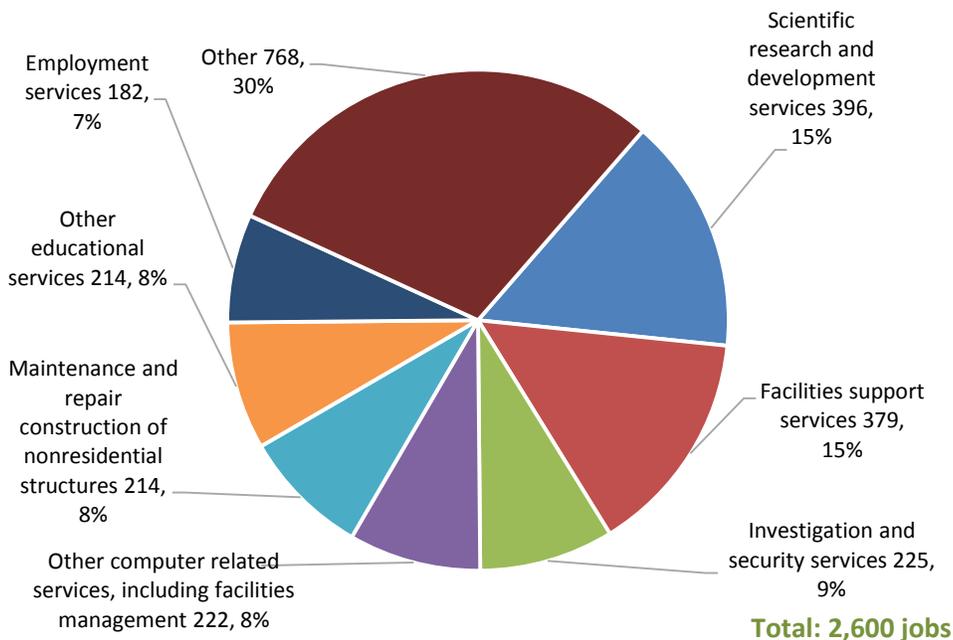
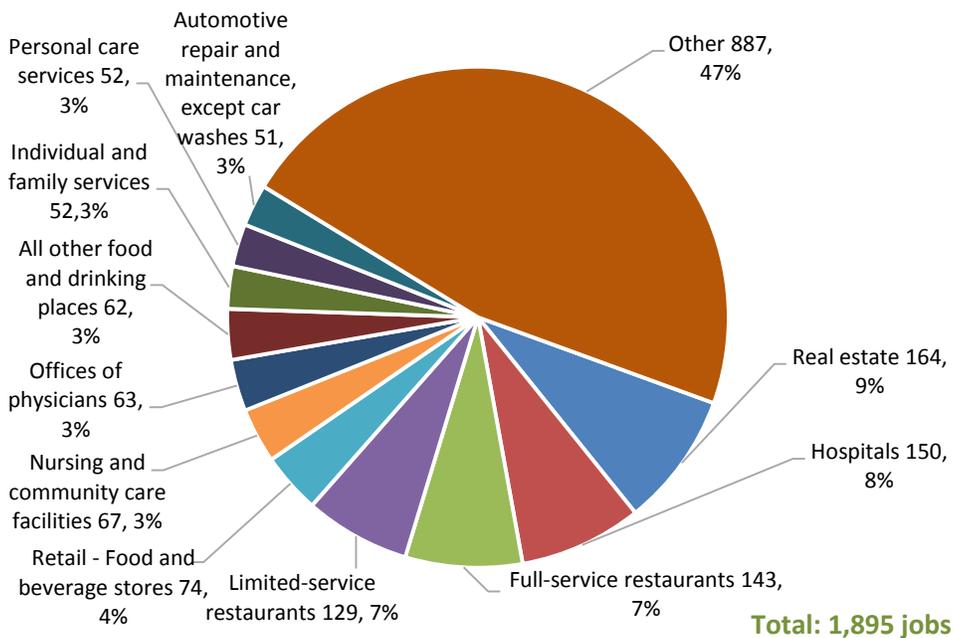


Figure 8. Increase in Jobs for Select Consumer-Driven Industries in Northeast Ohio, FY 2014



D.2.3. Labor Income Impact on Northeast Ohio, FY 2014

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 part of the income that employees who live outside of Northeast Ohio and commute to work spend in the region.

The direct economic impact represents the total compensation NASA Glenn pays its employees within and outside the region. Indirect impact is estimated by summing the money paid to people working for companies that provide products and services purchased by NASA Glenn and 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 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 19,136	\$ 81,379	\$ 100,514
Mining	\$ -	\$ 63,609	\$ 52,076	\$ 115,685
Utilities	\$ -	\$ 2,139,139	\$ 719,628	\$ 2,858,766
Construction	\$ -	\$ 12,257,971	\$ 1,450,220	\$ 13,708,191
Manufacturing	\$ -	\$ 1,135,947	\$ 1,082,770	\$ 2,218,716
Wholesale Trade	\$ -	\$ 1,430,802	\$ 4,675,550	\$ 6,106,351
Retail Trade	\$ -	\$ 3,083,823	\$ 11,109,334	\$ 14,193,157
Transportation and Warehousing	\$ -	\$ 1,335,014	\$ 2,954,981	\$ 4,289,995
Information	\$ -	\$ 1,124,290	\$ 2,495,657	\$ 3,619,947
Finance and Insurance	\$ -	\$ 2,644,634	\$ 10,156,957	\$ 12,801,590
Real Estate and Rental	\$ -	\$ 3,002,465	\$ 4,524,576	\$ 7,527,041
Professional, Scientific, and Tech Services	\$ -	\$ 69,545,578	\$ 7,014,055	\$ 76,559,633
Management of Companies	\$ -	\$ 1,812,453	\$ 2,000,693	\$ 3,813,146
Administrative and Waste Services	\$ -	\$ 33,212,230	\$ 4,500,710	\$ 37,712,940
Educational Services	\$ -	\$ 5,343,394	\$ 3,338,281	\$ 8,681,676
Health and Social Services	\$ -	\$ 368	\$ 29,640,225	\$ 29,640,593
Arts, Entertainment, and Recreation	\$ -	\$ 495,774	\$ 2,057,773	\$ 2,553,547
Accommodation and Food Services	\$ -	\$ 1,079,667	\$ 7,353,225	\$ 8,432,892
Other Services	\$ -	\$ 1,799,802	\$ 8,212,357	\$ 10,012,159
Government & non-NAICs	\$ 226,850,467	\$ 740,385	\$ 1,827,234	\$ 229,418,086
Total Labor Income	\$ 226,850,467	\$ 142,266,479	\$ 105,247,679	\$ 474,364,625

Notes:

Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy.

Total labor income in Northeast Ohio increased by \$474.4 million as a result of NASA operation in FY 2014. Of the \$474.4 million of the total labor income, \$226.9 million (47.8%) constituted wages and benefits paid directly to NASA Glenn employees (i.e., change in final demand or direct effect measured is 2015 dollars). Of the total impact, \$142.3 million (30%) represented indirect impact, or the money paid to employees of companies in Northeast Ohio that supply goods and services to NASA Glenn. The remaining induced earnings were \$105.2 million (22.2%); they occurred as the effects of NASA Glenn's spending rippled through the Northeast Ohio economy via labor income spending.

Of the \$247.5 million increase in labor income generated across Northeast Ohio due to the indirect and induced impacts, \$143.1 million (57.8%) was generated in NASA Glenn-driven industries, \$80.1 million (32.4%) was reported in consumer-driven industries, and \$24.3 million (9.9%) 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. The select industries shown in Figures 9 and 10 each added over \$7 million and \$3 million, respectively.

In the NASA Glenn-driven industries, people who were engaged in scientific research and development services saw their labor income increase by \$30.1 million in FY 2014 (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 \$30.1 million accounted for 21% of the \$143.1 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 \$11.3 million in FY 2014 (Figure 10). These earnings are the summation of the indirect and induced impacts generated by consumer spending for doctors' services. The \$11.3 million accounted for 14% of the \$80.1 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 2014

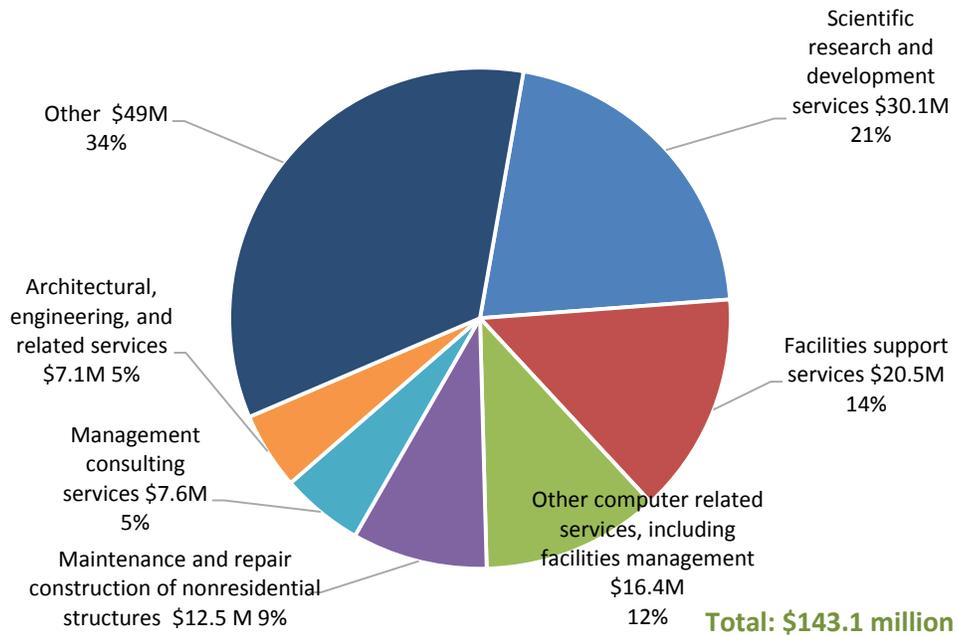
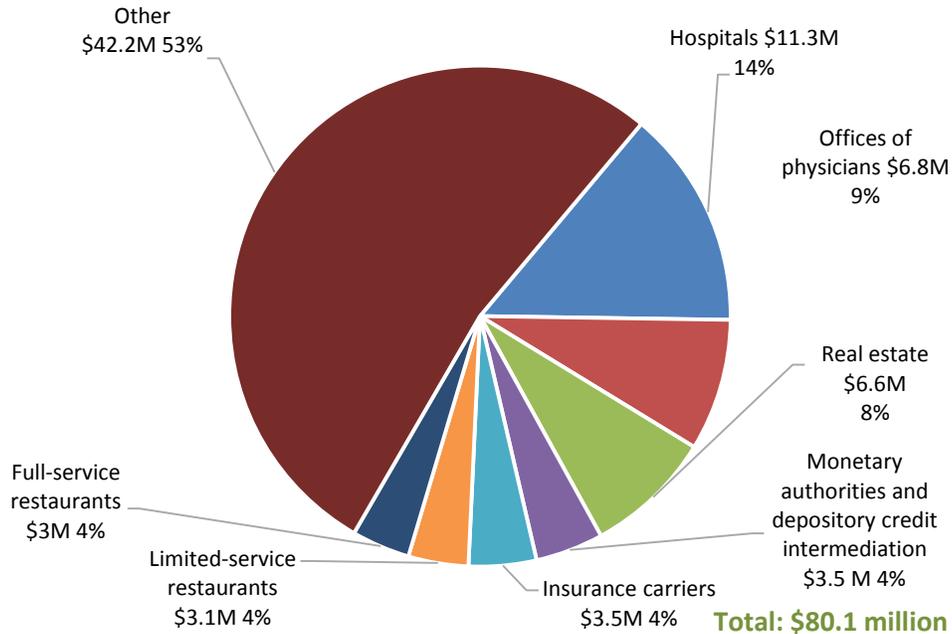


Figure 10. Increase in Labor Income for Consumer-Driven Industries in Northeast Ohio, FY 2014



D.2.4. Value Added Impact on Northeast Ohio, FY 2014

The total value added impact³³ in Northeast Ohio was \$667.2 million, which resulted from NASA Glenn's regional spending on goods and services. NASA Glenn's spending led to a \$667.2 million increase in sales (direct, indirect, and induced impacts) by all industries, excluding intermediary goods and services. The total output less intermediate expenditures, \$300.1 million in FY 2014, constituted the change in final demand (or direct impact) for value added. 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 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 22,419	\$ 109,868	\$ 132,287
Mining	\$ -	\$ 338,905	\$ 426,913	\$ 765,818
Utilities	\$ -	\$ 9,894,682	\$ 3,409,259	\$ 13,303,941
Construction	\$ -	\$ 12,487,288	\$ 1,468,022	\$ 13,955,310
Manufacturing	\$ -	\$ 1,644,629	\$ 2,090,245	\$ 3,734,874
Wholesale Trade	\$ -	\$ 2,547,677	\$ 8,325,257	\$ 10,872,934
Retail Trade	\$ -	\$ 4,577,757	\$ 16,876,432	\$ 21,454,189
Transportation and Warehousing	\$ -	\$ 1,541,786	\$ 3,395,150	\$ 4,936,936
Information	\$ -	\$ 2,155,417	\$ 5,691,128	\$ 7,846,545
Finance and Insurance	\$ -	\$ 4,900,904	\$ 17,442,206	\$ 22,343,109
Real Estate and Rental	\$ -	\$ 12,817,618	\$ 44,475,230	\$ 57,292,847
Professional, Scientific, and Tech Services	\$ -	\$ 77,812,679	\$ 8,549,967	\$ 86,362,646
Management of Companies	\$ -	\$ 2,174,783	\$ 2,400,654	\$ 4,575,437
Administrative and Waste Services	\$ -	\$ 45,581,675	\$ 5,787,325	\$ 51,369,000
Educational Services	\$ -	\$ 5,318,715	\$ 3,582,728	\$ 8,901,443
Health and Social Services	\$ -	\$ 386	\$ 30,990,834	\$ 30,991,220
Arts, Entertainment, and Recreation	\$ -	\$ 583,019	\$ 3,362,400	\$ 3,945,419
Accommodation and Food Services	\$ -	\$ 1,382,364	\$ 9,519,914	\$ 10,902,278
Other Services	\$ -	\$ 2,569,284	\$ 8,971,911	\$ 11,541,195
Government & non-NAICs	\$ 300,113,427	\$ 504,225	\$ 1,347,726	\$ 301,965,378
Total Value Added	\$ 300,113,427	\$ 188,856,211	\$ 178,223,168	\$ 667,192,806

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 51% of total output.

Total value added in Northeast Ohio increased by \$667.2 million in FY 2014 as a result of NASA Glenn's spending on goods and services.

Of this total amount, \$300.1 million (45%) 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 \$188.9 million (28.3%) represented the value of goods and services and fewer intermediary goods of companies in Northeast Ohio that supply NASA Glenn (i.e., indirect impact). The remaining value added impact (induced component) was estimated at \$178.2 million (26.7%). It occurred as a result of NASA Glenn's spending rippling through the Northeast Ohio economy.

Of the \$367.1 million increase in value added generated across Northeast Ohio due to the indirect (\$188.9 million) and induced impacts (\$178.2 million), \$181.7 million (49.5%) was reported in NASA Glenn-driven industries, \$150.3 million (41%) was generated in consumer-driven industries, and \$35.1 million (9.6%) 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 \$7 million and \$4 million each, respectively.

The scientific research and development services industry, the largest NASA Glenn-driven industries, saw a value added increase of \$37.7 million in FY 2014 (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 using scientific research and development services in Northeast Ohio. The \$37.7 million accounted for 21% of the \$181.7 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 \$28.4 million in FY 2014 (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 \$28.4 million accounted for 19% of the \$150.3 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 2014

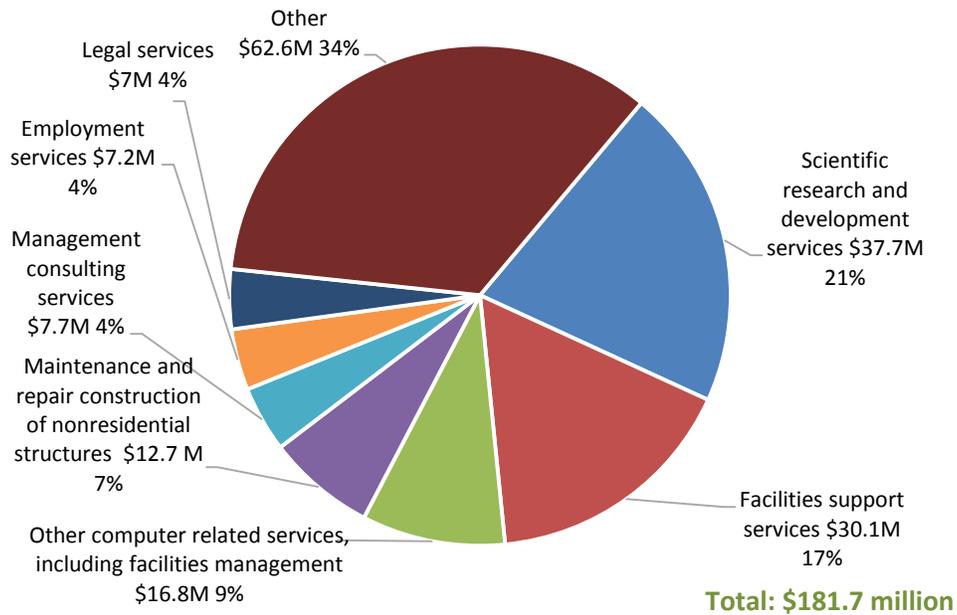
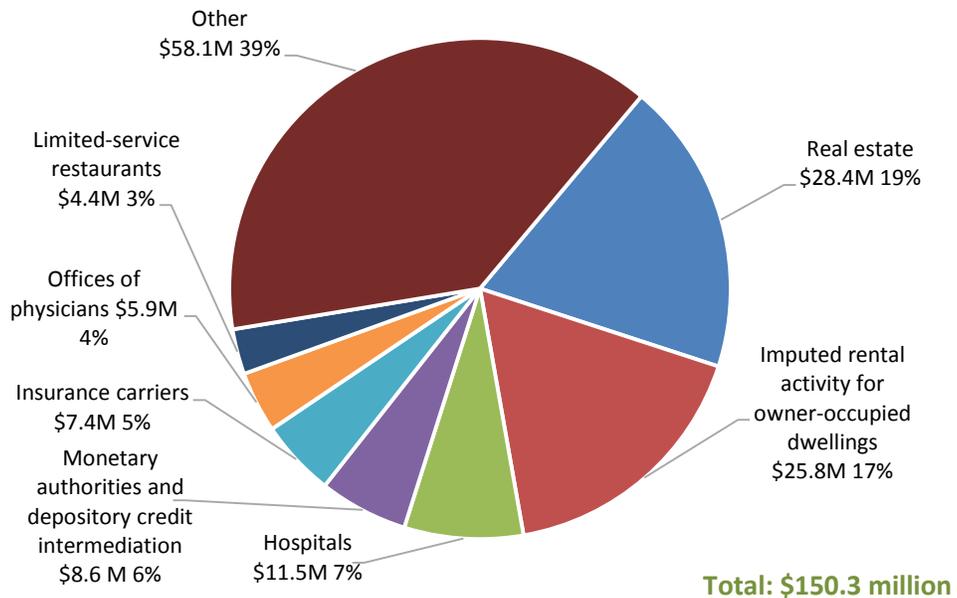


Figure 12. Increase in Value Added for Consumer-Driven Industries in Northeast Ohio, FY 2014



D.2.5. Tax Impact on Northeast Ohio, FY 2014

NASA Glenn’s operation in Northeast Ohio generated a total of \$112.4 million in tax revenues in FY 2014 (in 2015 dollars). The direct tax impact paid by NASA Glenn’s employees was \$32.9 million,³⁵ \$38.6 million was indirect tax impact, and \$40.9 came from induced tax impact.³⁶

D.2.6. FY 2014 Northeast Ohio Impact Summary

Economic activity conducted by NASA Glenn generated the following total economic impact on Northeast Ohio (in 2015 dollars):

- Total Output Impact: \$1,253.4 M
- Total Employment Impact: 6,589 jobs
- Total Labor Income Impact: \$474.4 M
- Total Value Added Impact: \$667.2 M
- Total Tax Impact: \$112.4 M

The economic impact of NASA Glenn Research Center’s activities on Northeast Ohio reflects the benefits of total expenditures of \$734.5 million. These expenditures include a total amount of \$225.6 million spent on purchases in Northeast Ohio in FY 2014 and expenditures on labor income paid to NEO employees and commuters at the amount of \$225.5 million (in 2014 dollars).

Excluding expenditures on labor income, 49.8% (almost \$112.3 million) of NASA Glenn’s expenditures were allocated to professional, scientific and technical services; 26.1% (\$58.9 million) was spent on administrative and support services; and 13.0% (\$29.3 million) was spent on construction – the three largest groups of NASA Glenn expenditures in Northeast

Ohio.³⁷ These three sectors constituted the largest categories of NASA Glenn spending in Northeast Ohio and, together, accounted for almost 90% of all NASA Glenn’s FY 2014 expenditures in Northeast Ohio, excluding labor income. Among other expenditures, utilities accounted for 5.6%; education 3.5%, wholesale and retail trade 1.2%; and manufacturing, 0.6%. Other sectors’ expenditures were less than 1%.

Businesses benefited the most 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 services, accounting services, commercial banks, miscellaneous retailers, real estate companies, motor vehicle dealers, and hospitals and healthcare services.

³⁵ \$33.1 million taxes reported by NASA Glenn as directly paid by its employees in FY 2014 (Table 6), deflated to 2015 dollars.

³⁶ Significant increase in taxes reported in FY 2014 is due to additional data provided by NASA Glenn on direct taxes paid by their employees. In previous reports, only

state and local taxes accounted for the direct tax impact. In this report, the direct tax impact includes local, state and federal taxes paid by NASA Glenn employees.

³⁷ Amounts in parentheses detailing percentage numbers are presented in 2014 dollars and correspond to Appendix Table A.3.

D.3. ECONOMIC IMPACT ON THE STATE OF OHIO, FY 2014

Assessment of the economic impact of NASA Glenn operations on Ohio's economy in FY 2014 followed a methodology similar to the assessment of economic impact of NASA Glenn on Northeast Ohio. For the state of Ohio, we considered all purchases NASA Glenn made from companies located in Ohio. The economic impact is assessed through a detailed analysis of the change in output (sales), employment, labor income, value added and taxes due to NASA Glenn's activities in Ohio. This section follows the structure of Section D.2., Economic Impact on Northeast Ohio, FY 2014.

D.3.1. Output Impact on the State of Ohio, FY 2014

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. This difference is due to a larger geographic area that allows for capturing more purchases within the state compared to Northeast Ohio. 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 of the state of Ohio. Local spending is then categorized by products made in the local economy, based on an IMPLAN classification system of industries that produced the products. 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 amount of 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 direct impact, indirect impact, and induced impact. Table 11 reports output impacts by industry sector, illustrating how NASA Glenn's spending across Ohio affects different sectors of the state economy.

Table 11. Output Impact in the State of Ohio, FY 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 163,321	\$ 1,178,799	\$ 1,342,119
Mining	\$ -	\$ 1,352,764	\$ 2,344,284	\$ 3,697,048
Utilities	\$ -	\$ 21,684,355	\$ 9,583,797	\$ 31,268,152
Construction	\$ -	\$ 32,647,336	\$ 5,009,957	\$ 37,657,293
Manufacturing	\$ -	\$ 10,739,959	\$ 21,531,330	\$ 32,271,290
Wholesale Trade	\$ -	\$ 4,537,716	\$ 14,633,275	\$ 19,170,990
Retail Trade	\$ -	\$ 7,993,363	\$ 30,867,645	\$ 38,861,008
Transportation and Warehousing	\$ -	\$ 4,696,548	\$ 10,171,785	\$ 14,868,334
Information	\$ -	\$ 7,147,089	\$ 16,052,767	\$ 23,199,856
Finance and Insurance	\$ -	\$ 10,490,000	\$ 39,268,218	\$ 49,758,218
Real Estate and Rental	\$ -	\$ 16,766,664	\$ 23,969,288	\$ 40,735,951
Professional, Scientific, and Tech Services	\$ -	\$ 153,603,484	\$ 12,840,203	\$ 166,443,688
Management of Companies	\$ -	\$ 4,330,136	\$ 4,928,483	\$ 9,258,619
Administrative and Waste Services	\$ -	\$ 118,311,796	\$ 9,621,935	\$ 127,933,731
Educational Services	\$ -	\$ 8,417,444	\$ 6,066,245	\$ 14,483,689
Health and Social Services	\$ -	\$ 1,117	\$ 58,373,698	\$ 58,374,814
Arts, Entertainment, and Recreation	\$ -	\$ 1,212,096	\$ 5,920,947	\$ 7,133,043
Accommodation and Food Services	\$ -	\$ 3,277,420	\$ 20,800,649	\$ 24,078,070
Other Services	\$ -	\$ 5,584,970	\$ 16,465,769	\$ 22,050,738
Government & non-NAICs	\$ 612,476,382	\$ 1,266,284	\$ 45,671,878	\$ 659,414,543
Total Output	\$ 612,476,382	\$ 414,223,861	\$ 355,300,952	\$ 1,382,001,195

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 (reported in 2015 dollars).

The total output impact of NASA Glenn Research Center's spending of goods and services on the state of Ohio was \$1.382 billion in FY 2014. Glenn's expenditures of \$612.5 million resulted in an increase of \$1.382 billion in output (sales) across all industry sectors (Table 11). For example, NASA Glenn's spending affected a \$166.4 million increase in sales (direct, indirect, and induced impacts) in professional, scientific, and technical services, as well as a \$127.9 million increase in sales in the administrative and waste services sector.

Of the total output impact, 44.3% (\$612.5 million) was accounted for by the change in final demand or direct impact due to NASA Glenn's activities bringing resources from outside of Ohio into the state. Approximately \$414.2 million (30%) 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 \$355.3 million (25.7%) was due to the induced impact of NASA Glenn's spending rippled throughout the state economy.³⁸

An analysis of the IMPLAN model shows that the \$769.5 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 industries (\$401 million, 52.1%), consumer-driven industries (\$266.8 million, 34.7%), and other industries (\$101.8 million, 13.2%).³⁹

The output distribution for select NASA Glenn-driven industries is shown in Figure 13. The output distribution for select consumer-driven industries is shown in Figure 14. The select industries shown in Figures 13 and 14 each added over \$10 and \$8 million, respectively.

The facilities support services industry in the state of Ohio saw an increase in revenue of \$92.8 million in FY 2014 (Figure 13). This amount is the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending. This increase of \$92.8 million accounted for a 23% share of the \$401 million increase in output value for all NASA Glenn-driven industries. Other industries shown in Figure 13 can be interpreted similarly.

The offices of physicians industry experienced a sales increase of \$10.9 million in FY 2014 (Figure 14). This amount is the summation of the indirect and induced impact components generated primarily by NASA Glenn employees and other workers using medical services. This increase of \$10.9 million represented a 4% share of the \$266.8 million increase in output for all consumer-driven industries. Other industries shown in Figure 14 can be interpreted similarly.

³⁸ All figures are reported in 2015 dollars.

³⁹ 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 2014

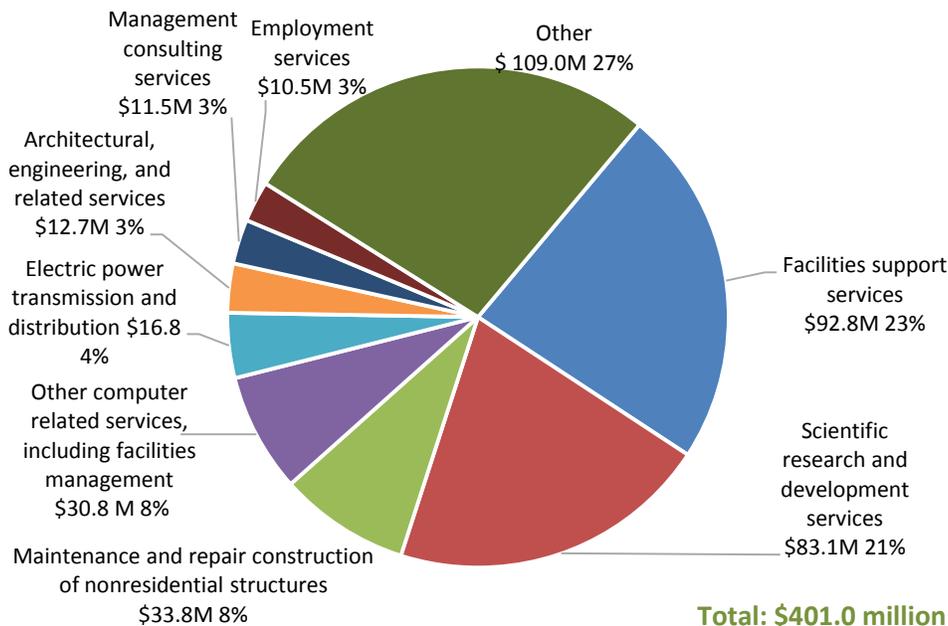
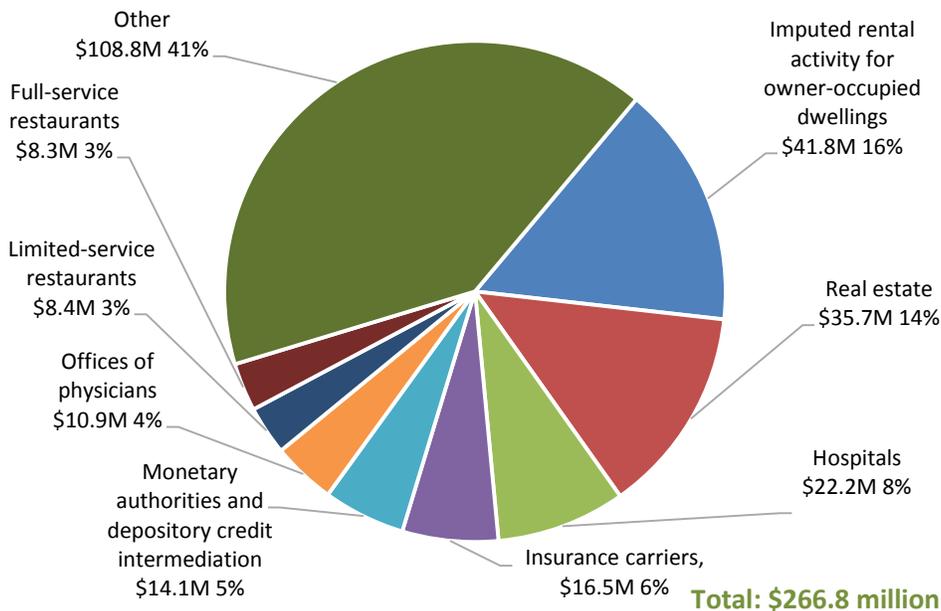


Figure 14. Increase in Sales for Select Consumer-Driven Industries in Ohio, FY 2014



D.3.2. Employment Impact on the State of Ohio, FY 2014

Spending for NASA Glenn’s 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 across the state of Ohio in the supply-chain industries from which it purchases goods and services (indirect impact).

In addition, money spent by NASA Glenn employees and employees of supply companies created jobs in various other industries that sell products and services to the population (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 2014

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	0	2	14	16
Mining	0	2	2	4
Utilities	0	22	7	29
Construction	0	216	27	243
Manufacturing	0	32	36	67
Wholesale Trade	0	21	66	88
Retail Trade	0	136	406	542
Transportation and Warehousing	0	35	75	110
Information	0	20	43	63
Finance and Insurance	0	49	188	238
Real Estate and Rental	0	77	118	195
Professional, Scientific, and Tech Services	0	1,009	104	1,112
Management of Companies	0	18	20	38
Administrative and Waste Services	0	1,140	148	1,287
Educational Services	0	225	103	328
Health and Social Services	0	0	614	614
Arts, Entertainment, and Recreation	0	18	84	102
Accommodation and Food Services	0	58	369	427
Other Services	0	46	273	319
Government & non-NAICs	1,624	5	16	1,645
Total Employment	1,624	3,130	2,714	7,468

Notes:

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

Employment increased by 7,468 jobs in Ohio in FY 2014 because of NASA Glenn’s spending in the state. Of these 7,468 jobs, 1,624 people (21.7%) 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, 3,130 jobs (41.9%) were supported and created (indirect effect). The remaining employment—2,714 jobs (36.3%)—was the induced impact resulting from spending wages and salaries of NASA Glenn’s workers and supply companies’ employees through the state economy.

Of the 5,844 jobs created in Ohio due to the indirect and induced effects, 3,063 (52.4%) were found in NASA Glenn-driven sectors, 2,176 (37.2%) were in consumer-driven sectors, and 605 (10.4%) were created in other sectors.⁴⁰

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 200 and 70 jobs, respectively.

Because of NASA Glenn’s spending in Ohio, 232 jobs were added in education services during FY 2014 (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 232 jobs accounted for an 8% share of the 3,063 jobs that were created in all NASA Glenn-driven industries.

The hospitals industry experienced an increase of 167 jobs in FY 2014 (Figure 16). The 167 jobs were supported or created due to NASA Glenn employees and employees of Glenn’s supply industries using hospital services in Ohio. These jobs accounted for an 8% share of the 2,177 jobs that were created in all consumer-driven industries in the state.

⁴⁰ 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 2014

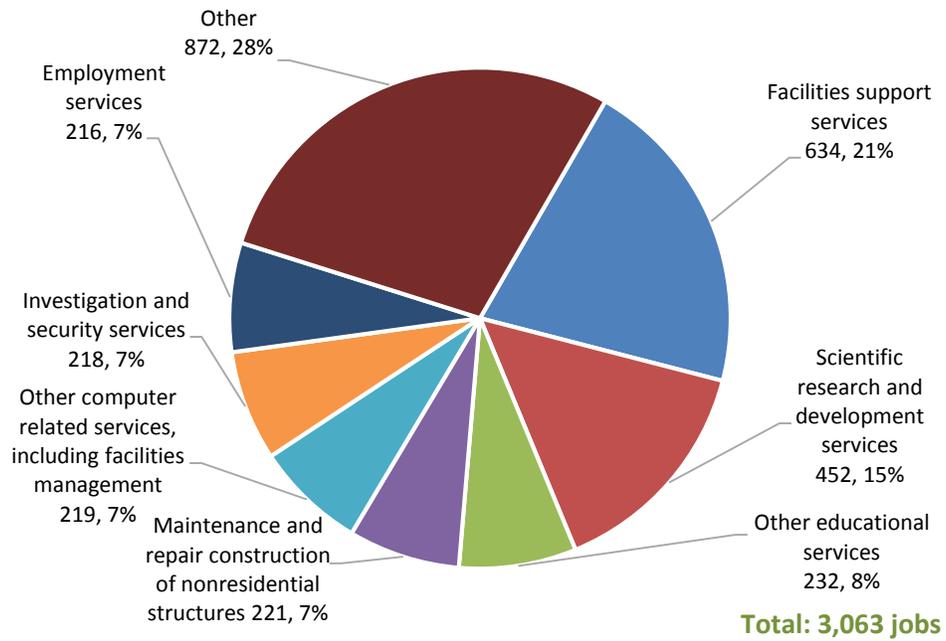
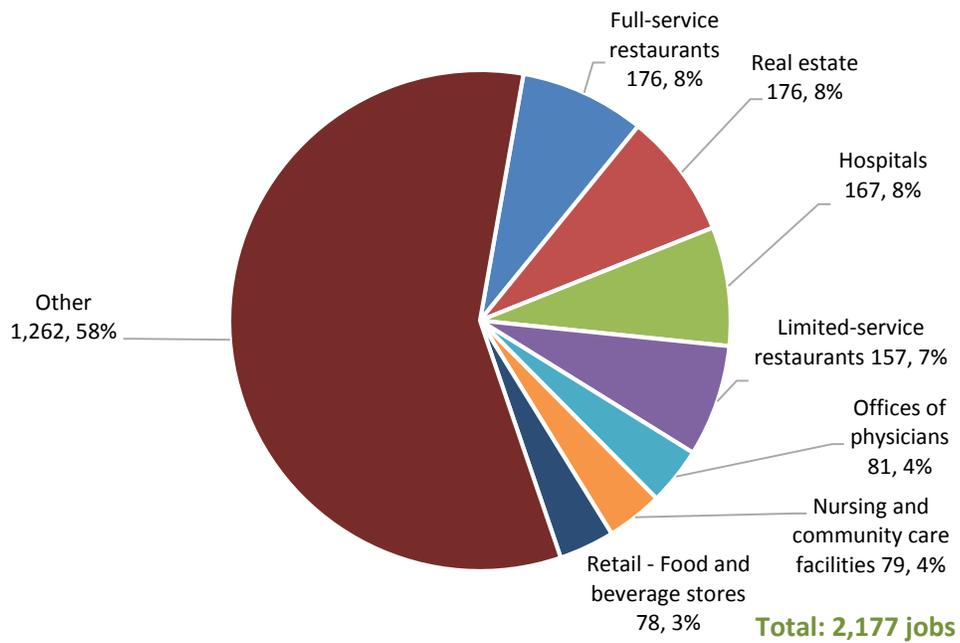


Figure 16. Increase in Jobs for Select Consumer-Driven Industries in Ohio, FY 2014



D.3.3 Labor Income Impact on the State of Ohio, FY 2014

Labor income is assessed as the estimated change in earnings received by NASA Glenn employees and 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 the suppliers of these companies 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. Adding the direct, indirect, and induced impacts defines the total labor income impact of NASA Glenn. Table 13 shows the labor income impact by industry sector.

Table 13. Labor Income Impact in the State of Ohio, FY 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 67,133	\$ 318,028	\$ 385,161
Mining	\$ -	\$ 198,698	\$ 205,824	\$ 404,522
Utilities	\$ -	\$ 2,410,867	\$ 991,671	\$ 3,402,538
Construction	\$ -	\$ 12,404,951	\$ 1,726,588	\$ 14,131,540
Manufacturing	\$ -	\$ 2,063,990	\$ 2,352,561	\$ 4,416,551
Wholesale Trade	\$ -	\$ 1,613,915	\$ 5,156,466	\$ 6,770,381
Retail Trade	\$ -	\$ 3,233,963	\$ 12,735,180	\$ 15,969,143
Transportation and Warehousing	\$ -	\$ 1,999,203	\$ 4,305,635	\$ 6,304,838
Information	\$ -	\$ 1,471,438	\$ 3,055,903	\$ 4,527,341
Finance and Insurance	\$ -	\$ 2,997,211	\$ 10,968,360	\$ 13,965,571
Real Estate and Rental	\$ -	\$ 2,600,173	\$ 3,994,666	\$ 6,594,839
Professional, Scientific, and Tech Services	\$ -	\$ 71,834,095	\$ 6,445,208	\$ 78,279,303
Management of Companies	\$ -	\$ 2,176,382	\$ 2,477,119	\$ 4,653,500
Administrative and Waste Services	\$ -	\$ 56,153,085	\$ 5,142,831	\$ 61,295,916
Educational Services	\$ -	\$ 5,129,561	\$ 3,270,338	\$ 8,399,899
Health and Social Services	\$ -	\$ 571	\$ 32,951,674	\$ 32,952,245
Arts, Entertainment, and Recreation	\$ -	\$ 481,475	\$ 2,007,752	\$ 2,489,227
Accommodation and Food Services	\$ -	\$ 1,293,063	\$ 8,233,213	\$ 9,526,276
Other Services	\$ -	\$ 2,323,967	\$ 9,302,460	\$ 11,626,427
Government & non-NAICs	\$ 226,850,467	\$ 415,327	\$ 1,242,495	\$ 228,508,289
Total Labor Income	\$ 226,850,467	\$ 170,869,067	\$ 116,883,973	\$ 514,603,507

Notes:

For labor income impact, the change in final demand or direct impact equals the wages and benefits paid to NASA Glenn employees.

Total labor income in the state of Ohio increased by \$514.6 million as a result of NASA Glenn's spending on goods and services in FY 2014. Of this amount, \$226.9 million (44.1%) included wages and benefits paid to NASA Glenn employees (change in final demand or direct impact). Monies paid to employees of companies across the state from which NASA Glenn buys its supplies and suppliers of those companies (indirect impact) represented \$170.9 million (33.2%). The remaining earnings impact (induced component), estimated to be \$116.9 million (22.7%), was the result of NASA Glenn employees' spending and spending of their suppliers employees' rippling through the Ohio economy.

Of the \$287.8 million increase in labor income attributed to the indirect and induced impacts, \$170 million (59.1%) was observed in Glenn-driven industries, \$87.3 million (30.3%) occurred in consumer-driven industries, and \$30.4 million (10.6%) was reported in other industries.⁴¹

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 \$7 million and \$3 million each in Figures 17 and 18, respectively).

In the NASA Glenn-driven industries, employees in other computer related services across the state of Ohio saw their labor income increase by \$16.6 million in FY 2014 (Figure 17). These earnings are the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's purchases of computer-related services. The \$16.6 million represented a 10% of the \$170 million earnings increase that occurred in all NASA Glenn-driven industries.

In the consumer-driven industries, employees working for the insurance carriers industry experienced an increase in labor income of \$4 million in FY 2014 (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 \$4 million accounted for a 5% share of the \$87.3 million earnings increase that was reported by all consumer-driven industries.

⁴¹ See section D.2.1. Output Impact on Northeast Ohio, FY 2014 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 2014

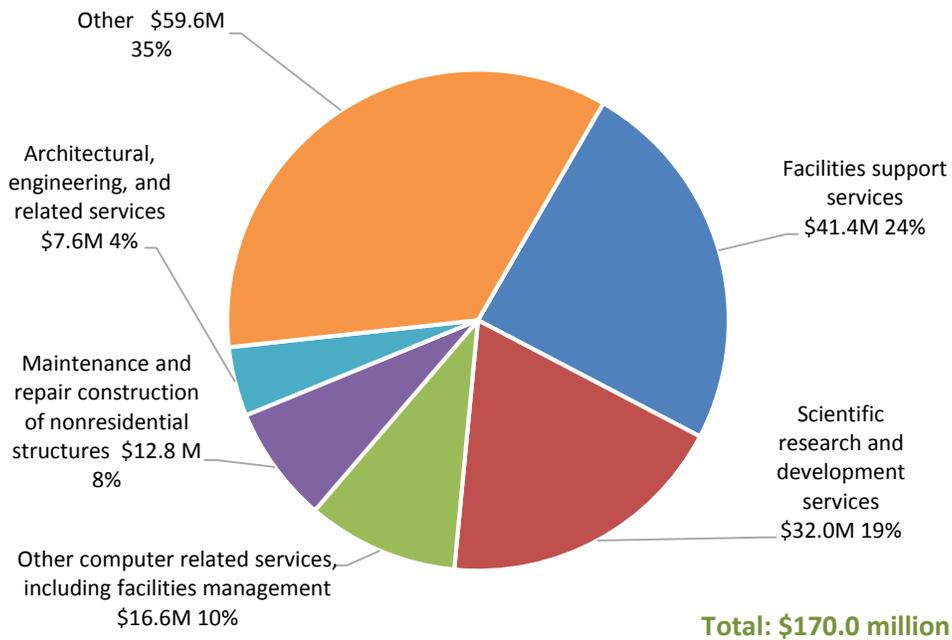
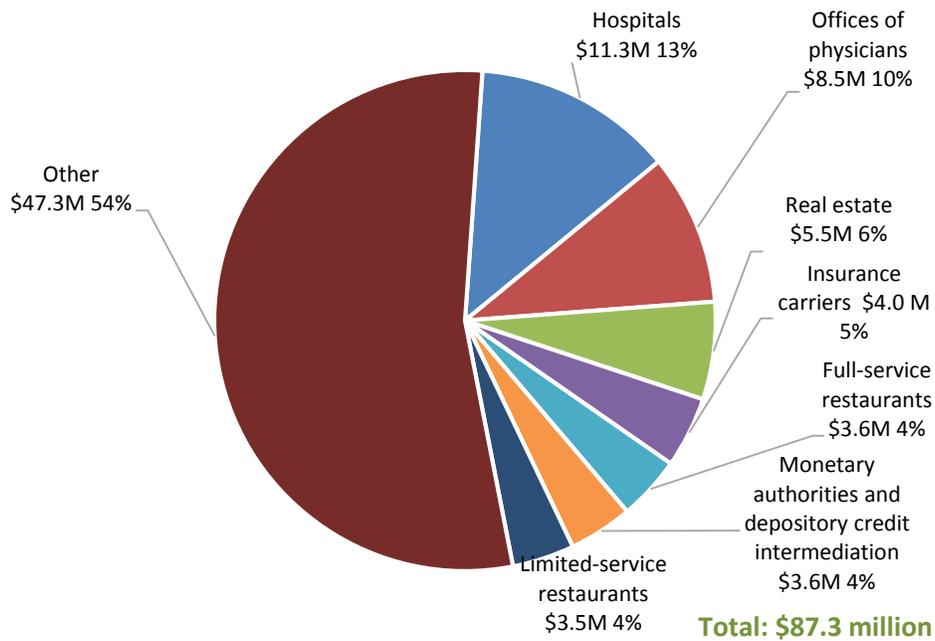


Figure 18. Increase in Labor Income for Select Consumer-Driven Industries in Ohio, FY 2014



D.3.4. Value Added Impact on the State of Ohio, FY 2014

NASA Glenn's spending created an increase of \$721.9 million in value added for all industries in Ohio.⁴² Of this total amount, \$287.9 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 is the wages and salaries paid to NASA Glenn employees. Another \$230.2 million (31.9%) 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 \$203.8 million (28.1%). 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 (Table 14).

⁴² "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). FY 2014's effect was significantly higher than years prior

to FY 2013 due to an improved means of capturing the direct effect of value added. In calculating economic impact for previous studies, total labor earnings were accounted for the direct value added impact.

Table 14. Value Added Impact in the State of Ohio, FY 2014 (in 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing and Hunting	\$ -	\$ 90,399	\$ 572,233	\$ 662,633
Mining	\$ -	\$ 1,067,263	\$ 1,934,289	\$ 3,001,551
Utilities	\$ -	\$ 10,861,108	\$ 4,617,414	\$ 15,478,522
Construction	\$ -	\$ 12,639,649	\$ 1,748,090	\$ 14,387,739
Manufacturing	\$ -	\$ 3,284,758	\$ 5,560,884	\$ 8,845,642
Wholesale Trade	\$ -	\$ 2,988,414	\$ 9,547,995	\$ 12,536,409
Retail Trade	\$ -	\$ 4,880,654	\$ 19,550,787	\$ 24,431,441
Transportation and Warehousing	\$ -	\$ 2,227,698	\$ 4,787,514	\$ 7,015,213
Information	\$ -	\$ 2,748,506	\$ 6,884,713	\$ 9,633,219
Finance and Insurance	\$ -	\$ 5,708,397	\$ 19,290,277	\$ 24,998,673
Real Estate and Rental	\$ -	\$ 13,060,786	\$ 18,950,581	\$ 32,011,367
Professional, Scientific, and Tech Services	\$ -	\$ 81,542,623	\$ 8,132,331	\$ 89,674,954
Management of Companies	\$ -	\$ 2,600,252	\$ 2,959,560	\$ 5,559,812
Administrative and Waste Services	\$ -	\$ 75,501,087	\$ 6,636,774	\$ 82,137,860
Educational Services	\$ -	\$ 5,117,027	\$ 3,520,625	\$ 8,637,653
Health and Social Services	\$ -	\$ 595	\$ 34,323,031	\$ 34,323,626
Arts, Entertainment, and Recreation	\$ -	\$ 583,546	\$ 3,302,794	\$ 3,886,339
Accommodation and Food Services	\$ -	\$ 1,675,694	\$ 10,810,807	\$ 12,486,501
Other Services	\$ -	\$ 3,495,430	\$ 10,121,833	\$ 13,617,263
Government & non-NAICs	\$ 287,863,900	\$ 165,973	\$ 30,550,915	\$ 318,580,788
Total Value Added	\$ 287,863,900	\$ 230,239,859	\$ 203,803,447	\$ 721,907,206

Notes:

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 53% of total output.

Total value added in the state of Ohio increased by \$721.9 million as a result of NASA Glenn's spending on goods and services in FY 2014. Of this total amount, \$287.9 million (40.0%) included the wages and benefits paid directly to NASA Glenn employees and other added values (change in final demand or direct impact). Another \$230.2 million (31.9%) 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 \$203.8 million (28.2%), occurred as the effects of NASA Glenn's spending rippled through the Ohio economy.

Of the \$434 million increase in value added generated across Ohio due to the indirect and induced impacts, \$219.9 million (50.7%) was observed in NASA Glenn-driven industries, \$165.9 (38.2%) was generated in consumer-driven industries, and \$48.2 million (11.1%) was reported in other industries.⁴³

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 \$6 and \$7 million, respectively.

Within the NASA Glenn-driven industries, persons engaged in facilities support services saw the sector's value added increase by \$57.4 million in FY 2014 (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 \$57.4 million accounted for 26% of the \$219.9 million value added increase that was reported by all NASA Glenn-driven industries.

In the consumer-driven industries, employees of the imputed rental activity for owner-occupied dwellings industry saw the sector's value added increase by \$29.8 million in FY 2014 (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 \$29.8 million accounted for 18% of the \$165.9 million value added increase that occurred in all consumer-driven industries.

⁴³ See section D.2.1 Output Impact on Northeast Ohio, FY 2014 for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 19. Increase in Value Added for NASA Glenn-Driven Industries in Ohio, FY 2014

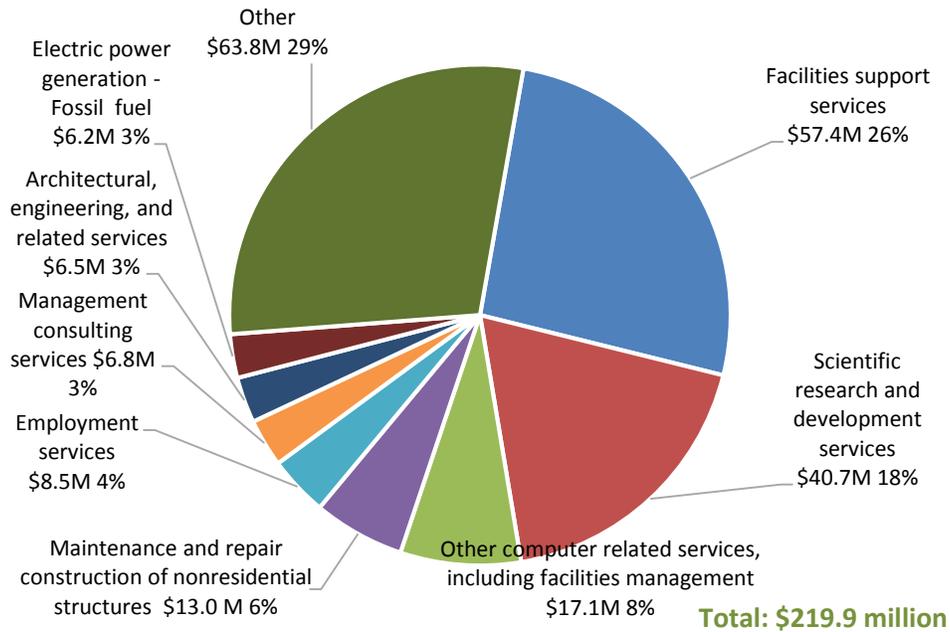
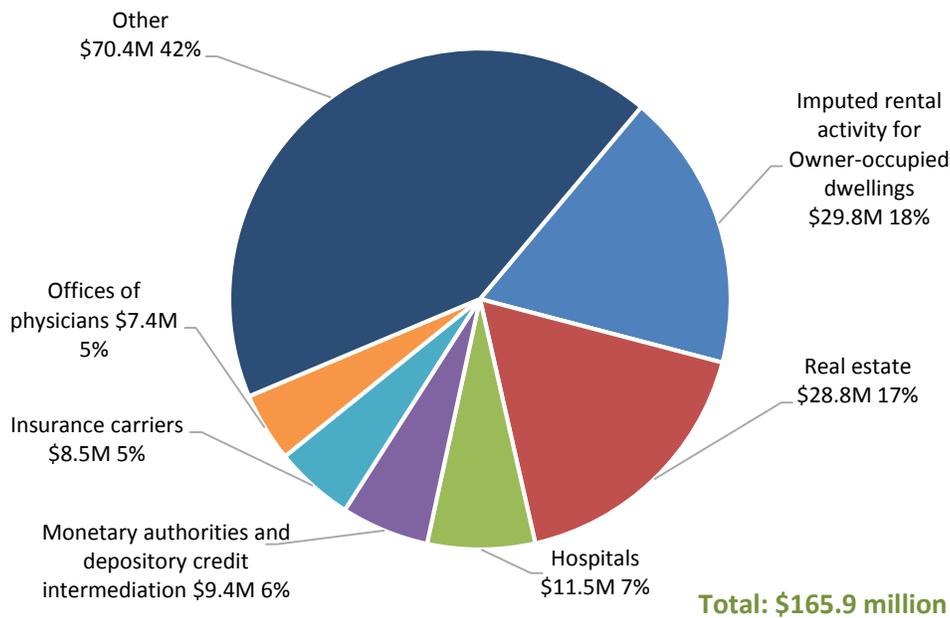


Figure 20. Increase in Value Added for Consumer-Driven Industries in Ohio, FY 2014



D.3.5. Tax Impact on the State of Ohio, FY 2014

NASA Glenn’s operation and economic impact on the state of Ohio in FY 2014 increased tax revenues by a total of \$125.2 million. Of that amount, direct tax impact was \$33.1 million in Glenn’s employee taxes on wages, \$45.6 million indirect tax impact, and \$46.6 million – induced tax impact.⁴⁴

D.3.6. FY 2014 Ohio Impact Summary

The economic activity of NASA Glenn in the state of Ohio generated the following total economic impact (in 2015 dollars):

- Total Output Impact: \$1,382 M
- Total Employment Impact: 7,468 jobs
- Total Labor Income Impact: \$514.6 M
- Total Value Added Impact: \$721.9 M
- Total Tax Impact: \$125.2 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. The majority of NASA Glenn’s expenditures in Ohio were spent in Northeast Ohio.

In FY 2014, NASA Glenn’s expenditures in the state of Ohio were \$502.4 million, including labor income (adjusted for commuter spending). These Ohio expenditures were only \$51.2 million more than in Northeast Ohio (in 2015 dollars).

NASA Glenn decreased the total spending in Ohio in FY 2014 compared to FY 2013 by more than \$1.5 million (compared to \$503.9 million spent in Ohio in 2015 dollars). Ohio’s administrative and support services sector saw

a nearly \$49 million increase in spending (almost a 97% gain in 2015 dollars). However, Ohio’s professional, scientific, and technical services sector saw a nearly \$50 million decrease in spending (a 28.9% drop in 2015 dollars).⁴⁵

Compared to the expenditures made in Northeast Ohio in FY 2014, the largest share of the total payments, excluding labor income, was spent on professional, scientific, and technical services in Ohio (43.7% in Ohio, compared to 49.8% in Northeast Ohio). More than 94.8% of NASA Glenn spending in Ohio (\$261.2 million), excluding labor income, went to the following industry sectors: professional, scientific and technical services (\$120.3 million); administrative and support services (\$98.9 million); construction (\$29.3 million); and utilities (\$12.7 million).⁴⁶ Additionally, 2.9% (\$8.1 million) went toward the education sector and 1.0% (\$2.9 million) for wholesale and retail trade.

NASA Glenn’s statewide expenditure pattern is similar to the expenditures in Northeast Ohio. Being a large institution employing highly qualified and highly paid labor, NASA Glenn is accountable for a large part of the economic impact through the spending of its employees. Businesses deriving the most benefit from spending by NASA Glenn personnel and other workers whose earnings are due in part to NASA Glenn’s expenditures followed typical 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.

⁴⁴ Significant increase in taxes reported this year is due to additional data provided by NASA Glenn on direct taxes paid by their employees. In previous reports, only state and local taxes accounted for the direct tax impact. In this report, the direct tax impact includes local, state and federal taxes paid by NASA Glenn employees.

⁴⁵ The majority (\$40M) of the increase in administrative and support services and corresponding reduction in

professional, scientific, and technical services is due to an IMPLAN Code change for a large contractor supporting NASA Glenn’s Plum Brook Station.

⁴⁶ Amounts in parentheses detailing percentage numbers are presented in 2014 dollars and correspond to Appendix table A.4.

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APPENDIX A: DATA TABLES

Table A.1. NASA Glenn Spending by State, FY 2014

Table A.2. NASA Glenn Monies Allocated to Academic Institutions, FY 2014

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2014

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2014

Table A.1. NASA Glenn Spending by State, Excluding Payroll, FY 2014

State	Spending	Share
Ohio	\$275,503,199	70.89%
Maryland	\$24,576,174	6.32%
California	\$17,283,369	4.45%
Connecticut	\$12,583,673	3.24%
Virginia	\$7,445,580	1.92%
Pennsylvania	\$6,451,682	1.66%
Texas	\$4,046,826	1.04%
Massachusetts	\$4,037,191	1.04%
Georgia	\$3,934,859	1.01%
Colorado	\$3,526,126	0.91%
Missouri	\$3,158,762	0.81%
Florida	\$2,879,627	0.74%
Arizona	\$2,760,486	0.71%
Indiana	\$2,410,201	0.62%
New York	\$2,139,407	0.55%
Michigan	\$1,808,745	0.47%
Illinois	\$1,222,101	0.31%
Alabama	\$1,157,404	0.30%
Wisconsin	\$1,141,137	0.29%
New Jersey	\$1,043,235	0.27%
Washington	\$973,093	0.25%
Iowa	\$968,364	0.25%
North Carolina	\$890,597	0.23%
New Hampshire	\$806,138	0.21%
Minnesota	\$727,041	0.19%
New Mexico	\$700,810	0.18%
District of Columbia	\$552,392	0.14%
Tennessee	\$463,760	0.12%
Oregon	\$439,534	0.11%
Utah	\$415,078	0.11%
Arkansas	\$215,849	0.06%
Idaho	\$197,098	0.05%
Puerto Rico	\$187,432	0.05%

State	Spending	Share
Kansas	\$171,168	0.04%
South Carolina	\$155,204	0.04%
Mississippi	\$137,349	0.04%
Nebraska	\$133,984	0.03%
Nevada	\$131,491	0.03%
Delaware	\$128,251	0.03%
South Dakota	\$126,782	0.03%
Kentucky	\$73,953	0.02%
Rhode Island	\$52,990	0.01%
Vermont	\$43,896	0.01%
West Virginia	\$31,558	0.01%
Montana	\$30,107	0.01%
Hawaii	\$21,684	0.01%
Oklahoma	\$15,823	0.00%
Wyoming	\$13,928	0.00%
Maine	\$10,453	0.00%
Great Britain	\$470,832	0.12%
Canada	\$167,601	0.04%
Germany	\$68,473	0.02%
Australia	\$11,787	0.00%
New Zealand	\$11,205	0.00%
France	\$4,582	0.00%
<i>Outside U.S.</i>	<i>\$734,480</i>	<i>0.19%</i>
Total	\$388,660,067	

Table A.2. NASA Glenn Funding Allocated to Academic Institutions by State, FY 2014

State	Amount	Share
California	\$1,369,486	13.06%
Ohio	\$1,340,021	12.78%
Massachusetts	\$1,251,238	11.93%
Pennsylvania	\$695,348	6.63%
Michigan	\$694,400	6.62%
Indiana	\$660,693	6.30%
Illinois	\$615,750	5.87%
Maryland	\$568,440	5.42%
North Carolina	\$370,886	3.54%
Texas	\$346,822	3.31%
New Jersey	\$304,188	2.90%
Missouri	\$260,398	2.48%
Colorado	\$237,495	2.27%
Oregon	\$237,135	2.26%
Iowa	\$192,187	1.83%
Puerto Rico	\$187,432	1.79%
Mississippi	\$131,835	1.26%
Florida	\$117,246	1.12%
Georgia	\$111,824	1.07%
Delaware	\$108,370	1.03%
Alabama	\$100,714	0.96%
New Mexico	\$88,778	0.85%
Connecticut	\$78,260	0.75%
Virginia	\$77,829	0.74%
New York	\$67,860	0.65%
Kansas	\$34,136	0.33%
Utah	\$28,755	0.27%
South Carolina	\$23,845	0.23%
Hawaii	\$21,684	0.21%
Montana	\$10,618	0.10%
Wisconsin	\$6,440	0.06%
Washington	\$4,833	0.05%
District of Columbia	\$1,772	0.02%
Kentucky	\$1,162	0.01%
Great Britain	\$136,519	1.30%
Total	\$10,484,397	

Note: Academic institutions in eighteen states did not receive NASA Glenn grants in 2014.

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2014

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			\$12,543,908
	Electric power transmission and distribution	49	\$9,867,304
	Natural gas distribution	50	\$606,983
	Water, sewage and other systems	51	\$2,069,621
Construction			\$29,258,255
	Construction of other new nonresidential structures	58	\$1,017,839
	Maintenance and repair construction of nonresidential structures	62	\$28,240,416
Manufacturing			\$1,251,811
	Printing	154	\$597
	Industrial gas manufacturing	162	\$30,469
	Other plastics product manufacturing	195	\$792
	Prefabricated metal buildings and components manufacturing	237	\$36,426
	Metal window and door manufacturing	240	\$14,562
	Power boiler and heat exchanger manufacturing	243	\$4,604
	Hardware manufacturing	247	\$12,430
	Machine shops	249	\$218,646
	Metal heat treating	251	\$3,962
	Valve and fittings, other than plumbing, manufacturing	254	\$78,481
	Other fabricated metal manufacturing	261	\$13,365
	Other commercial service industry machinery manufacturing	274	\$6,564
	Cutting tool and machine tool accessory manufacturing	280	\$10,563
	Machine tool manufacturing	281	\$129,950
	Rolling mill and other metalworking machinery manufacturing	282	\$24,990
	Pump and pumping equipment manufacturing	287	\$232,840
	Welding and soldering equipment manufacturing	295	\$10,194
	Industrial process furnace and oven manufacturing	297	\$9,585
	Audio and video equipment manufacturing	307	\$44,117

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Semiconductor and related device manufacturing	309	\$5,614
	Industrial process variable instruments manufacturing	317	\$54,876
	Totalizing fluid meter and counting device manufacturing	318	\$3,524
	Electricity and signal testing instruments manufacturing	319	\$11,281
	Analytical laboratory instrument manufacturing	320	\$24
	Watch, clock, and other measuring and controlling device manufacturing	322	\$45,006
	All other miscellaneous electrical equipment and component manufacturing	342	\$18,792
	Aircraft manufacturing	357	\$107,187
	Other aircraft parts and auxiliary equipment manufacturing	359	\$122,135
	Office supplies (except paper) manufacturing	387	\$235
Wholesale & Retail Trade			\$2,661,922
	Wholesale trade	395	\$628,655
	Retail - Motor vehicle and parts dealers	396	\$3,660
	Retail - Electronics and appliance stores	398	\$10,600
	Retail - Miscellaneous store retailers	406	\$2,019,007
Transportation			\$23,558
	Truck transportation	411	\$6,698
	Transit and ground passenger transportation	412	\$16,860
Information & Telecommunication			\$20,180
	Book publishers	419	\$4,875
	Motion picture and video industries	423	\$4,736
	Wired telecommunications carriers	427	\$10,568
Real Estate and Rental & Leasing			\$79,837
	Commercial and industrial machinery and equipment rental and leasing	445	\$79,837
Professional, Scientific, & Technical Services			\$112,274,256
	Legal services	447	\$18,938
	Accounting, tax preparation, bookkeeping, and payroll services	448	\$4,450
	Architectural, engineering, and related services	449	\$5,212,702

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Other computer related services, including facilities management	453	\$28,204,898
	Management consulting services	454	\$4,484,934
	Environmental and other technical consulting services	455	\$6,062,978
	Scientific research and development services	456	\$68,167,453
	Marketing research and all other miscellaneous professional, scientific, and technical services	460	\$117,902
Administrative & Support and Waste Management Services			\$58,870,712
	Facilities support services	463	\$49,828,002
	Investigation and security services	467	\$6,826,234
	Services to buildings	468	\$2,120,320
	Other support services	470	\$1,600
	Waste management and remediation services	471	\$94,556
Education			\$7,963,621
	Junior colleges, colleges, universities, and professional schools	473	\$1,215,846
	Other educational services	474	\$6,747,774
Arts, Entertainment & Recreation			\$547,671
	Museums, historical sites, zoos, and parks	493	\$547,671
Other Services, Except Public Administration			\$124,846
	Electronic and precision equipment repair and maintenance	506	\$124,846
Labor Income			\$225,505,439
	Employee Compensation (c)	5001	\$225,505,439
TOTAL EXPENDITURES IN NEO			\$451,126,015

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 2014. 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 2014 dollars.

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2014

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			\$ 12,663,866
	Electric power transmission and distribution	49	\$ 9,903,467
	Natural gas distribution	50	\$ 606,983
	Water, sewage and other systems	51	\$ 2,153,416
Construction			\$ 29,265,151
	Construction of other new nonresidential structures	58	\$ 1,017,839
	Maintenance and repair construction of nonresidential structures	62	\$ 28,247,312
Manufacturing			\$ 2,429,258
	Printing	154	\$ 597
	Industrial gas manufacturing	162	\$ 30,469
	Plastics material and resin manufacturing	166	\$ 17,950
	Other miscellaneous chemical product manufacturing	187	\$ 5,170
	Polystyrene foam product manufacturing	192	\$ 6,914
	Other plastics product manufacturing	195	\$ 390
	Ferrous metal foundries	229	\$ 56,478
	Prefabricated metal buildings and components manufacturing	237	\$ 59,476
	Metal window and door manufacturing	240	\$ 14,562
	Power boiler and heat exchanger manufacturing	243	\$ 4,604
	Hardware manufacturing	247	\$ 12,430
	Machine shops	249	\$ 507,035
	Turned product and screw, nut, and bolt manufacturing	250	\$ 7,375
	Metal heat treating	251	\$ 6,796
	Valve and fittings, other than plumbing, manufacturing	254	\$ 249,105
	Fabricated pipe and pipe fitting manufacturing	260	\$ 23,620
	Other fabricated metal manufacturing	261	\$ 13,365
	Other commercial service industry machinery manufacturing	274	\$ 6,564
	Cutting tool and machine tool accessory manufacturing	280	\$ 10,563

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NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Machine tool manufacturing	281	\$ 129,950
	Rolling mill and other metalworking machinery manufacturing	282	\$ 24,990
	Pump and pumping equipment manufacturing	287	\$ 232,840
	Welding and soldering equipment manufacturing	295	\$ 10,194
	Industrial process furnace and oven manufacturing	297	\$ 15,802
	Scales, balances, and miscellaneous general purpose machinery manufacturing	300	\$ 15,607
	Audio and video equipment manufacturing	307	\$ 44,117
	Semiconductor and related device manufacturing	309	\$ 5,614
	Other electronic component manufacturing	313	\$ 86,557
	Industrial process variable instruments manufacturing	317	\$ 71,068
	Totalizing fluid meter and counting device manufacturing	318	\$ 3,524
	Electricity and signal testing instruments manufacturing	319	\$ 57,247
	Analytical laboratory instrument manufacturing	320	\$ 19,209
	Watch, clock, and other measuring and controlling device manufacturing	322	\$ 61,593
	Lighting fixture manufacturing	326	\$ 198,500
	Power, distribution, and specialty transformer manufacturing	332	\$ 80,972
	All other miscellaneous electrical equipment and component manufacturing	342	\$ 18,792
	Aircraft manufacturing	357	\$ 107,187
	Other aircraft parts and auxiliary equipment manufacturing	359	\$ 148,152
	All other transportation equipment manufacturing	367	\$ 57,123
	Showcase, partition, shelving, and locker manufacturing	376	\$ 6,524
	Office supplies (except paper) manufacturing	387	\$ 235
Wholesale & Retail Trade			\$ 2,883,128
	Wholesale trade	395	\$ 708,713
	Retail - Motor vehicle and parts dealers	396	\$ 3,660
	Retail - Electronics and appliance stores	398	\$ 10,600
	Retail - Building material and garden equipment and supplies stores	399	\$ 27,986
	Retail - Miscellaneous store retailers	406	\$ 2,132,169

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NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Transportation			\$ 23,645
	Truck transportation	411	\$ 6,784
	Transit and ground passenger transportation	412	\$ 16,860
Information & Telecommunication			\$ 20,180
	Book publishers	419	\$ 4,875
	Motion picture and video industries	423	\$ 4,736
	Wired telecommunications carriers	427	\$ 10,568
Real Estate and Rental & Leasing			\$ 79,837
	Commercial and industrial machinery and equipment rental and leasing	445	\$ 79,837
Professional, Scientific, & Technical Services			\$ 120,339,564
	Legal services	447	\$ 74,053
	Accounting, tax preparation, bookkeeping, and payroll services	448	\$ 4,450
	Architectural, engineering, and related services	449	\$ 5,781,297
	Custom computer programming services	451	\$ 10,000
	Other computer related services, including facilities management	453	\$ 28,204,898
	Management consulting services	454	\$ 4,486,034
	Environmental and other technical consulting services	455	\$ 6,062,978
	Scientific research and development services	456	\$ 75,550,470
	Marketing research and all other miscellaneous professional, scientific, and technical services	460	\$ 165,383
Administrative & Support and Waste Management Services			\$ 98,907,965
	Facilities support services	463	\$ 89,865,255
	Investigation and security services	467	\$ 6,826,234
	Services to buildings	468	\$ 2,120,320
	Other support services	470	\$ 1,600
	Waste management and remediation services	471	\$ 94,556
Education			\$ 8,087,795
	Junior colleges, colleges, universities, and professional schools	473	\$ 1,340,021
	Other educational services	474	\$ 6,747,774

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Arts, Entertainment & Recreation			\$ 547,671
	Museums, historical sites, zoos, and parks	493	\$ 547,671
Other Services, Except Public Administration			\$ 159,918
	Electronic and precision equipment repair and maintenance	506	\$ 150,987
	Grant making, giving, and social advocacy organizations	514	\$ 8,931
Government Enterprise			\$ 95,220
	Other federal government enterprises	520	\$ 95,220
Labor Income			\$226,850,467
	Employee Compensation (c)	5001	\$226,850,467
TOTAL EXPENDITURES IN OHIO			\$502,353,666

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 2014. 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 2014 dollars.