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NASA GLENN RESEARCH CENTER

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**The NASA Glenn
Research
Center:**

**An Economic
Impact Study
Fiscal Year 2010**

**CENTER FOR
ECONOMIC
DEVELOPMENT**

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EXECUTIVE SUMMARY

- The John H. Glenn Research Center at Lewis Field (Glenn) is one of 10 National Aeronautics and Space Administration (NASA) Centers. NASA Glenn is located at Lewis Field, a 350-acre site adjacent to Cleveland Hopkins International Airport. Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class 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 \$433 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately \$2.0 billion. NASA Glenn also includes the 6,400-acre Plum Brook Station near Sandusky, Ohio, 50 miles west of Cleveland. It specializes in large-scale tests that would be hazardous within the confines of the main campus.
- During the period covered in this report, NASA Glenn has had leadership roles that are critical to programs and projects in all of NASA's missions: Exploration, Science, Space Operation, and Aeronautics Research. Within the **Exploration mission** (human spaceflight to the International Space Station (ISS), Moon and Beyond), NASA Glenn provided oversight of the Service Module (SM) for the shuttle-replacement vehicle (Orion). The SM provides power, propulsion, and communications for Orion's Crew Module (CM), where the astronauts reside in flight. Glenn also provided oversight of important elements of the CM project including building test flight hardware. NASA Glenn's **Science mission** includes management of the In-Space Propulsion Technology Program and development of its associated technologies; management of Radioisotope Power Systems and the development of associated technologies. These develop new ways to power scientific spacecraft including the Advanced Stirling Converter (ASC) for the Advanced Stirling Radioisotope Generator (ASRG). These systems will allow allow more scientific missions through more efficient use of power generating material. Within **Space Operations**, NASA Glenn supports the Space Shuttle Program (SSP) by providing expert engineers for the shuttle's electrical power system, its purge, vent, and drain subsystem and for determination of stress, loads, and dynamics on the vehicle. NASA Glenn also has the role of Lead Quality Auditor for the SSP. NASA Glenn supports the International Space Station's operation of the electrical power system and leads the development of new, advanced communications technology including a demonstration on the International Space Station of software-defined radios. In **Aeronautics**, NASA Glenn enriches its aeronautics heritage by concentrating research and program management efforts on the principles of flight in any atmosphere at any speed and the enhancement of aviation safety. For the Fundamental Aeronautics Program, NASA Glenn provides technical project management leadership and conduct research. For the Aviation Safety Program, NASA Glenn provides technical project management leadership for three projects.
- Sections A and B provide an introduction and background for this report, followed by two major sections. 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 eight-county Northeast Ohio region and the state of Ohio during FY 2010. The report is an update of several earlier studies where economic impacts on Northeast Ohio and the state of Ohio were estimated.

ECONOMIC IMPACT GENERATED BY NASA GLENN RESEARCH CENTER SPENDING

- Economic impact is an analytical approach used to estimate economic benefits generated by an entity for an affected region. It uses an input/output (I-O) model to estimate the effect of NASA Glenn spending on the studied economies. This model measures economic impact in terms

of growth in output (sales), value added (output less intermediary goods), the number of new jobs created, the increase in household earnings, and additional tax revenues. The table below summarizes NASA Glenn’s economic impact on Northeast Ohio and the state of Ohio during FY 2010.

Economic Impact	Northeast Ohio	State of Ohio
<i>Output</i>	<i>\$1,242.6 million</i>	<i>\$1,360.8 million</i>
<i>Value Added</i>	<i>\$610.5 million</i>	<i>\$676.5 million</i>
<i>Employment</i>	<i>7,680 jobs</i>	<i>8,868 jobs</i>
<i>Labor Income</i>	<i>\$463.7 million</i>	<i>\$515.8 million</i>
<i>Taxes</i>	<i>\$87.4 million</i>	<i>\$102.1 million</i>

- NASA Glenn activities in Northeast Ohio in FY 2010, stimulated by \$736.2 million in revenues primarily from outside the region, generated an increased demand in output (sales) for products and services produced in Northeast Ohio valued at more than \$1.2 billion. Value-added output increased by \$610.5 million as a result of NASA Glenn activities. In addition, 7,680 jobs were created in the region, and households in Northeast Ohio saw labor income increase by \$463.7 million. NASA Glenn operations also generated additional \$87.4 million local, state, and federal taxes.

- NASA Glenn activities in Ohio in FY 2010, stimulated by \$736.2 million in revenues primarily from outside the state, generated an increased demand in output (sales) for products and services produced across the state that were valued at \$1,360.8 million. Value-added output increased by \$676.5 million as a result of NASA Glenn activities. In addition, 8,868 jobs were created in Ohio and households across the state saw labor income increase by \$515.8 million. NASA Glenn’s activities also generated an additional \$102.1 million in local, state, and federal taxes.
- Industries deriving the most benefit from direct NASA Glenn spending

include scientific research and development services, other professional and technical services, colleges and universities, information services, power generation, business and facilities support, and facilities maintenance and repair.

- Businesses deriving the most benefits from spending by NASA Glenn personnel and other workers follow typical consumer spending patterns. These include food services, real estate companies, hospitals and healthcare services, motor vehicle dealers, accounting services, commercial banks, and miscellaneous retailers.

NASA GLENN RESEARCH CENTER: AN OVERVIEW

- In FY 2010, NASA Glenn had 1,658 civil service employees. The number of civil service employees peaked in FY 2006 at a total of 1,678. NASA Glenn employment has slightly decreased by 1.7% between FY 2006 and FY 2009. Between FY 2009 and FY 2010, however, NASA Glenn added eight civil service employees to the end of the fiscal year total. The employment number of NASA's on- or near-site contractors increased by 17 from FY 2009 to FY 2010 and increased by 462 from FY 2006 to FY 2010.
- The employees at NASA Glenn are highly educated and highly skilled. In FY 2010, 81% of NASA Glenn's employees held a bachelor's or higher degree. Out of all NASA Glenn employees, 18% held a doctoral degree, 35% had a master's degree and 28% possessed a bachelor's degree. There was a 3% increase in the share of employees holding a bachelor's or higher degree between FY 2009 and FY 2010. The increasing share of highly educated employees between FY 2009 and FY 2010 reflects the increase in scientists and engineers at NASA Glenn during this period of time.
- Total compensation for NASA Glenn's civil service employees was \$221.7 million in FY 2010. The total compensation included payroll that accounted for \$178.2 million and employee benefits that accounted for another \$43.5 million. Total payroll grew by \$3.6 million (1.6%) between FY 2009 and FY 2010, after adjusting for inflation.¹ The average wage per civil service employee roughly remained the same, accounting for a 0.6% increase after adjusting for inflation, from \$106,845 in FY 2009 (inflated to 2010 dollars) to \$107,455 in FY 2010.
- In FY 2010, vendors in 50 states, Washington, D.C., Puerto Rico, and 14 foreign countries shared the benefits of NASA Glenn's spending of \$552.9 million. Compared to the total expenditure of \$541.2 million in FY 2009, NASA Glenn increased its expenditures by 2.2% in FY 2010 in nominal dollars.
- Ohio is the largest beneficiary from NASA Glenn's spending. In FY 2010, Ohio received \$324.3 million, accounting for 58.7% of NASA Glenn's total expenditures. The share of NASA Glenn's expenditures in Ohio slightly decreased from 60.3% in FY 2009 to 58.7% in FY 2010, which reflects a \$2.15 million decrease between FY 2009 and FY 2010. Besides Ohio, five other states (Oklahoma, California, Maryland, Virginia, and Massachusetts) received over \$10 million or at least 2% of NASA Glenn's total expenditures. Among

¹ Total nominal payroll increased by 3.2% between FY2008 and FY2009.

foreign countries, in FY 2010, the largest beneficiaries were Canada, Sweden, Great Britain, and Germany, which all together accounted for 98% of total Glenn spending abroad.

- Spending in Ohio and Northeast Ohio has a significant economic impact on area economies. Of NASA Glenn's expenditures in Ohio, Northeast Ohio received \$255.4 million, which accounted for 78.8% of the Ohio spending in FY 2010. Northeast Ohio accounted for 46.2% of total NASA Glenn spending in FY 2010. NASA Glenn's largest expenditures are on scientific research and development including equipment, supplies and materials, grants, and professional services.
- NASA Glenn provides funding to colleges, universities and other nonprofit institutions in the form of contracts and grants for assisting research and development activities. The amount of NASA Glenn's funding to academia is determined annually based on its goals and mission for each year. In FY 2010, the total funding of NASA Glenn's academic awards to colleges and universities in the United States, including Puerto Rico, was \$37.1 million in 37 states, Washington, D.C., and Puerto Rico. This constitutes a \$2.3 million increase (6.6%) from FY 2009 in nominal dollars.
- Three universities in Ohio received awards over \$1 million in FY 2010. The University of Toledo has been awarded the highest share of funding from NASA Glenn over the last 5 years; it obtained \$2.8 million in FY 2010, which accounted for 38.5% of total awards to colleges and universities in Ohio. Ohio State University received the second largest funding of \$1.5 million (20.2%) from NASA Glenn in FY 2010. NASA Glenn awarded \$1 million (14.2%) to Cleveland State University, the third largest recipient of NASA Glenn's academic awards in Ohio in FY 2010.
- NASA Glenn total revenue in FY 2010 reached \$736.2 million, which showed a 3.6% decrease from the last year (FY 2009) and a 2.3% increase from FY 2006 (beginning of the study period) without adjustment for inflation. NASA Glenn's total revenue was the lowest in FY 2007; thereafter it showed growth. NASA Glenn's revenue has increased 13.8% from FY 2007 in nominal dollars.
- NASA Glenn continues to be an important economic player in Northeast Ohio and across the state, continually increasing its economic impact on the region and Ohio. NASA Glenn's employees are part of the knowledge-intensive labor force with unique skills on the cutting edge of science and technologies that generate wealth in the region and advance the nation.

A. INTRODUCTION

This report presents an analysis of the economic impact of the National Aeronautics and Space Administration's (NASA) Glenn Research Center (Glenn) on the eight-county Northeast Ohio region and the state of Ohio during fiscal year (FY) 2010.² It uses an input/output model that reflects the buy-sell relationships among industries in the corresponding regions. The model estimates the effect of NASA Glenn spending on the studied economies. This model assesses economic impact in terms of growth in total output (sales), value added (output less intermediary goods),³ household earnings, the number of new jobs, and taxes.

The report also describes some of NASA Glenn's R&D activities and provides an overview of NASA Glenn.

It looks at change in the structure of NASA Glenn's employees through their occupations, place of residence, and payroll. The report 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 2011 report is an update to previous studies (published in 1996, 2000, 2005, 2007, 2008, 2009, and 2010), which estimated Glenn's FY 1994, FY 1998, FY 2004, FY 2006, FY 2007, FY 2008 and FY 2009 economic impact on Northeast Ohio and the state of Ohio.⁴

² For purposes of this study, Northeast Ohio includes Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

³ 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 which are 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, among others, include research supplies, utilities, research services of intermediary steps of research, etc.

⁴ Austrian, Z. (1996) *The NASA Lewis Research Center: An Economic Impact Study*. Cleveland State University, Center for Economic Development.
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B. NASA GLENN RESEARCH CENTER: BACKGROUND

The NASA Glenn Research Center, in partnership with U.S. industry, universities, and other government institutions, develops critical systems' technologies and capabilities that address national aerospace priorities. The Center is distinguished by a unique blend of aeronautics and space flight development; research as well as project management expertise and experience. Its work is focused on

technological advances in space flight systems, aeropropulsion, space propulsion, power systems, nuclear systems, aerospace communications, and technology to enable human health in space. Its research, technology, and capability development efforts are vital to advancing exploration of our solar system and beyond while maintaining global leadership in aeronautics.

B.1 NASA GLENN TEST FACILITIES

NASA Glenn is located at Lewis Field, a 350-acre site adjacent to Cleveland Hopkins International Airport. NASA Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class 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 \$433 million has been invested in Glenn's physical plant. The estimated replacement cost is approximately \$2.0 billion.

NASA Glenn also includes the 6,400-acre Plum Brook Station near Sandusky, Ohio, 50 miles west of Cleveland. It specializes in large-scale tests that would be hazardous within the

confines of the main campus. Plum Brook contains the world's largest space environment simulation chamber (100 feet in diameter by 122 feet high). Its large size makes it ideal for testing full-size systems. This facility is undergoing a \$200 million expansion to add spacecraft vibration and acoustic test capability and can be used to conduct integrated system-level testing of the new Orion Crew Exploration Vehicle, and commercial crew vehicles, simulating conditions from launch through insertion into orbit. Plum Brook Station also has the largest liquid hydrogen capable vacuum chamber in the world, which doubles as the only cold soak start/restart facility to test upper stage rocket engines.

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, and Aeronautics Research.

Exploration (human spaceflight to the International Space Station (ISS), Moon and Beyond)

- Oversight of the Service Module (SM) for the shuttle-replacement vehicle (Orion). The SM provides power, propulsion, and communications for Orion's Crew Module (CM), where the astronauts reside in flight.
- Oversight of important elements of the CM project including building test flight hardware.
- Vital support for a new rocket that carries Orion to space including power, thrust vector control and shroud studies.
- Environmental testing at Plum Brook Station of the entire Orion spacecraft.
- Management of several research and advanced technology development projects on the ISS and on Earth, in support of human exploration.

Science

- Management of the In-Space Propulsion Technology Program and development of its associated technologies.
- Management of Radioisotope Power Systems and the development of associated technologies. These develop new ways to power scientific spacecraft including the Advanced Stirling Convertor (ASC) for the Advanced Stirling Radioisotope Generator (ASRG). These systems will more scientific missions through more efficient use of power generating material.

Space Operations

- Support of the Space Shuttle Program (SSP) by providing expert engineers for the shuttle's electrical power system, its purge, vent, and drain subsystem and for determination of stress, loads, and

dynamics on the vehicle. The Lead Quality Auditor role for the SSP is also at NASA Glenn.

- Support of the International Space Station's operation of the electrical power system.
- Leads development of new, advanced communications technology including a demonstration on the International Space Station of software-defined radios.

Aeronautics

NASA Glenn continues to enrich its world class aeronautics heritage by concentrating research and program management efforts on the principles of flight in any atmosphere at any speed and the enhancement of aviation safety.

For the Fundamental Aeronautics Program, NASA Glenn provides technical project management leadership and conducts research for the following four projects:

- Hypersonics Project: Research in propulsion and high temperature materials, instrumentation and dynamic controls to enable very high speed flight, and reliable re-entry into planetary atmospheres.
- Supersonics Project: Scientific leadership in propulsion, combustion, and acoustic research to eliminate environmental (e.g., sonic boom) and performance barriers.
- Subsonics: Fixed Wing: Developing revolutionary technologies and aircraft concepts to achieve highly improved performance (e.g., fuel efficiency) while satisfying strict noise and emission constraints.
- Subsonics: Rotary Wing: Research to improve civilian potential of rotary wing vehicles (helicopters) so that they can carry more payload to farther destinations.

For the Aviation Safety Program, NASA Glenn provides technical project management leadership for the following three projects: Atmospheric Environment Safety Technologies (AEST) Project, Atmospheric Environment Safety Technologies (AEST) Project, and Vehicle Systems Safety Technologies Project. NASA

Glenn plays a key role in conducting long-term, cutting-edge research that will produce tools, methods, concepts, and technologies to improve the intrinsic safety features of aircraft engines. NASA Glenn also investigates sources of risk and provides technologies needed to help ensure safe flight in and around atmospheric hazards.

For the Integrated Systems Research Program (ISRP), NASA Glenn provides technical project management leadership and subject matter

expertise for the Environmental Responsible Aircraft (ERA) Project with primary responsibility for the propulsion technology sub-element. ERA Propulsion Technology Sub-element is 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 time frame.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents an economic overview of the NASA Glenn Research Center during fiscal year 2010. Changes between FY 2006 and FY 2010 are described using the number of employees and their occupations, workers' place of residence, payroll, expenditures, and awards to academic institutions, revenues, and income taxes paid by Glenn employees. This report includes data from FY 2006 to FY 2010.

C.1 EMPLOYMENT AND OCCUPATIONS

The NASA Glenn Research Center comprises two components in its labor force: civil service employees and local contractors. Federal laboratories commonly contract employees to have necessary flexibility in their labor force. Contracted employees can be easily adjusted

depending on the needs of research labs. Hiring civil servants is more complex and lengthy.

Table 1 shows the total number of NASA Glenn's civil service employees and the shares of four occupational categories between FY 2006 and FY 2010. In FY 2010, NASA Glenn had 1,658 civil service employees. Glenn civil service employment peaked in FY 2006 at a total of 1,678. NASA Glenn employment has slightly decreased by 1.7% between FY 2006 and FY 2009. This change was consistent with the overall decline in Northeast Ohio's employment during the last period of the recession. Between FY 2009 and FY 2010, however, NASA Glenn added eight civil service employees to the end of the fiscal year. The recent employment increase of NASA Glenn reflected the overall economic recovery under way.

Table 1. NASA Glenn Civil Service Employment Distribution by Occupational Category, FY 2006-2010

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2006	1,678	20.9%	5.2%	59.5%	14.4%
2007	1,672	21.2%	5.2%	60.0%	13.6%
2008	1,662	21.4%	4.6%	61.1%	12.5%
2009	1,650	20.4%	4.4%	63.0%	12.2%
2010	1,658	20.1%	4.1%	64.5%	11.2%

Note: Table does not include local contractors.⁵

⁵ A detailed listing of NASA Glenn's local contractors is at <http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm>

NASA Glenn’s civil service employment consists of four occupational categories: administrative professional, clerical, scientists and engineers, and technicians. The occupational structure of NASA Glenn’s employment has changed slightly during the analyzed period.

The largest occupational category in FY 2010 is the scientists and engineers group which accounted for 64.5% of the civil service employees in FY 2010. Even though the total number of NASA Glenn’s employees had decreased from FY 2006 to FY 2009, the share of scientists and engineers in NASA Glenn has gradually increased since FY 2006 from 59.5% (998 employees) in FY 2006 to 64.5% (1,069 employees) in FY 2010. Between FY 2009 and FY 2010, NASA Glenn hired 42 scientists and engineers that resulted in a 2% increase in the occupational category.

The second largest occupational category in NASA Glenn is the administrative professional group. This category decreased by 17 (1%) employees between FY 2006 and FY 2010, but has consistently accounted for about 20% of the total civil service employees. The technician group decreased by 56 (3%) employees since FY 2006. The loss of technicians accompanies the increased share of scientists and engineers over the 5-year period. The share of technicians fell

from 14.4% in FY 2006 to 11.2% in FY 2010. The number of clerical staff decreased by 19 (1%) between FY 2006 and FY 2010, which accounts for 4.1% of the total civil service employees.

The civil service employees at NASA Glenn are highly educated and highly skilled. In FY 2010, 81% of NASA Glenn’s employees held a bachelor’s or higher degree. Out of all NASA Glenn employees, 18% held a doctoral degree, 35% had a master’s degree and 28% possessed a bachelor’s degree. There was a 3% increase in the share of employees holding a bachelor’s or higher degree between FY 2009 and FY 2010. The increasing share of highly educated employees between FY 2009 and FY 2010 reflects the increase in scientists and engineers at NASA Glenn during this period of time.

Total number of employees at NASA Glenn, including both civil service employees and local contractors, was 3,570 in FY 2010. This total NASA Glenn labor force showed an increase of 25 employees from FY 2009 to FY 2010. The civil sector employment added eight employees to the total number of employees between FY 2009 and FY 2010, while the on- or near-site employment increased by 17 during the same period of time. Between FY 2006 and FY 2010, NASA Glenn’s on- or near-site employment has grown by 32% (Table 2).

Table 2. NASA Glenn On- or Near-Site Contractors’ Employment, FY 2006-2010

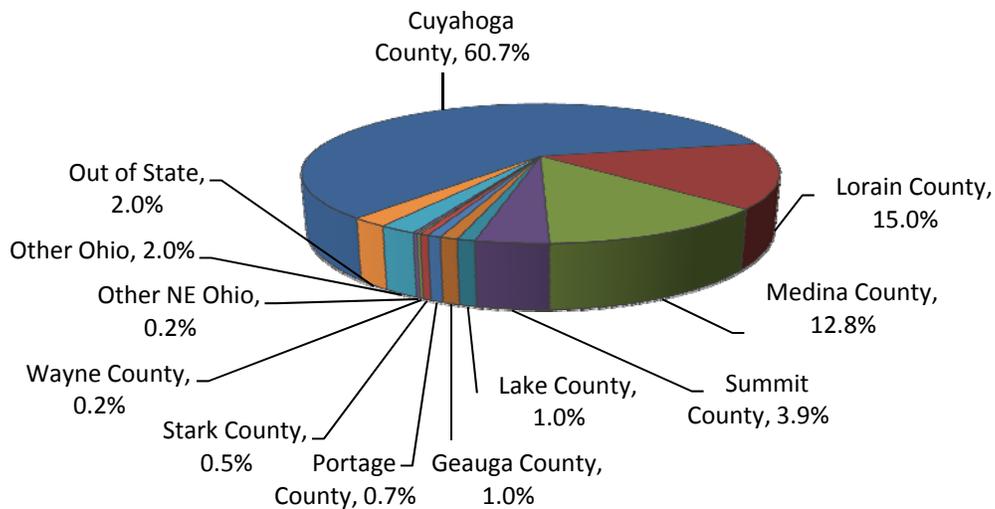
Fiscal Year	Employment of on- or near-site contractors
2006	1,450
2007	1,755
2008	1,874
2009	1,895
2010	1,912

C.2 Place of Residence for Glenn Employees

NASA Glenn is located near Cleveland Hopkins International Airport in Cuyahoga County in Northeast Ohio. NASA Glenn also includes Plum Brook Station near Sandusky, Ohio, west of Northeast Ohio. Most civil service employees at NASA Glenn live in Cuyahoga County and its surrounding counties. Figure 1 shows Glenn employees' postal address by county in Northeast Ohio, other Ohio regions, and other states. A vast majority of civil service employees (1,590 employees, 96%) at NASA Glenn live in

Northeast Ohio. Specifically, 60.7% of Glenn civil servants live in Cuyahoga County where NASA Glenn is located. A significant number of NASA Glenn employees live in Lorain (15%), Medina (12.8%), and Summit Counties (3.9%), as well as in counties southwest of Cuyahoga County. Out of the 2010 total employment of 1,658 Glenn civil servants, 34 employees (2%) live in the remainder of Ohio and 34 employees (2%) postal address is in other states.

Figure 1. NASA Glenn Civil Service Employees by County of Residence, FY 2010



The places of residence of NASA Glenn civil service employees are shown by their occupations in Table 3. In FY 2010, over 96% of the employees in all four occupational categories reside in Northeast Ohio. Cuyahoga County accounts for the highest share in places of residence of employees in each occupational

category within Northeast Ohio. More than 60% of the *Scientists & Engineers* and *Administrative Professional employees* live in Cuyahoga County. Approximately 4% to 5% of employees in these occupations have a postal address outside of Northeast Ohio.

Table 3. NASA Glenn Civil Service Employees by Occupation and Place of Residence, FY 2010

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	95.2%	97.5%	95.7%	98.8%	96.0%
Cuyahoga County	60.5%	62.5%	61.6%	54.0%	60.7%
Lorain County	15.3%	22.5%	13.9%	19.3%	15.0%
Medina County	11.9%	7.5%	12.7%	16.8%	12.8%
Summit County	5.4%	0.0%	3.9%	1.9%	3.9%
Lake County	0.9%	2.5%	0.9%	1.2%	1.0%
Geauga County	0.3%	2.5%	1.0%	1.9%	1.0%
Portage County	0.0%	0.0%	0.8%	1.9%	0.7%
Stark County	0.3%	0.0%	0.5%	1.2%	0.5%
Wayne County	0.3%	0.0%	0.2%	0.0%	0.2%
Other NE Ohio	0.3%	0.0%	0.2%	0.6%	0.2%
Other Ohio	2.8%	2.5%	1.9%	1.2%	2.0%
Out of State	2.0%	0.0%	2.4%	0.0%	2.0%

C.3 PAYROLL

Total compensation for NASA Glenn’s civil service employees was \$221.7 million in FY 2010. The total compensation includes payroll that accounted for \$178.2 million and employee benefits that accounted for another \$43.5 million. Total payroll grew by \$3.6 million (1.6%) between FY 2009 and FY 2010 after adjusting for inflation.⁶ The average wage per civil service employee remained about the same, accounting for a 0.6% increase after adjusting for inflation, from \$106,845 in FY 2009 (inflated to 2010 dollars) to \$107,455 in FY 2010.⁷

Compared to FY 2006, in real dollars adjusted for inflation, total compensation has grown by 10.8%, including a salary increase of 10% and a growth in benefits of 13.9%. During the same time period, the average wage per NASA Glenn employee increased from \$96,504 in FY 2006 to \$107,455 in FY 2010 after adjusting for inflation.⁸

⁶ Total nominal payroll increased by 3.7% between FY2009 and FY2010.

⁷ The average wage per employee in nominal terms increased by 2.6% between FY 2009 and FY 2010.

⁸ In nominal dollars, the average employee wage rose from \$90,233 to \$107,455, which accounts for 19.1%.

C.4 GLENN EXPENDITURES, FY 2010

In FY 2010, vendors in 50 states, Washington, D.C., Puerto Rico, and 14 foreign countries shared the benefits of NASA Glenn’s spending of \$552.9 million. Compared to the total expenditure of \$541.2 million in FY 2009, NASA Glenn increased its expenditures by 2.2% in FY 2010 in nominal dollars.

Figure 2 shows the geographical distribution of NASA Glenn’s spending in FY 2010, of which Ohio is the largest beneficiary. In FY 2010, Ohio received \$324.3 million, accounting for 58.7% of NASA Glenn’s total expenditures. The share of NASA Glenn’s expenditures in Ohio slightly decreased from 60.3% in FY 2009 to 58.7% in FY 2010, which reflects a \$2.15 million decline between FY 2009 and FY 2010. Within Ohio’s expenditures, Northeast Ohio received \$255.4 million, which accounted for 78.8% of the Ohio spending in FY 2010. Northeast Ohio accounted for 46.2% of total NASA Glenn spending in FY 2010.

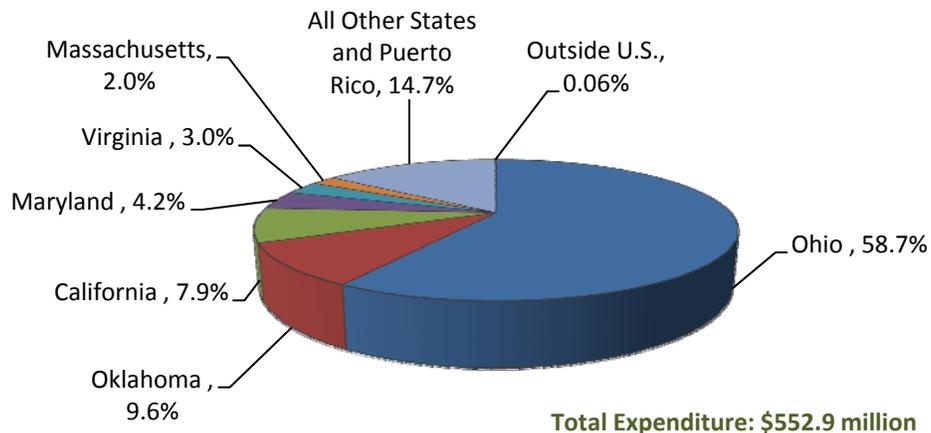
In addition to the state of Ohio, the remaining states and Puerto Rico received \$228.3 million in FY 2010 (41.3% of the total NASA Glenn spending in FY 2010), and foreign countries received \$0.3 million (or 0.06% of total spending) (See Appendix Table A.1).

Besides Ohio, five other states (Oklahoma, California, Maryland, Virginia, and Massachusetts) received over \$10 million or at least a 2% of NASA Glenn’s total expenditures during FY 2010. In FY 2010, Oklahoma was the second largest beneficiary from NASA Glenn’s spending, receiving \$53.1 million which accounted for 9.6% of Glenn’s total expenditures in FY 2009. Compared to FY 2009, NASA Glenn increased its expenditures in Oklahoma by \$28.7 million which was 72.5% more than in FY 2009 in nominal dollars. NASA Glenn’s expenditures in California increased slightly in FY 2010 (\$43.5 million) compared to FY 2009 (\$40.8 million). California received \$43.5 million, accounting for 7.9% of Glenn’s total spending in FY 2010.

At the same time, NASA Glenn decreased its spending in Maryland, the third largest beneficiary in FY 2010. The state of Maryland received \$23 million in FY 2010, compared to \$32 million in FY 2009. Between FY 2009 and FY 2010, NASA Glenn’s spending in Maryland fell by 38.3% in nominal dollars.

Among foreign countries, in FY 2010, the largest beneficiaries were Canada, Sweden, Great Britain, and Germany, which together accounted for 98% of the total Glenn spending in foreign countries.

Figure 2. NASA Glenn Spending in Select States, FY 2010 (in nominal dollars)



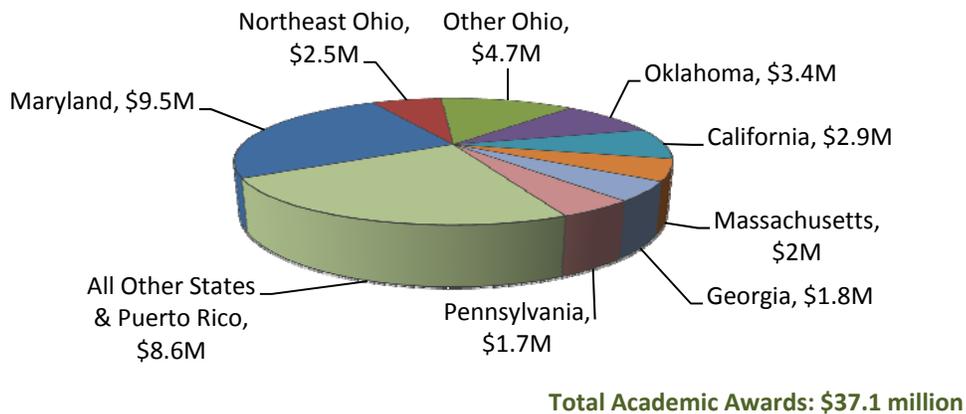
C.5 NASA GLENN AWARDS TO ACADEMIC AND OTHER INSTITUTIONS

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 research and development activities. The amount of NASA Glenn’s funding to academia is determined annually based on NASA Glenn’s goals and mission of each year.

In FY 2010, the total funding of NASA Glenn’s academic awards to colleges and universities in the United States, including Puerto Rico, was \$37.1 million in 37 states, Washington, D.C., and Puerto Rico. This constitutes a \$2.3 million increase (6.6%) from FY 2009 in nominal dollars.

Figure 3 shows the distribution of funding awarded to colleges and universities with emphasis s on selected states, which received more than \$1 million funding from NASA Glenn in FY 2010. Seven states, including Maryland, Ohio, Oklahoma, California, Massachusetts, Georgia, and Pennsylvania, received over \$1 million funding from NASA Glenn in FY 2010. All seven states’ academic funding awarded from NASA Glenn accounted for 76.8% of the total of FY 2010 (See Appendix Table A.2).

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2010 (in nominal dollars)



Colleges and universities in Maryland received \$9.5 million, which accounted for the largest share (25.5%) of Glenn academic awards to colleges and universities in FY 2010. NASA Glenn's academic awards to Maryland showed an 18.2% increase (\$1.5 million) between FY 2009 and FY 2010.

The colleges and universities in the state of Ohio received \$7.2 million of funding from NASA Glenn in FY 2010, which accounted for 19.4% of all Glenn academic awards. Within the state of Ohio, academic institutions in Northeast Ohio received \$2.5 million, which accounted for 6.7% of NASA Glenn's total academic awards in FY 2010 and accounted for 34.6% of all Ohio university grants received in FY 2010. This constitutes a slight decrease of \$0.2 million from \$2.7 million in FY 2009 in nominal dollars.

Oklahoma received \$3.4 million and California received \$2.9 million of academic funding from Glenn. Massachusetts, Georgia, and Pennsylvania each received more than \$1 million in NASA Glenn awards to their colleges and universities during FY 2010 (See Appendix Table A.2).

Table 4 shows the distribution of NASA Glenn awards by colleges and universities in

the state of Ohio for FY 2006 to FY 2010 in adjusted 2010 dollars. NASA Glenn FY 2010 academic awards were reduced by 55.7% compared to \$16.3 million in FY 2006.

In FY 2010, academic awards in Ohio were \$7.2 million. Between FY 2009 and FY 2010, NASA Glenn reduced its academic grants to Ohio's universities and colleges by 11.3% (\$0.9 million), in adjusted 2010 dollars.

Three universities in Ohio received awards over \$1 million in FY 2010. The University of Toledo has been awarded the highest share of funding from NASA Glenn over the last 5 years; it obtained \$2.8 million in FY 2010, which accounted for 38.5% of total awards to colleges and universities in Ohio. Ohio State University received the second largest funding of \$1.5 million (20.2%) from NASA Glenn in FY 2010. NASA Glenn awarded \$1 million (14.2%) to Cleveland State University, the third largest recipient of NASA Glenn's academic awards in Ohio in FY 2010.

Colleges and universities in Northeast Ohio received \$2.5 million in FY 2010: Cleveland State University (\$1 million), Case Western Reserve University (\$0.8 million), and University of Akron (\$0.6 million).

**Table 4. NASA Glenn Educational Grants in Ohio by Academic Institution,
FY 2006 – FY 2010, in \$2010**

OHIO COLLEGES & UNIVERSITIES	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010*	FY 2010 Share
University of Toledo	\$5,056,285	\$3,929,234	\$3,435,247	\$2,583,180	\$2,776,561	38.5%
Ohio State University	\$3,789,564	\$2,058,215	\$1,828,097	\$2,078,230	\$1,453,643	20.2%
Cleveland State University	\$2,407,487	\$1,679,870	\$1,482,379	\$726,780	\$1,024,413	14.2%
Case Western Reserve University	\$3,317,521	\$2,291,354	\$1,646,080	\$811,810	\$834,248	11.6%
University of Akron	\$854,249	\$565,144	\$1,133,293	\$1,243,656	\$633,302	8.8%
University of Cincinnati	\$79,352	\$184,232	\$623,981	\$493,445	\$271,004	3.8%
Ohio University	\$123,107	\$38,481	\$55,148	\$69,661	\$194,662	2.7%
Wright State University	\$83,621	\$46,539	\$489	\$32,917	\$16,944	0.2%
Kent State University	\$13,049	\$2,423			\$350	
University of Dayton	\$162,730	\$13,115		\$48,919		
Bowling Green State University	\$306,081	\$32,389		\$28,710		
Cuyahoga Community College	\$38,990	\$577	\$36,232	\$10,204		
John Carroll University		(\$10,452)				
Lake County Community College						
Baldwin Wallace College	\$21,098					
Myers University	\$6,860					
Lorain County Community College	\$1,258					
Malone College	\$686					
Capital University	(\$86)					
TOTAL	\$16,261,851	\$10,831,121	\$10,240,947	\$8,127,511	\$7,205,127	100.0%

Table is sorted by this column.

C.6 NASA GLENN REVENUES

NASA Glenn’s total revenue in FY 2010 reached \$736.2 million, which showed a 3.6% decrease from FY 2009 and a 2.3% increase from FY 2006 without adjustment for inflation. NASA Glenn’s total revenue was the lowest in FY 2007; thereafter, it showed growth. NASA Glenn’s revenue has increased 13.8% from FY 2007 in nominal dollars.

Table 5 shows NASA Glenn revenue by revenue source from FY 2006 to FY 2010. NASA Glenn’s revenue comes from two sources: NASA direct authority and reimbursable commitments. The share of revenue from NASA’s direct authority has been over 95% since FY 2007, departing

from its lowest level of 93% in FY 2006. In FY 2010, Glenn received \$705.6 million in revenue directly from NASA, which accounted for 95.8% of NASA Glenn total revenue. NASA Glenn also received an additional \$30.7 million from reimbursable commitments.

NASA Glenn’s revenue from other sources besides direct authority from NASA fell by \$ 1.9 million (5.9%) from FY 2009 to FY 2010 in nominal dollars. During FY 2010, the structure of reimbursable commitments included other federal agencies (65.5%), domestic, nonfederal entities (29.1%), and the Department of Defense (5.3%).

**Table 5. NASA Glenn Revenues,
FY 2006- FY 2010, thousands of nominal dollars**

Revenue Source	FY06	FY07	FY08	FY09	FY10
NASA Direct Authority	669,585	626,910	671,663	731,026	705,550
Reimbursable Commitments	50,243	20,172	27,886	32,606	30,682
Total FY Authority	719,828	647,082	699,549	763,632	736,232
Revenue from NASA	93.0%	96.9%	96.0%	95.7%	95.8%

C.7 TAXES PAID BY NASA GLENN EMPLOYEES

State and local taxes paid directly to state and local governments by NASA Glenn employees play an important role in the regional economies of Northeast Ohio and Ohio. NASA Glenn’s total employment and payroll of employees whose workplaces are located on the NASA Glenn campus determine the amount of taxes paid by NASA Glenn. Most NASA Glenn employees are located in the cities of Brook Park, Cleveland, and Fairview Park, which affects the distribution of their tax dollars.

Table 6 shows the amount of income taxes withheld from NASA Glenn employee paychecks and sent directly to state and local governments. This excludes taxes paid by employees to local governments based on their place of residence. The total amount of income taxes from NASA Glenn’s employees was \$9.8 million in FY 2010. Total income taxes paid by NASA Glenn employees increased by 3.7% between FY 2009 and FY 2010 in nominal dollars. Compared to FY 2006, NASA Glenn employees paid \$587,885 more income taxes in FY 2010 in nominal dollars.

The state of Ohio and the city of Brook Park are the two largest beneficiaries of the income taxes paid by NASA Glenn’s employees.

Together they accounted for 98.2% of total state and local income taxes paid by NASA Glenn employees in FY 2010. The share of income tax that the state of Ohio received was 65% (\$6.3 million) of total income taxes paid by Glenn’s employees in FY 2010.

In FY 2010, the city of Brook Park withheld \$3.3 million in income tax from NASA Glenn employees, which was an 11% increase compared to FY 2009. Over the past 5 years, NASA Glenn employees paid \$30.9 million to the state of Ohio and \$14.4 million to the city of Brook Park.

NASA Glenn employees’ income taxes paid to the city of Fairview Park fell by 58% between FY 2009 and FY 2010, although the income taxes from NASA Glenn to the city of Brook Park and the city of Cleveland kept increasing. Income taxes paid to the city of Cleveland in FY 2010 increased about five times compared to FY 2006, even though the share of these taxes of total NASA Glenn income tax amount paid is not significant (0.1%). This shift in taxes occurred due to moving some of the civil servants from facilities located in Fairview Park to the main campus in 2010.

Table 6. Income Taxes Paid by NASA Glenn Employees
(in nominal dollars)

Year	City of Brook Park	City of Cleveland	City of Fairview Park	State of Ohio	Total
2006	\$2,600,094	\$2,433	\$386,722	\$6,205,963	\$9,195,211
2007	\$2,748,507	\$2,362	\$389,630	\$6,097,704	\$9,238,203
2008	\$2,844,033	\$6,910	\$399,634	\$6,189,703	\$9,440,279
2009	\$2,941,876	\$9,174	\$385,752	\$6,098,786	\$9,435,588
2010	\$3,264,189	\$11,465	\$160,915	\$6,346,527	\$9,783,096

D. ECONOMIC IMPACT OF NASA GLENN

In this section we discuss the economic impact of the NASA Glenn on Northeast Ohio⁹ and the state of Ohio in FY 2010. Total impact is measured in terms of output (sales), employment, value added, household earnings, and taxes contributed to local, state, and federal budgets. Each of these categories (except for taxes) is estimated as the sum of four components: change in final demand, direct impact, indirect impact, and induced impact. NASA Glenn's total impact on Northeast Ohio and the state of Ohio are estimated separately.

D.1 METHODOLOGY

Total economic impact is estimated based on the assumption that NASA Glenn came into existence at the beginning of FY 2010 and instantly generated a demand for goods and services needed for its operation. The demand reflects the investment NASA Glenn generates in Northeast Ohio and Ohio economies. The increase in demand from NASA's expenditures in the region generates economic impact (on Northeast Ohio or Ohio) that can be quantified by including the change of final demand in a statistical model.¹⁰ The effects of a change in final demand is traced throughout Northeast Ohio or Ohio economies using an input-output model that reflects the buy-sell relationships among all industry sectors and the household sector in relevant economies.

In order for NASA Glenn to engage in research and development, other goods and services are needed as intermediate input and other

purchases occur from income received by NASA Glenn employees. This leads to the generation of other components of economic impact: direct, indirect, and induced. Changes in final demand also include initial first-round effects. The first-round effects consist of total spending by NASA Glenn, value added, household income (total payroll of NASA Glenn's employees), and employment (total employment of NASA Glenn in a given year), for this estimation in FY 2010.

Direct impact refers to the initial value of goods and services, including labor, purchased by NASA Glenn to conduct its operations within Northeast Ohio or the state of Ohio.¹¹ Indirect impact measures the value of labor, capital, and other input of production needed to produce the goods and services required by NASA Glenn. Induced impact measures the change in spending by local households due to increased earnings by employees in local industries who produce goods and services for NASA Glenn and its suppliers.

Economic impact analysis takes into account inter-industry buy-sell relationships within the economy. These relationships largely 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 industrial distribution of input purchased and outputs sold by each industry and the household sector. Thus, by using I-O models, it is possible to estimate how the impact of one additional dollar or one additional job ripples through the respective economy, creating additional expenditures and jobs. The economic multiplier measures the extent of

⁹ For the purposes of this analysis, Northeast Ohio is limited to the Akron and Cleveland metropolitan areas and includes Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

¹⁰ Change in final demand is defined as the purchases of goods and services for NASA Glenn's final consumption.

¹¹ For NASA Glenn it is a first-order indirect effect.

the ripple effect that an initial expenditure has on the local economy.¹² This study utilizes regional I-O multipliers from the IMPLAN Professional model.¹³

Two factors need to be addressed when estimating economic impact: (1) purchases from companies located outside the studied region need to be excluded, and (2) the share of revenues received from local sources needs to be considered. For this analysis, economic impact on the Northeast Ohio economy is generated only by NASA Glenn purchases from companies located within Northeast Ohio; economic impact on the state of Ohio is generated only by NASA Glenn purchases from companies located throughout the state of Ohio. Therefore, when estimating the impact on Northeast Ohio, goods and services purchased from businesses and other entities located outside the eight-county region were excluded from the model. Likewise, when estimating the impact on the state of Ohio, all goods and services purchased within Ohio are included and goods and services purchased from businesses and other entities located outside the state were excluded from the respective model. Regarding sources of revenues, all of NASA Glenn's revenues are received from non-local sources (federal sources) and, therefore, no further adjustments are required.

¹² For example, suppose that company XYZ 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.

¹³ IMPLAN 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 model was later commercialized by the Minnesota IMPLAN Group, Inc. as a software package.

Before entering local (Northeast Ohio or the state of Ohio) expenditures into the IMPLAN model, the amounts are discounted by the percentage of revenues that are received from local sources. If expenditures were not discounted by the percentage of revenues coming from local sources, sometimes referred to as “neutral monies” that reflect a substitution effect, then the economic impact values would simply reflect the redistribution of local funds. The objective of impact analysis is to estimate the effect of monies coming from outside the studied economy rather than the redistribution of monies already existing in that economy. Revenues coming from outside the respective economy are sometimes referred to as “good money.” Since almost all NASA Glenn revenues are derived from federal sources (95.8%),¹⁴ discounting of expenditures due to local revenues was not necessary. We also account for the effect of income spending by NASA Glenn employees, including in the model only personnel that live inside Northeast Ohio.

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 household 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 output less the value of intermediary goods.¹⁵

¹⁴ This includes revenue from NASA and other federal agencies.

¹⁵ Intermediary goods and services—such as energy, materials, and purchased services—are purchased for the production of other goods and services rather than for final consumption.

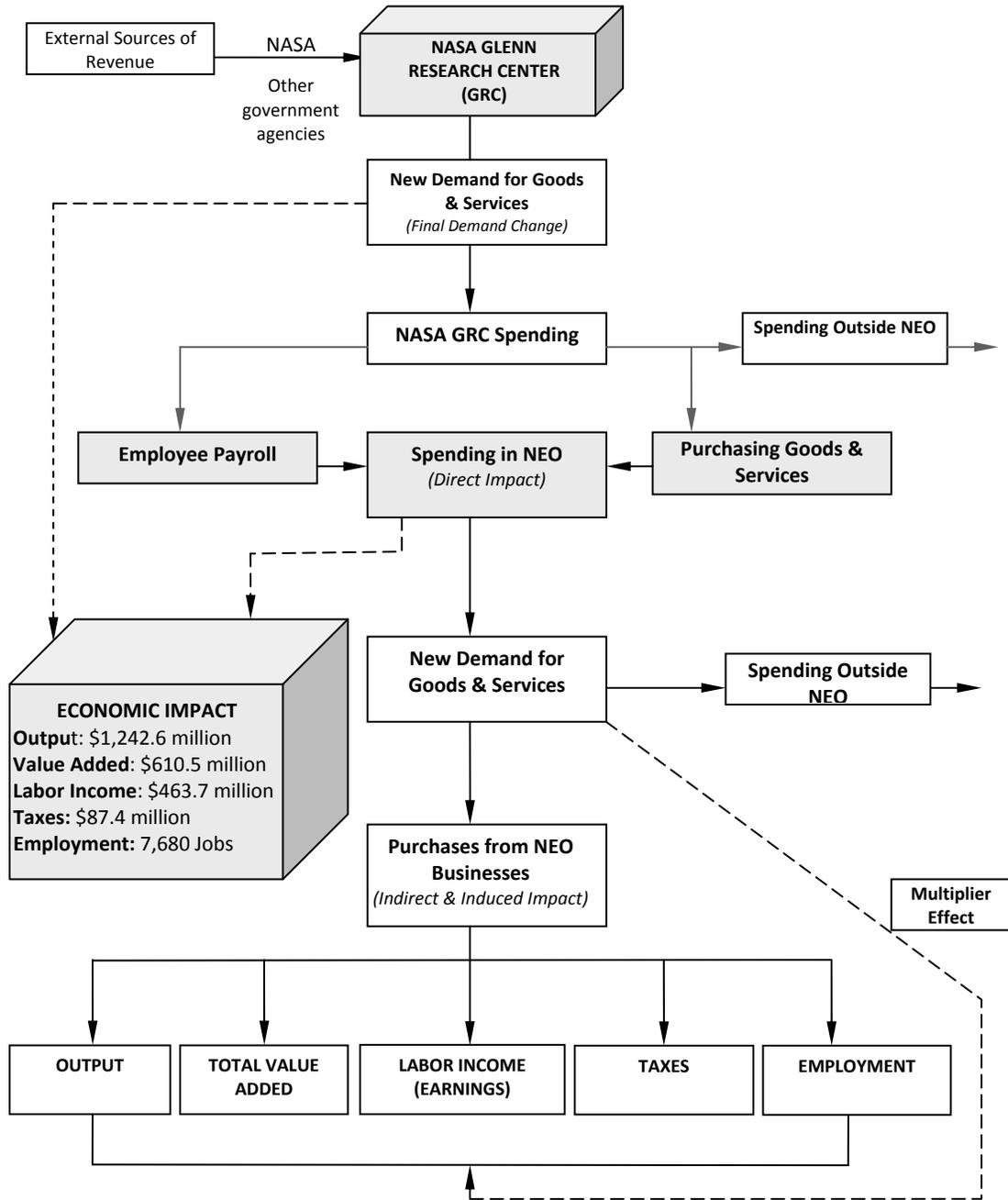
- Output impact measures the additional value of goods and services produced in the region as a result of NASA Glenn expenditures.
- Tax impact measures the additional federal, state, and local tax revenues collected in the region as a result of NASA Glenn expenditures.

The employment, labor income, value-added and output impacts are each a summation of three impacts: direct impact, indirect impact, and induced impact.¹⁶

Figure 4 illustrates the process by which NASA Glenn impacted the local economy through its spending in Northeast Ohio in FY 2010. Through its attraction of federal dollars, NASA Glenn creates new demand for goods and services (final demand change). Some of this demand is generated for goods and services provided by vendors outside the Northeast Ohio, resulting in dollars leaking from the regional economy many goods and services are purchased locally, however.

¹⁶ The summation of direct, indirect, and induced impacts to the total impact across the lines of industries in the impact tables in the next few pages (tables 7-14) may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling.

Figure 4. NASA Glenn Research Center—Economic Impact on Northeast Ohio, FY 2010



D.2 ECONOMIC IMPACT ON NORTHEAST OHIO IN FY 2010

This section presents the economic impact that NASA Glenn spending produced for the Northeast Ohio economy in FY 2010. This analyses includes detailed overview of the changes in output (sales), value added, labor income (earnings), taxes, and employment generated by NASA Glenn activities.

D.2.1 Output Impact on Northeast Ohio in FY 2010

These analyses use SAM multipliers to estimate the ripple effect that an initial expenditure made by NASA Glenn has on a local economy.¹⁷ The multipliers measure the effect of NASA Glenn spending on output (sales) in Northeast Ohio. They provide a quantitative measure of the total change in output produced by Northeast Ohio industries for each additional final demand dollar spent by NASA Glenn.

NASA Glenn expenditures were divided into spending for goods and services purchased from companies and other entities (such as universities) located in Northeast Ohio (local) and spending for goods and services from businesses and other entities located outside of Northeast Ohio. Local spending is then taken into account for economic modeling and categorized by industry, based upon an IMPLAN industry classification system. IMPLAN classifies all expenditures across 440 different sectors which are similar to industries in the North American Industry Classification System (NAICS). Table A.3, Appendix A, provides detailed NASA Glenn expenditures in Northeast Ohio by specific industry.

NASA Glenn makes its largest expenditures on scientific research and development services including equipment, supplies and materials, grants, and professional services. The spending made in Ohio and Northeast Ohio produces significant economic impact on these economies.

Table 7 presents the total output impact and its components. NASA Glenn expenditures in Northeast Ohio represent direct output impact. Indirect impact is estimated by summing the contributions of individual industries that provide input to the producers of the goods and services consumed by NASA Glenn through the chain of suppliers. Induced impact is estimated by measuring the spending of workers who are employed as a result of the demand for products and services created by NASA Glenn. Total output impact is the sum of change in final demand, direct impact, indirect impact, and induced impact. Table 7 reports output impacts by industry sector and shows how NASA Glenn spending across Northeast Ohio affects all sectors in the economy.

¹⁷ IMPLAN type SAM multipliers are used in this study. SAM multipliers are based on information in a social account matrix that considers social security and income tax leakage, institution savings, commuting, and inter-institutional transfers.

**Table 7. Output* Impact Based on NASA Glenn Spending in Northeast Ohio,
FY 2010**

NASA Glenn Expenditures in Northeast Ohio: \$445,170,893

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$117,020	\$287,596	\$404,616
Mining	\$0	\$498,188	\$447,867	\$946,055
Utilities	\$15,996,050	\$2,133,270	\$7,058,655	\$25,187,975
Construction	\$22,266,341	\$2,172,643	\$2,424,352	\$26,863,336
Manufacturing	\$1,862,861	\$4,701,938	\$10,330,355	\$16,895,154
Wholesale trade	\$197,060	\$3,156,958	\$16,936,321	\$20,290,339
Retail trade	\$958,359	\$915,273	\$32,981,031	\$34,854,663
Transportation & warehousing	\$62,013	\$4,939,670	\$8,000,699	\$13,002,382
Information	\$16,912,148	\$7,701,389	\$10,450,131	\$35,063,668
Finance & insurance	\$0	\$9,559,816	\$49,260,416	\$58,820,232
Real estate & rental	\$430,405	\$11,120,761	\$65,145,611	\$76,696,777
Professional- scientific & tech services	\$149,364,628	\$22,017,032	\$15,560,509	\$186,942,169
Management of companies	\$0	\$2,769,765	\$3,395,923	\$6,165,688
Administrative & waste services	\$45,212,035	\$13,165,592	\$8,646,900	\$67,024,527
Educational services	\$4,075,910	\$41,823	\$6,285,217	\$10,402,950
Health & social services	\$1,506,148	\$55,348	\$56,321,384	\$57,882,880
Arts- entertainment & recreation	\$6,122	\$621,841	\$4,424,306	\$5,052,268
Accommodation & food services	\$0	\$2,884,499	\$18,499,790	\$21,384,290
Other services	\$10,126	\$3,017,373	\$14,786,215	\$17,813,714
Government & non NAICs	\$16	\$1,843,822	\$6,139,850	\$7,983,688
TOTAL	\$258,860,221	\$93,434,023	\$337,383,127	\$689,677,371
Change in final demand*	\$552,920,673			
Direct impact	\$258,860,221			
Indirect impact	\$93,434,023			
Induced impact	\$337,383,127			
Total output impact	\$1,242,598,044			

*For output impact, the change in final demand equals to spending by NASA Glenn within and outside Northeast Ohio excluding payroll and health benefits.

**Total does not add up to "Direct + Indirect + Induced" because of rounding.

The total output impact across Northeast Ohio as a result of NASA Glenn FY 2010 activities was \$1.243 billion.

NASA Glenn's expenditures of \$445 million in Northeast Ohio resulted in an output (sales) change of \$690 million across all industry sectors (Table 7). For example, NASA Glenn spending affected a \$186.9 million increase in total sales by all professional, scientific, and technical services industries or \$16.9 million increase in sales (direct, indirect, and induced impacts) by all manufacturing-related industries. 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, 44.5% (\$552 million) is accounted for by the change in final demand that occurs because NASA Glenn operations bring resources into Northeast Ohio from outside the region. Approximately \$259 million (20.8%) of the total output impact is a result of direct spending by NASA Glenn for goods and services purchased within Northeast Ohio. The remaining output impact of \$431 million (34.7%) is attributable to the indirect and induced components as NASA Glenn spending ripples through the economy.

A detailed analysis of the IMPLAN model's results indicates that the \$690 million change in output (sales) generated by the direct, indirect, and induced impacts can be divided into three broad categories—NASA Glenn-driven industries, consumer-driven industries, and other industries. NASA Glenn-driven industries are those whose increased sales, employment, and earnings are attributed primarily but not exclusively to NASA Glenn spending. They include utilities, construction, information, professional and scientific services, administrative and support services, and

education. The total increase in output for these industries in FY 2010 was \$351.5 million or 51.0% of the total impact generated by the direct, indirect, and induced impacts.

Consumer-driven industries are those whose increased sales, employment, and earnings are attributed primarily to spending by NASA Glenn employees and other workers who produce goods and services for NASA Glenn and their suppliers. They include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.¹⁸ The total increase in output for these industries in FY 2010 was \$273 million or 39.5% of the total impact.

Other industries are those that are driven by both NASA Glenn and consumer spending or whose impact is less significant. They include manufacturing, government enterprises, agriculture, mining, wholesale trade, and transportation and warehousing. The total increase in output for these industries in FY 2010 was \$66 million or 9.5% of the total impact.

The output distribution for select industries within the NASA Glenn-driven sectors is shown in Figure 5 and the output distribution for select industries within the consumer-driven ones is presented in Figure 6. Industries with additional sales of at least \$9 million and \$17 million were

¹⁸ 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.

selected to be presented in Figures 5 and 6, respectively.

The scientific research and development services industry generates the largest impact of output; it increased by \$104.5 million in FY 2010 due to NASA Glenn's operations (Figure 5). This amount is the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by NASA Glenn spending for research services. The increase of \$104.5 million accounts for 30% of the \$351.5

million increase in output for all NASA Glenn-driven industries.

Other industries shown in Figure 5 can be interpreted similarly. The food services industry saw an increase in sales of \$20.7 million in FY 2010 (Figure 6). This amount is the summation of the direct, indirect, and induced impacts generated primarily by NASA Glenn employees and other workers for food and drinks. The increase of \$20.7 million accounts for 8% of the \$272.5 million increase in output for all industries within the consumer-driven industries.

Figure 5. Increase in Sales for Select Industries in NASA Glenn-Driven Industries in Northeast Ohio, FY 2010

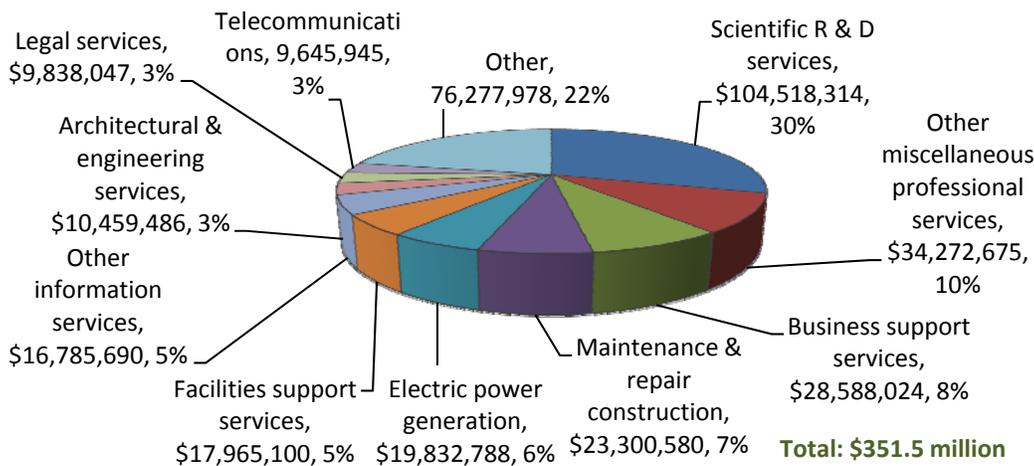
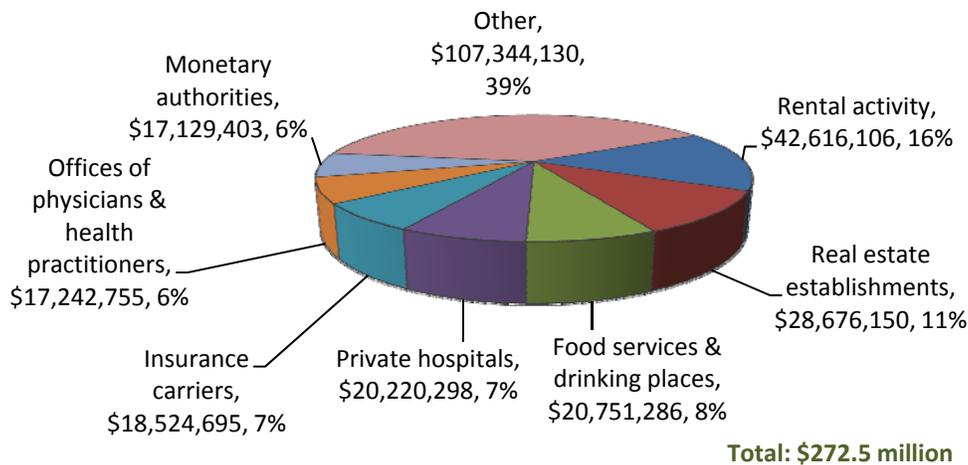


Figure 6. Increase in Sales for Select Industries in Consumer-Driven Industries in Northeast Ohio, FY 2010



D.2.2 Employment Impact on Northeast Ohio in FY 2010

NASA Glenn’s operation in Northeast Ohio affects job creation beyond Glenn’s hiring of its own employees (change in final demand). NASA Glenn spending triggers increased employment in industries from which it purchases goods and services (direct impact) and employment in industries that provide input into those goods (indirect impact).

In addition, money spent by employees of NASA Glenn and employees of those companies with which NASA Glenn does business create jobs in a variety of other industries (induced impact). Total employment impact equals the sum of NASA Glenn full-time equivalent (FTE) employment, direct impact, indirect impact, and induced impact. Table 8 shows the number of jobs created by the industry sectors.

Table 8. Employment Impact Based on NASA Glenn Spending in Northeast Ohio, FY 2010

NASA Glenn Expenditures in Northeast Ohio: \$445,170,893

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	0	3	5	8
Mining	0	2	2	4
Utilities	29	3	9	41
Construction	233	20	21	274
Manufacturing	7	15	27	49
Wholesale trade	1	17	91	109
Retail trade	64	17	592	672
Transportation & warehousing	1	37	60	98
Information	231	31	40	301
Finance & insurance	0	40	214	254
Real estate & rental	2	80	196	278
Professional- scientific & tech services	1,106	177	127	1,410
Management of companies	0	14	17	31
Administrative & waste services	605	211	133	949
Educational services	55	1	113	169
Health & social services	13	0	573	586
Arts- entertainment & recreation	0	12	76	88
Accommodation & food services	0	51	331	382
Other services	0	36	242	278
Government & non NAICs	0	12	29	41
TOTAL	2,346	778	2,898	6,022
Change in final demand*	1,658			
Direct impact	2,346			
Indirect impact	778			
Induced impact	2,898			
Total employment impact	7,680			

*For employment impact, the change in final demand equals the number of full-time equivalent employees working for NASA Glenn.

**Total does not add up to “Direct + Indirect + Induced” because of rounding.

The total employment impact by NASA Glenn Research Center on the Northeast Ohio economy in FY 2010 was 7,680 jobs. Out of the total employment, 1,658 (21.6%) were directly employed at NASA Glenn in FY 2010. As a result of Glenn's direct spending for goods and services purchased in the region, 2,346 jobs (30.5%) were created. The remaining employment impact, 3,676 jobs (47.9%), is in the form of indirect and induced impacts as NASA Glenn spending ripples through the economy.

Of the 6,022 jobs created in Northeast Ohio due to the direct, indirect, and induced impacts, 3,143 (52.2%) were found in the NASA Glenn-driven industries, 2,538 (42.1%) were in the consumer-driven industries, and 341 (5.7%) fall under the category of other industries.¹⁹ The job distribution for select industries within the NASA Glenn-driven industries is shown in Figure 7. The job distribution for select industries within the consumer-driven ones is shown in Figure 8. The industries presented in figures 7 and 8 are the leading industries with the most increased employment (minimum of 90 employees per sector in Figure 7 and 98 in Figure 8).

NASA Glenn's scientific R&D services generated the highest number of additional jobs. Companies engaged in scientific R&D (professional, scientific, and technical services sector) saw an increase of 783 jobs in FY 2010 due to NASA Glenn operation (Figure 7). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily but not exclusively by NASA Glenn spending for R&D contractors in Northeast Ohio. The 783 jobs account for 25% of the 3,143 jobs that were created in all industries within the NASA Glenn-driven ones.

The real estate industry saw an increase of 258 jobs in FY 2010 because of NASA Glenn spending (Figure 8). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily by NASA Glenn employees and other workers using real estate services in Northeast Ohio. The 258 jobs account for 10% of the 2,538 jobs that were created in all consumer-driven industries.

¹⁹ NASA Glenn-driven industries include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven industries include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 7. Increase in Jobs for Select Industries in NASA Glenn-Driven Industries in Northeast Ohio, FY 2010

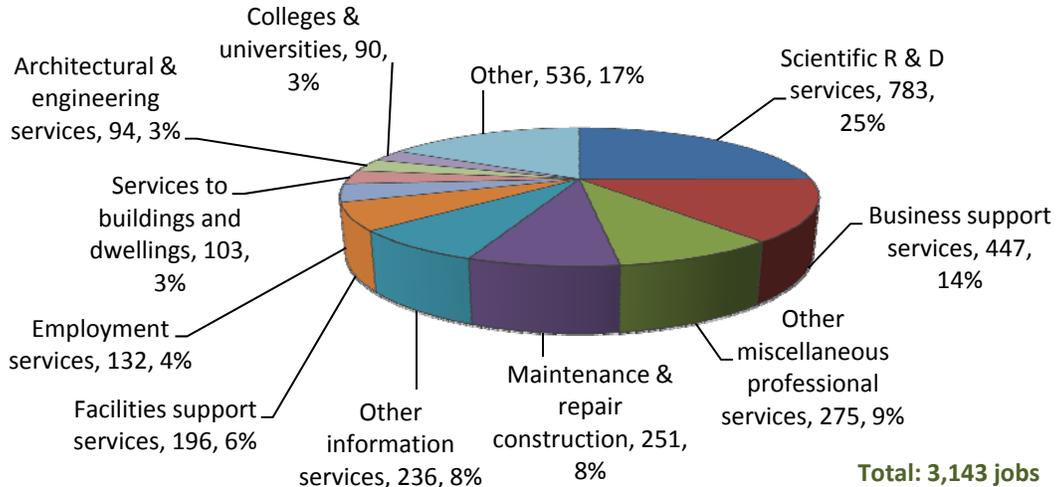
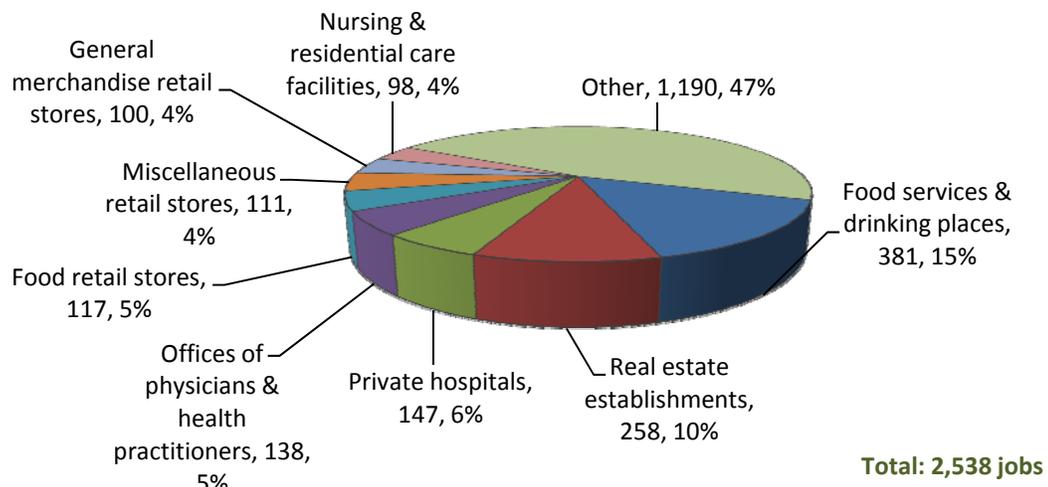


Figure 8. Increase in Jobs for Select Industries in Consumer-Driven Industries in Northeast Ohio, FY 2010



D.2.3 Labor Income Impact on Northeast Ohio in FY 2010

Labor income impact²⁰ is the estimated total change in earnings paid to local households due to spending by NASA Glenn for goods and services from businesses and other entities in Northeast Ohio. Money paid to employees of companies and other entities that supply goods and services to NASA Glenn represent direct earnings impact. Indirect impact is estimated by summing the money paid to people working for companies that provide input to the producers of the 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 households whose income is affected by the demand for products and services created by NASA Glenn. Adding the direct, indirect, and induced impacts to the disposable income and healthcare benefits received by NASA Glenn employees (final demand change) results in total earnings impact. Table 9 shows earnings impact by industry sector.

²⁰ In previous studies labor income impact was referred to as household earnings impact.

**Table 9. Labor Income* Impact Based on NASA Glenn Spending in Northeast Ohio,
FY 2010**

NASA Glenn Expenditures in Northeast Ohio: \$445,170,893

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$46,282	\$94,954	\$141,236
Mining	\$0	\$112,320	\$107,666	\$219,986
Utilities	\$3,576,402	\$356,435	\$1,141,868	\$5,074,705
Construction	\$10,409,529	\$935,904	\$997,096	\$12,342,529
Manufacturing	\$408,461	\$956,457	\$1,589,792	\$2,954,710
Wholesale trade	\$76,161	\$1,297,273	\$6,959,555	\$8,332,989
Retail trade	\$1,190,917	\$506,366	\$17,581,928	\$19,279,211
Transportation & warehousing	\$27,084	\$1,733,902	\$2,824,543	\$4,585,528
Information	\$11,822,062	\$1,916,904	\$2,404,273	\$16,143,238
Finance & insurance	\$0	\$2,715,319	\$13,641,981	\$16,357,300
Real estate & rental	\$118,055	\$1,201,818	\$2,607,426	\$3,927,299
Professional- scientific & tech services	\$69,911,032	\$11,232,658	\$7,566,946	\$88,710,636
Management of companies	\$0	\$1,357,018	\$1,663,798	\$3,020,816
Administrative & waste services	\$24,567,975	\$6,850,090	\$4,267,522	\$35,685,586
Educational services	\$2,077,160	\$19,086	\$3,235,938	\$5,332,184
Health & social services	\$619,731	\$22,383	\$28,891,272	\$29,533,386
Arts- entertainment & recreation	\$2,085	\$308,665	\$1,913,908	\$2,224,658
Accommodation & food services	\$0	\$996,618	\$6,400,356	\$7,396,974
Other services	\$5,525	\$1,562,895	\$7,944,770	\$9,513,190
Government & non NAICs	\$4	\$932,429	\$2,231,529	\$3,163,963
TOTAL	\$124,812,181	\$35,060,820	\$114,067,123	\$273,940,124
Change in final demand*	\$189,801,396			
Direct impact	\$124,812,181			
Indirect impact	\$35,060,820			
Induced impact	\$114,067,123			
Total labor income impact	\$463,741,521			

*Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy. In previous studies, this was called "Household earnings impact".

**For labor income impact, change in final demand is equal to the disposable income (75% of gross income) plus healthcare benefits paid to NASA Glenn employees.

***Total does not add up to "Direct + Indirect + Induced" because of rounding.

Total labor income in Northeast Ohio increased by \$463.7 million as a result of NASA Glenn's spending in FY 2010 for goods and services. Out of this total amount, \$189.8 million (40.9%) is disposable income plus healthcare benefits paid directly to NASA Glenn employees, i.e., change in final demand. Out of total impact, \$124.8 million (26.9%) represents money paid to employees of companies in Northeast Ohio that supply goods and services to NASA Glenn, i.e., direct impact. The remaining earnings impact, (indirect and induced components) estimated at \$149.1 million (32.2%), occurs as the effects of NASA Glenn spending ripples through the Northeast Ohio economy.

Of the \$273.9 million increase in labor income generated across Northeast Ohio due to the direct, indirect, and induced impacts, \$160 million (58.4%) was reported in NASA Glenn-driven industries; \$86.5 (31.6%) was generated in consumer-driven industries; and \$27.4 million (10%) was reported in other industries.²¹ The labor income distribution for select industries within the NASA Glenn-driven sectors is shown in Figure 9.

The labor income distribution for select industries within the consumer-driven industries is shown in Figure 10. Selected industries, shown in Figures 9 and 10, added over \$3 million each.

In the NASA Glenn-driven industries, people engaged in business support services saw their household earnings increase by \$18.4 million in FY 2010 (Figure 9). These earnings are the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn using business support services in Northeast Ohio. The \$18.4 million is 11% of the \$160 million labor income increase that was reported by all industries within the NASA Glenn-driven industries.

Persons working in private hospitals saw their household earnings increase by \$9.5 million in FY 2010 (Figure 10). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending at private hospitals. The \$9.5 million accounts for 11% of the \$86.5 million labor income increase that occurred in all industries within the consumer-driven ones.

²¹ 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 Select Industries in NASA Glenn-Driven Industries in Northeast Ohio, FY 2010

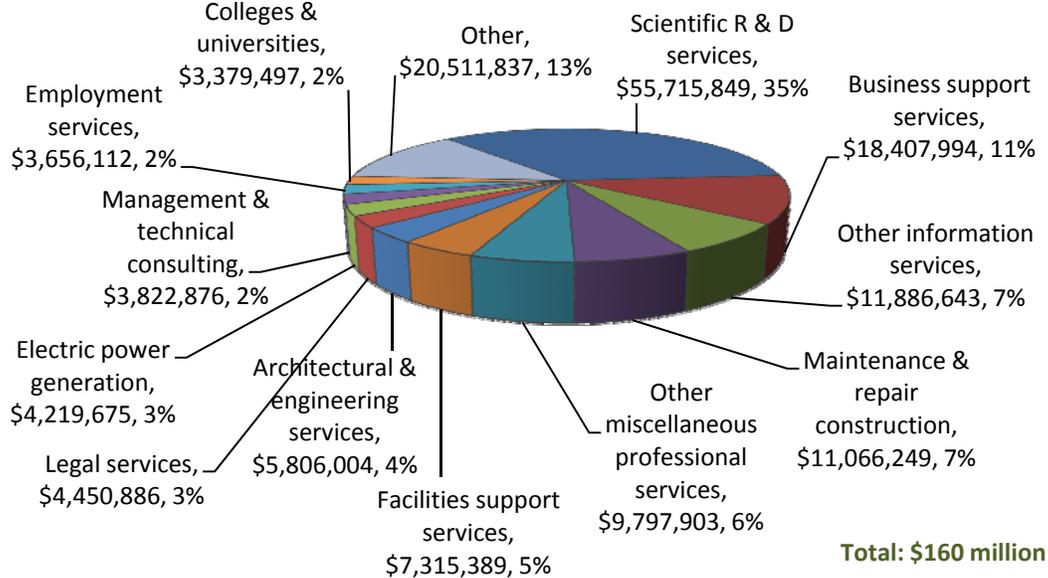
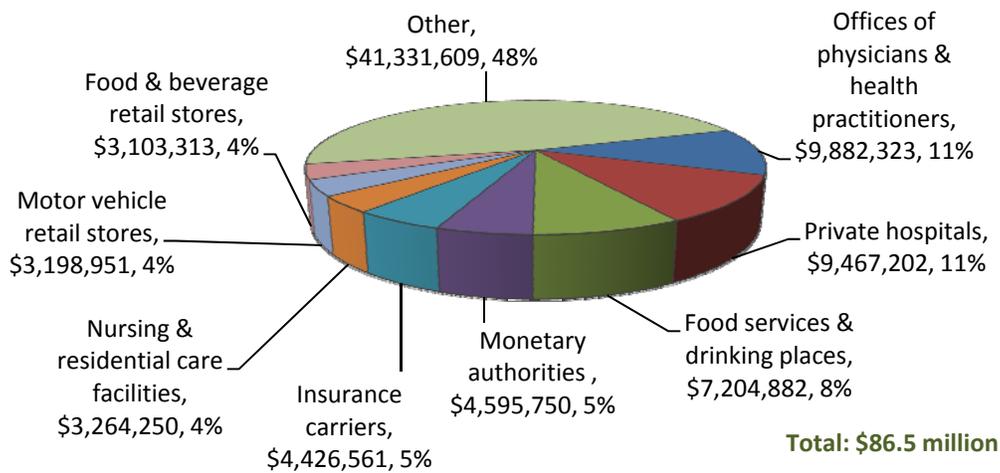


Figure 10. Increase in Labor Income for Industries in Consumer-Driven Industries in Northeast Ohio, FY 2010



D.2.4 Value Added Impact on Northeast Ohio in FY 2010

Value added measures the economic impact of all goods and services produced in Northeast Ohio because of operation of NASA Glenn excluding intermediary goods which are goods used in the production of other goods and not for final consumption. NASA Glenn spending affected a \$420.7 million increase in sales (direct, indirect, and induced impacts) by all industries excluding intermediary goods and services. The disposable income and healthcare benefits received by NASA Glenn employees constitute the final demand change for value added. Sales of companies and other entities who supply goods and services to NASA Glenn excluding value of intermediary goods and services represent direct value-added impact.

Indirect impact is estimated by summing the sales of companies that provide input to the producers of the goods and services ultimately consumed by NASA Glenn excluding value of intermediary goods and services. Induced impact represents sales excluding intermediary goods and services in all industries that produce products for households whose income is affected by the demand for products and services created by NASA Glenn. Adding the direct, indirect, and induced impacts to the disposable income and healthcare benefits received by NASA Glenn employees (final demand change) results in total value-added impact. Table 10 shows value-added impact by industry sector.

**Table 10. Value-Added Impact Based on NASA Glenn Spending in Northeast Ohio,
FY 2010**

NASA Glenn Expenditures in Northeast Ohio: \$445,170,893

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$51,042	\$117,974	\$169,016
Mining	\$0	\$247,604	\$241,895	\$489,499
Utilities	\$11,681,024	\$1,245,110	\$3,950,511	\$16,876,645
Construction	\$12,264,030	\$1,105,233	\$1,217,955	\$14,587,218
Manufacturing	\$672,361	\$1,633,449	\$2,742,036	\$5,047,846
Wholesale trade	\$130,988	\$2,231,141	\$11,969,535	\$14,331,664
Retail trade	\$1,782,500	\$790,887	\$28,488,761	\$31,062,147
Transportation & warehousing	\$34,268	\$2,481,796	\$3,929,758	\$6,445,822
Information	\$10,850,870	\$3,899,028	\$5,383,443	\$20,133,342
Finance & insurance	\$0	\$5,460,723	\$27,288,987	\$32,749,710
Real estate & rental	\$222,623	\$7,982,128	\$47,431,748	\$55,636,500
Professional- scientific & tech services	\$86,524,180	\$14,387,341	\$10,748,400	\$111,659,920
Management of companies	\$0	\$1,652,634	\$2,026,243	\$3,678,877
Administrative & waste services	\$29,052,099	\$8,443,800	\$5,385,371	\$42,881,270
Educational services	\$2,145,258	\$23,746	\$3,510,381	\$5,679,385
Health & social services	\$796,658	\$28,318	\$31,243,348	\$32,068,323
Arts- entertainment & recreation	\$3,781	\$364,386	\$2,582,741	\$2,950,907
Accommodation & food services	\$0	\$1,431,667	\$9,177,689	\$10,609,356
Other services	\$6,916	\$1,828,071	\$8,593,825	\$10,428,811
Government & non NAICs	\$5	\$899,233	\$2,269,471	\$3,168,710
TOTAL	\$156,167,558	\$56,187,337	\$208,300,071	\$420,654,966
Change in final demand*	\$189,801,396			
Direct impact	\$156,167,558			
Indirect impact	\$56,187,337			
Induced impact	\$208,300,071			
Total value added impact	\$610,456,363			

*For value-added impact, change in final demand is equal to the disposable income (75% of gross income) plus healthcare benefits paid to NASA Glenn employees.

**Total does not add up to "Direct + Indirect + Induced" because of rounding.

Total value added in Northeast Ohio increased by \$610.5 million in FY 2010 as a result of NASA Glenn's spending for goods and services. Out of this total amount, \$189.8 million (31.1%) is disposable income, plus healthcare benefits, paid directly to NASA Glenn employees--change in final demand. Out of total impact, \$156.2 million (25.6%) represents values of goods and services less intermediary goods of companies in Northeast Ohio that supply goods and services to NASA Glenn, i.e., direct impact. The remaining value-added impact, (indirect and induced components) estimated at \$264.5 million (43.3%), occurs as the effects of NASA Glenn spending ripples through the Northeast Ohio economy.

Of the \$420.7 million increase in value added generated across Northeast Ohio due to the direct, indirect, and induced impacts, \$207.6 million (49.3%) was reported in NASA Glenn-driven industries; \$172 (40.9%) was generated in consumer-driven industries; and \$41.1 million (9.8%) was reported in other industries.²² The value-added distribution for select industries within the NASA Glenn-driven industries is shown in Figure 11. The value-added distribution for select industries within the consumer-driven industries is shown in Figure 12. Selected industries in Figures 11 and 12 added over \$5.3 and \$3.5 million, respectively.

Persons engaged in the other miscellaneous professional services sector saw their industry's value added increase by \$25.8 million in FY 2010 (Figure 11). This increase of value added is a result of the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn using other miscellaneous professional services in Northeast Ohio. The \$25.8 million accounts for 12% of the \$207.6 million value-added increase that was reported by all NASA Glenn-driven industries.

Persons working in offices of physicians and health practitioners saw their household earnings increase by \$10.5 million in FY 2010 (Figure 12). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending at offices of local physicians and health practitioners. The \$10.5 million accounts for 6% of the \$172 million value-added increase that occurred in all industries within the consumer-driven ones.

²²See 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 Industries in NASA Glenn-Driven Industries in Northeast Ohio, FY 2010

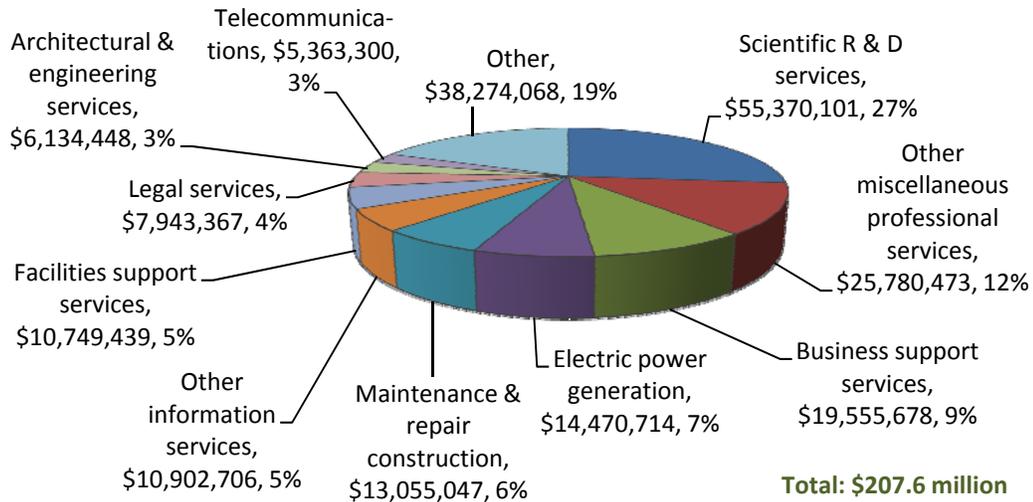
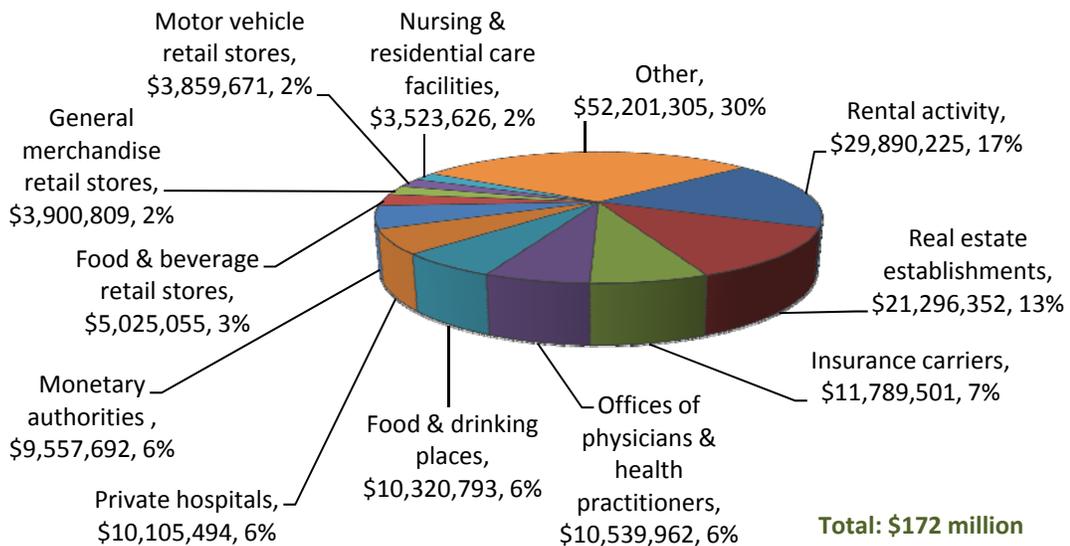


Figure 12. Increase in Value Added for Industries in Consumer-Driven Industries in Northeast Ohio, FY 2010



D.2.5 Tax Impact on Northeast Ohio in FY 2010

The NASA Glenn operation in FY 2010 increased tax revenues by a total of \$87.4 million. Of that, state and local governments in Northeast Ohio benefited from increased tax revenues of \$38.4 million. Federal tax revenues in FY 2010 increased by \$49 million.

D.2.6 FY 2010 Northeast Ohio Impact Summary

Economic activity generated by NASA Glenn produced the following impact on Northeast Ohio (2010 dollars):

- Total Output Impact: \$1,242.6 M
- Total Employment Impact: 7,680 jobs
- Total Labor Income Impact: \$463.7 M
- Total Value-Added Impact: \$610.5 M
- Total Tax Impact: \$87.4 M

The economic impact presented here reflects benefits of NASA Glenn expenditures in Northeast Ohio in FY 2010. During that time period, 56.6% (\$144.5 million) of NASA Glenn expenditures were allocated to professional, scientific and technical services; 17.1% (\$43.7 million) to administrative and support services; and 8.4% (\$21.3 million) to construction – three major areas of NASA Glenn spending. These three sectors together accounted for 82.1% of all NASA Glenn FY 2010 expenditures in Northeast Ohio.

Other industries deriving significant benefits from direct NASA Glenn spending include electric power generation, transmission, and distribution; guided missile and space vehicle manufacturing; and other information services. Businesses deriving the most benefit from spending by NASA Glenn personnel and other workers whose earnings are due in part to NASA Glenn expenditures follow typical consumer spending patterns. These include food services, real estate companies, hospitals and healthcare services, motor vehicle dealers, accounting services, commercial banks, and miscellaneous retailers.

D.3 ECONOMIC IMPACT ON THE STATE OF OHIO IN FY 2010

In this section, we present the economic impact that NASA Glenn had on the Ohio economy during FY 2010. The economic impact is discussed through a detailed analysis of the change in output (sales), employment, and labor income (household earning), value added and taxes due to NASA Glenn activities. This section follows the structure of Section D.2, Economic Impact on Northeast Ohio.

D.3.1 Output Impact on the State of Ohio in FY 2010

The economic impact analysis uses multipliers to estimate the ripple effect that an initial expenditure has on a studied economy. These multipliers measure the effect of NASA Glenn Research Center spending on output (sales) across the state of Ohio. The multipliers that are applied to spending in Ohio are generally larger than those applied to expenditures in Northeast Ohio because a larger geographic area allows capturing more purchases within the region and enabling less leakage from the economy. Stated another way, as the analyzed geographic area increases in size, the amount of goods and services purchased from outside that area decreases.

NASA Glenn expenditures were divided into spending on goods and services purchased from companies and other entities located in the state of Ohio (local) and spending for goods and services from businesses located elsewhere. Local spending is then categorized by industry, based upon the IMPLAN industry classification system. Table A.4 in Appendix A lists detailed NASA Glenn expenditures by specific industry.

Table 11 presents the total output impact and its components. Local NASA Glenn expenditures represent direct output impact. Indirect impact is estimated by summing the contributions of individual industries that provide input to the producers of the goods and services ultimately consumed by NASA Glenn. Induced impact is estimated by measuring the spending of workers who are employed as a result of the demand for products and services created by NASA Glenn. Total output impact is the sum of change in final demand, direct impact, indirect impact, and induced impact. Table 11 reports output impacts by industry sector, illustrating how NASA Glenn spending across Ohio affects all sectors of the state economy.²³

²³ Disposable income spent by NASA Glenn employees is automatically distributed by IMPLAN to those industries from which households typically make purchases. As a result, "households" is not identified as a unique industry sector in Table 11.

**Table 11. Output Impact Based on NASA Glenn Spending in the State of Ohio,
FY 2010**

NASA Glenn Expenditures in Ohio: \$514,093,765

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$234,202	\$938,975	\$1,173,177
Mining	\$0	\$610,193	\$398,367	\$1,008,560
Utilities	\$16,022,006	\$2,845,797	\$7,899,502	\$26,767,306
Construction	\$21,783,689	\$2,678,265	\$2,870,791	\$27,332,746
Manufacturing	\$2,595,050	\$9,025,135	\$22,081,650	\$33,701,835
Wholesale trade	\$212,137	\$3,611,620	\$17,641,838	\$21,465,595
Retail trade	\$1,122,372	\$1,059,756	\$38,417,083	\$40,599,211
Transportation & warehousing	\$60,634	\$6,051,311	\$9,144,576	\$15,256,520
Information	\$16,410,502	\$10,372,419	\$12,130,913	\$38,913,834
Finance & insurance	\$0	\$11,436,582	\$52,185,292	\$63,621,874
Real estate & rental	\$416,494	\$10,783,233	\$68,335,194	\$79,534,920
Professional- scientific & tech services	\$200,934,986	\$23,307,928	\$13,916,600	\$238,159,513
Management of companies	\$0	\$3,302,427	\$3,884,715	\$7,187,142
Administrative & waste services	\$49,891,266	\$16,203,448	\$9,310,316	\$75,405,030
Educational services	\$8,400,738	\$49,502	\$5,633,859	\$14,084,099
Health & social services	\$1,465,300	\$53,482	\$62,095,891	\$63,614,673
Arts- entertainment & recreation	\$5,960	\$735,118	\$4,860,582	\$5,601,660
Accommodation & food services	\$2,434	\$3,633,604	\$21,024,885	\$24,660,923
Other services	\$56,045	\$3,641,008	\$16,832,820	\$20,529,874
Government & non NAICs	\$5,589	\$2,320,538	\$6,976,512	\$9,302,639
TOTAL	\$319,385,202	\$111,955,567	\$376,580,360	\$807,921,130
Change in final demand*	\$552,920,673			
Direct impact	\$319,385,202			
Indirect impact	\$111,955,567			
Induced impact	\$376,580,360			
Total output impact	\$1,360,841,803			

*For output impact, the change in final demand equals spending by NASA Glenn within and outside Ohio excluding payroll and health benefits.

**Total does not add up to "Direct + Indirect + Induced" because of rounding.

The total output impact across the state of Ohio as a result of NASA Glenn activities in FY 2010 was over \$1.36 billion. NASA Glenn's expenditures of \$514.1 million resulted in an increase in output (sales) of \$807.9 million across all industry sectors (Table 11). For example, NASA Glenn spending affected a \$38.9 million increase in sales (direct, indirect, and induced impacts) by the information sector and \$238.2 million in professional, scientific, and technical services.

Of the total output impact, 40.6% (\$552.9 million) is accounted for by the change in final demand that occurs because NASA Glenn activities bring resources into Ohio from outside the state. Approximately \$319.4 million (23.5%) of the total output impact is a result of direct spending by NASA Glenn for goods and services purchased within the state of Ohio. The remaining output impact of \$488.5 million (35.9%) is attributable to the indirect and induced components as NASA Glenn spending ripples through the economy.

An analysis of the IMPLAN model shows that the \$807.9 million increase in sales generated by the direct, indirect, and induced impacts can be divided into the same broad categories that were identified for Northeast Ohio—NASA Glenn-driven industries (\$420.7 million, 52.1%), consumer-driven industries (\$298.2 million, 36.9%), and other industries (\$89 million, 11%).²⁴

The output distribution for select industries within the NASA Glenn-driven industries is shown in Figure 13. The output distribution for select industries within the consumer-driven ones is shown in Figure 14. Selected industries in these figures added over \$10 million and \$12 million, respectively.

Colleges and universities (education sector) across the state of Ohio saw an increase in revenues of \$11 million in FY 2010 (Figure 13). This amount is the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by NASA Glenn spending for research by colleges and universities. This increase of \$11 million accounts for a 2% share of the \$420.7 million increase in output value for all industries within the NASA Glenn-driven industries.

Insurance carriers (finance and insurance sector) experienced a sales increase of \$20.9 million in FY 2010 (Figure 14). This amount is the summation of the direct, indirect, and induced impact components generated primarily by NASA Glenn employees and other workers for insurance products. This increase of \$20.9 million represents a 7% share of the \$298.2 million increase in output for all consumer-driven industries.

²⁴ NASA Glenn-driven sectors include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven sectors include retail, finance and insurance, real estate, health care, entertainment and food, other services, and owner-occupied buildings.

Figure 13. Increase in Sales for Select Industries in NASA Glenn-Driven Industries, Ohio, FY 2010

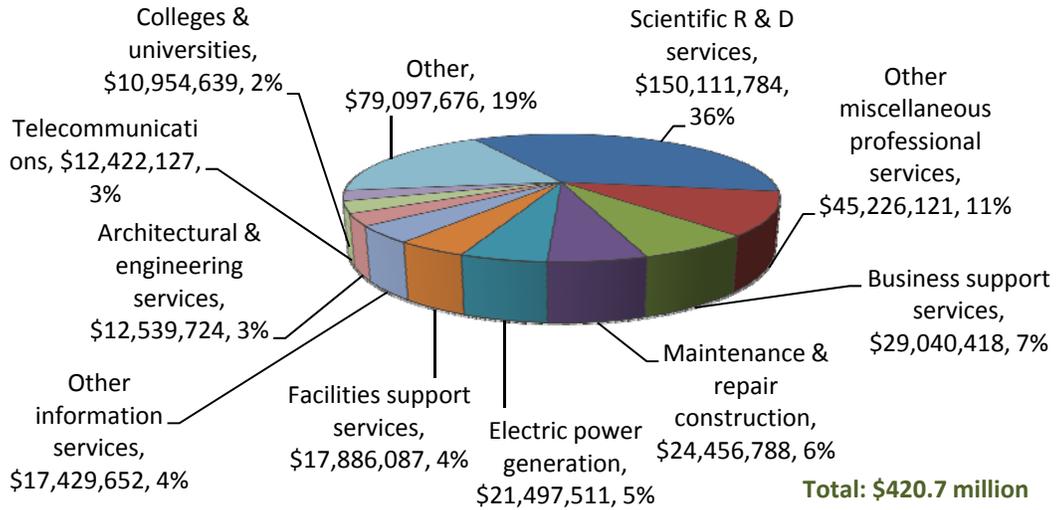
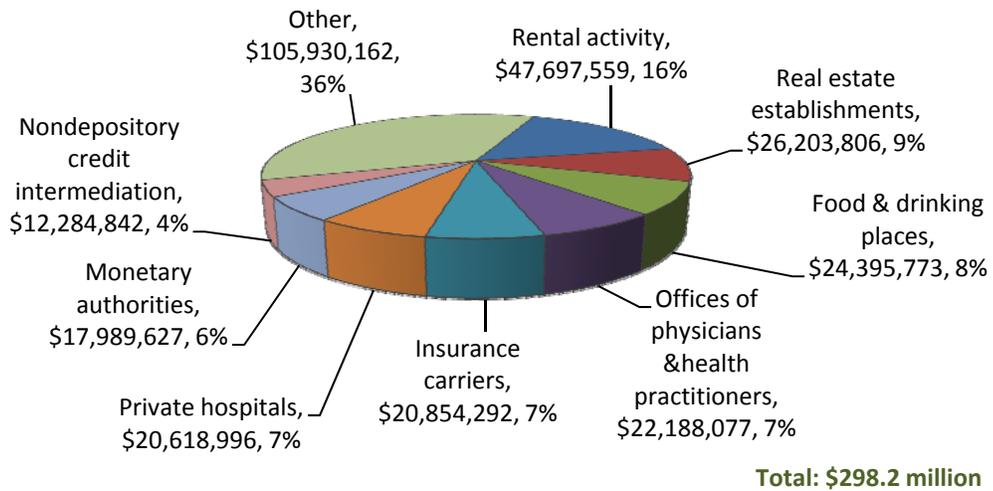


Figure 14. Increase in Sales for Select Industries in Consumer-Driven Industries, Ohio, FY 2010



D.3.2 Employment Impact on the State of Ohio in FY 2010

NASAS Glenn’s activities affect job creation beyond NASA Glenn’s hiring of its own employees (change in final demand). NASA Glenn spending creates employment across the state of Ohio in industries from which it purchases goods and services (direct impact) and employment in industries that provide input into those goods and services (indirect impact).

In addition, money spent by NASA Glenn employees and employees of those companies with which NASA Glenn does business create jobs in a variety of other industries (induced impact). Total employment impact equals the sum of NASA Glenn Research Center full-time equivalent employment and the direct, indirect, and induced components. Table 12 shows the number of jobs created by industry sector.

Table 12. Employment Impact Based on NASA Glenn Spending in the State of Ohio, FY 2010

NASA Glenn Expenditures in Ohio: \$514,093,765

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	0	4	10	14
Mining	0	2	2	4
Utilities	33	4	11	49
Construction	242	26	27	295
Manufacturing	9	24	46	79
Wholesale trade	1	20	99	120
Retail trade	75	20	705	800
Transportation & warehousing	1	44	68	114
Information	175	45	49	269
Finance & insurance	0	50	229	279
Real estate & rental	2	81	177	260
Professional- scientific & tech services	1,467	195	124	1,786
Management of companies	0	16	19	35
Administrative & waste services	837	278	152	1,266
Educational services	119	1	104	224
Health & social services	13	0	654	667
Arts- entertainment & recreation	0	16	94	110
Accommodation & food services	0	67	388	455
Other services	1	48	287	336
Government & non NAICs	0	15	35	49
TOTAL	2,975	956	3,278	7,210
Change in final demand*	1,658			
Direct impact	2,975			
Indirect impact	956			
Induced impact	3,278			
Total employment impact	8,868			

*For employment impact, the change in final demand equals to the number of full-time equivalent employees working for NASA Glenn. **Total does not add up to “Direct + Indirect + Induced” because of rounding.

Employment increased by 8,868 jobs across the state of Ohio in FY 2010 because of the presence of NASA Glenn. Of these jobs, 1,658 people (18.7%) are directly employed at NASA Glenn. As a result of NASA Glenn's direct spending for goods and services purchased in Ohio, 2,975 jobs (33.5%) were created. The remaining employment impact—4,235 jobs (47.8%)—is in the form of indirect and induced impacts as NASA Glenn spending ripples through the economy.

Of the 7,210 jobs created in Ohio due to the direct, indirect, and induced components, 3,888 (53.9%) are found in the NASA Glenn-driven sectors, 2,906 (40.3%) are in the consumer-driven sectors, and 416 (5.8%) fall under the category of other sectors.²⁵ The job distribution for select industries within the NASA Glenn-driven industries is shown in Figure 15. The job distribution for select industries within the consumer-driven industries is shown in Figure 16. Selected industries in these figures added the most jobs (over 112 in Figure 15 and 73 in Figure 16).

Because of NASA Glenn spending in the state of Ohio, 269 jobs were added in maintenance and repair constructions during FY 2010 (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 maintenance and repair construction services. The 269 jobs account for a 7% share of the 3,888 jobs that were created in all industries within the NASA Glenn-driven ones.

The civic and social organizations industry experienced an increase of 90 jobs in FY 2010 (Figure 16). These jobs are the summation of the direct, indirect, and induced components generated primarily by NASA Glenn employees and other workers used services provided by civic and social organizations. The 90 jobs account for a 3% share of the 2,906 jobs that were created in all industries within the consumer-driven industries.

²⁵ Glenn-driven industries include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven industries include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 15. Increase in Jobs for Select Industries in NASA Glenn-Driven Industries in Ohio, FY 2010

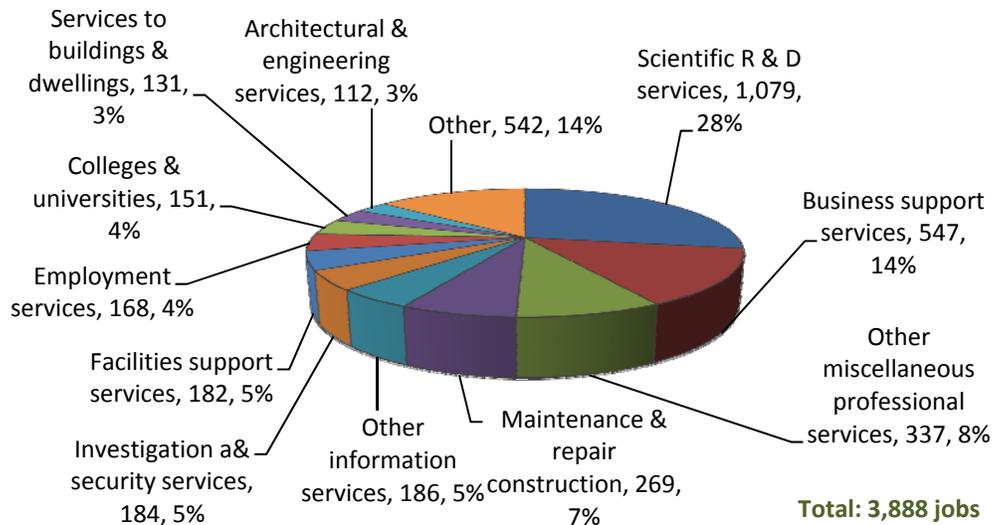
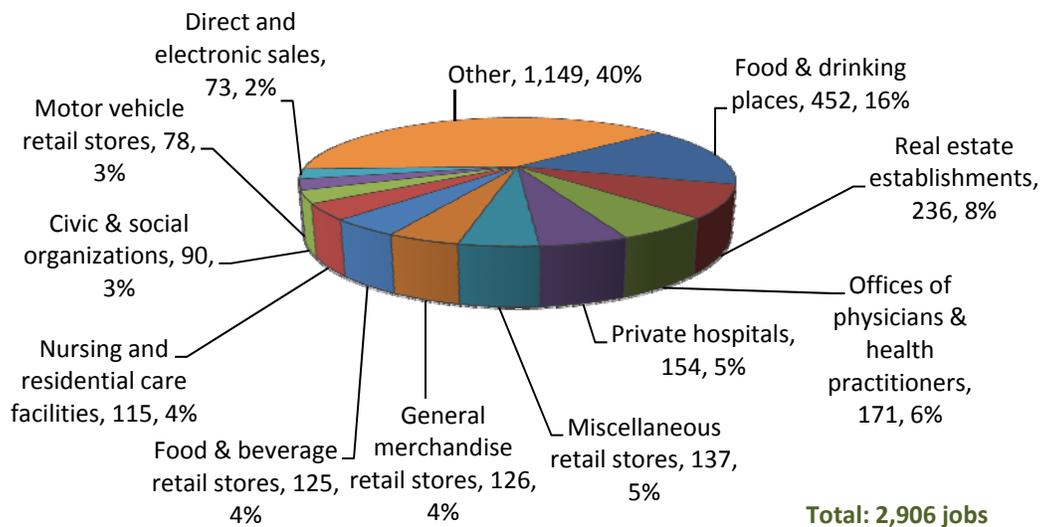


Figure 16. Increase in Jobs for Select Industries in Consumer-Driven Industries in Ohio, FY 2010



D.3.3 Labor Income Impact on the State of Ohio in FY 2010

Labor income (household earnings) is the estimated change in earnings received by households in the state of Ohio due to spending by NASA Glenn Research Center for goods and services from businesses and other entities across the state. Money paid to employees of companies and other entities who supply goods and services to NASA Glenn represent direct earnings impact. Indirect impact is estimated by summing the monies paid to persons who work for companies that provide input to the

producers of the goods and services ultimately consumed by NASA Glenn. Induced impact represents monies paid to workers in all industries who are employed as a result of the demand for products and services created by NASA Glenn. Adding the direct, indirect, and induced impacts to the disposable income and healthcare benefits received by NASA Glenn employees (final demand change) results in total earnings impact. Table 13 shows labor income impact by industry sector.

Table 13. Labor Income Impact Based on NASA Glenn Spending in the State of Ohio, FY 2010

NASA Glenn Expenditures in Ohio: \$514,093,765

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$68,120	\$229,665	\$297,785
Mining	\$0	\$150,860	\$102,385	\$253,245
Utilities	\$3,536,608	\$481,507	\$1,316,414	\$5,334,529
Construction	\$10,273,989	\$1,164,176	\$1,196,200	\$12,634,365
Manufacturing	\$537,921	\$1,585,654	\$2,819,976	\$4,943,551
Wholesale trade	\$78,876	\$1,427,775	\$6,974,317	\$8,480,969
Retail trade	\$1,420,020	\$577,480	\$20,160,617	\$22,158,117
Transportation & warehousing	\$26,809	\$2,214,014	\$3,368,653	\$5,609,476
Information	\$13,202,140	\$2,984,666	\$2,912,509	\$19,099,314
Finance & insurance	\$0	\$3,045,274	\$13,559,088	\$16,604,362
Real estate & rental	\$115,975	\$1,251,581	\$2,525,772	\$3,893,327
Professional- scientific & tech services	\$98,685,294	\$11,992,428	\$6,941,243	\$117,618,965
Management of companies	\$0	\$1,689,287	\$1,987,144	\$3,676,431
Administrative & waste services	\$27,050,760	\$8,364,639	\$4,567,885	\$39,983,284
Educational services	\$4,330,956	\$23,020	\$2,996,733	\$7,350,708
Health & social services	\$609,533	\$21,821	\$32,450,879	\$33,082,233
Arts- entertainment & recreation	\$1,955	\$336,656	\$1,987,667	\$2,326,278
Accommodation & food services	\$733	\$1,250,371	\$7,250,308	\$8,501,412
Other services	\$29,328	\$1,876,536	\$8,669,554	\$10,575,418
Government & non NAICs	\$1,786	\$1,109,121	\$2,468,824	\$3,579,732
TOTAL	\$159,902,685	\$41,614,986	\$124,485,831	\$326,003,502
Change in final demand*	\$189,801,396			
Direct impact	\$159,902,685			
Indirect impact	\$41,614,986			
Induced impact	\$124,485,831			
Total labor income impact	\$515,804,898			

*Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy. In previous studies it is called "Earnings impact".

**For labor income impact, change in final demand is equal to the disposable income (75% of gross income) plus healthcare benefits paid to NASA Glenn employees.

***Total does not add up to "Direct + Indirect + Induced" because of rounding.

Total labor income in the state of Ohio increased by \$515.8 million as a result of NASA Glenn's spending for goods and services in FY 2010. Of this amount, \$189.8 million (36.8%) is the disposable income and healthcare benefits paid to NASA Glenn employees (change in final demand). Monies paid to employees of companies across the state that supply goods and services to NASA Glenn (direct impact) represent \$159.9 million (31%). The remaining earnings impact (indirect and induced components), estimated at \$166.1 million (32.2%), occur as the effects of NASA Glenn spending ripples through the Ohio economy.

Of the \$326 million increase in household earnings attributed to the direct, indirect, and induced components, \$202 million (62%) was reported in Glenn-driven industries, \$97.1 million (29.7%) occurred in consumer-driven industries, and \$26.9 million (8.3%) was reported in other industries.²⁶ The household earnings distribution for select industries within the NASA Glenn-driven industries is shown in Figure 17. The household earnings distribution for select industries within the consumer-driven industries is shown in Figure 18. Selected industries in these figures experienced the most gains in earnings (over \$4.5 million each in Figure 17 and over \$2.5 million each in Figure 18).

Within the NASA Glenn-driven industries, employees in the electric power generation industry across the state of Ohio saw their household earnings increase by \$4.5 million in FY 2010 (Figure 17). These earnings are the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by NASA Glenn for electric power generation. The \$4.5 million represents a 2% share of the \$202 million earnings increase that occurred in all industries within the NASA Glenn-driven ones.

Within the consumer-driven industries, persons working for motor vehicle and parts dealers (retail trade sector) experienced an increase in household earnings of \$3.7 million in FY 2010 (Figure 18). This amount is the summation of the direct, indirect, and induced impacts generated primarily by NASA Glenn employees and other workers on spending for automobiles and other types of motor vehicles. The \$3.7 million accounts for a 4% share of the \$97.1 million earnings increase that was reported by all consumer-driven industries.

²⁶See section D.2.1 Output Impact on Northeast Ohio for detailed definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 17. Increase in Earnings for Select Industries in NASA Glenn-Driven Industries in Ohio, FY 2010

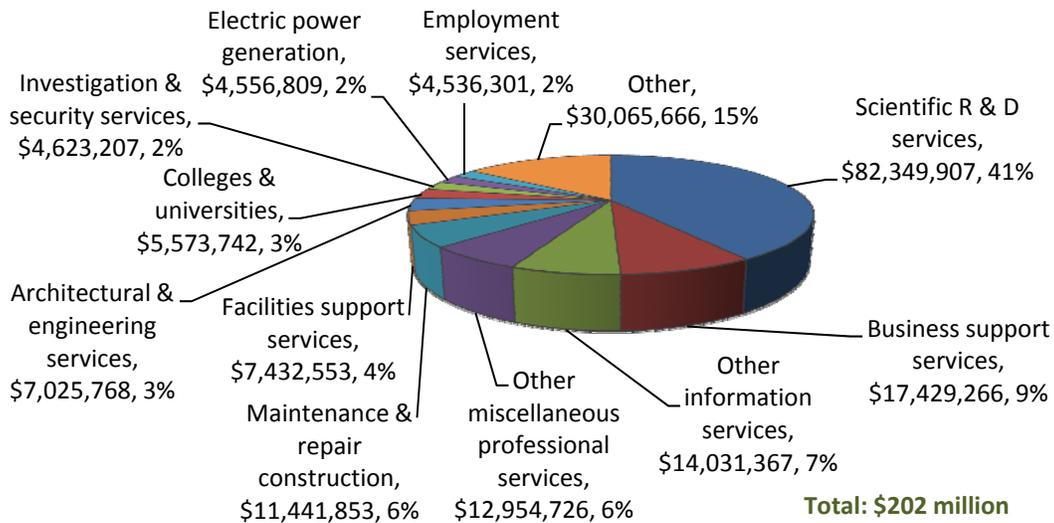
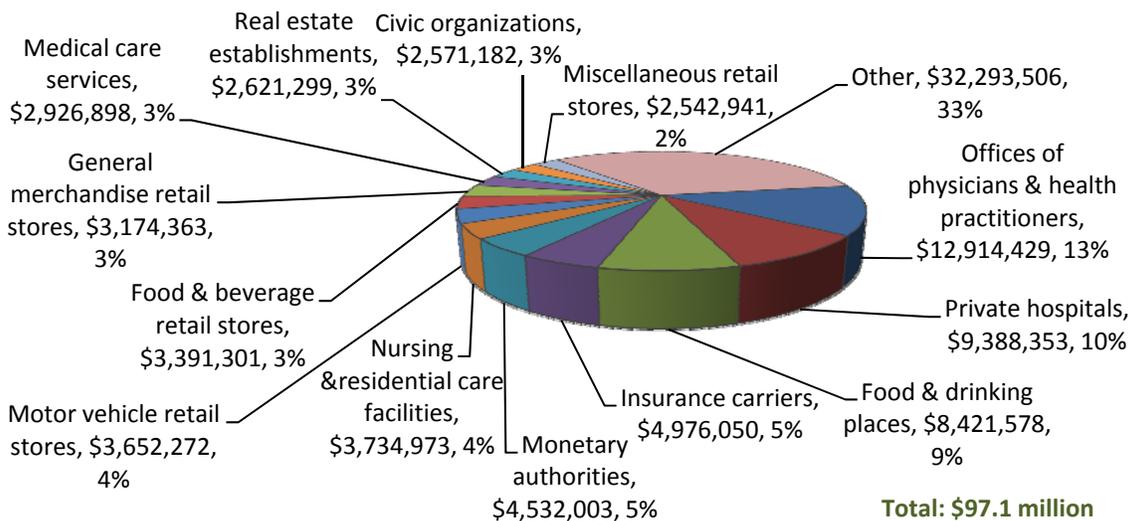


Figure 18. Increase in Earnings for Select Industries in Consumer-Driven Industries in Ohio, FY 2010



D.3.4 Value-Added Impact on the State of Ohio in FY 2010

Value added measures economic impact of all goods and services produced in the state of Ohio due to NASA Glenn operation excluding intermediary goods. NASA Glenn spending affected an increase in value added (direct, indirect, and induced impacts) by all industries (sales excluding intermediary goods and services). The disposable income and healthcare benefits received by NASA Glenn employees constitute the final demand change for value added. Sales less intermediary goods and services of companies and other entities who supply goods and services to NASA Glenn represent direct value-added impact. Indirect impact is estimated by summing the sales of

companies that provide input to the producers of the goods and services ultimately consumed by NASA Glenn excluding value of intermediary goods and services. Induced impact represents sales excluding intermediary goods and services in all industries that produce products for households whose income is affected by the demand for products and services created by NASA Glenn. The total value-added impact is a summation of the direct, indirect, and induced impacts and the disposable income and healthcare benefits received by NASA Glenn employees (final demand change) (Table 14).

Table 14. Value-Added Impact Based on NASA Glenn Spending in the State of Ohio, FY 2010

NASA Glenn Expenditures in Ohio: \$514,093,765

Industry	Direct	Indirect	Induced	Total**
Agriculture, forestry, fishing & hunting	\$0	\$97,647	\$339,880	\$437,527
Mining	\$0	\$315,267	\$219,166	\$534,433
Utilities	\$11,520,044	\$1,683,811	\$4,572,337	\$17,776,191
Construction	\$12,117,627	\$1,376,172	\$1,460,903	\$14,954,702
Manufacturing	\$849,135	\$2,771,011	\$5,421,899	\$9,042,045
Wholesale trade	\$135,522	\$2,453,141	\$11,982,968	\$14,571,631
Retail trade	\$2,106,986	\$904,926	\$32,792,211	\$35,804,124
Transportation & warehousing	\$33,901	\$3,130,870	\$4,654,098	\$7,818,869
Information	\$12,158,948	\$5,409,504	\$6,273,386	\$23,841,838
Finance & insurance	\$0	\$6,294,505	\$28,232,976	\$34,527,481
Real estate & rental	\$220,008	\$7,795,247	\$48,471,801	\$56,487,057
Professional- scientific & tech services	\$119,326,620	\$15,452,330	\$9,668,549	\$144,447,498
Management of companies	\$0	\$2,057,739	\$2,420,561	\$4,478,300
Administrative & waste services	\$31,842,040	\$10,345,199	\$5,787,750	\$47,974,989
Educational services	\$4,474,077	\$28,974	\$3,226,656	\$7,729,707
Health & social services	\$783,479	\$27,673	\$35,086,024	\$35,897,176
Arts- entertainment & recreation	\$3,547	\$398,297	\$2,732,519	\$3,134,363
Accommodation & food services	\$1,311	\$1,797,517	\$10,393,425	\$12,192,253
Other services	\$37,040	\$2,188,905	\$9,390,261	\$11,616,206
Government & non NAICs	-\$423	\$1,050,770	\$2,417,756	\$3,468,103
TOTAL	\$195,609,862	\$65,579,504	\$225,545,126	\$486,734,493
Change in final demand*	\$189,801,396			
Direct impact	\$195,609,862			
Indirect impact	\$65,579,504			
Induced impact	\$225,545,126			
Total output impact	\$676,535,889			

*For value-added impact, change in final demand is equal to the disposable income (75% of gross income) plus healthcare benefits paid to NASA Glenn employees.

**Total does not add up to "Direct + Indirect + Induced" because of rounding.

Total value added in the state of Ohio increased by \$676.5 million as a result of NASA Glenn's spending for goods and services in FY 2010. Out of this total amount, \$189.8 million (28.1%) is disposable income, plus healthcare benefits, paid directly to NASA Glenn employees (change in final demand). Out of total impact, \$195.6 million (28.9%) represents the value of goods and services less intermediary goods of companies in Ohio that supply goods and services to NASA Glenn (direct impact). The remaining value-added impact, (indirect and induced components) estimated at \$291.1 million (43%), occurs as the effects of NASA Glenn spending ripples through the Ohio economy.

Of the \$486.7 million increase in value added generated across Ohio due to the direct, indirect, and induced impacts, \$256.7 million (52.7%) was reported in NASA Glenn-driven industries; \$189.7 (39%) was generated in consumer-driven industries; and \$40.3 million (8.3%) was reported in other industries.²⁷ The value-added distribution for select industries within the NASA Glenn-driven ones is shown in

Figure 19. The value-added distribution for select industries within the consumer-driven ones is shown in Figure 20. Selected industries in Figures 19 and 20 added over \$6 and \$5 million, respectively.

Within the NASA Glenn-driven industries, persons engaged in telecommunication saw the sector's value added increase by \$6.9 million in FY 2010 (Figure 19). This increase is a result of the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn spending for telecommunication. The \$6.9 million accounts for 3% of the \$256.7 million value-added increase that was reported by all industries within the NASA Glenn-driven ones.

Within the consumer-driven industries, persons working for monetary authorities saw their household earnings increase by \$9.4 million in FY 2010 (Figure 20). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending for monetary authorities. The increase of \$9.4 million accounts for 5% of the \$189.7 million value-added increase that occurred in all consumer-driven industries

²⁷See section D.2.1 Output Impact on Northeast Ohio for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 19. Increase in Value Added for Industries in NASA Glenn-Driven Industries in the State of Ohio, FY 2010

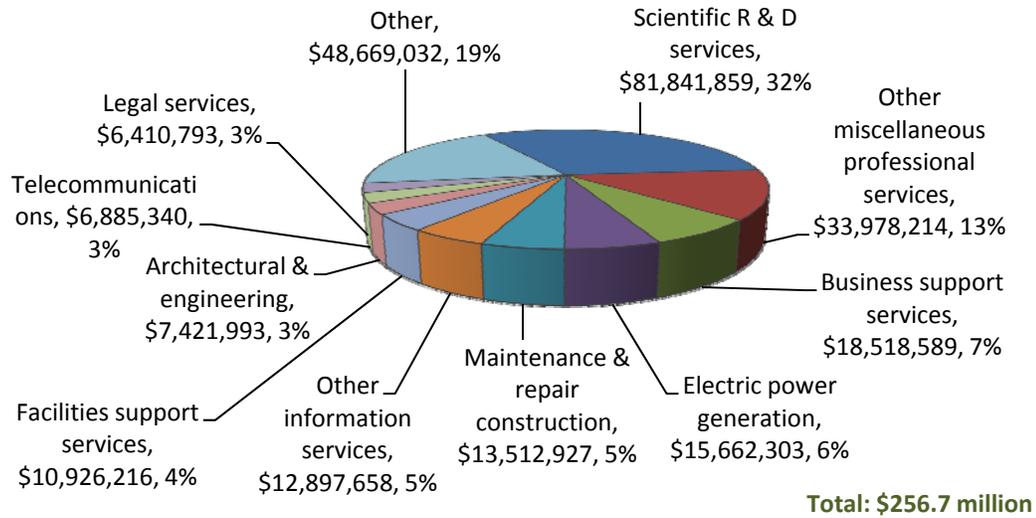
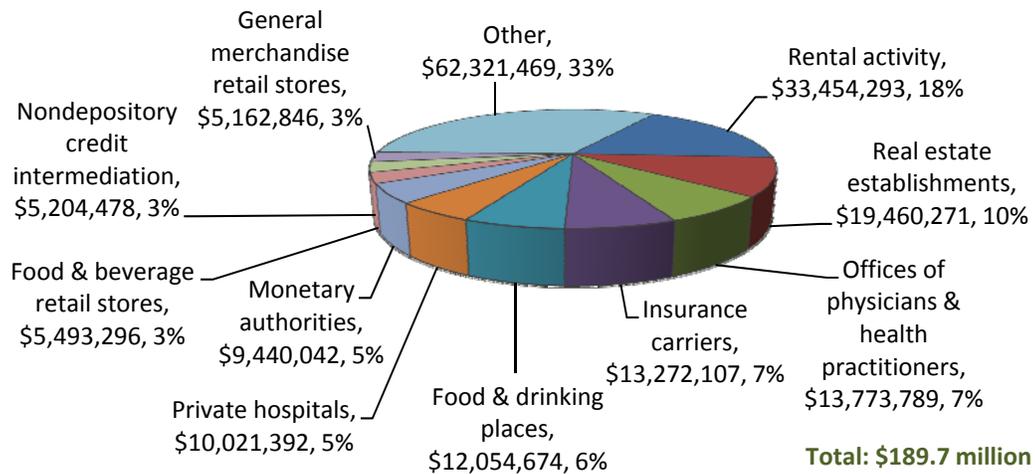


Figure 20. Increase in Value Added for Industries in Consumer-Driven Industries in Northeast Ohio, FY 2010



D.3.5 Tax Impact on the State of Ohio in FY 2010

The operation of NASA Glenn in FY 2010 increased tax revenues by a total of \$102.1 million as a result of Glenn’s economic impact on the state of Ohio. Of that total, state and local governments in Ohio benefited from increased tax revenues of \$43.8 million, and federal tax revenues increased by \$58.3 million in FY 2010.

D.3.6 FY 2010 Ohio Impact Summary

Economic activity generated by the NASA Glenn produced the following impact on the state of Ohio (2010 dollars):

- Total Output Impact: \$1,360.8 M
- Total Employment Impact: 8,868 jobs
- Total Labor Income Impact: \$515.8 M
- Total Value-Added Impact: \$676.5 M
- Total Tax Impact: \$102.1 M

The impact of NASA Glenn’s expenditures in the state of Ohio is only slightly higher than the impact on Northeast Ohio because the majority of NASA Glenn’s Ohio expenditures are in Northeast Ohio (including NASA Glenn’s entire

payroll expenditures). In FY 2010, NASA Glenn’s expenditures in the state of Ohio were \$324.3 billion (only \$68.9 million bigger than in Northeast Ohio). More than 90% of the Ohio spending went to Ohio’s five large industry sectors: professional, scientific and technical services (\$200.9 million); administrative and support services (\$49.9 million); construction (\$21.8 million); utilities (\$16 million); and education (\$8.4 million). The result is that Ohio businesses, excluding those located in the eight-county Northeast Ohio region, experienced an increase in sales of \$118.2 million, added 1,188 jobs, saw an increase in labor income of \$52.1 million, and increased value added by \$66 million. Accounting for the whole state of Ohio, additional taxes from NASA Glenn operation in FY 2010 increased by \$14.7 million compared to Northeast Ohio.

Since main NASA Glenn expenditures elsewhere in the state of Ohio mirrored expenditures in Northeast Ohio, industries across Ohio that derive the most benefit from NASA Glenn spending and spending by NASA Glenn employees and other workers are similar to those reported for Northeast Ohio.²⁸

²⁸ A close examination of the IMPLAN results show that a few industry sectors have slightly higher values for the direct impact for Northeast Ohio than for the state of Ohio. The reason for this is the distribution of disposable income (NASA Glenn payroll) by IMPLAN to those industries from which households typically make purchases. When making this distribution for the state of Ohio, IMPLAN assumes that households have the same distribution as the population across the state. Persons living in the Appalachian area of southeast Ohio or the farming regions of western Ohio do not have the same spending patterns as their counterparts in Greater Cleveland. For example, persons living in Appalachia do not spend as much on the arts and financial services as people living in suburban Cleveland. The IMPLAN results simply reflect this reality.

E. COMPARISON OF NASA GLENN ECONOMIC IMPACTS IN FY 2009 AND FY 2010

NASA Glenn continues to be an important economic player in Northeast Ohio and across the state (Table 15). The economic impact in FY 2010 was comparable to the economic impact in FY 2009 for all measures. NASA Glenn generated 8,868 jobs in **Ohio** in FY 2010 compared to 8,293 in the previous year (a 6.9% increase). Output impact on the state was \$1.36 billion in FY 2010 compared to \$1.38 billion in FY 2009 accounting for inflation (1.5% lower compared to FY 2009). The household earnings increased by \$515.8 million in FY 2010 as a result of NASA Glenn activities (2.2% higher than in the previous year). In FY 2010, the value added increased to \$676.5 compared to \$645.6 in FY 2009 (a 4.8% increase). Federal, state, and local taxes amounted to \$102.1 million, almost the same amount as for FY 2009.

In **Northeast Ohio**, NASA Glenn output impact in FY 2010 was \$1.24 billion in FY 2010 compared to \$1.26 billion in FY 2009, accounting for inflation. Glenn also generated 7,680 jobs in Northeast Ohio in FY 2010 compared to 7,017 jobs in FY 2009 (a 9.4% increase). In addition, the labor income impact in Northeast Ohio in FY 2010 was higher by \$112.3 million (a 32% increase) compared to FY 2009. The value added (output less

intermediary goods and services) impact in Northeast Ohio increased in FY 2010 to \$610.5 million compared to \$579.8 million in FY 2009 (a 5.3% increase). Due to NASA Glenn operations in FY 2010, taxes generated at all levels add up to \$87.4 million compared to \$89.3 million in FY 2009. taxes generated due to FY 2010 NASA Glenn operation. The large economic impact on the state and regional economies emphasizes the importance of NASA Glenn’s activities and jobs in the region and the state.

NASA Glenn continues to be one of the major economic anchors of Northeast Ohio and a crucial part of the region’s intellectual infrastructure. It is an invaluable asset for Northeast Ohio as the region struggles to restructure and transform its economy by attracting knowledge-based, research-intensive businesses and organizations. NASA Glenn is a positive presence in Northeast Ohio and serves as a magnet for many types of businesses and start-up companies based on innovation. NASA Glenn’s employees are part of the region’s knowledge-intensive labor force with unique cutting-edge skills in science and technology and the potential to generate wealth in the region.

**Table 15. NASA Glenn Economic Impact,²⁹
FY 2009- FY 2010**

Economic Impact	Northeast Ohio		State of Ohio	
	FY 2009	FY 2010	FY 2009	FY 2010
Output	\$1,263.1 million*	\$1,242.6 million	\$1,382.1 million	\$1,360.8 million
Value Added	\$579.8 million	\$610.5 million	\$645.6 million	\$676.5 million
Employment	7,017 jobs	7,680 jobs	8,293 jobs	8,868 jobs
Labor Income	\$351.4 million	\$463.7 million	\$504.5 million	\$515.8 million
Taxes	\$89.3 million	\$87.4 million	\$104.2 million	\$102.1 million

* Monetary values are adjusted to \$2010 for comparison.

²⁹ It should be noted that annual impact is measured in a hypothetical situation if NASA Glenn would not exist during the previous year. For example, the jobs created in Ohio in FY 2010 (8,868) are not new jobs created in addition to a previous-year jobs (8,293). Majority of FY 2010 jobs existed in FY 2009.

APPENDIX A: DATA TABLES

Table A.1 NASA Glenn Spending by State, FY 2010

Table A.2 NASA Glenn Monies Allocated to Academic Institutions, FY 2010

Table A.3 NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2010

Table A.4 NASA Glenn Detailed Expenditures in the State of Ohio, FY 2010

Table A.1. NASA Glenn Spending by State, FY 2010

State	Spending	Share
Ohio	\$324,292,368	58.65%
Oklahoma	\$53,111,014	9.61%
California	\$43,450,543	7.86%
Maryland	\$22,966,313	4.15%
Virginia	\$16,484,955	2.98%
Massachusetts	\$11,072,981	2.00%
Connecticut	\$9,288,748	1.68%
Florida	\$6,443,023	1.17%
Pennsylvania	\$6,316,559	1.14%
Colorado	\$6,189,785	1.12%
Arizona	\$5,397,669	0.98%
New York	\$5,149,553	0.93%
New Jersey	\$3,622,630	0.66%
Texas	\$3,618,573	0.65%
Missouri	\$3,446,216	0.62%
Michigan	\$3,316,199	0.60%
Illinois	\$3,214,024	0.58%
Tennessee	\$3,195,025	0.58%
Georgia	\$2,517,434	0.46%
Minnesota	\$2,215,713	0.40%
Washington DC	\$2,174,384	0.39%
Indiana	\$2,158,695	0.39%
New Hampshire	\$1,703,722	0.31%
Washington	\$1,647,118	0.30%
Alabama	\$1,508,753	0.27%
Nevada	\$867,350	0.16%
New Mexico	\$849,746	0.15%
Utah	\$824,056	0.15%
Oregon	\$748,663	0.14%
North Carolina	\$650,430	0.12%
Wisconsin	\$453,345	0.08%
West Virginia	\$442,471	0.08%

State	Spending	Share
Rhode Island	\$438,489	0.08%
Iowa	\$372,658	0.07%
Nebraska	\$323,033	0.06%
Delaware	\$265,281	0.05%
Louisiana	\$251,277	0.05%
Wyoming	\$240,401	0.04%
Kentucky	\$231,107	0.04%
Vermont	\$207,561	0.04%
Mississippi	\$199,695	0.04%
Idaho	\$158,137	0.03%
Arkansas	\$148,666	0.03%
Montana	\$111,059	0.02%
Kansas	\$67,737	0.01%
Puerto Rico	\$60,897	0.01%
South Carolina	\$59,538	0.01%
Hawaii	\$49,538	0.01%
Alaska	\$34,690	0.01%
North Dakota	\$28,676	0.01%
South Dakota	\$282	0.00%
Maine	\$102	0.00%
Outside U.S.	\$333,795	0.06%
Total	\$552,920,673	100%

Table A.2. NASA Glenn Funding Allocated to Academic Institutions by State, FY 2010

State	Amount	Share
Maryland	\$9,447,754.65	25.47%
Ohio	\$7,205,127.08	19.43%
Oklahoma	\$3,424,026.59	9.23%
California	\$2,923,738.46	7.88%
Massachusetts	\$1,995,163.28	5.38%
Georgia	\$1,779,683.17	4.80%
Pennsylvania	\$1,703,028.89	4.59%
New York	\$979,574.40	2.64%
Illinois	\$652,499.64	1.76%
Tennessee	\$556,917.41	1.50%
Virginia	\$552,244.83	1.49%
New Jersey	\$452,541.25	1.22%
Indiana	\$449,496.88	1.21%
Florida	\$360,911.57	0.97%
Michigan	\$357,498.18	0.96%
Oregon	\$341,670.75	0.92%
Colorado	\$338,650.65	0.91%
West Virginia	\$314,123.80	0.85%
Rhode Island	\$306,181.08	0.83%
Nebraska	\$299,445.80	0.81%
Texas	\$279,274.20	0.75%
Arizona	\$262,881.87	0.71%
Louisiana	\$244,750.88	0.66%
Missouri	\$222,323.26	0.60%
Minnesota	\$217,270.78	0.59%
Connecticut	\$190,326.94	0.51%
Kentucky	\$188,817.28	0.51%
Delaware	\$187,161.63	0.50%
Washington	\$184,295.94	0.50%
Iowa	\$157,974.84	0.43%
New Mexico	\$125,000.00	0.34%
Alabama	\$109,217.17	0.29%
Wyoming	\$81,126.23	0.22%
Puerto Rico	\$60,896.52	0.16%
Hawaii	\$47,623.94	0.13%
Wisconsin	\$39,821.64	0.11%
North Carolina	\$18,784.98	0.05%
Mississippi	\$17,070.10	0.05%
Washington DC	\$12,692.02	0.03%
Total	\$37,087,588.58	100%

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2010

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			\$15,915,437
	Electric power generation, transmission, and distribution	31	\$14,313,198
	Natural gas distribution	32	\$545,914
	Water, sewage and other treatment and delivery systems	33	\$1,056,324
Construction			\$21,349,485
	Construction of other new nonresidential structures	36	\$836,130
	Maintenance and repair construction of nonresidential structures	39	\$20,513,355
Manufacturing			\$5,398,430
	Printing	113	\$151,336
	Petroleum lubricating oil and grease manufacturing	118	\$58,737
	All other petroleum and coal products manufacturing	119	\$22,596
	Industrial gas manufacturing	121	\$579,568
	Plastics material and resin manufacturing	127	\$4,510
	Paint and coating manufacturing	136	\$270
	Tire manufacturing	150	\$2,000
	Steel product manufacturing from purchased steel	171	\$965
	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	178	\$6,281
	Plate work and fabricated structural product manufacturing	186	\$33,146
	Metal tank (heavy gauge) manufacturing	189	\$13,759
	Hardware manufacturing	193	\$98,851
	Machine shops	195	\$125,835
	Valve and fittings other than plumbing manufacturing	198	\$168,240
	Fabricated pipe and pipe fitting manufacturing	201	\$5,113
	Other fabricated metal manufacturing	202	\$4,150
	Other industrial machinery manufacturing	207	\$110,248
	Heating equipment (except warm air furnaces) manufacturing	215	(\$3,526)
	Metal cutting and forming machine tool manufacturing	218	\$109,950
	Other general purpose machinery manufacturing	230	\$15,973
	Industrial process furnace and oven manufacturing	232	\$6,960

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Other communications equipment manufacturing	239	\$1,458
	Bare printed circuit board manufacturing	242	\$156,000
	Industrial process variable instruments manufacturing	251	\$47,750
	Electricity and signal testing instruments manufacturing	253	\$22,271
	Analytical laboratory instrument manufacturing	254	\$46,649
	Watch, clock, and other measuring and controlling device manufacturing	256	\$15,558
	Heavy duty truck manufacturing	278	\$47,975
	Guided missile and space vehicle manufacturing	287	\$3,492,007
	Gasket, packing, and sealing device manufacturing	315	\$4,404
	All other miscellaneous manufacturing	317	\$49,397
Wholesale & Retail Trade			\$2,308,426
	Wholesale trade businesses	319	\$200,235
	Retail - Electronics and appliances	322	\$39,103
	Retail - Miscellaneous	330	\$2,052,102
	Retail - Nonstore	331	\$16,986
Transportation			\$60,227
	Transport by truck	335	\$32,894
	Transit and ground passenger transportation	336	\$27,334
Information & Telecommunication			\$16,357,645
	Telecommunications	351	\$19,278
	Other information services	353	\$16,338,367
Real Estate and Rental & Leasing			\$416,494
	Commercial and industrial machinery and equipment rental and leasing	365	\$416,494
Professional, Scientific, & Technical Services			\$144,479,388
	Legal services	367	\$112,334
	Accounting, tax preparation, bookkeeping, and payroll services	368	\$10,800
	Architectural, engineering, and related services	369	\$4,711,837
	Other computer related services, including facilities management	373	\$3,239,424
	Management, scientific, and technical consulting services	374	\$33,697
	Scientific research and development services	376	\$103,527,444
	All other miscellaneous professional, scientific, and technical services	380	\$32,843,852

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Administrative & Support and Waste Management Services			\$43,678,315
	Facilities support services	385	\$17,426,632
	Business support services	386	\$26,251,683
Education			\$3,924,305
	Private junior colleges, colleges, universities, and professional schools	392	\$3,924,305
Health Care & Social Assistance			\$1,465,300
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	\$1,465,300
Arts, Entertainment & Recreation			\$5,960
	Museums, historical sites, zoos, and parks	406	\$5,960
Repair & Maintenance			\$10,070
	Electronic and precision equipment repair and maintenance	416	\$2,889
	Commercial and industrial machinery and equipment repair and maintenance	417	\$7,181
Government Enterprise			\$15
	Other state and local government enterprises	432	\$15
Household			\$189,801,396
	Household spending (c)	10001-10009	\$189,801,396
TOTAL EXPENDITURES in NEO			\$445,170,893

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 2010. Values shown in Table A-3 are limited to expenditures made in Ohio.

c. Households: Household expenditures include Glenn employee payroll and medical insurance. Payments have been reduced to include only disposable income. In this analysis, disposable income equals the gross amount and medical benefits. Disposable income excludes income that is used for savings and to pay taxes.

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2010

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			\$16,022,007
	Electric power generation, transmission, and distribution	31	\$14,313,198
	Natural gas distribution	32	\$545,914
	Water, sewage and other treatment and delivery systems	33	\$1,162,895
Construction			\$21,783,690
	Construction of other new nonresidential structures	36	\$836,130
	Maintenance and repair construction of nonresidential structures	39	\$20,947,560
Manufacturing			\$6,087,057
	Footwear manufacturing	93	\$1,358
	Printing	113	\$151,539
	Petroleum lubricating oil and grease manufacturing	118	\$58,737
	All other petroleum and coal products manufacturing	119	\$22,596
	Industrial gas manufacturing	121	\$579,568
	Plastics material and resin manufacturing	127	\$4,510
	Paint and coating manufacturing	136	\$270
	All other chemical product and preparation manufacturing	141	\$767
	Polystyrene foam product manufacturing	146	\$12,177
	Tire manufacturing	150	\$2,000
	Steel product manufacturing from purchased steel	171	\$965
	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	178	\$6,281
	Ferrous metal foundries	179	\$8,300
	All other forging, stamping, and sintering	181	\$13,867
	Plate work and fabricated structural product manufacturing	186	\$33,146
	Metal tank (heavy gauge) manufacturing	189	\$13,759
	Hardware manufacturing	193	\$98,851
	Machine shops	195	\$152,214
	Valve and fittings other than plumbing manufacturing	198	\$168,240
	Plumbing fixture fitting and trim manufacturing	199	\$4,661
	Fabricated pipe and pipe fitting manufacturing	201	\$56,792

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Other fabricated metal manufacturing	202	\$4,150
	Other industrial machinery manufacturing	207	\$182,310
	Heating equipment (except warm air furnaces) manufacturing	215	(\$3,526)
	Metal cutting and forming machine tool manufacturing	218	\$109,950
	Air and gas compressor manufacturing	227	\$4,368
	Material handling equipment manufacturing	228	\$84,220
	Other general purpose machinery manufacturing	230	\$19,208
	Industrial process furnace and oven manufacturing	232	\$6,960
	Other communications equipment manufacturing	239	\$1,458
	Bare printed circuit board manufacturing	242	\$156,000
	Industrial process variable instruments manufacturing	251	\$47,750
	Electricity and signal testing instruments manufacturing	253	\$27,766
	Analytical laboratory instrument manufacturing	254	\$225,552
	Watch, clock, and other measuring and controlling device manufacturing	256	\$15,558
	Wiring device manufacturing	273	\$13,852
	Carbon and graphite product manufacturing	274	\$20,500
	All other miscellaneous electrical equipment and component manufacturing	275	\$4,075
	Light truck and utility vehicle manufacturing	277	\$32,999
	Heavy duty truck manufacturing	278	\$47,975
	Other aircraft parts and auxiliary equipment manufacturing	286	\$9,859
	Guided missile and space vehicle manufacturing	287	\$3,492,007
	All other transportation equipment manufacturing	294	\$128,665
	Office furniture and custom architectural woodwork and millwork manufacturing ¹	301	\$11,004
	Gasket, packing, and sealing device manufacturing	315	\$4,404
	All other miscellaneous manufacturing	317	\$49,397
Wholesale & Retail Trade			\$2,749,673
	Wholesale trade businesses	319	\$212,137
	Retail - Motor vehicle and parts	320	\$85,336
	Retail - Electronics and appliances	322	\$53,661
	Retail - Miscellaneous	330	\$2,381,552

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Retail - Nonstore	331	\$16,986
Transportation			\$60,634
	Transport by truck	335	\$33,300
	Transit and ground passenger transportation	336	\$27,334
Information & Telecommunication			\$16,410,502
	Periodical publishers	342	\$2,613
	Directory, mailing list, and other publishers	344	(\$160)
	Software publishers	345	\$22,837
	Telecommunications	351	\$46,845
	Other information services	353	\$16,338,367
Real Estate and Rental & Leasing			\$416,494
	Commercial and industrial machinery and equipment rental and leasing	365	\$416,494
Professional, Scientific, & Technical Services			\$200,934,981
	Legal services	367	\$117,861
	Accounting, tax preparation, bookkeeping, and payroll services	368	\$10,800
	Architectural, engineering, and related services	369	\$6,280,248
	Custom computer programming services	371	\$54,640
	Computer systems design services	372	\$8,945
	Other computer related services, including facilities management	373	\$3,239,424
	Management, scientific, and technical consulting services	374	\$38,697
	Scientific research and development services	376	\$148,696,239
	All other miscellaneous professional, scientific, and technical services	380	\$42,488,126
Administrative & Support and Waste Management Services			\$49,891,266
	Facilities support services	385	\$17,426,632
	Business support services	386	\$26,251,683
	Investigation and security services	387	\$6,212,950
Education			\$8,400,738
	Private junior colleges, colleges, universities, and professional schools	392	\$8,390,738
	Other educational services	393	\$10,000
Health Care & Social Assistance			\$1,465,300
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	\$1,465,300

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Arts, Entertainment & Recreation			\$5,960
	Museums, historical sites, zoos, and parks	406	\$5,960
Accommodation			\$2,434
	Hotels and motels, including casino hotels	411	\$2,434
Repair & Maintenance			\$56,045
	Electronic and precision equipment repair and maintenance	416	\$26,136
	Commercial and industrial machinery and equipment repair and maintenance	417	\$29,909
Government Enterprise			\$5,589
	Other federal government enterprises	429	\$2,454
	Other state and local government enterprises	432	\$3,135
Household			\$189,801,396
	Household spending (c)	10001-10009	\$189,801,396
TOTAL EXPENDITURES in Ohio			\$514,093,764

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 2010. Values shown in Table A-4 are limited to expenditures made in Ohio.

c. Households: Household expenditures include Glenn employee payroll and medical insurance. Payments have been reduced to include only disposable income. In this analysis, disposable income equals the gross amount and medical benefits. Disposable income excludes income that is used for savings and to pay taxes.