



Prepared for:
NASA GLENN RESEARCH CENTER

Prepared by:
Iryna Lendel, Ph.D.

August 2009

**The NASA
Glenn
Research
Center:**

**An Economic
Impact Study
Fiscal Year
2008**

**CENTER FOR
ECONOMIC
DEVELOPMENT**



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**THE NASA GLENN RESEARCH CENTER:
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Table of Contents

Executive Summary	i
Economic Impact Generated by Glenn Research Center Spending	i
Glenn Research Center: An Overview	ii
A. Introduction	1
B. NASA Glenn Research Center: Background	2
B.1 NASA Glenn Test Facilities	2
B.2 Glenn Mission Areas Supporting NASA Themes	3
C. NASA Glenn Research Center: Economic Overview	5
C.1 Employment and Occupations	5
C.2 Place of Residence for Glenn Employees	7
C.3 Payroll	8
C.4 Glenn Expenditures, FY 2008	9
C.5 Glenn Awards to Academia and Other Institutions	10
C.6 Glenn Revenues	13
C.7 Taxes Paid by Glenn Employees	14
D. Economic Impact of NASA Glenn	15
D.1 Methodology	15
D.2 Economic Impact on Northeast Ohio in FY 2008	19
D.2.1 Output Impact on Northeast Ohio in FY 2008	19
D.2.2 Employment Impact on Northeast Ohio in FY 2008	23
D.2.3 Earnings Impact on Northeast Ohio in FY 2008	26
D.2.4 FY 2008 Northeast Ohio Impact Summary	29
D.3 Economic Impact on the State of Ohio in FY 2008	31
D.3.1 Output Impact on the State of Ohio in FY 2008	31
D.3.2 Employment Impact on the State of Ohio in FY 2008	34
D.3.3 Earnings Impact on the State of Ohio in FY 2008	37
D.3.4 FY 2008 Ohio Impact Summary	41
E. Comparison of NASA Glenn Economic Impacts in FY 2007 and FY 2008	42
Appendix A: Data Tables	43

List of Tables

Table 1.	Glenn Civil Service Employment Distribution by Occupational Category, FY 2004-2008.....	6
Table 2.	Glenn Civil Service Employees by Occupation and Place of Residence, FY 2008.....	8
Table 3.	Glenn Educational Grants in Ohio by Academic Institution (FY 2004 – FY 2008, in \$ 2008).....	12
Table 4.	NASA Glenn Revenues, FY 2004 – FY 2008 (millions of nominal dollars).....	13
Table 5.	Income Taxes Paid by Glenn Employees (in nominal dollars).....	14
Table 6.	Output Impact Based on Glenn Spending in Northeast Ohio, FY 2008.....	20
Table 7.	Employment Impact Based on Glenn Spending in Northeast Ohio, FY 2008.....	24
Table 8.	Earnings Impact Based on Glenn Spending in Northeast Ohio, FY 2008.....	27
Table 9.	Output Impact Based on Glenn Spending in the State of Ohio, FY 2008.....	32
Table 10.	Employment Impact Based on Glenn Spending in the State of Ohio, FY 2008.....	35
Table 11.	Earnings Impact Based on Glenn Spending in the State of Ohio, FY 2008.....	38
Table 12.	NASA Glenn Economic Impacts, FY 2007- FY 2008.....	42
Table A.1.	Glenn Spending by State, FY 2008.....	44
Table A.2.	Glenn Funding Allocated to Academic Institutions by State, FY 2008.....	45
Table A.3.	NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2008.....	46
Table A.4.	NASA Glenn Detailed Expenditures in the State of Ohio, FY 2008.....	49

LIST OF FIGURES

Figure 1. Glenn Civil Service Employees by County of Residence, FY 2008	7
Figure 2. NASA Glenn Spending in Select States, FY 2008	10
Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2008.....	11
Figure 4. Glenn Research Center—Economic Impact on Northeast Ohio, FY 2008.....	18
Figure 5. Increase in Sales for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008.....	22
Figure 6. Increase in Sales for Select Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008.....	23
Figure 7. Increase in Jobs for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008.....	25
Figure 8. Increase in Jobs for Select Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008.....	26
Figure 9. Increase in Earnings for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008.....	28
Figure 10. Increase in Earnings for Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008.....	29
Figure 11. Increase in Sales for Select Industries in Glenn-Driven Sectors, Ohio, FY 2008	33
Figure 12. Increase in Sales for Select Industries in Consumer-Driven Sectors, Ohio, FY 2008	34
Figure 13. Increase in Jobs for Select Industries in Glenn-Driven Sectors in Ohio, FY 2008.....	36
Figure 14. Increase in Jobs for Select Industries in Consumer-Driven Sectors in Ohio, FY 2008	37
Figure 15. Increase in Earnings for Select Industries in Glenn-Driven Sectors in Ohio, FY 2008	39
Figure 16. Increase in Earnings for Select Industries in Consumer-Driven Sectors in Ohio, FY 2008	40

EXECUTIVE SUMMARY

- The John H. Glenn Research Center at Lewis Field (Glenn) is one of 10 National Aeronautics and Space Administration (NASA) Centers. Glenn is situated on 350 acres adjacent to Cleveland Hopkins International Airport. Its physical plant includes more than 150 buildings that contain a unique collection of world-class test facilities. 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.
- NASA Glenn is focused on efforts related to all of NASA's missions: Exploration, Science, Space Operation, and Aeronautics Research. Within the Exploration mission, Glenn oversight of the Service Module (SM) for the Shuttle-replacement vehicle (Orion); oversight of important elements of the Crew Module (CM) project, including building test flight hardware; vital support for the new rocket (Ares) that carries Orion to space; and environmental testing at Plum Brook Station of the entire Orion spacecraft. For the Science mission, among others, NASA Glenn manages the In-Space Propulsion Technology Program and development of its associated technologies; management of Radioisotope Power Systems and the development of associated technologies. For the Space Operations mission, 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; supports the International Space Station; and leads the development of new, advanced communications technology. For the Aeronautics mission, NASA Glenn continues to improve upon its world-class Aeronautics heritage by concentrating research and program management efforts on the mastery of 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 for the following four projects: Hypersonics Project, Supersonics Project, and Subsonics.
- In addition to the background section, this report has two major sections. Section C is an economic overview of Glenn, including information related to employment and occupations, employee residence, 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 on an eight-county Northeast Ohio region and the state of Ohio during FY 2008. The report is an update of earlier studies (published in May 2000, December 2005, September 2007, and September 2008) in which Glenn's FY 1998, FY 2004, FY 2006, and FY 2007 economic impacts on Northeast Ohio and the state of Ohio were estimated.

ECONOMIC IMPACT GENERATED BY GLENN RESEARCH CENTER SPENDING

- Economic impact is an analytical approach used to estimate economic benefits generated by an entity on 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), the number of new jobs created, and the increase in household earnings. The table below summarizes Glenn's economic impact on Northeast Ohio and the state of Ohio during FY 2008.

IMPACT FY 2008	NORTHEAST OHIO	STATE OF OHIO
Output	\$1,055.7 Million	\$1,210.3 Million
Employment	6,225 Jobs	7,599 Jobs
Household Earnings	\$344.4 Million	\$401.8 Million

- NASA Glenn activities in Northeast Ohio in FY 2008, stimulated by \$699.5 million in revenues primarily from outside the region, generated an increased demand in output (sales) for products and services produced in Northeast Ohio that were valued at more than \$1,055.7 million. In addition, 6,225 jobs were created in the region, and households in Northeast Ohio saw their earnings increase by \$344.4 million.
- Glenn activities in Ohio in FY 2008, stimulated by \$699.5 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 \$1,210.3 million. In addition, 7,599 jobs were created in Ohio and households across the state saw their earnings increase by \$401.8 million.
- 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 benefit from spending by Glenn personnel and other workers, whose earnings are due, in part, to 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.

GLENN RESEARCH CENTER: AN OVERVIEW

- For the first time in several years, total employment at NASA Glenn increased by 109 from FY 2007 to FY 2008, when both civil service employment and on- or near-site contractors are taken into account. Although civil service employment fell by 10 from 1672 to 1662, the number of on- or near-site contractors increased by 119 to 1,874 in 2008, compared to 1,755 in 2007, 1,450 in 2006, and 1,800 in 2005. During the analyzed period of time, from FY 2004 to FY 2008, civil service employment at NASA Glenn peaked in FY 2004. It declined slightly each year between 2004 and 2008, with total number of employees falling from 1,945 in FY 2004 to 1,662 in FY 2008. This 15.6% decline is consistent with the overall economic trend of economic stagnation and the current recession that affected Northeast Ohio. The figures of Glenn's total employment do not include employees who work for NASA Glenn's local prime contractors.
- Glenn's employees are highly skilled and highly educated. In FY 2008, more than 50% of NASA employees possessed a graduate degree. More specifically, 17% of NASA Glenn's civil servants held a doctoral degree, 34% had a master's degree, and an

additional 26% had a bachelor's degree. Even though NASA Glenn lost some of its employment, it retained the best and brightest and slightly increased the percentage of employment with doctoral and bachelor's degrees.

- Total compensation for NASA Glenn's civil service employees was \$206.6 million in FY 2008. The total compensation included payroll that accounted for \$167.5 million and employee benefits that accounted for another \$39.1 million. Total payroll grew by \$5.2 million (2.6%) between FY2007 and FY2008, after adjusting for inflation. During the last year, NASA Glenn lost only 10 employees, and therefore the average wage per employee grew by 3.2% after adjusting for inflation, from \$97,651 in FY2007 (inflated to 2008 dollars) to \$100,760 in FY2008.
- Compared to FY 2007, NASA Glenn increased its expenditures by 9.6%, spending \$45.8 million more in FY 2008. Total Glenn expenditures, excluding payroll and benefits, were \$523.8 million in FY 2008. However, Glenn's total U.S. spending in FY 2008 was 10.2% lower than expenditures in FY 2004 after adjusting for inflation. Northeast Ohio vendors, however, received a significant share of Glenn's expenditures. In FY 2008, Glenn distributed 45.4% of its total spending to Northeast Ohio vendors in comparison to 45.5% in FY2004. This spending share remained almost unchanged between 2004 and 2008; it increased slightly between FY 2004 and FY 2007 and then declined slightly during the last fiscal year. Ohio's vendors received 60.6% (\$316.0 million) of total Glenn expenditures in FY2008, a significantly lower share than in FY2007 (64.0%). In the prior 3 years, 2004-2007, the spending share across the state of Ohio was stable, decreasing only slightly from 64.2% in 2004 to 64.0% in 2007. The share of expenditures accounted for by vendors located in Northeast Ohio and Ohio has a strong influence on the economic impact in both the region and the state since the greater the amount of money Glenn spends locally, the greater the impact on local economies.
- In FY 2008, Glenn's total revenue increased 8.1%, reversing a long-time trend of decline. In FY 2008, Glenn received \$671.7 million in revenues from NASA. This amount represents 96% of its total income. In nominal dollars, Glenn revenues declined between FY 2004 and FY 2008: revenues fell by 9% over the period from FY 2004 to FY 2005, 1% from FY 2005 to FY 2006, and 11% between FY 2006 and FY 2007.
- 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 the 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) 2008.¹ The report also describes some of the NASA Glenn's R&D activities and provides an overview of Glenn. It uses an input/output (I-O) matrix that reflects the buy-sell relationships among industries. The model estimates the effect of Glenn spending on the studied economies. This model assesses economic impact in terms of growth in total output (sales), household earnings, and the number of new jobs.

The analysis was conducted by the Center for Economic Development at Cleveland State University's Maxine Goodman Levin College of Urban Affairs. This report is an update to previous studies (published in February 1996, May 2000, December 2005, September 2007, and September 2008), which estimated Glenn's FY 1994, FY 1998, FY 2004, FY 2006, and FY 2007 economic impact on Northeast Ohio and the state of Ohio.²

¹ For purposes of this study, Northeast Ohio includes Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

² Austrian, Z. (1996) *The NASA Lewis Research Center: An Economic Impact Study*. Cleveland State University, Center for Economic Development.

Austrian, Z. & Wolf, A. (2000). *The NASA Glenn 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, space flight and project management expertise and experience. Its work is focused on technological advances in space flight systems, aeropropulsion, space propulsion, power systems, nuclear systems, 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. 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 \$1.6 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 Mars lander systems and International Space Station hardware. This facility is undergoing a \$62 million expansion to add spacecraft vibration and acoustic test capability and will then be used to conduct integrated system-level testing of the new Orion Crew Exploration Vehicle, simulating conditions from launch through insertion into orbit. The total replacement cost of all Plum Brook facilities is approximately \$651 million.

B.2 GLENN MISSION AREAS SUPPORTING NASA THEMES

NASA Glenn has 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 the new rocket (Ares) that carries Orion to space including development of Ares I power and delivery of the Upper Stage Simulator (USS) for the Ares I-X mission, the first planned test flight of the Crew Launch Vehicle.
- 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 Converter (ASC) for the Advanced Stirling Radioisotope Generator (ASRG). These systems will allow much longer scientific missions so that more scientific data can be obtained from each mission.

Space Operations

- 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. The Lead Quality Auditor role for the SSP is also at Glenn.
- Supports the International Space Station by providing the electrical power system management and integration expertise.
- Leads the development of new, advanced communications technology including a demonstration on the International Space Station of software-defined radios.

Aeronautics

NASA Glenn continues to improve upon its world-class aeronautics heritage by concentrating research and program management efforts on the mastery of 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 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 plays key roles in conducting long-term, cutting-edge research that will produce tools, methods, concepts, and technologies to improve the intrinsic safety attributes of current and future aircraft engines. These include studies of the safety of aging aircraft, which is important because aircraft remain in service by the military and industry for long periods of time.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents a description of the NASA Glenn Research Center during FY 2008. We describe changes that occurred in employment and occupations, workers' places of residence, payroll, expenditures, awards to academia and other institutions, revenues, and taxes paid by Glenn employees. This report includes data from FY 2004 to FY 2008.

C.1 EMPLOYMENT AND OCCUPATIONS

The NASA Glenn labor force has two components: civil service employees and local contractors. This dual approach is common to federal labs because contract employees provide the necessary labor force flexibility. The number of contract employees can easily be adjusted according to the needs of the research lab, whereas hiring of civil servants is more complex and lengthy.

For the first time in several years, total employment at NASA Glenn increased by 109 from FY 2007 to FY 2008, when both civil service employment and on- or near-site contractors are taken into account. Although civil service employment fell by 10 from 1672 to 1662, the number of on- or near-site contractors increased by 119 to 1,874 in 2008, compared to 1,755 in 2007, 1,450 in 2006, and 1,800 in 2005. During the analyzed period of time, from FY 2004 to FY 2008, civil service employment at NASA Glenn peaked in FY 2004 (Table 1). It declined slightly each year between 2004 and 2008, decreasing from 1,945 employees in FY 2004 to 1,662 in FY 2008. This change constitutes a 15.6% decline from 2004 and is consistent with the overall economic stagnation followed by the current recession that affected Northeast Ohio. The figures of Glenn's total employment do not include employees who work for NASA Glenn's local prime contractors.³

Glenn's employees are highly skilled and highly educated. In FY 2008, more than 50% of NASA employees possessed a graduate degree. More specifically, 17% of NASA Glenn's civil servants held a doctoral degree, 34% had a master's degree, and an additional 26% had a bachelor's degree. Even though NASA Glenn lost some of its employment, it retained the best and brightest and slightly increased the percentage of employment with doctoral and bachelor's degrees.

³ For a detailed listing of Glenn's local contractors, visit <http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm>

Civil service employees at Glenn are categorized into four occupational groups: administrative professional, clerical, scientists and engineers, and technicians. Table 1 shows occupational mix and its change at Glenn between FY 2004 and FY 2008.

Table 1. Glenn Civil Service Employment Distribution by Occupational Category, FY 2004-2008

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2004	1,945	20%	6%	57%	17%
2005	1,769	21%	6%	58%	15%
2006	1,678	21%	5%	60%	14%
2007	1,672	21%	5%	60%	14%
2008	1,662	21%	5%	61%	13%

The occupational structure of Glenn’s employment remains almost unchanged during the analyzed period of time. Scientists and engineers are the largest occupational category at NASA Glenn, accounting for an average of 59% of civil service employees between FY 2004 and FY 2008. This average percentage is higher than the 57% average observed during the previously analyzed period from 1999 to 2007. The share of scientists and engineers relative to total employment has increased gradually from 57% in FY 2004 to 61% in FY 2008. In absolute numbers, even though the percentage of scientists and engineers was growing, the total number of Glenn’s employees reflected a decline in the number of scientists and engineers. The total loss in employment for the analyzed period was 99 scientists and engineers, the majority of whom left Glenn through attrition or buyouts in FY 2005 (81 of them). Over the last fiscal year, 11 scientists and engineers left Glenn after a slight gain in this occupation (5 employees) during the previous year.

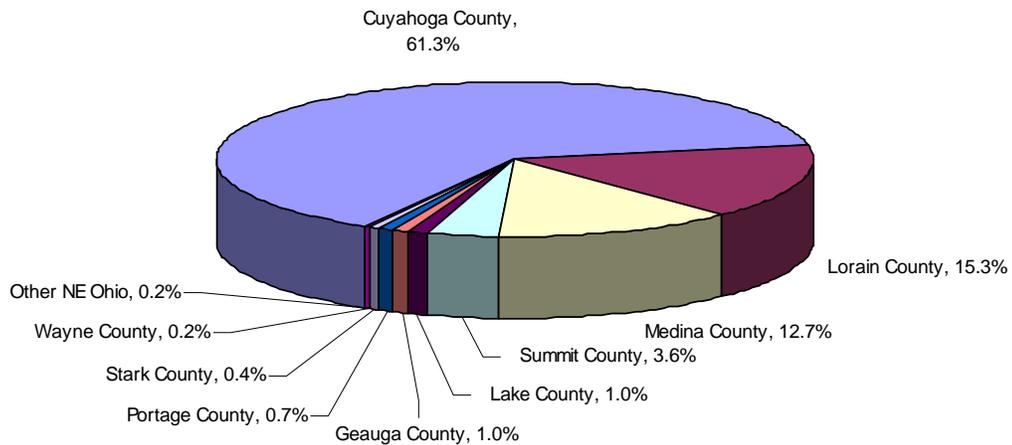
The increase of the share of scientists and engineers was complemented by a percentage decrease in the number of technicians from 17% in FY 2004 to 12% in FY 2008. In absolute numbers this occupational category lost 124 employees with 51 employees leaving in FY 2005, which was the year when Glenn lost the largest amount of employment between FY 2004 and FY 2008. During the last year, 28 technicians left NASA Glenn through attrition or buyouts.

Administrative professionals and clerical staff held their occupational shares almost unchanged, at 21% and 5%, respectively. In absolute numbers, 44 administrative professionals and 34 of the clerical staff positions were reduced between FY 2004 and FY 2007. Over the most recent year, these losses were 5 and 4 employees, respectively.

C.2 PLACE OF RESIDENCE FOR GLENN EMPLOYEES

The vast majority of NASA Glenn’s civil servants (96.5%) live in Northeast Ohio. The majority live in Cuyahoga County (61.3%) but a significant number also live in Lorain (15.3%) and Medina Counties (12.7%). The Akron metropolitan area is the place of residence for 4% of the Glenn workforce (Figure 1).

Figure 1. Glenn Civil Service Employees by County of Residence, FY 2008



The majority of NASA Glenn employees, (61.3%) regardless of occupation, live in Cuyahoga County (Table 2). Lorain and Medina Counties have the second and third highest residential share (15.3% and 12.7%, respectively), including the highest shares in each occupational category. The trends of occupations by place of residence in FY 2008 are consistent with the pattern of previous years.

Table 2. Glenn Civil Service Employees by Occupation and Place of Residence, FY 2008

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	97.6%	97.1%	95.7%	98.8%	96.5%
Cuyahoga County	60.4%	61.8%	62.9%	53.5%	61.3%
Lorain County	17.3%	23.5%	13.1%	21.2%	15.3%
Medina County	13.0%	5.9%	12.4%	16.5%	12.7%
Summit County	5.1%	0.0%	3.6%	1.8%	3.6%
Lake County	0.8%	4.4%	0.9%	0.6%	1.0%
Geauga County	0.0%	1.5%	1.2%	1.8%	1.0%
Portage County	0.0%	0.0%	0.9%	1.8%	0.7%
Stark County	0.3%	0.0%	0.4%	1.2%	0.4%
Wayne County	0.5%	0.0%	0.2%	0.0%	0.2%
Other NE Ohio	0.3%	0.0%	0.2%	0.6%	0.2%
Other Ohio	2.1%	2.9%	1.7%	1.2%	1.8%
Out of State	0.3%	0.0%	2.6%	0.0%	1.7%

C.3 PAYROLL

Total compensation for NASA Glenn’s civil service employees was \$206.6 million in FY 2008. The total compensation included payroll that accounted for \$167.5 million and employee benefits that accounted for another \$39.1 million. Total payroll grew by \$5.2 million (2.6%) between FY 2007 and FY 2008, after adjusting for inflation.⁴ During the past year, NASA Glenn lost only 10 employees, and therefore the average wage per employee grew by 3.2% after adjusting for inflation, from \$97,651 in FY 2007 (inflated to 2008 dollars) to \$100,760 in FY 2008.⁵

Compared to FY 2004, in real dollars adjusted for inflation, total compensation fell by 7%, including a salary decline of 7.7% and a decline in benefits of 3.9%. This is not surprising because during this same time period, civil service employment decreased from 1,945 to 1,662 workers. As a result, the average wage per Glenn employee increased from \$93,324 in FY 2004 to \$100,760 in FY 2008 accounting for inflation. In real dollars, the average employee wage rose by 8%, or about 2% per year, the same average growth rate Glenn experienced for the last decade.

⁴ Total nominal payroll increased by 6.4% between FY2007 and FY2008.

⁵ Average wage per employee in nominal terms increased by 7.1% between FY 2007 and FY 2008.

C.4 GLENN EXPENDITURES, FY 2008

NASA Glenn conducts its projects nationally and globally and Glenn's expenditures cover geographies far beyond the state of Ohio. In 2008, vendors in 49 states (including Ohio) and several foreign countries were beneficiaries of Glenn spending. Expenditures generally fall within one of the following classifications: equipment, supplies and materials, grants, R&D contracts, and advisory services. Total Glenn expenditures, excluding monies allocated for payroll and benefits, were \$523.8 million in FY 2008. Compared to FY 2007, NASA Glenn increased its expenditures by 9.6%, spending \$45.8 million more in FY 2008, without adjusting for inflation. Accounting for inflation, NASA Glenn's expenditures rose by 5.7%. Analyzing the period between FY 2004 and FY 2008 shows that total U.S. spending in FY 2008 was 10.2% lower than expenditures in FY 2004 when adjusting for inflation.⁶

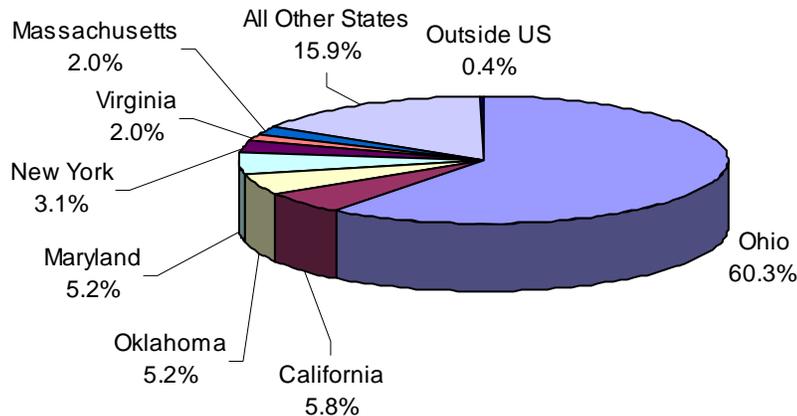
Northeast Ohio vendors, however, received a significant share of Glenn's expenditures. In FY 2008, Glenn distributed 45.4% of its total spending to Northeast Ohio vendors in comparison to 45.5% in FY 2004. This spending share remained almost unchanged between FY 2004 and FY 2008, slightly increasing between FY 2004 and FY 2007 and slightly decreasing for the last fiscal year.

Ohio's vendors received 60.3% (\$316.0 million) of total Glenn's expenditures in FY 2008, a significantly lower share than in FY 2007 (64.0%). In the prior 3 years, FY 2004 to FY 2007, the spending share across the state of Ohio decreased only slightly from 64.2% in FY 2004 to 64.0% in FY 2007. The share of expenditures accounted for by Northeast Ohio and Ohio have a strong influence on the economic impact in both the region and the state since the greater the amount of money Glenn spends locally, the greater the impact on local economies.

Six states other than Ohio received more than \$10 million (or 2%) in expenditures from NASA Glenn during FY 2008, including California, Oklahoma, Maryland, New York, Virginia, and Massachusetts in descending order (See Appendix Table A.1). Illinois, Florida, New Jersey, Pennsylvania, and Colorado were the states that accounted for amounts greater than \$5 million in FY 2008, concluding the list of the states other than Ohio that received more than 1% of the total NASA Glenn funding. Figure 2 shows Glenn spending in select states.

⁶ NASA nominal U.S. expenditures totaled \$511.9 million in 2004; however, adjusted for inflation, these expenditures amount to \$583.4 million in 2008 dollars. To adjust for inflation, the Consumer Price Index data were used.

Figure 2. NASA Glenn Spending in Select States, FY 2008



Total Expenditures: \$523.8 million

C.5 GLENN AWARDS TO ACADEMIA AND OTHER INSTITUTIONS

In support of its mission, NASA Glenn provides funding for research and educational activities to colleges, universities, and other nonprofit institutions around the country. The amount of funding depends on NASA Glenn needs, which are determined by its goals and mission for each year. This funding is provided primarily in the form of R&D contracts and grants.⁷

In FY 2008, total funding allocated to academia and other nonprofits across the United States and Puerto Rico in nominal dollars was \$69.5 million, compared to \$71.6 million in FY 2007, \$96.4 million for FY 2006 and \$78.1 million for FY 2004. Adjusting for inflation, in 2008 dollars, the grant and contracts to academic and other institutions decreased from \$89.1 million in 2004 to \$69.5 million in 2008, which constitutes a decrease of 22%. Between FY 2004 and FY 2008, the dynamic for this funding varied; it grew between FY 2004 and FY 2006 by 15.6% and declined between FY 2006 and FY 2008 by 32.5%.⁸ The past year's decline, between FY 2007 and FY 2008, was only 6.6%.

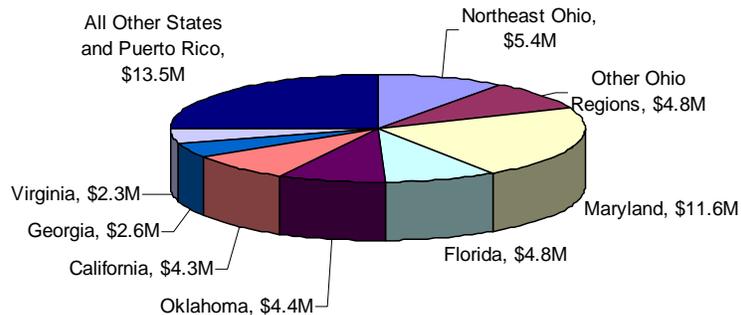
Even though the total funding awarded to colleges and universities was declining, in

⁷ Grants to colleges and universities include funding provided through university foundations. It does not include funding of professional associations and high schools.

⁸ In nominal dollars, the funding allocated to academia and other nonprofits in FY 2008 decreased by 3% compared to FY 2007 and by 11.1% compared to FY 2004.

FY 2008 Ohio continued to receive one of the largest amounts--\$18.8 million (or 27.1%) for all research institutions, of which \$10.2 million went to universities and colleges (14.7% of the total). The amount of funding to universities and colleges in Ohio in FY 2008 compares to \$10.8 million in FY 2007 and \$19.5 million in FY 2004 (Table 3). Only universities and colleges in Maryland received more funding in FY 2008 (\$11.6 million) than universities in Ohio. However, approximately \$4.1 million of this total went to Universities Space Research Association which funds universities across the country, not just in Maryland. Of Glenn's total funding of \$53.8 million to universities and colleges in FY 2008, Ohio received 18.9% and Maryland received 21.6%. Ohio received a larger share in FY 2008 than in FY 2007 (17.1%), but still lags behind the 22.2% share in FY 2004. Table A.2, Appendix A, provides a complete listing of NASA Glenn awards to colleges and universities by state in FY 2008. Colleges and universities in Florida, Oklahoma, and California each received more than \$4 million, while colleges and universities in Georgia, Virginia, New York, and Pennsylvania each received more than \$1 million from NASA Glenn during FY 2008. Figure 3 shows the distribution of funding awarded to educational institutions in select states. Academic institutions in Northeast Ohio received \$4.3 million (42% of the Ohio amount), nearly the same amount that Northeast Ohio colleges and universities received from awards in the previous year.

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2008



Total Academic Awards: \$53.8 million

Table 3 shows Glenn awards to colleges and universities in the state of Ohio for FY 2004, FY 2006, FY 2007, and FY 2008 (if applicable). The University of Toledo received the highest funding in the past 3 years; it received \$3.4 million in FY 2008. Four more universities received more than \$1 million each in FY 2008: the Ohio State University (\$1.8 million), Case Western Reserve University (\$1.6 million), Cleveland State University (\$1.5 million), and the

University of Akron (\$1.1 million). Combined, these five universities received \$9.5 million, which is more than 93% of the funding allocated by NASA Glenn to academic institutions across the state of Ohio.

Other organizations in Ohio that received major grants from NASA Glenn in FY 2008 included the Ohio Aerospace Institute (\$8 million), Battelle Memorial Institute (\$440,756), the Cleveland Clinic Foundation (\$274,222), and Innovative Scientific Solutions (\$11,550). Ohio Aerospace, Battelle, and Cleveland Clinic received less in FY 2008 than in FY 2007.

**Table 3. Glenn Educational Grants in Ohio by Academic Institution
(FY 2004 – FY 2008, in \$ 2008)**

OHIO COLLEGES & UNIVERSITIES	FY 2004	FY 2006	FY 2007	FY 2008	2008 SHARE
University of Toledo	\$3,619,339	\$5,023,889	\$3,904,059	\$3,413,238	33.5%
Ohio State University	\$4,767,713	\$3,765,284	\$2,045,028	\$1,816,384	17.9%
Case Western Reserve University	\$3,806,863	\$3,296,265	\$2,276,673	\$1,635,533	16.1%
Cleveland State University	\$4,154,378	\$2,392,062	\$1,669,107	\$1,472,882	14.5%
University of Akron	\$1,578,831	\$848,776	\$561,523	\$1,126,032	11.1%
University of Cincinnati	\$252,544	\$78,843	\$183,052	\$619,983	6.1%
Ohio University	\$253	\$122,319	\$38,234	\$54,795	0.5%
Cuyahoga Community College	\$36,339	\$38,740	\$573	\$36,000	0.4%
Wright State University	\$60,292	\$83,085	\$46,241	\$486	0.005%
Bowling Green State University	\$432,766	\$304,120	\$32,182		
University of Dayton	\$3,147	\$161,687	\$13,031		
Kent State University	\$156,004	\$12,966	\$2,408		
John Carroll University	\$39,803		(\$10,385)		
Lake County Community College			(\$0)		
Baldwin Wallace College	\$87,554	\$20,963			
Myers University	\$21,857	\$6,816			
Lorain County Community College	\$2,831	\$1,250			
Malone College		\$681			
Capital University		(\$85)			
Central State University	\$471,635				
Oberlin College	\$25,746				
Xavier University	\$4,748				
Notre Dame College of Ohio	\$1,367				
Youngstown State University	\$843				
Ohio Northern University	\$236				
TOTAL	\$19,525,088	\$16,157,662	\$10,761,727	\$10,175,333	100.0%

C.6 GLENN REVENUES

Reversing a long-time trend of decline, total revenue in FY 2008 increased 8.1% from FY 2007 without adjustment for inflation. Even after accounting for inflation, Glenn revenues rose by 4.1% over the previous year. When the years FY 2004 to FY 2008 are analyzed, it shows that revenues fell by 12% in nominal dollars or 21% after adjusting for inflation.

Funds authorized by NASA accounted for more than 96% of Glenn’s revenues for fiscal years 2004 through 2008, except in FY 2006 when other sources provided a slightly larger share of Glenn’s revenues and NASA authorized funding accounted for 93% of total revenues. The dynamics of structural components of the total revenue, reimbursable commitments, and NASA direct authority, went through similar changes with the exception of FY 2006, when reimbursable commitments almost doubled. Table 4 provides a detailed breakdown of Glenn revenues from FY 2004 through FY 2008. For example, in FY 2008, Glenn received \$671.7 million in revenues from NASA. This amount represents 96% of its total revenues. An additional \$27.9 million in revenues was received from the Department of Defense, other federal agencies, and other domestic, non-federal entities. NASA Glenn’s total revenues during FY 2008 were \$699.6 million.

Table 4. NASA Glenn Revenues, FY 2004 – FY 2008 (millions of nominal dollars)

Revenue Source	FY04	FY05	FY06	FY07	FY08
NASA Direct Authority	\$767.3	\$704.5	\$669.6	\$626.9	\$671.7
Reimbursable Commitments	\$27.7	\$25.3	\$50.2	\$20.2	\$27.9
Total FY Authority	\$795.0	\$729.8	\$719.8	\$647.1	\$699.5
Revenue from NASA	96.5%	96.5%	93.0%	96.9%	96.0%

Glenn’s revenue from sources other than NASA (reimbursable commitments) increased between FY 2007 and FY 2008 by 33.5% after adjusting for inflation mainly due to increased reimbursable commitments from other federal agencies. At the same time, reimbursable commitments from non-federal sources, including state and local governments, declined. The structure of reimbursable commitments include: other federal agencies (65.1%), Department of Defense (18.8%); and domestic, non-federal entities including state and local governments (16.1%).

C.7 TAXES PAID BY GLENN EMPLOYEES

Taxes paid by NASA Glenn employees to state and local governments are important to Ohio's economy. The amounts are determined by the number of civil service employees, their physical location on the Glenn campus, and their earnings. Most Glenn employees' workplaces are located in the city of Brook Park. Other facilities fall within the boundaries of the cities of Cleveland and Fairview Park.

The data shown in Table 5 represent taxes withheld from employee paychecks and sent directly to state and local governments. It excludes taxes paid directly by employees to local governments based on residence. Income taxes increased by 2.2% between 2007 and 2008 in nominal dollars, but fell by 1.6% after accounting for inflation. From 2004 to 2008, the amount of paid state and local taxes decreased by 5.1% in nominal dollars or 21.6% after adjusting for inflation. During this period of time, the state of Ohio received \$31.9 million (\$6.2 million in 2008) and local municipalities received \$15.5 million (\$3.3 million in 2008) in taxes from Glenn employees. The state of Ohio and city of Brook Park are two the largest beneficiaries of Glenn's taxes. The city of Brook Park received 89% of the amount of taxes paid to local municipalities. Out of all taxes paid by Glenn's employees, the state of Ohio received 67%.

Table 5: Income Taxes Paid by Glenn Employees (in nominal dollars)

Year	City of Brook Park	City of Cleveland	City of Fairview Park	State of Ohio	Total
2004	\$2,968,106	\$1,486	\$166,488	\$6,811,979	\$9,948,059
2005	\$2,625,474	\$2,311	\$336,740	\$6,613,854	\$9,578,379
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

D. ECONOMIC IMPACT OF NASA GLENN

In this section the economic impact of the NASA Glenn Research Center on Northeast Ohio⁹ and the state of Ohio in FY 2008 will be discussed. Total impact is measured in terms of output (sales), employment, and household earnings. Each of these categories is estimated as the sum of four components: change in final demand, direct impact, indirect impact, and induced impact. Glenn's total impacts on Northeast Ohio and the state of Ohio are estimated separately.

D.1 METHODOLOGY

The total economic impact is estimated based on the assumption that an enterprise (in this case, NASA Glenn) comes into existence in one day and generates a demand for goods and services needed for its operation. The demand reflects the investment NASA Glenn generates in the Northeast Ohio and Ohio economy. The increase in demand from NASA's investments 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 the Northeast Ohio or state economy using an input-output model that captures the buy-sell linkages among all industry sectors and the household sector.

In order for Glenn to engage in research and development, other goods and services are needed as intermediate inputs. This leads to the generation of other components of economic impact: direct, indirect, and induced. Direct impact refers to the initial value of goods and services, including labor, purchased by Glenn within Northeast Ohio or the state of Ohio. These purchases are sometimes referred to as the first-round effects. Indirect impact measures the value of labor, capital, and other inputs of production needed to produce the goods and services required by Glenn (second-round and additional-round effects). 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 Glenn and its suppliers.

Economic impact analysis takes into account inter-industry buy-sell relationships within an economy. These relationships largely determine how an economy responds to changes in economic activity. Input-output (I-O) models estimate inter-industry relationships in a county,

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 purchase of goods and services for final consumption—in this case by the Glenn Research Center.

region, state, or country by measuring the industrial distribution of inputs 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 job ripples through the respective economy, creating additional expenditures and jobs. The economic multiplier measures the ripple effect that an initial expenditure has on the local economy.¹¹ This study utilizes regional I-O multipliers from IMPLAN Professional model.¹²

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) 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 Glenn purchases from companies located within Northeast Ohio; economic impact on the state of Ohio economy is generated only by 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 Glenn's revenues are received from non-local sources (federal sources) and, therefore, no further adjustments are required.

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

¹¹ 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.

¹² 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.

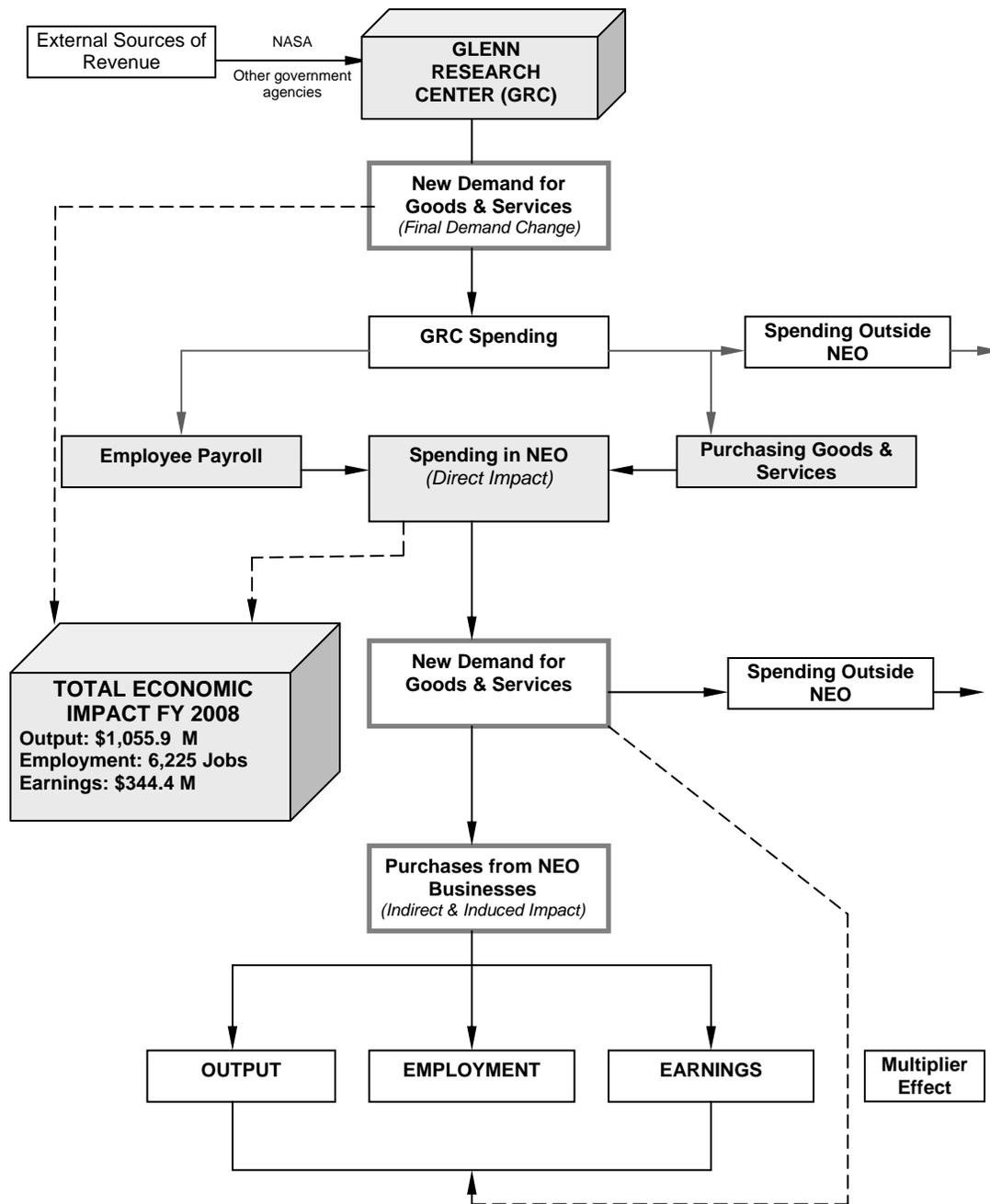
all Glenn revenues are derived from federal sources (96%),¹³ discounting of expenditures due to local revenues was not necessary.

Figure 4 illustrates the process by which NASA Glenn impacted the local economy through its spending in the Akron and Cleveland metro areas in FY 2008. Through its attraction of federal dollars, 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 Akron-Cleveland metro areas, resulting in dollars leaking from the local economy. However, many goods and services are purchased locally. Local spending by Glenn for goods, services, and labor is the direct impact. As these dollars move through the economy, they result in additional demand for goods and services, creating indirect and induced impact. The total economic impact of Glenn is equal to the sum of the change in final demand, direct, indirect, and induced impacts.¹⁴

¹³ This includes revenue from NASA and other federal agencies.

¹⁴ 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 6-11) may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling.

Figure 4. Glenn Research Center—Economic Impact on Northeast Ohio, FY 2008



D.2 ECONOMIC IMPACT ON NORTHEAST OHIO IN FY 2008

In this section, the economic impact that NASA Glenn spending generated for the Northeast Ohio economy in FY 2008 is discussed. More specifically, a detailed analysis of the change in output (sales), employment, and household earnings due to Glenn activities is presented.

D.2.1 Output Impact on Northeast Ohio in FY 2008

This analysis uses SAM multipliers to estimate the ripple effect that an initial expenditure has on a local economy.¹⁵ These multipliers measure the effect of Glenn Research Center 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 expended by 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 elsewhere. Local spending is then categorized by industry, based upon an IMPLAN industry classification system that is analogous to the North American Industry Classification System (NAICS). Table A.3, Appendix A, provides a detailed Glenn expenditure list by specific industry.

Table 6 presents the total output impact and its components. Local Glenn expenditures represent direct output impact. Indirect impact is estimated by summing the contributions of individual industries that provide inputs to the producers of the goods and services ultimately consumed by 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 Glenn. Total output impact is the sum of change in final demand, direct impact, indirect impact, and induced impact. Table 6 reports output impacts by industry sector. It shows how Glenn spending across Northeast Ohio affects all sectors of the economy.¹⁶

¹⁵ 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.

¹⁶ Households (Glenn employees' disposable income) are not shown as an industry sector in Table 6, although they are included as an industry in Table A.3. This is done because IMPLAN automatically distributes these monies directly to the industries from which households typically make purchases.

Table 6. Output Impact Based on Glenn Spending in Northeast Ohio, FY 2008

NASA Glenn Expenditures in Northeast Ohio: \$373,755,843

Industry	Direct	Indirect	Induced	Total
Utilities	\$17,394,029	\$2,357,580	\$2,113,119	\$21,864,727
Construction	\$28,948,553	\$4,430,781	\$791,474	\$34,170,809
Manufacturing	\$7,027,366	\$10,842,099	\$7,334,716	\$25,204,211
Retail Trade	\$16,182,659	\$1,703,824	\$12,934,438	\$30,820,922
Transportation & Warehousing	\$1,946,008	\$6,131,539	\$2,438,868	\$10,516,416
Information	\$18,685,686	\$5,897,335	\$3,338,569	\$27,921,589
Finance & Insurance	\$5,759,212	\$11,722,786	\$9,812,243	\$27,294,237
Real Estate, Rental, Leasing	\$18,565,783	\$12,078,913	\$19,240,321	\$49,885,016
Professional, Scientific, Technical Services	\$125,157,793	\$21,866,565	\$3,972,484	\$150,996,845
Administrative & Support Services	\$42,965,640	\$12,109,258	\$2,097,825	\$57,172,722
Educational Services	\$7,362,175	\$128,817	\$1,888,603	\$9,379,593
Health Care & Social Assistance	\$20,520,769	\$301,541	\$16,787,441	\$37,609,751
Arts, Entertainment, Recreation	\$1,475,427	\$550,979	\$1,300,069	\$3,326,474
Accommodation & Food Services	\$5,926,162	\$3,629,752	\$5,768,864	\$15,324,778
Other Services	\$4,908,793	\$4,504,367	\$4,687,329	\$14,100,489
Government Enterprises	\$4,249,520	\$2,473,011	\$1,696,714	\$8,419,247
Other ^a	\$825,764	\$5,179,509	\$2,075,704	\$8,080,974
Total	\$327,901,399	\$105,908,657	\$98,278,781	\$532,088,800

Change in Final Demand ^b	\$523,815,952
Direct Impact	\$327,901,339
Indirect Impact	\$105,908,657
Induced Impact	\$98,278,781
Total Output Impact	\$1,055,904,728

^a Other includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

^b For output impact, the change in final demand equals spending by Glenn within and outside Northeast Ohio excluding payroll and healthcare benefits.

The total output impact across Northeast Ohio as a result of Glenn Research Center FY 2007 activities was \$1.056 billion. Glenn's expenditures of \$374 million in Northeast Ohio resulted in a change in output (sales) of \$532 million across all industry sectors (Table 6). For example, Glenn spending affected a \$25.2 million increase in sales (direct, indirect, and induced impacts) by all manufacturing-related industries. Thus, the impact of Glenn's presence in the area is represented as the increase in output in comparison to the hypothetical absence of Glenn in Northeast Ohio.

Of the total output impact, 50% (\$524 million) is accounted for by the change in final demand that occurs because Glenn activities bring resources into Northeast Ohio from outside the region. Approximately \$328 million (31%) of the total output impact is a result of direct spending by Glenn for goods and services purchased within Northeast Ohio. The remaining output impact of \$204 million (19.3%) is attributable to the indirect and induced components as Glenn spending ripples through the economy.

A detailed analysis of the IMPLAN model results indicates that the \$532.1 million change in output (sales) generated by the direct, indirect, and induced impacts can be divided into three broad categories—Glenn-driven sectors, consumer-driven sectors, and other sectors. Glenn-driven sectors are those industry groups whose increased sales, employment, and earnings are attributed primarily but not exclusively to Glenn spending. They include utilities, construction, information, professional and scientific services, administrative and support services, and education. The total increase in output for these sectors in FY 2008 was \$301.5 million or 57% of the total impact generated by the direct, indirect, and induced impacts.

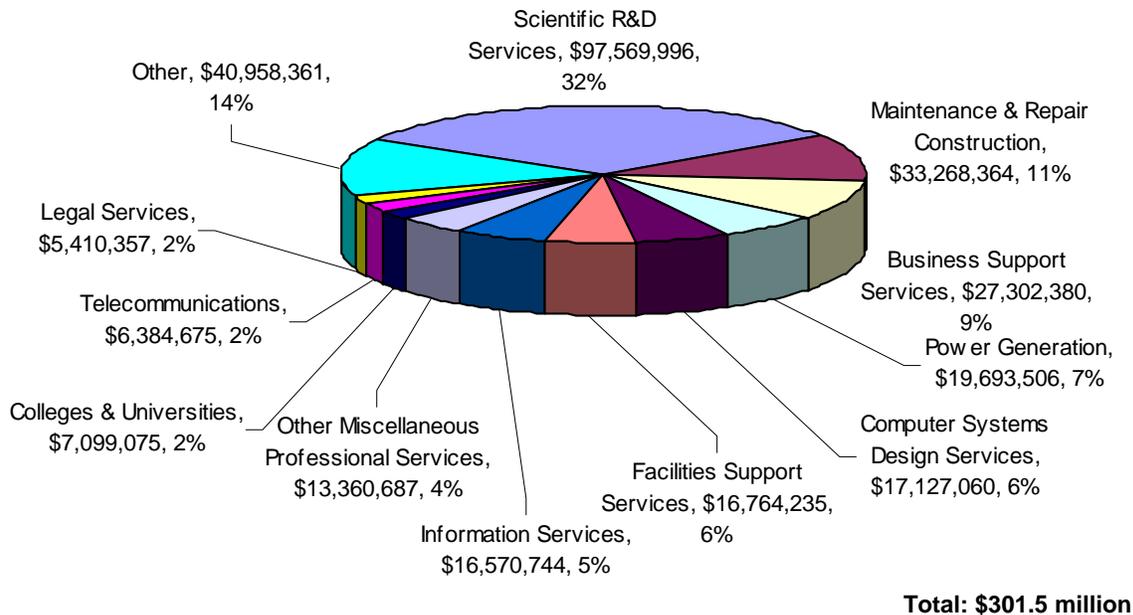
Consumer-driven sectors are those industry groups whose increased sales, employment, and earnings are attributed primarily to spending by Glenn employees and other workers who produce goods and services for Glenn and their suppliers. They include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.¹⁷ The total increase in output for these sectors in FY 2008 was \$178.4 million or 33.5% of the total impact.

Other sectors are those industry groups that are driven by both Glenn and consumer spending or whose impact is insignificant. They include manufacturing, government enterprises, agriculture, mining, wholesale trade, and transportation and warehousing.

¹⁷ *Owner-occupied dwellings* 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.

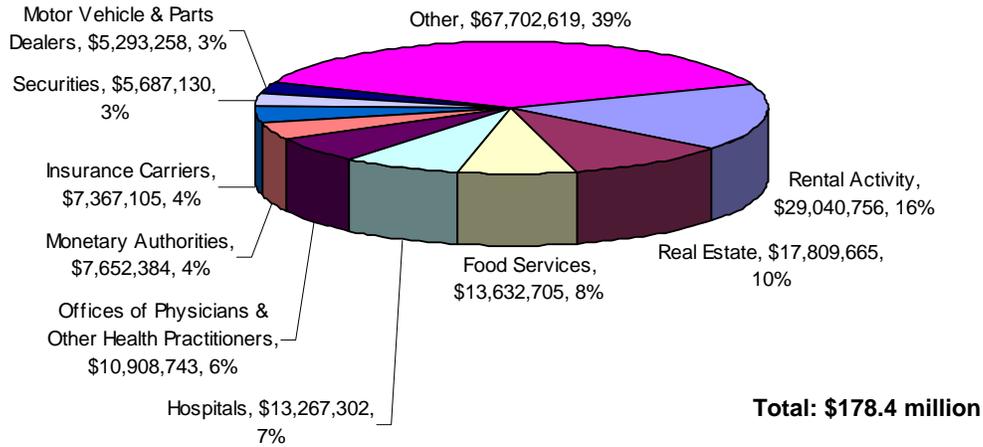
The output distribution for select industries within the Glenn-driven sectors is shown in Figure 5 and the output distribution for select industries within the consumer-driven sectors is presented in Figure 6. Industries with additional sales of at least \$5 million were selected to be presented in figures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

Figure 5. Increase in Sales for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008



The power generation industry (utilities sector) saw an increase in sales of \$19.7 million in FY 2008 due to Glenn's spending patterns (Figure 4). This amount is the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by Glenn spending for electric utilities. The increase of \$19.7 million accounts for 7% of the \$301.5 million increase in output for all industries within the Glenn-driven sectors. Other industries shown in Figure 5 can be interpreted in a similar manner.

Figure 6. Increase in Sales for Select Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008



The food services industry saw an increase in sales of \$13.6 million in FY 2008 (Figure 6). This amount is the summation of the direct, indirect, and induced impacts generated primarily by Glenn employees and other workers for food and drink. The increase of \$13.6 million accounts for 8% of the \$178.4 million increase in output for all industries within the consumer-driven sectors.

D.2.2 Employment Impact on Northeast Ohio in FY 2008

Glenn Research Center’s activities in Northeast Ohio affect job creation beyond Glenn’s hiring of its own employees (change in final demand). Glenn spending creates employment in industries from which it purchases goods and services (direct impact) and employment in industries that provide inputs into those goods and services (indirect impact). In addition, monies spent by Glenn employees and employees of those companies with which Glenn does business create jobs in a variety of other industries (induced impact). Total employment impact equals the sum of Glenn Research Center full-time equivalent employment, direct impact, indirect impact, and induced impact. Table 7 shows the number of jobs created by the industry sector.

Table 7. Employment Impact Based on Glenn Spending in Northeast Ohio, FY 2008

NASA Glenn Expenditures in Northeast Ohio: \$373,755,843

Industry	Direct	Indirect	Induced	Total
Utilities	27	4	3	34
Construction	300	42	5	347
Manufacturing	18	35	18	73
Retail Trade	263	26	202	491
Transportation & Warehousing	13	44	19	75
Information	117	20	11	148
Finance & Insurance	23	58	45	126
Real Estate, Rental, Leasing	18	91	52	161
Professional, Scientific, Technical Services	901	173	32	1,106
Administrative & Support Services	525	198	32	755
Educational Services	116	2	35	152
Health Care & Social Assistance	244	2	198	444
Arts, Entertainment, Recreation	29	11	26	65
Accommodation & Food Services	109	65	107	281
Other Services	92	49	83	223
Government Enterprises	8	18	11	38
Other ^a	6	25	12	42
Total	2,810	863	891	4,563

Change in Final Demand ^b	1,662
Direct Impact	2,810
Indirect Impact	863
Induced Impact	891
Total Employment Impact	6,225

^a Other includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

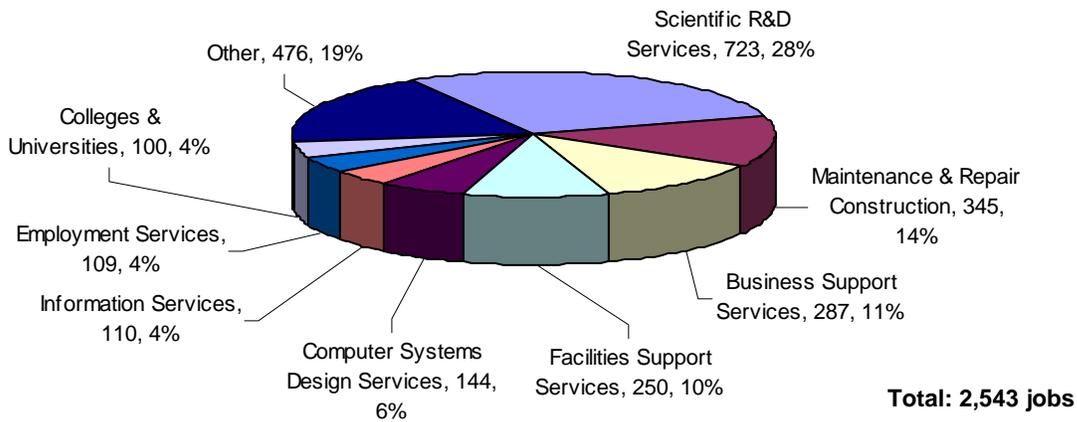
^b For employment impact, the change in final demand is equal to the number of full-time equivalent employees working for Glenn.

The total employment impact by Glenn Research Center on the Northeast Ohio economy in FY 2007 is 6,225 jobs. Out of the total employment impact, 1,662 (26.7%) are directly employed at NASA Glenn. As a result of Glenn's direct spending for goods and services purchased in the region, 2,810 jobs (45.1%) were created. The remaining employment impact, 1,753 jobs (28.2%), is in the form of indirect and induced impacts as Glenn spending ripples through the economy.

Of the 4,563 jobs created in Northeast Ohio due to the direct, indirect, and induced impacts, 2,543 (55.7%) are found in the Glenn-driven sectors, 1,791 (39.3%) are in the

consumer-driven sectors, and 228 (5.0%) fall under other sectors.¹⁸ The job distribution for select industries within the Glenn-driven sectors is shown in Figure 7. The job distribution for select industries within the consumer-driven sectors is shown in Figure 8. The industries presented in figures 7 and 8 are the leading industries with the most increased employment (100 in Figure 7 and 71 in Figure 8).

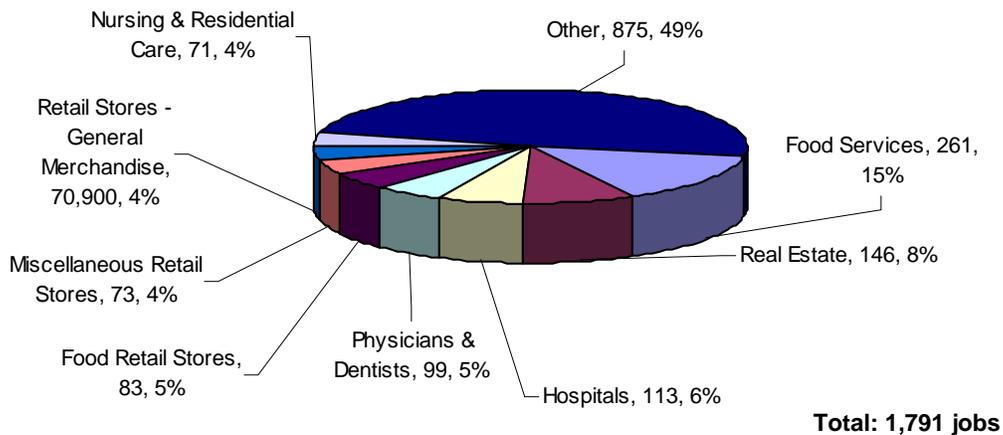
Figure 7. Increase in Jobs for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008



Companies engaged in scientific R&D (professional, scientific, and technical services sector) saw an increase of 723 jobs in FY 2008 due to NASA Glenn activities (Figure 6). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily but not exclusively by Glenn spending for local R&D contractors. The 723 jobs account for 28% of the 2,543 jobs that were created in all industries within the Glenn-driven sectors.

¹⁸ 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, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 8. Increase in Jobs for Select Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008



Food and beverage stores (retail trade sector) saw an increase of 83 jobs in FY 2008 because of Glenn spending (Figure 8). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily by Glenn employees and other workers for food and drink products. The 83 jobs account for 5% of the 1,791 jobs that were created in all industries within the consumer-driven sectors.

D.2.3 Earnings Impact on Northeast Ohio in FY 2008

Earnings impact is the estimated total change in earnings paid to local households due to spending by Glenn Research Center for goods and services from businesses and other entities in Northeast Ohio. Monies paid to employees of companies and other entities who supply goods and services to Glenn represent direct earnings impact. Indirect impact is estimated by summing the monies paid to persons who work for companies that provide inputs to the producers of the goods and services ultimately consumed by Glenn. Induced impact represents monies 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 Glenn. Adding the direct, indirect, and induced impacts to the disposable income and healthcare benefits received by Glenn employees (final demand change) results in total earnings impact. Table 8 shows earnings impact by industry sector.

Table 8. Earnings Impact Based on Glenn Spending in Northeast Ohio, FY 2008

NASA Glenn Expenditures in Northeast Ohio: \$373,755,843

Industry	Direct	Indirect	Induced	Total
Utilities	\$3,433,604	\$438,538	\$398,310	\$4,270,453
Construction	\$13,073,135	\$1,880,185	\$265,322	\$15,218,641
Manufacturing	\$1,308,075	\$2,398,612	\$1,313,428	\$5,020,128
Retail Trade	\$7,005,052	\$738,839	\$5,530,886	\$13,274,779
Transportation & Warehousing	\$615,783	\$2,142,439	\$885,372	\$3,643,595
Information	\$3,852,881	\$1,179,629	\$628,853	\$5,661,361
Finance & Insurance	\$1,599,300	\$3,906,436	\$3,021,728	\$8,527,464
Real Estate, Rental, Leasing	\$436,827	\$1,931,857	\$1,052,835	\$3,421,519
Professional, Scientific, Technical Services	\$66,108,026	\$10,735,622	\$1,981,741	\$78,825,389
Administrative & Support Services	\$22,018,929	\$5,819,524	\$969,815	\$28,808,266
Educational Services	\$3,543,078	\$56,507	\$899,342	\$4,498,927
Health Care & Social Assistance	\$10,622,305	\$115,273	\$8,859,993	\$19,597,572
Arts, Entertainment, Recreation	\$638,297	\$262,015	\$569,803	\$1,470,118
Accommodation & Food Services	\$1,882,245	\$1,159,623	\$1,831,174	\$4,873,041
Other Services	\$1,924,635	\$1,686,300	\$1,862,324	\$5,473,257
Government Enterprises	\$527,674	\$1,432,319	\$762,985	\$2,722,977
Other ^a	\$286,961	\$1,968,727	\$768,444	\$3,024,129
Total	\$138,876,807	\$37,852,445	\$31,602,355	\$208,331,616

Change in Final Demand ^b	\$ 136,065,949
Direct Impact	\$138,876,807
Indirect Impact	\$37,852,445
Induced Impact	\$31,602,355
Total Earnings Impact	\$ 344,397,556

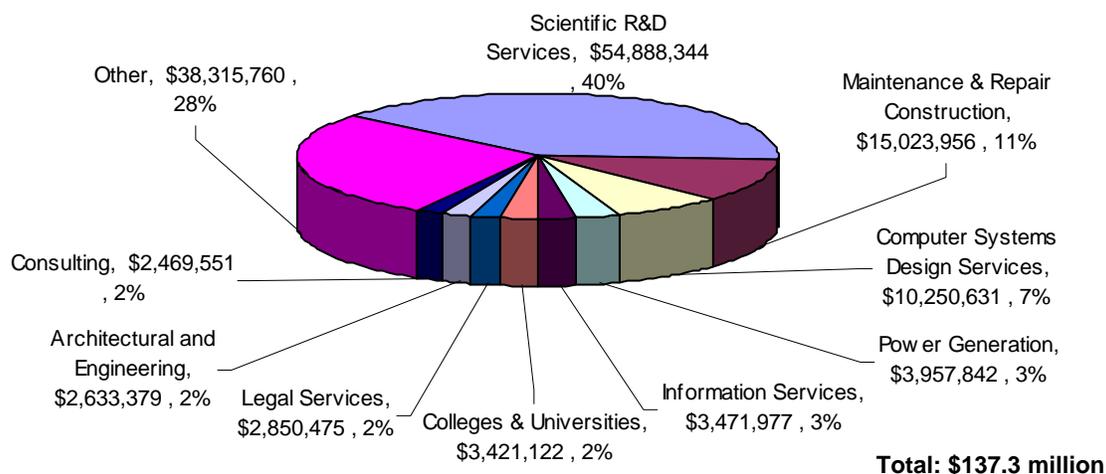
^a "Other" includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

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

Total household earnings in Northeast Ohio increased by \$344.4 million as a result of Glenn’s spending in FY 2008 for goods and services. Out of this total amount, \$136.1 million (39.5%) is the disposable income, plus healthcare benefits, paid directly to NASA Glenn employees--change in final demand. \$138.9 million (40.3%) represents monies paid to employees of companies in Northeast Ohio that supply goods and services to Glenn--direct impact. The remaining earnings impact, (indirect and induced components) estimated at \$69.5 million (20.2%), occurs as the effects of Glenn spending ripples through the Northeast Ohio economy.

Of the \$208.3 million increase in household earnings generated across Northeast Ohio due to the direct, indirect, and induced impacts, \$137.3 million (65.9%) was reported in Glenn-driven sectors; \$56.6 (27.2%) was generated in consumer-driven sectors; and \$14.4 million (6.9%) was reported in other sectors.¹⁹ The household earnings distribution for select industries within the Glenn-driven sectors is shown in Figure 9. The household earnings distribution for select industries within the consumer-driven sectors is shown in Figure 10. Selected industries in these figures added over \$2 million each.

Figure 9. Increase in Earnings for Select Industries in Glenn-Driven Sectors in Northeast Ohio, FY 2008

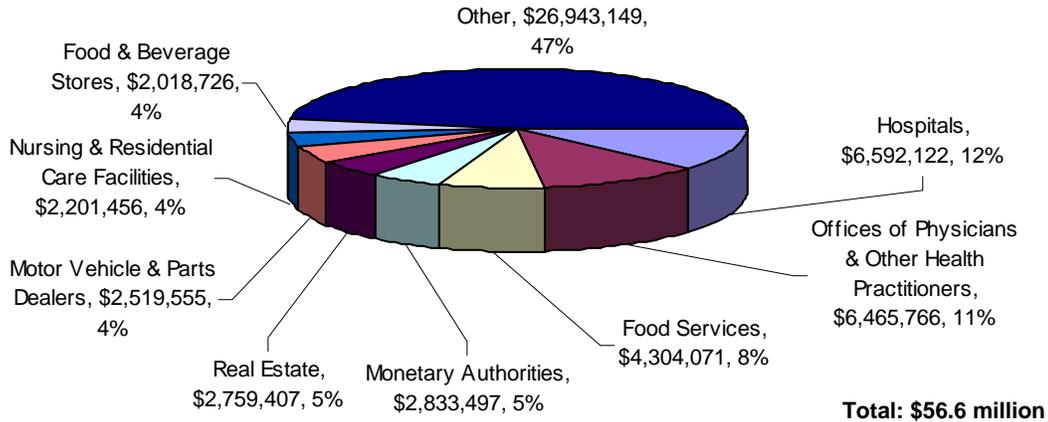


Persons engaged in computer systems design services saw their household earnings increase by \$10.3 million in FY 2008 (Figure 9). These earnings are the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by Glenn spending for computer systems design services. The \$10.3 million accounts for a 7% of the

¹⁹See section D.2.1 Output Impact on Northeast Ohio for definitions of Glenn-driven, consumer-driven, and other sectors.

\$137.3 million earnings increase that was reported by all industries within the Glenn-driven sectors.

Figure 10. Increase in Earnings for Industries in Consumer-Driven Sectors in Northeast Ohio, FY 2008



Persons working in food and beverages stores services saw their household earnings increase by \$2 million in FY 2008 (Figure 10). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending at restaurants and bars. The \$2 million accounts for a 4% of the \$56.6 million earnings increase that occurred in all industries within the consumer-driven sectors.

D.2.4 FY 2008 Northeast Ohio Impact Summary

Economic activity generated by Glenn Research Center produced the following impacts on Northeast Ohio (2008 dollars):

- Total Output Impact: \$1,055.7 million
- Total Employment Impact: 6,225 jobs
- Total Earnings Impact: \$344.4 million

The economic impact presented here reflects NASA Glenn expenditures in Northeast Ohio in FY 2008. During that time period, 89% (\$331 million) of Glenn expenditures were allocated to Glenn payroll; professional, scientific research and development services; administrative and support and waste management services, and construction.

Other industries deriving significant benefits from direct Glenn spending include information services, power generation, business and facilities support, facilities maintenance and repair. Businesses deriving the most benefit from spending by Glenn personnel and other workers whose earnings are due in part to 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 2008

In this section, we discuss the economic impact that NASA Glenn spending had on the Ohio economy during FY 2008. More specifically, we present a detailed analysis of the change in output (sales), employment, and household earnings due to Glenn activities.

This section follows the structure of Section D.2, Economic Impact on Northeast Ohio. Readers who are less interested in the detailed discussion should proceed to section D.3.4, Ohio Impact Summary.

D.3.1 Output Impact on the State of Ohio in FY 2008

This analysis uses multipliers to estimate the ripple effect that an initial expenditure has on a studied economy. These multipliers measure the effect of Glenn Research Center (Glenn) 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 assures less leakage from the economy. Stated another way, as the geographic area being analyzed 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 Glenn expenditures by specific industry.

Table 9 presents the total output impact and its components. Local Glenn expenditures represent direct output impact. Indirect impact is estimated by summing the contributions of individual industries that provide inputs 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 Glenn. Total output impact is the sum of change in final demand, direct impact, indirect impact, and induced impact. Table 9 reports output impacts by industry sector. It shows how Glenn spending across Ohio affects all sectors of the economy.²⁰

²⁰ Disposable income spent by 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 9.

Table 9. Output Impact Based on Glenn Spending in the State of Ohio, FY 2008

NASA Glenn Expenditures in Ohio: \$452,086,175

2008				
	Direct	Indirect	Induced	Total
Utilities	\$17,602,252	\$3,490,612	\$3,144,246	\$24,237,110
Construction	\$42,985,157	\$5,910,921	\$1,225,097	\$50,121,174
Manufacturing	\$10,806,738	\$18,042,399	\$14,671,237	\$43,520,380
Transportation & Warehousing	\$1,909,641	\$7,526,965	\$3,487,388	\$12,923,994
Retail Trade	\$17,119,731	\$2,476,468	\$17,771,702	\$37,367,900
Information	\$18,743,802	\$7,530,189	\$4,528,306	\$30,802,298
Finance & Insurance	\$5,798,220	\$14,135,535	\$13,183,207	\$33,116,963
Real Estate, Rental, Leasing	\$18,457,184	\$13,831,231	\$24,755,283	\$57,043,695
Professional, Scientific, Technical Services	\$175,706,502	\$29,442,389	\$5,540,476	\$210,689,369
Administrative & Support Services	\$48,743,626	\$15,033,466	\$2,805,939	\$66,583,031
Educational Services	\$12,574,148	\$140,458	\$2,135,579	\$14,850,186
Health Care & Social Assistance	\$20,834,596	\$305,559	\$22,564,167	\$43,704,321
Arts, Entertainment, Recreation	\$1,475,119	\$692,178	\$1,714,174	\$3,881,471
Accommodation & Food Services	\$5,912,344	\$4,549,976	\$7,638,174	\$18,100,493
Other Services	\$4,918,864	\$5,588,100	\$6,187,937	\$16,694,903
Government Enterprises	\$5,080,168	\$3,155,157	\$2,354,665	\$10,589,990
Other ^a	\$908,841	\$7,476,191	\$3,833,355	\$12,218,390
Total	\$409,576,936	\$139,327,787	\$137,540,931	\$686,445,654
Change in Final Demand ^b	\$523,815,952			
Direct Impact	\$409,576,936			
Indirect Impact	\$139,327,787			
Induced Impact	\$137,540,931			
Total Output Impact	\$1,210,261,605			

^a Other includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

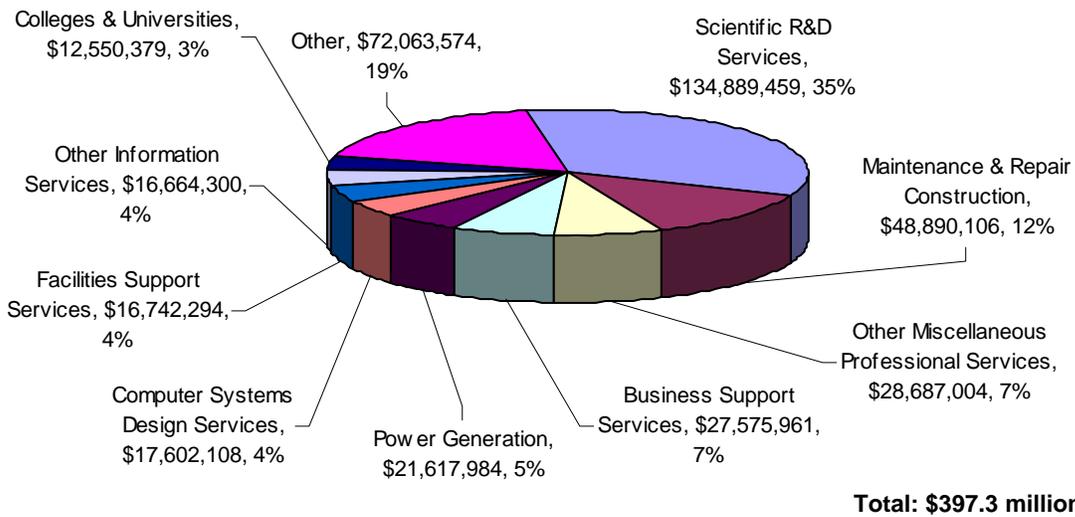
^b For output impact, the change in final demand equals spending by Glenn within and outside Ohio excluding payroll and healthcare benefits.

The total output impact across the state of Ohio as a result of Glenn Research Center activities in FY 2008 was over \$1.2 billion. Glenn’s expenditures of \$452.1 million resulted in an increase in output (sales) of \$686.5 million across all industry sectors (Table 9). For example, Glenn spending affected a \$43.5 million increase in sales (direct, indirect, and induced impacts) by the manufacturing sector and \$210.7 million in professional, scientific, and technical services.

Of the total output impact, 43% (\$523.8 million) is accounted for by the change in final demand that occurs because Glenn activities bring resources into Ohio from outside the state. Approximately \$409.6 million (33.8%) of the total output impact is a result of direct spending by Glenn for goods and services purchased within the state of Ohio. The remaining output impact of \$276.9 million (23%) is attributable to the indirect and induced components as Glenn spending ripples through the economy.

An analysis of the IMPLAN model shows that the \$686.5 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—Glenn-driven sectors (\$397.3 million, 57.9%), consumer-driven sectors (\$209.9 million, 30.6%), and other sectors (\$79.3 million, 11.5%).²¹ The output distribution for select industries within the Glenn-driven sectors is shown in Figure 11. The output distribution for select industries within the consumer-driven sectors is shown in Figure 12. Selected industries in these figures added over \$12 million and \$6 million, respectively.

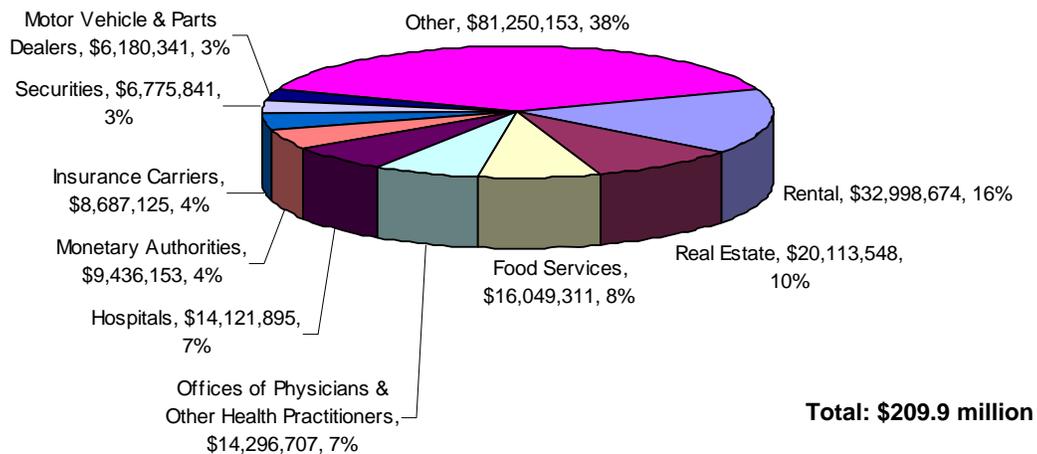
Figure 11. Increase in Sales for Select Industries in Glenn-Driven Sectors, Ohio, FY 2008



²¹ 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.

Colleges and universities (education sector) across the state of Ohio saw an increase in revenues of \$12.6 million in FY 2008 (Figure 11). This amount is the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by Glenn spending for research by colleges and universities. This increase of \$12.6 million accounts for a 3% share of the \$397.3 million increase in output value for all industries within the Glenn-driven sectors.

Figure 12. Increase in Sales for Select Industries in Consumer-Driven Sectors, Ohio, FY 2008



Insurance carriers (finance and insurance sector) experienced a sales increase of \$8.7 million in FY 2008 (Figure 12). This amount is the summation of the direct, indirect, and induced impact components generated primarily by Glenn employees and other workers for insurance products. This increase of \$8.7 million represents a 4% share of the \$209.9 million increase in output for all industries within the consumer-driven sectors.

D.3.2 Employment Impact on the State of Ohio in FY 2008

Glenn Research Center's activities affect job creation beyond Glenn's hiring of its own employees (change in final demand). 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 inputs into those goods and services (indirect impact). In addition, monies spent by 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 Glenn Research Center full-time equivalent employment and the

direct, indirect, and induced components. Table 10 shows the number of jobs created by industry sector.

Table 10. Employment Impact Based on Glenn Spending in the State of Ohio, FY 2008

NASA Glenn Expenditures in Ohio: \$452,086,175

Industry	Direct	Indirect	Induced	Total
Utilities	28	5	5	39
Construction	455	57	8	520
Manufacturing	27	47	30	108
Transportation & Warehousing	13	55	26	94
Retail Trade	296	40	290	626
Information	70	26	16	113
Finance & Insurance	25	76	65	165
Real Estate, Rental, Leasing	17	102	64	184
Professional, Scientific, Technical Services	1,215	229	45	1,489
Administrative & Support Services	743	258	45	1,046
Educational Services	189	3	39	231
Health Care & Social Assistance	250	3	267	519
Arts, Entertainment, Recreation	30	15	35	80
Accommodation & Food Services	110	83	143	336
Other Services	96	65	114	275
Government Enterprises	9	22	15	46
Other ^a	7	37	23	67
Total	3,580	1,125	1,233	5,937
Change in Final Demand ^b	1,662			
Direct Impact	3,580			
Indirect Impact	1,125			
Induced Impact	1,233			
Total Employment Impact	7,599			

^a Other includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

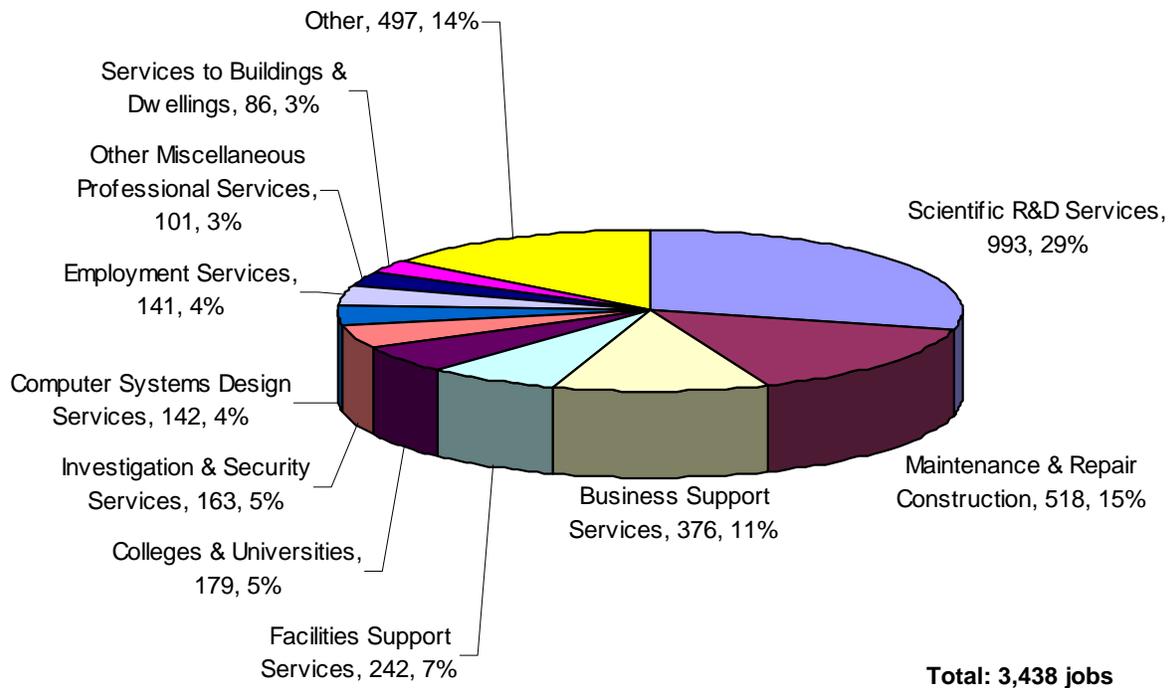
^b For employment impact, the change in final demand is equal to the number of full-time equivalent employees working for Glenn.

Employment increased by 7,599 jobs across the state of Ohio in FY 2008 due to the presence of NASA Glenn. Of these, 1,662 people (22%) are directly employed at Glenn. As a result of Glenn’s direct spending for goods and services purchased in Ohio, 3,580 jobs (47%) were created. The remaining employment impact--2,357 jobs (31%)--is in the form of indirect and induced impacts as NASA Glenn spending ripples through the economy.

Of the 5,937 jobs created in Ohio due to the direct, indirect, and induced components, 3,438 (57.9%) are found in the Glenn-driven sectors, 2,184 (36.8%) are in the consumer-driven

sectors, and 315 (5.3%) fall under other sectors.²² The job distribution for select industries within the Glenn-driven sectors is shown in Figure 13. The job distribution for select industries within the consumer-driven sectors is shown in Figure 14. Selected industries in these figures added the most jobs (over 86 in Figure 13 and over 96 in Figure 14).

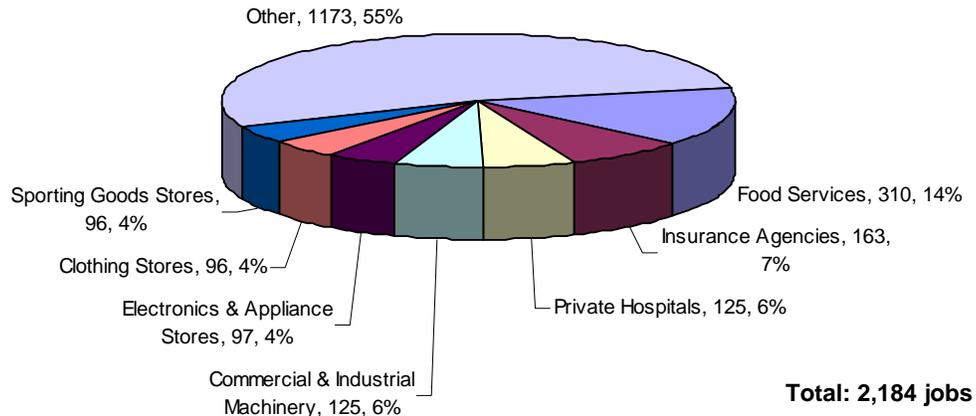
Figure 13. Increase in Jobs for Select Industries in Glenn-Driven Sectors in Ohio, FY 2008



Due to spending by Glenn Research Center in the state of Ohio, 993 jobs were added in scientific R&D services during FY 2008 (Figure 13). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily but not exclusively by Glenn's need for information services. The 993 jobs account for a 29% share of the 3,438 jobs that were created in all industries within the Glenn-driven sectors.

²² 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, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 14. Increase in Jobs for Select Industries in Consumer-Driven Sectors in Ohio, FY 2008



The food services industry experienced an increase of 310 jobs in FY 2008 (Figure 14). These jobs are the summation of the direct, indirect, and induced components generated primarily by NASA Glenn employees and other workers who patronize restaurants and bars. The 310 jobs account for a 14% share of the 2,184 jobs that were created in all industries within the consumer-driven sectors.

D.3.3 Earnings Impact on the State of Ohio in FY 2008

Earnings impact is the estimated change in earnings received by households in the state of Ohio due to spending by Glenn Research Center for goods and services from businesses and other entities across the state. Monies paid to employees of companies and other entities who supply goods and services to Glenn represent direct earnings impact. Indirect impact is estimated by summing the monies paid to persons who work for companies that provide inputs to the producers of the goods and services ultimately consumed by 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 Glenn employees (final demand change) results in total earnings impact. Table 11 shows earnings impact by industry sector.

Table 11. Earnings Impact Based on Glenn Spending in the State of Ohio, FY 2008

NASA Glenn Expenditures in Ohio: \$452,086,175

Industry	Direct	Indirect	Induced	Total
Utilities	\$3,515,592	\$646,406	\$590,171	\$4,752,167
Construction	\$19,049,784	\$2,483,529	\$408,604	\$21,941,916
Manufacturing	\$1,833,221	\$3,249,338	\$2,151,728	\$7,234,299
Transportation & Warehousing	\$217,212	\$213,549	\$318,352	\$749,114
Retail Trade	\$7,386,926	\$1,067,164	\$7,553,430	\$16,007,520
Information	\$3,922,164	\$1,531,950	\$878,279	\$6,332,393
Finance & Insurance	\$1,583,119	\$4,675,943	\$4,016,826	\$10,275,888
Real Estate, Rental, Leasing	\$434,578	\$2,258,439	\$1,325,529	\$4,018,545
Professional, Scientific, Technical Services	\$89,868,383	\$13,927,645	\$2,695,024	\$106,491,054
Administrative & Support Services	\$24,562,657	\$7,078,663	\$1,275,284	\$32,916,605
Educational Services	\$5,995,609	\$60,872	\$1,023,719	\$7,080,201
Health Care & Social Assistance	\$10,786,771	\$116,463	\$11,915,376	\$22,818,612
Arts, Entertainment, Recreation	\$619,426	\$307,151	\$724,743	\$1,651,316
Accommodation & Food Services	\$1,863,388	\$1,442,683	\$2,406,081	\$5,712,151
Other Services	\$1,888,332	\$2,006,241	\$2,391,768	\$6,286,342
Government Enterprises	\$547,899	\$1,793,857	\$1,058,975	\$3,400,730
Other ^a	\$695,107	\$5,139,035	\$2,190,117	\$8,024,260
Total	\$174,770,168	\$47,998,926	\$42,924,007	\$265,693,101
Change in Final Demand ^b	\$136,065,949			
Direct Impact	\$174,770,168			
Indirect Impact	\$47,998,926			
Induced Impact	\$42,924,007			
Total Earnings Impact	\$401,759,050			

^a Other includes the following industry sectors: agriculture, forestry, fishing and hunting; mining; wholesale trade; and management of companies.

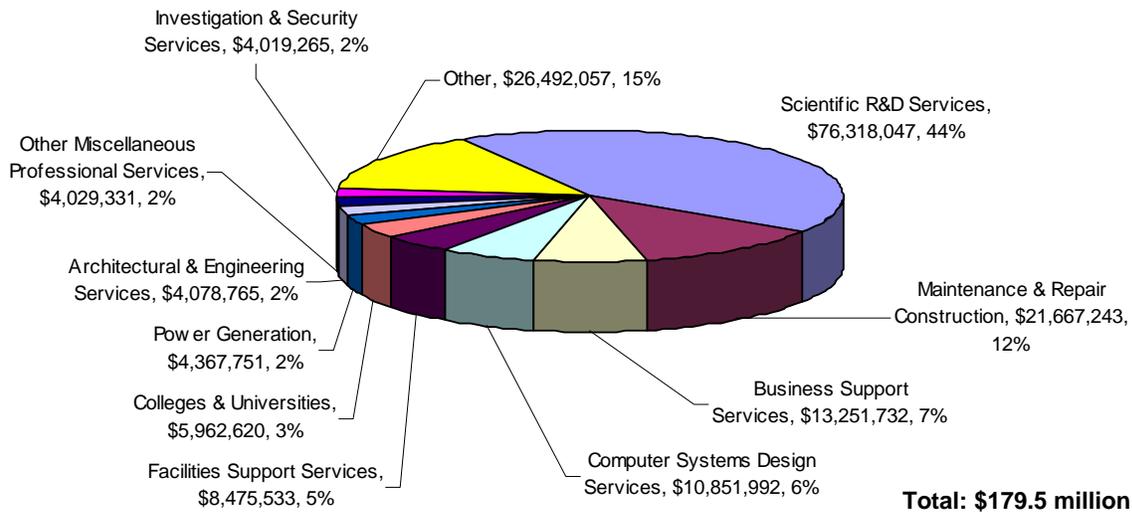
^b For earnings impact, change in final demand is equal to the disposable income (75% of gross income) plus healthcare benefits paid to Glenn employees.

Total household earnings in the state of Ohio increased by \$401.8 million as a result of Glenn’s spending in FY 2008 for goods and services. Of this amount, \$136.1 million (34%) is the disposable income and healthcare benefits paid to NASA Glenn employees—change in final demand. Direct impact --monies paid to employees of companies across the state that supply goods and services to Glenn represent \$174.8 million (44%). The remaining earnings impact (indirect and induced components), estimated at \$90.9 million (23%), occurs as the effects of Glenn spending ripples through the Ohio economy.

Of the \$265.7 million increase in household earnings attributed to the direct, indirect, and induced components, \$179.5 million (68%) was reported in Glenn-driven sectors, \$66.8 million (25%) occurred in consumer-driven sectors, and \$19.4 million (7%) was reported in other

sectors.²³ The household earnings distribution for select industries within the Glenn-driven sectors is shown in Figure 15. The household earnings distribution for select industries within the consumer-driven sectors is shown in Figure 16. Selected industries in these figures experienced the most gains in earnings (over \$4 million each in Figure 15 and over \$2 million each in Figure 16).

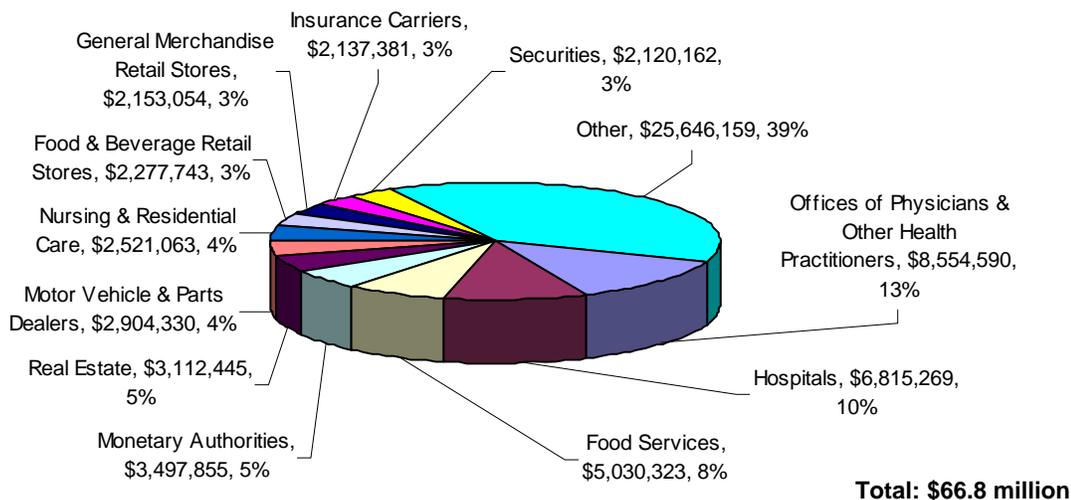
Figure 15. Increase in Earnings for Select Industries in Glenn-Driven Sectors in Ohio, FY 2008



Employees in facilities support services industries (administrative and support services sector) across the state of Ohio saw their household earnings increase by \$8.5 million in FY 2008 (Figure 15). These earnings are the summation of the direct, indirect, and induced impacts generated primarily but not exclusively by NASA Glenn for facilities support services. The \$8.5 million represents a 5% share of the \$179.5 million earnings increase that occurred in all industries within the Glenn-driven sectors.

²³See section D.2.1 Output Impact on Northeast Ohio for detailed definitions of Glenn-driven, consumer-driven, and other sectors.

Figure 16. Increase in Earnings for Select Industries in Consumer-Driven Sectors in Ohio, FY 2008



Persons working for motor vehicle and parts dealers (retail trade sector) experienced an increase in household earnings of \$2.9 million in FY 2008 (Figure 16). This amount is the summation of the direct, indirect, and induced impacts generated primarily by Glenn employees and other workers on spending for automobiles and other types of motor vehicles. The \$2.9 million accounts for a 4% share of the \$66.8 million earnings increase that was reported by all industries within the consumer-driven sectors.

D.3.4 FY 2008 Ohio Impact Summary

Economic activity generated by the Glenn Research Center produced the following impacts on the state of Ohio (2008 dollars):

- Total Output Impact: \$1,210.3 million
- Total Employment Impact: 7,599 jobs
- Total Earnings Impact: \$401.8 million

The impact of NASA Glenn's expenditures in the state of Ohio is only slightly higher than the impact on Northeast Ohio. This is due to the fact that the majority of Glenn's Ohio expenditures are in Northeast Ohio (including all of Glenn's payroll expenditures). In FY 2008, NASA Glenn's expenditures in the state of Ohio, excluding the eight-county Northeast Ohio region, were only \$78.3 million. Almost all of this spending (more than 99% was allocated to just five industries: scientific R&D (\$51 million), construction (\$14.1 million), administrative and support and waste management services (\$5.8 million), colleges and universities (\$5.6 million), and manufacturing (\$1.6 million). The result is that Ohio businesses, excluding those located in the eight-county Northeast Ohio region, experienced an increase in sales of \$154.5 million, added 1,374 jobs, and saw an increase in household earnings of \$57.4 million.

Since major Glenn expenditures elsewhere in the state of Ohio mirrored expenditures in Northeast Ohio, industries across Ohio that derive the most benefit from Glenn spending and spending by NASA Glenn employees and other workers are similar to those reported for Northeast Ohio.²⁴

²⁴ 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 (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 2007 AND FY 2008

NASA Glenn continues to be an important economic player in Northeast Ohio and across the state (Table 12). The economic impact in FY 2008 was comparable to the economic impact in FY 2007 for all measures, although slightly lower. NASA Glenn generated nearly 7,600 jobs in Ohio in FY 2008 compared to 8,050 in the previous year (a 5.6% decline). Output impact on the state was \$1,210.3 million in FY 2008 (3.8% lower compared to FY 2007), while household earnings increased by \$401.8 million in FY 2008 as a result of NASA Glenn activities (4.7% lower than in the previous year).

Table 12. NASA Glenn Economic Impacts, FY 2007- FY 2008

Economic Impact	Northeast Ohio		State of Ohio	
	FY 2007	FY 2008	FY 2007	FY 2008
Output Impact	\$1,084.7 million*	\$1,055.7 million	\$1,258.5 million*	\$1,210.3 million
Employment Impact	6,407 jobs	6,225 jobs	8,051 jobs	7,599 jobs
Earnings Impact	\$346.5 million*	\$344.4 million	\$421.7 million*	\$401.8 million

* Monetary values are adjusted to \$2008 for comparison

In Northeast Ohio, NASA Glenn generated 6,225 jobs in FY 2008 compared to 6,407 jobs in FY 2007 (2.8% decrease). In addition, the earnings impact in Northeast Ohio in FY 2008 generated additional \$344.4 million in household earnings, only \$2.1 million (or 0.6%) less than in FY 2007. The output generated in Northeast Ohio, was \$1,055.7 million in FY 2008, compared to \$1,094.7 million (2.7 % less) in FY 2007. The large economic impact on the state and regional economies emphasize the importance of NASA Glenn’s activities and jobs that NASA Glenn provides 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 with hopes to grow and attract more knowledge-based, research-intensive businesses and organizations. The presence of NASA Glenn in Northeast Ohio is a positive attribute for many of these types of businesses and potential start-up companies that grow their business based on innovation. NASA Glenn’s employees are part of the region’s knowledge-intensive labor force with unique skills at the cutting edge of science and technology that generate wealth in the region and advance the nation.

APPENDIX A: DATA TABLES

Table A.1 Glenn Spending by State, FY 2008

Table A.2 Glenn Monies Allocated to Academic Institutions, FY 2008

Table A.3 NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2008

Table A.4 NASA Glenn Detailed Expenditures in the State of Ohio, FY 2008

Table A.1. Glenn Spending by State, FY 2008

State	Spending	Share
Ohio	\$316,020,226	60.33%
California	\$30,361,617	5.80%
Oklahoma	\$27,498,457	5.25%
Maryland	\$27,432,449	5.24%
New York	\$16,206,143	3.09%
Virginia	\$10,539,577	2.01%
Massachusetts	\$10,217,280	1.95%
Illinois	\$8,300,952	1.58%
Florida	\$7,550,129	1.44%
New Jersey	\$6,856,846	1.31%
Pennsylvania	\$5,175,619	0.99%
Colorado	\$5,119,980	0.98%
Arizona	\$4,617,196	0.88%
Connecticut	\$4,321,781	0.83%
Washington DC	\$3,994,455	0.76%
Alabama	\$3,711,228	0.71%
Texas	\$3,475,035	0.66%
Georgia	\$3,252,255	0.62%
Michigan	\$3,125,925	0.60%
Washington	\$2,454,892	0.47%
Nevada	\$2,043,051	0.39%
New Hampshire	\$1,820,914	0.35%
Minnesota	\$1,773,291	0.34%
Indiana	\$1,698,702	0.32%
Missouri	\$1,621,609	0.31%
Oregon	\$1,468,446	0.28%
Tennessee	\$1,291,431	0.25%
New Mexico	\$1,273,366	0.24%
North Carolina	\$1,253,998	0.24%
Wisconsin	\$1,094,755	0.21%
Louisiana	\$880,501	0.17%
Kentucky	\$673,859	0.13%
Iowa	\$632,526	0.12%
Kansas	\$582,970	0.11%
Delaware	\$563,080	0.11%
Utah	\$535,629	0.10%
Rhode Island	\$508,439	0.10%
Arkansas	\$447,319	0.09%
Mississippi	\$407,421	0.08%
Nebraska	\$268,007	0.05%
Idaho	\$223,123	0.04%
Montana	\$131,562	0.03%
West Virginia	\$116,223	0.02%
South Carolina	\$61,244	0.01%
Wyoming	\$51,794	0.01%
Vermont	\$28,741	0.01%
Hawaii	\$24,072	0.005%
Maine	\$20,676	0.004%
North Dakota	\$2,441	0.0005%
Outside U.S.	\$2,084,719	0.40%
Total	\$523,815,952	100.00%

Spending in Ohio excludes Glenn employee payroll and benefits.

Table A.2. Glenn Funding Allocated to Academic Institutions by State, FY 2008

STATE	AMOUNT	SHARE
Maryland	\$11,611,159.12	21.60%
Ohio	\$10,175,332.66	18.93%
Florida	\$4,817,423.60	8.96%
Oklahoma	\$4,426,523.32	8.23%
California	\$4,298,504.88	7.99%
Georgia	\$2,642,032.99	4.91%
Virginia	\$2,281,841.52	4.24%
New York	\$1,782,379.47	3.32%
Pennsylvania	\$1,202,891.86	2.24%
Tennessee	\$928,023.53	1.73%
Texas	\$848,536.73	1.58%
Massachusetts	\$820,412.45	1.53%
Louisiana	\$804,777.83	1.50%
Indiana	\$703,060.25	1.31%
New Jersey	\$632,590.01	1.18%
Illinois	\$597,159.11	1.11%
Alabama	\$573,703.35	1.07%
Kentucky	\$562,171.29	1.05%
Kansas	\$504,506.69	0.94%
Michigan	\$403,968.28	0.75%
North Carolina	\$348,338.39	0.65%
Connecticut	\$347,797.46	0.65%
Arizona	\$337,781.58	0.63%
Minnesota	\$267,308.05	0.50%
Iowa	\$255,089.33	0.47%
Nebraska	\$252,369.20	0.47%
Colorado	\$236,501.98	0.44%
Rhode Island	\$228,589.96	0.43%
Oregon	\$219,934.32	0.41%
Wisconsin	\$190,869.02	0.36%
Missouri	\$178,027.79	0.33%
Delaware	\$121,775.55	0.23%
Washington	\$60,359.34	0.11%
South Carolina	\$30,000.00	0.06%
Arkansas	\$28,250.24	0.05%
Wyoming	\$15,404.00	0.03%
Washington D.C.	\$14,890.14	0.03%
Idaho	\$11,946.33	0.02%
Hawaii	\$3,901.29	0.01%
Mississippi	(\$683.19)	0.00%
Total	\$53,765,449.72	100.00%

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2008

Description	IMPLAN Sector ^a	Expenditure ^b	Basis ^c
Utilities		\$15,486,147	
Electric power generation, transmission, and distribution	31	\$14,753,573	Industry
Natural gas distribution	32	\$647,575	Industry
Water, sewage and other systems	33	\$85,000	Industry
Construction		\$28,908,449	
Maintenance and repair construction of nonresidential maintenance and repair	39	\$28,908,449	Industry
Manufacturing		\$2,371,519	
Printing	113	\$120,688	Industry
Petroleum lubricating oil and grease manufacturing	118	\$232,998	Commodity
All other petroleum and coal products manufacturing	119	\$143,729	Commodity
Industrial gas manufacturing	121	\$6,557	Commodity
Other basic organic chemical manufacturing	126	\$1,132	Commodity
Plastics material and resin manufacturing	127	\$50,096	Commodity
Paint and coating manufacturing	136	\$5,480	Commodity
Adhesive manufacturing	137	\$193	Commodity
All other chemical product and preparation manufacturing	141	\$3,370	
Tire manufacturing	150	\$514,029	
Rubber and plastics hoses and belting manufacturing	151	\$9,167	Commodity
Other rubber product manufacturing	152	\$13,699	Commodity
Flat glass manufacturing	156	\$1,263	Commodity
Abrasive product manufacturing	165	\$3,585	Commodity
Cut stone and stone product manufacturing	166	\$150	Commodity
Alumina refining and primary aluminum production	172	\$4,960	Commodity
Primary smelting and refining of nonferrous metal (except copper and aluminum)	176	\$19,529	Commodity
Copper rolling, drawing, extruding and alloying	177	\$7,081	Commodity
Plate work and fabricated structural product manufacturing	186	\$5,595	Commodity
Metal can, box, and other metal container (light gauge) manufacturing	190	\$2,055	Commodity
Machine shops	195	\$147,196	Industry
Coating, engraving, heat treating and allied activities	197	\$845	Commodity
Valve and fittings other than plumbing	198	\$100,197	Commodity
Fabricated pipe and pipe fitting manufacturing	201	\$173	Commodity
Other fabricated metal manufacturing	202	\$30,643	Commodity
Other industrial machinery manufacturing	207	\$5,503	Commodity
Heating equipment (except warm air furnaces) manufacturing	215	\$3,116	Commodity
Pump and pumping equipment manufacturing	226	\$64,392	Commodity
Material handling equipment manufacturing	228	\$20,984	Commodity
Fluid power process machinery	233	\$38,081	Commodity
Computer terminals and other computer peripheral equipment manufacturing	236	\$26,576	Commodity
Broadcast and wireless communications equipment	238	\$6,930	Commodity
Other communications equipment manufacturing	239	\$219,420	Commodity
Audio and video equipment manufacturing	240	\$11,959	Commodity
Bare printed circuit board manufacturing	242	\$157,086	Commodity
Industrial process variable instruments manufacturing	251	\$91,006	Commodity
Analytical laboratory instrument manufacturing	254	\$156,865	Commodity

Description	IMPLAN Sector ^a	Expenditure ^b	Basis ^c
Watch, clock, and other measuring and controlling device manufacturing	256	\$7,435	Commodity
Lighting fixture manufacturing	260	\$43,240	Commodity
Motor and generator manufacturing	267	\$22,401	Commodity
Communication and energy wire and cable manufacturing	272	\$5,172	Commodity
Wiring device manufacturing	273	\$7,200	Commodity
Carbon and graphite product manufacturing	274	\$5,573	Commodity
All other miscellaneous electrical equipment and component manufacturing	275	\$3,602	Commodity
Surgical and medical instrument manufacturing	305	\$26,603	Commodity
Office supplies (except paper) manufacturing	313	\$23,966	Commodity
Retail Trade		\$1,696,431	
Retail – Motor vehicle and parts	320	\$28,250	Industry
Retail - Electronics and appliances	322	\$3,781	Industry
Retail - Health and personal care	325	\$3,764	Industry
Retail – Miscellaneous	330	\$1,660,636	Industry
Transportation & Warehousing		\$101,261	
Truck transportation	335	\$101,261	Industry
Information		\$16,601,353	
Software publishers	345	\$35,352	Industry
Telecommunications	351	\$129,944	Industry
Other information services	353	\$16,436,057	Industry
Financial Services		\$2,500	
Monetary authorities and depository credit intermediation	354	\$2,500	Industry
Real Estate and Rental & Leasing		\$330,266	
Commercial and industrial machinery and equipment rental and leasing	365	\$330,266	Industry
Professional, Scientific & Technical Services		\$123,542,443	
Legal services	367	\$165,218	Industry
Accounting, tax preparation, bookkeeping, and payroll services	368	\$9,500	Industry
Specialized design services	370	\$20,172	Industry
Computer systems design services	372	\$15,662,304	Industry
Other computer related services, including facilities management	373	\$1,645	Industry
Management, scientific, and technical consulting services	374	\$73,830	Industry
Scientific research and development services	376	\$96,287,145	Industry
Advertising and related services	377	\$19,490	Industry
All other miscellaneous professional, scientific, and technical services	380	\$11,303,138	Industry
Administrative & Support and Waste Management Services		\$42,522,407	
Office administrative services	384	\$36,243	Industry
Facilities support services	385	\$16,559,932	Industry
Business support services	386	\$25,917,401	Industry
Investigation and security services	387	\$8,831	Industry
Education		\$4,778,029	
Junior colleges, colleges, universities, and professional schools	392	\$4,777,029	Industry
Other educational services	393	\$1,000	Industry
Health Care & Social Assistance		\$1,267,554	
Medical and diagnostic labs and outpatient and other ambulatory care services	396	\$1,277,598	Industry
Hospitals	397	(\$10,043)	

Description	IMPLAN Sector ^a	Expenditure ^b	Basis ^c
Repair & Maintenance		\$12,120	
Electronic and precision equipment repair and maintenance	416	\$4,000	Industry
Commercial and industrial machinery and equipment repair and maintenance	417	\$8,120	Industry
Other Services		\$2,000	
Civic, social, professional, and similar organizations	425	\$2,000	Industry
Government Enterprises		\$87,413	
Other Federal Government enterprises	429	\$87,000	Industry
Other state and local government enterprises	432	\$413	Industry
Households		\$136,065,949	
Household Spending ^d	10007	\$136,065,949	Industry
TOTAL EXPENDITURES		\$237,709,894	

^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 Research Center (Glenn) in FY 2008. Values shown in Table A-3 are limited to expenditures made in Northeast Ohio.

^c **Basis:** Industries consist of businesses producing goods and services; commodities are the goods and services. An **industry** impact gives the entire sector dollar value to the industry that has been selected. For example, Glenn spent \$28.9 million for maintenance and repairs of its buildings and infrastructure. Therefore, the entire dollar value spent for this work in the impact analysis is assigned to the construction sector. A **commodity** impact splits the sector dollar value among all industries producing that commodity. For example, Glenn spent \$157.1 million on bare printed circuit board manufacturing (IMPLAN sector 242). Since Glenn purchased these valves from distributors rather than the actual manufacturer, IMPLAN splits the dollar value among all industries that produce valves. If these industries are located outside Northeast Ohio, IMPLAN only assigns margin values (transportation, wholesale, and retail) in the impact analysis.

^d **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 75% of 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 2008

Description	IMPLAN Sector ^a	Expenditure	Basis ^c
Mining		\$5,321	
Gold, silver, and other metal ore mining	24	\$5,321	Industry
Utilities		\$15,599,439	
Electric power generation, transmission, and distribution	31	\$14,753,573	Industry
Natural gas distribution	32	\$647,575	Industry
Water, sewage and other systems	33	\$198,292	Industry
Construction		\$42,987,436	
Construction of new nonresidential commercial and health care structures	34	\$6,992	Industry
Maintenance and repair construction of nonresidential maintenance and repair	39	\$42,980,444	Industry
Manufacturing		\$4,001,397	
Footwear manufacturing	93	\$22,318	Commodity
Printing	113	\$120,688	Industry
Petroleum lubricating oil and grease manufacturing	118	\$232,942	Commodity
All other petroleum and coal products manufacturing	119	\$143,729	Commodity
Industrial gas manufacturing	121	\$20,387	Commodity
Alkalies and chlorine manufacturing	123	\$3,428	Commodity
Other basic organic chemical manufacturing	126	\$1,132	Commodity
Plastics material and resin manufacturing	127	\$50,096	Commodity
Paint and coating manufacturing	136	\$5,480	Commodity
Adhesive manufacturing	137	\$931	Commodity
All other chemical product and preparation manufacturing	141	\$10,870	Commodity
Polystyrene foam product manufacturing	146	\$21,054	Commodity
Tire manufacturing	150	\$514,029	Commodity
Rubber and plastics hoses and belting manufacturing	151	\$9,167	Commodity
Other rubber product manufacturing	152	\$13,699	Commodity
Pottery, ceramics, and plumbing fixture manufacturing	153	\$4,622	Commodity
Flat glass manufacturing	156	\$1,263	Commodity
Abrasive product manufacturing	165	\$3,585	Commodity
Cut stone and stone product manufacturing	166	\$150	Commodity
Alumina refining and primary aluminum production	172	\$4,960	Commodity
Primary smelting and refining of nonferrous metal (except copper and aluminum)	176	\$19,529	Commodity
Copper rolling, drawing, extruding and alloying	177	\$7,081	Commodity
All other forging, stamping, and sintering	181	\$24,713	Commodity
Plate work and fabricated structural product manufacturing	186	\$5,595	Commodity
Metal can, box, and other metal container (light gauge) manufacturing	190	\$2,055	Commodity
Hardware manufacturing	193	\$10,945	Commodity
Machine shops	195	\$168,642	Industry
Coating, engraving, heat treating and allied activities	197	\$3,303	Commodity
Valve and fittings other than plumbing	198	\$104,771	Commodity
Fabricated pipe and pipe fitting manufacturing	201	\$173	Commodity
Other fabricated metal manufacturing	202	\$40,523	Commodity
Other industrial machinery manufacturing	207	\$5,503	Commodity
Other commercial and service industry machinery manufacturing	213	\$21,106	Commodity
Heating equipment (except warm air furnaces) manufacturing	215	\$3,116	Commodity

Description	IMPLAN Sector ^a	Expenditure	Basis ^c
Pump and pumping equipment manufacturing	226	\$192,569	Commodity
Air and gas compressor manufacturing	227	\$43,229	Commodity
Material handling equipment manufacturing	228	\$20,984	Commodity
Other general purpose machinery manufacturing	230	\$4,800	Commodity
Industrial process furnace and oven manufacturing	232	\$6,000	Commodity
Fluid power process machinery	233	\$44,219	Commodity
Computer terminals and other computer peripheral equipment manufacturing	236	\$35,112	Commodity
Broadcast and wireless communications equipment	238	\$106,924	Commodity
Other communications equipment manufacturing	239	\$219,420	Commodity
Audio and video equipment manufacturing	240	\$11,959	Commodity
Bare printed circuit board manufacturing	242	\$186,770	Commodity
Other electronic component manufacturing	247	\$1,216	Commodity
Industrial process variable instruments manufacturing	251	\$238,353	Commodity
Electricity and signal testing instruments manufacturing	253	\$11,839	Commodity
Analytical laboratory instrument manufacturing	254	\$287,452	Commodity
Watch, clock, and other measuring and controlling device manufacturing	256	\$24,054	Commodity
Lighting fixture manufacturing	260	\$43,240	Commodity
Motor and generator manufacturing	267	\$22,401	Commodity
Communication and energy wire and cable manufacturing	272	\$5,172	Commodity
Wiring device manufacturing	273	\$7,200	Commodity
Carbon and graphite product manufacturing	274	\$314,644	Commodity
All other miscellaneous electrical equipment and component manufacturing	275	\$3,602	Commodity
Aircraft engine and engine parts manufacturing	285	\$8,974	Commodity
Other aircraft parts and auxiliary equipment manufacturing	286	\$9,674	Commodity
All other transportation equipment manufacturing	294	\$219,007	Commodity
Office furniture and custom architectural woodwork and millwork manufacturing ¹	301	\$279,063	Commodity
Surgical and medical instrument manufacturing	305	\$26,603	Commodity
Office supplies (except paper) manufacturing	313	\$25,334	Commodity
Retail Trade		\$2,069,093	
Retail - Motor vehicle and parts	320	\$28,250	Industry
Retail - Electronics and appliances	322	\$12,936	Industry
Retail - Health and personal care	325	\$3,764	Industry
Retail - Miscellaneous	330	\$2,024,143	Industry
Transportation & Warehousing		\$101,413	
Truck transportation	335	\$101,413	Industry
Information		\$16,622,087	
Software publishers	345	\$40,432	Industry
Telecommunications	351	\$145,598	Industry
Other information services	353	\$16,436,057	Industry
Financial Services		\$2,500	
Monetary authorities and depository credit intermediation	354	\$2,500	Industry
Professional, Scientific & Technical Services		\$174,549,874	
Commercial and industrial machinery and equipment rental and leasing	365	\$331,919	Industry
Legal services	367	\$165,822	Industry
Accounting, tax preparation, bookkeeping, and payroll services	368	\$9,500	Industry
Architectural, engineering, and related services	369	\$913,017	Industry

Description	IMPLAN Sector ^a	Expenditure	Basis ^c
Specialized design services	370	\$24,057	Industry
Custom computer programming services	371	\$43,156	Industry
Computer systems design services	372	\$15,662,304	Industry
Other computer related services, including facilities management	373	\$1,645	Industry
Management, scientific, and technical consulting services	374	\$73,830	Industry
Scientific research and development services	376	\$133,167,966	Industry
Advertising and related services	377	\$19,490	Industry
All other miscellaneous professional, scientific, and technical services	380	\$24,137,167	Industry
Administrative & Support and Waste Management Services		\$48,363,718	
Office administrative services	384	\$36,243	Industry
Facilities support services	385	\$16,559,932	Industry
Business support services	386	\$25,917,401	Industry
Investigation and security services	387	\$5,829,302	Industry
Waste management and remediation services	390	\$20,840	Industry
Education		\$10,342,800	
Junior colleges, colleges, universities, and professional schools	392	\$10,341,800	Industry
Other educational services	393	\$1,000	Industry
Health Care & Social Assistance		\$1,267,554	
Medical and diagnostic labs and outpatient and other ambulatory care services	396	\$1,277,598	Industry
Hospitals	397	(\$10,043)	Industry
Repair & Maintenance		\$12,120	
Electronic and precision equipment repair and maintenance	416	\$4,000	Industry
Commercial and industrial machinery and equipment repair and maintenance	417	\$8,120	Industry
Other Services		\$2,000	
Civic, social, professional, and similar organizations	425	\$2,000	Industry
Government Enterprises		\$93,473	
Other Federal Government enterprises	429	\$87,000	Industry
Other state and local government enterprises	432	\$6,473	Industry
Households		\$136,065,949	
Household Spending ^d		\$136,065,949	Industry
TOTAL EXPENDITURES		\$452,086,175	

^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 Research Center (Glenn) in FY 2008. Values shown in Table A-4 are limited to expenditures made in the state of Ohio.

^c **Basis:** Industries consist of businesses producing goods and services; commodities are the goods and services. An **industry** impact gives the entire sector dollar value to the industry that has been selected. A **commodity** impact splits the sector dollar value among all industries producing that commodity.

^d **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 75% of the gross amount. Disposable income excludes income that is used for savings and to pay taxes.