ECONOMIC IMPACT

FISCAL YEAR 1998

National Aeronautics and
Space Administration

Langley Research Center
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CONTENTS

PURPOSE

This Economic Impact document summarizes the institutional and financial impact that the NASA Langley Research Center has on the Nation and the State of Virginia. The statistical summaries in this document are based on Fiscal Year 1998 data.

NASA Langley Research Center is an important national resource serving inherent government functions such as safety, national defense, the environment, and the national airspace system and providing competitive technologies to U.S. industry. The Center not only makes major contributions to our Nation's aerospace program but also has a significant financial and institutional impact on local and national companies, universities and colleges, regional small businesses and many nonprofit organizations.

Recognized as a world-class research laboratory, Langley Research Center has a staff of well-trained and highly productive scientists, engineers and support personnel. The laboratory and its employees are a vital part of the Nation's research system. The Center's influence extends beyond its technology contributions to being a solid financial contributor to the economies of the Virginia Peninsula, the State of Virginia and the Nation.

The primary purpose of this document is to provide our stakeholders with meaningful data regarding the economic impact of NASA Langley Research Center. This document was prepared by Donna Roper, Office of Public Services, with financial information provided by Dan Tenney, Office of Chief Financial Officer, and Mary Deuell, Office of Procurement. The Economic Impact and Analysis Study (pages 25 to 26) was prepared for NASA Langley by Dr. Marshall Booker, Christopher Newport University.

Any feedback about this document and how it is used would be helpful and can be sent to Donna Roper (d.g.roper@larc.nasa.gov) Mail Stop 154, NASA Langley Research Center, Hampton, VA 23681. This document is also available on the Internet via the World Wide Web at the following URL: http://oea.larc.nasa.gov/org/impact/

NASA LANGLEY MANAGEMENT SYSTEM

Under the NASA Langley Management System, we have developed the Strategic and Quality Framework, which includes the NASA vision, Langley mission and critical success factors. The Strategic and Quality Framework is designed to be an enduring, overarching guide for the overall management of the Center and is in accordance with ISO 9001 requirements.

NASA Vision

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth. The Langley contribution to the NASA Vision is *to be the world leader in pioneering science and innovative technology to enable U.S. aeronautical and space preeminence.*

NASA Langley Mission

In alliance with industry, other agencies and academia, we develop airframe and synergistic space frame systems technologies to enable preeminence of the U.S. civil and military aeronautics and space industries. In alliance with the global research community, we pioneer the scientific understanding of the Earth's atmosphere to preserve the environment.

Critical Success Factors

We have identified three factors that are critical to accomplishing our mission: product user value, funder value and organizational value.

Product users understand our role, value our partnership and use our results. NASA Langley's product users include the aerospace industry, other NASA centers, federal agencies, science and education communities, nonaerospace industries and others who receive our products directly and use them for purposes that yield public benefit.

Funders' decisions reflect that NASA Langley returns good value on their investments. NASA Langley's funders provide us with the policy direction and financial resources to conduct our research. They include NASA Headquarters, the Administration and the Congress acting on behalf of the public. As the Nation reassesses the role of the federal government, it is essential that we inform those who set priorities and allocate resources about NASA's contribution to the Nation.

Langley is an organization that learns, adapts and improves to benefit employees, product users and funders. NASA Langley recognizes that our employees are our most valuable asset. This success factor focuses on the employees creating increased value, through use of the Langley management system, for product users and funders.

Metrics

NASA Langley's success will be measured by the extent to which our research results and technologies contribute to the design, development, and operation of future aerospace vehicles and missions and the extent to which our scientific research contributes to the understanding of human-induced climatic and environmental change. NASA Langley will enhance the value of aerospace technologies by promoting technology transfer and commercialization by nonaerospace industries and thus contributing to the overall economic competitiveness of U.S. industry.

NASA LANGLEY RESEARCH CENTER
A UNIQUE NATIONAL RESOURCE
Overview

NASA Langley Research Center performs innovative aeronautics and space research relevant to national needs. The Center's primary mission assignments are Airframe Systems and Atmospheric Sciences with an increasingly important role in developing space transportation technology for the future. NASA Langley is the Agency's Center of Excellence for structures and materials research as well as the Agency's focal point for wind tunnels and test facilities. In addition to contributing research and technologies to all four of NASA's strategic areas, Langley manages several critical, high-payoff programs for the Agency.

NASA Langley leads the Agency's Aviation Safety Program. Part of a national aviation safety initiative, this program is developing technologies to enable an 80-percent reduction in the fatal accident rate by 2009 and a 90-percent reduction by 2018. To achieve these goals, NASA is working with the Federal Aviation Administration (FAA), other government agencies and the aerospace industry. Langley also leads the Agency's program for Airframe Systems Base Research and Technology. This program develops advanced tools and testing techniques, pioneers innovative advanced technologies and provides the basis for future systems technology programs.

Langley also leads the Agency's Advanced Subsonic Technology Program, which will wind up in FY 1999, as well as leads the High-Speed Research Program, which will be phased out in FY 1999. These programs have provided many high-payoff technologies for a safer global air transportation system, environmentally compatible aircraft and more affordable air travel. Many of these technologies also benefit space transportation. In FY 1998, Langley was assigned to lead the Agency's new Intelligent Synthesis Environment Program. Collaborative engineering technologies developed under this program will revolutionize the engineering process for the 21st century.

NASA Langley plays a vital role in the Nation's space program. Langley develops technologies for advanced space transportation systems, small spacecraft and instruments. Langley researchers also develop spaceframe technologies that are synergistic with our airframe systems capabilities. In addition, Langley's Atmospheric Sciences program is conducted in collaboration with other NASA centers, government agencies and the international research community.

Central to NASA Langley's ability to accomplish its mission and programs is the integration of skills, facilities and technological capabilities in areas called core competencies. These core competencies differentiate Langley from other organizations and result in new applications for aerospace and nonaerospace industries. Langley is currently reorganizing to better align with our core competencies in the following areas:

- Mission and Systems Analysis, Integrations and Assessment
- Aerodynamics, Aerothermodynamics, Acoustics and Hypersonic Propulsion
- Airborne Systems and Crew Station Design and Integration
- Structures and Materials
- Atmospheric Sciences and Remote Sensing

As in the past 80 years, NASA Langley researchers continue to develop breakthrough technologies that will make aircraft and space transportation vehicles safer, more environmentally friendly and cheaper to manufacture, maintain and fly. Today, Langley remains dedicated to serving traditional aerospace customers and to transferring aerospace technology to nontraditional commercial users. The taxpayers' investment in NASA Langley is an investment in the technical strength and economic vitality of the Nation.

Facts and Figures

History

- 1915: National Advisory Committee for Aeronautics (NACA) formed
- 1917: Langley Memorial Aeronautical Laboratory founded
- 1948: Name changed to Langley Aeronautical Laboratory
- 1958: National Aeronautics and Space Administration (NASA) founded; name changed to NASA Langley Research Center

Accomplishments

For more than 80 years, NASA Langley research has broken numerous barriers in aerospace, making air and space transportation faster, cheaper and safer. Langley has made significant contributions to programs such as Apollo, the space shuttle and space station as well as improved our understanding of changes in the Earth's atmosphere. Among its recent accomplishments, NASA Langley has provided critical data necessary for designing the next-generation of reusable launch vehicles. Langley has also developed technologies that will enable airbreathing hypersonic vehicles to fly for the first time ever at 10 times the speed of sound. Langley's aeronautics research has resulted in technology developed with industry that is saving lives around the globe. For example, aging aircraft can now fly safer and longer because of Langley's nondestructive methods to find structural disbonds, cracks and corrosion. Many airline pilots now have up to 30 seconds advance warning of dangerous microbursts, a major cause of airline accidents in the 1980s. Crashworthiness of light planes is also increasing as a result of Langley research on energy-absorbing seats, crushable subfloors, seat belt mounts and air bags. In the future, passengers will experience greatly reduced travel time at affordable rates because of Langley's technology developments in general aviation and advanced subsonic and supersonic transports.

Director

Jeremiah F. Creedon

Location

Located in Hampton, Virginia. NASA Langley Research Center occupies 788 acres of government-owned land and shares aircraft runways, utilities, and some facilities with the neighboring Langley Air Force Base (LAFB).

Physical Statistics

- 788 acres (West Area) + 20 acres "permitted" by LAFB (East)
- 220 buildings (not including power stations or trailers)
- $733M original investment value
- $2.2B replacement value on today's market

Total Budget ($M)

FY	NASA-WIDE	Langley*
1994	14,548.9	713.3
1995	13,996.4	666.3
1996	13,884.0	629.0
1997	13,709.2	689.5
1998	13,638.0	685.7

* Includes Langley programs from other Centers

Langley's FY 1998 Contribution

National economy:	**$474.0M**
Awards to businesses	402.2M
Non-profit institutions	17.5M
Educational institutions	54.3M
Virginia economy:	**$221.5M**
Awards to businesses	192.4M
Non-profit institutions	13.6M
Educational institutions	15.5M
Hampton Roads economy:	**$190.6M**
Awards to businesses	171.8M
Non-profit institutions	9.5M
Educational institutions	9.3M

Note: Hampton Roads figures are included in Virginia figures.
Does not include civil service and contractor payroll.

Civil Service Workforce

Civil service full-time, permanent employees	2,241
Civil service nonpermanent employees	127

Note: Civil service employees on board as of September 30, 1998; maximum positions authorized varies from actual number of employees at any given time.

Civil Service Fiscal Year Payroll

• 1998 Salaries/benefits: $188.2M (includes all compensation)

Civil Service Workforce Educational Mix

Highest degree earned		
Doctoral	271	12.1%
Masters	558	24.9%
Bachelor	582	25.9%
Associate	374	16.7%
Some college	279	12.5%
H.S. diploma	173	7.7%
Less than H.S. diploma	4	0.2%
Total	**2,241**	**100%**

Civil Service Workforce Skill Mix

Scientific/engineering	1,148	51.2%
Administrative	298	13.3%
Tech/craft/production	627	28.0%
Clerical	168	7.5%
Total	**2,241**	**100%**

Note: Fiscal year payroll, workforce educational mix, and workforce skill mix are as of September 30, 1998.

Civil Service Residential Distribution

Hampton	520	23.2%
York County	511	22.8%
Newport News	383	17.1%
Poquoson	214	9.5%
Williamsburg	133	5.9%
Gloucester	119	5.3%
Norfolk	42	1.9%
Virginia Beach	35	1.5%
Chesapeake	31	1.4%
Suffolk	26	1.2%
Portsmouth	15	0.7%
Other	212	9.5%
Total	**2,241**	**100%**

Contracted Work, Annual Procurements

NASA Langley depends on commercial business for many of its day-to-day support activities and operations.

• Support service personnel FY 1998	1,576
• All active contracts, grants, and unexercised options through end of FY 1998, total value (excluding purchase orders)	$3.7B
• Total procurements awarded in FY 1998 (contracts, purchase orders, grants, etc.)	$605.8M

Note: Contract employment shown is for multi-year program support contracts. It does not include contractor employees for short-term work, generally a year or less, and those working on construction of facility projects.

Contract Categories	***Number of Contracts***
Architect and Engineering Services	8
Computer Programming Support	4
Groundskeeping and Janitorial Services	2
Medical Services	1
Models and Fabrication Support	1
Research and Development Support	3
Research Facility Operation and Maintenance Support	7
Total	26

Employee Residence By Zip Code

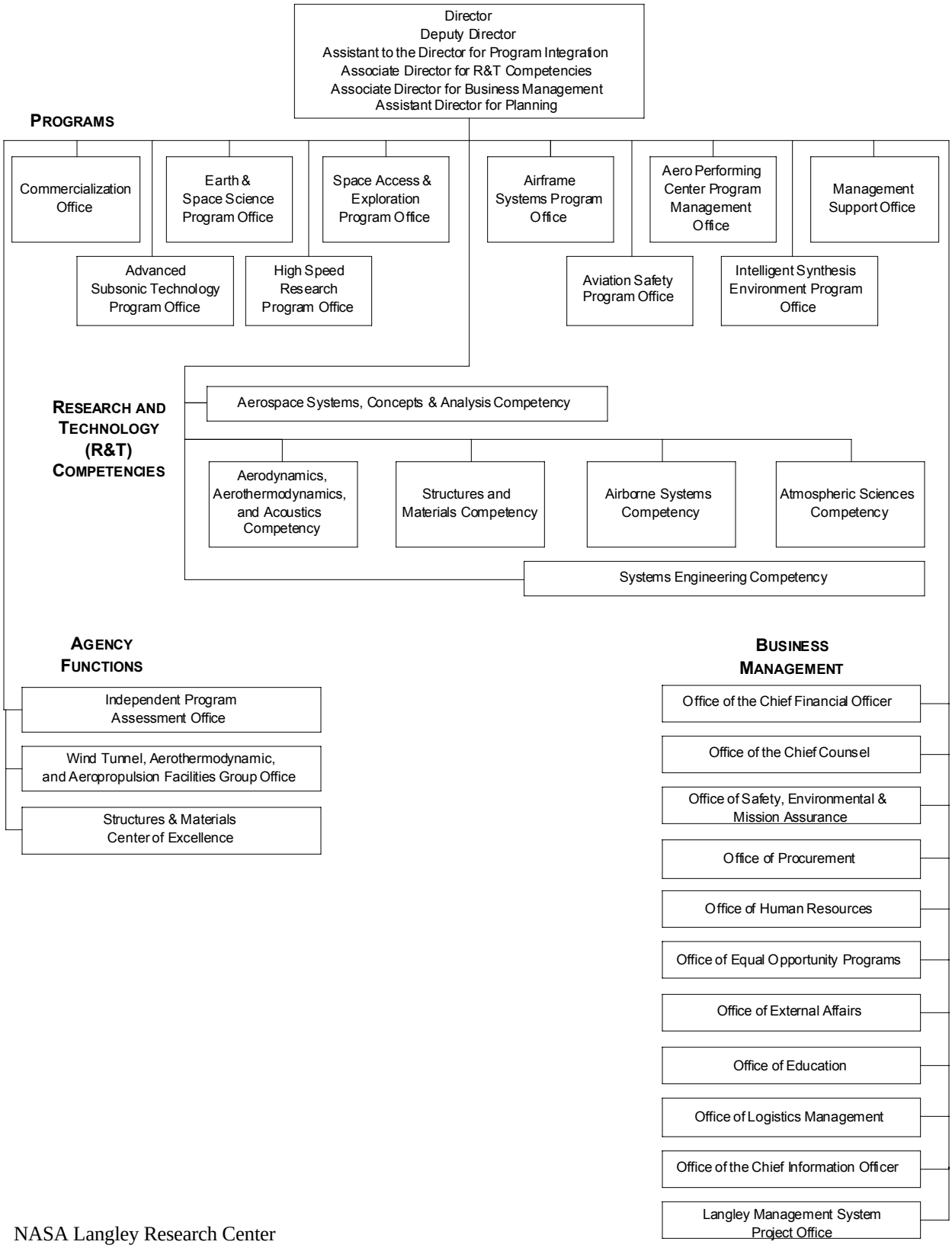
Zip code	No. employees	Zip code	No. employees	Zip code	No. employees
11372	1	23187	1	23518	5
14623	1	23188	31	23601	87
20012	1	23190	1	23602	142
21144	1	23235	1	23605	24
22043	1	23304	1	23606	100
22102	1	23314	20	23607	26
22578	1	23320	8	23608	83
23001	3	23321	16	23609	4
23003	1	23322	5	23661	47
23011	1	23323	1	23662	214
23018	1	23324	1	23663	25
23021	1	23362	1	23664	77
23045	1	23424	1	23665	1
23056	1	23430	25	23666	242
23061	37	23432	1	23669	177
23062	13	23433	4	23681	1
23072	26	23434	7	23690	9
23076	1	23435	12	23692	233
23079	1	23436	2	23693	230
23090	1	23451	6	23696	41
23107	1	23452	4	23701	3
23109	5	23454	3	23702	1
23119	2	23455	7	23703	8
23128	4	23456	3	23707	3
23130	2	23462	2	23883	3
23131	1	23464	10	23898	3
23138	2	23487	3	23899	1
23140	1	23502	3	24064	1
23141	1	23503	13	24553	1
23149	1	23504	1	27717	1
23168	4	23505	6	30309	1
23169	1	23507	2	33317	1
23178	1	23508	5	35803	1
23181	1	23509	2	45440	1
23183	8	23510	2	61820	1
23184	4	23513	1	**Total:**	
23185	95	23517	2	**Employees**	**2,241**
				Zip Codes	**109**

Graduates From Virginia Schools

School	Number
Averett College	1
Christopher Newport University	73
College of William and Mary (Central Office)	6
College of William and Mary (Main Campus)	79
College of William and Mary (Richard Bland)	2
Eastern Shore Community College	1
Emory and Henry College	2
George Mason University	1
Hampden-Sydney College	1
Hampton University	12
J. Sargeant Reynolds Community College	2
James Madison University	6
Longwood College	1
Lynchburg College	2
Mary Washington College	2
New River Community College	1
Norfolk State University	17
Northern Virginia Community College	1
Old Dominion University	210
Radford University	1
Rappahannock Community College	2
Roanoke College	1
Thomas Nelson Community College	413
Tidewater Community College	21
University of Richmond	8
University of Virginia (Central Office)	1
University of Virginia (Main Campus)	81
Virginia Commonwealth University	15
Virginia Polytechnic Institute and State University	226
Virginia State University	6
Virginia Union University	1
Virginia Wesleyan College	2
Washington and Lee University	1
Total Langley civil service employees with at least one degree from a Virginia school	**1,199**

Organizational Structure

NASA Langley has reorganized to better align with our research and technology competencies, focused programs and business management operations. The new structure is as follows.



Major Facilities and Aircraft

NASA Langley's specialized research facilities enable the center to perform world-class research in aeronautics, atmospheric sciences and space technology. Langley's wind tunnels allow engineers to conduct testing that encompasses the entire speed range from 0 mph to nearly Mach 25, or approximately 17,500 mph. Some of these tunnels are unique to the Nation, including the National Transonic Facility, the Transonic Dynamics Tunnel, the 8-Foot High Temperature Tunnel and the Supersonic Low Disturbance Tunnel. Other NASA Langley facilities support structures, materials, flight simulation and electronics research. These critical facilities contribute to the well-being of the American people, the U.S. economy and the world. In FY 1998, the Center had the following major facilities and aircraft.

Wind Tunnels

National Transonic Facility
Transonic Dynamics Tunnel
14- x 22-Foot Tunnel
16-Foot Transonic Tunnel
20-Foot Vertical Spin Tunnel
Unitary Wind Tunnel (Two Test Sections)
8-Foot High Temperature Tunnel
Low Turbulence Pressure Tunnel
22-Inch Mach 20 Helium Tunnel
31-Inch Mach 10 Tunnel
20-Inch Mach 6 CF4 Tunnel
20-Inch Mach 6 Tunnel
20-Inch Supersonic Wind Tunnel
18-Inch Mach 8 Quiet Tunnel
Basic Aerodynamics Research Tunnel
1/3 Meter Transonic Cryogenic Tunnel
Supersonic Low-Disturbance Tunnel
15-Inch Mach 6 High Temperature Tunnel
Arc-Heated Scramjet Test Facility
Combustion-Heated Scramjet Test Facility

Structures and Materials Research

Structures and Materials Laboratory
Aircraft Landing Dynamics Facility
Structural Dynamics Laboratory DTRL
High Temperature Materials Laboratory
Impact Dynamics Research Facility
Nondestructive Evaluation Techniques Laboratory
Thermal Structures Laboratory
Composite Materials Laboratory
Materials Research Laboratory
High Intensity Noise Research Facility
Combined Loads Test System (COLTS)
Helicopter Hover Facility

Acoustics

Acoustics Research Laboratory
Jet Noise Laboratory
Thermal Acoustics Fatigue Apparatus

Flight Electronics

Flight Electronics Laboratory
Electromagnetics Research Facility
High Intensity Radiated Fields Laboratory

Simulation Facility Simulators

Advanced Civil Transport Simulator (ACTS)
Differential Maneuvering Simulator (DMS)
General Purpose Fighter Simulator (GPFS)
Transport Systems Research Vehicle (TSRV)
Visual Motion Simulator, 6 degrees of freedom

Simulation Facility Components

Advanced Real-Time Simulation System
    High-Speed (50 Mb) Fiber Optic Data Network
Cockpit Graphics Generators
    Calligraphic/Raster Terabit Eagle 1000 computers
    Onyx/Reality Engine 2 Graphics Supercomputers
Target Image Generators (DMS and GPFS)
    Silicon Graphics
    Laser Target Generators
Visual Scene Image Generators
    Evans & Sutherlands CT-6 computer
    ESIG 3000 AT – Advanced Computer-Generated Image (ACGI) System

Scientific and General Purpose Computing Complex

Centralized Mass Storage Facility
Data Visualization and Animation Laboratory
Geometry Laboratory
Electronic Photography Laboratory
IBM RS-6000 Computer Cluster Facility

NASA Aircraft Based at Langley

NASA 557, Boeing 757
NASA 524, OV-10A
NASA 511, T-38
NASA 529, BE-200 Super King Air

DIRECT IMPACT OF NASA LANGLEY ON GOVERNMENT AND U.S. INDUSTRY

Technology Partnerships

The President, Congress, and the NASA Administrator are emphasizing the value of NASA's research and technology base to U.S. industry in helping to increase industrial competitiveness, provide jobs and improve the quality of life and the balance of trade. The taxpayers' investment in NASA is an investment in the international competitiveness of U.S. industry through partnerships that build upon NASA's research and make it available to U.S. industry.

NASA Langley has reached out to its local community to build a strong partnership with the companies, universities and local government organizations of Hampton Roads. As the major research facility in the area, NASA Langley plays a central role in the region's economic development. In an effort to maximize its positive impact on the area, NASA Langley has played an integral role in regional planning activities. NASA Langley's liaison with local stakeholders through the Hampton Roads Partnership is one of the major mechanisms through which this has been accomplished. The board of directors for the Hampton Roads Partnership is comprised of mayors and chairs of the cities and counties, presidents of universities and colleges, business leaders and directors of federal facilities located within the region. This innovative approach has led to an appreciation by regional stakeholders of the role of NASA Langley in helping achieve mutually beneficial goals for technology commercialization and economic development.

Some examples of Langley successes are listed below:

Intracranial Pressure Monitor Technology - The monitoring of intracranial pressure (ICP) and pressure volume index is of significant importance for many patients with cranial injuries and for patients who have undergone brain surgery. Abnormally elevated ICP occurs in about 60 percent of patients with head trauma. When ICP increases above 20mmHg, a 95 percent death rate occurs. High ICP reduces blood flow to the brain, preventing oxygen and nutrients from reaching brain tissue. This "starvation" results in the death of brain tissue. ICP is now measured in several ways, all of which are invasive. The most common method uses a catheter-mounted pressure sensor inserted through a small hole drilled in the skull. Researchers at NASA Langley have invented a noninvasive method for measuring ICP using ultrasonics. An exclusive license to use this patented technology was granted to Kinetic Concepts, Inc. (KCI) of San Antonio, TX. In 1998, a prototype ICP instrument was built, tested and delivered to KCI for clinical testing. Non-invasive ICP measurement also has applications to astronaut monitoring.

Crew Response Evaluation Window - NASA researchers developed a Crew Response Evaluation Window (CREW) technology to improve the process of monitoring human responses and evaluate the effects of pharmaceuticals, products and medical disorders on human behavior. CREW technology has been licensed to Capita Research Group, Inc., of Blue Bell, PA. This company designs and markets systems and services that measure psychological engagement, receptiveness and communication effectiveness. These systems utilize electroencephalogram (EEG) and the CREW technology licensed under an exclusive agreement from NASA to measure electrical activity in the human brain.

Stainless Steel Inspection - Allegheny Ludlum Corporation of Breckenridge, PA, is a producer of continuously cast stainless steel. Detailed metallographic inspection techniques are used to determine the "heat" quality of the finished steel. This labor-intensive and expensive process often results in significant and costly delays. NASA has developed an innovative

inspection technique that allows near real-time detection of non-metallic inclusions in stainless steel samples before late stage processing and shipment. According to Bal V. Patil, Manager - Melting & Primary Operations, "This inspection process has resulted in savings of about $80,000 through October 1998. In 1999, we expect the benefits to increase substantially as we intend to use the equipment to test more products. Our manufacturing cost savings could exceed $500,000."

Bolt Tension Monitoring Technology - Ultrasonic sensors are a new and important tool for accurately measuring the strain in bolts and fasteners. In today's manufacturing environment, applying the proper clamping force is particularly important due to the use of lighter weight materials and more precise tolerances. Micro Control, Inc., an automotive inspection company, located in Michigan, has licensed NASA Langley's ultrasonic measurement technology. Micro Control intends to combine its existing product line with this technology to provide an improved method for measuring ultrasonic lengths (i.e., high degree of accuracy, fewer components and relatively inexpensive). The technology will be used to measure the tension in bolts, fasteners and other materials for motor vehicle and aircraft applications.

Crack Detection Probe - An innovative crack detection probe has been developed in an effort to enhance the safety of America's aging commercial airline fleet. This technology, licensed to Foerster Instruments, Incorporated (FII), is currently available for sale as the Rivet Check™ System. The system is designed to detect small cracks under installed rivets in the thin outer layers of an airframe fuselage skin. Foerster is a leading supplier of eddy current and electromagnetic testing equipment and services to both the aerospace and automotive inspection industries. Research conducted by Langley scientists resulted in the development of the Rotating Self-Nulling Eddy Current Probe. The unique eddy current distribution and simple flaw signature from this probe and the associated computer signal processing techniques provide a simple-to-use and highly accurate fatigue crack detector. Test results demonstrated that the probe is capable of tracing the crack tip location in real-time during fatigue load cycles.

LaRC™-CP1 and LaRC™-CP2 Inflatables for Outer Space - Lightweight structures are revolutionizing the business of large space structures. SRS Technologies in Huntsville, AL, has developed a business niche producing superior NASA polymeric materials called LaRC™-CP1 and LaRC™-CP2. These materials are being cast into large reflective elements for use in space communications, power and advanced propulsion. This film material combined with the innovative collector designs is resulting in spacecraft that will enable a new market of lower cost and higher performance communication and propulsion systems. SRS Technologies is manufacturing the NASA-developed materials under a license agreement. SRS manufactures the LaRC™-CP1 and LaRC™-CP2 as powder, resin and rolled film. For the United States Air Force, SRS cast NASA's polyimide into a doubly-curved film and created a 16-foot inflatable solar concentrator/antenna for solar thermal propulsion.

Piezoelectric Device - A NASA-developed piezoelectric device is being used by the Naval Coastal Systems in Panama City, FL. This device is being used by Frank Downs a Coastal Systems Researcher to improve his design of a prototype head-contact microphone. This prototype microphone was demonstrated at the 1998 Metropolitan Fire Chiefs Conference which was attended by more than 120 fire chiefs from major U.S. cities and some foreign countries. The fire helmets were outfitted with the microphone and waterproof speakers and demonstrated to a live audience. This joint venture between NASA and the United States Navy should return benefits not only to the fire fighting industry but also to the armed services.

Dual Wavelength Infrared Laser - While investigating methods for measuring the wind speed or density of atmospheric constituents for the remote sensing program, Langley researchers determined that producing two or more useful wavelengths from a single laser source is possible. Typically, a laser operates efficiently at a single wavelength, which is determined by the lasing medium present in the laser cavity. Applications that demanded more than one wavelength have, in

the past, been addressed by duplicating some hardware. That approach greatly increased the cost, complexity and "footprint" of a laser device. The dual wavelength infrared laser provides the ability to control the lasing wavelength of a laser material without changing any mechanical components. This method controls wavelength by the rate and energy level at which the laser material is pumped. Since the wavelengths are switched electronically, the operator can rapidly alternate between wavelengths. A partnership with Lantis Laser, Inc., has been established to apply this technology to developing a dental laser for both hard and soft tissue.

Statistics

During FY 1998, 134 invention disclosures, 29 patent applications and 34 patents were granted from NASA Langley programs. In addition, 10 licenses were executed bringing the Langley total to 64 and 35 Space Act Agreements were signed, with 20 representing nonaerospace industries.

Small Business Partnerships

There were 54 Phase I proposals and 15 Phase II Proposals selected for funding under the Small Business Innovation Research Program. The resulting contracts will stimulate technological innovation, increase the use of small businesses in meeting Langley research and development needs and help private sector commercialization of federally funded research.

Scientific and Technical Publications

During FY 1998, Langley's contributions to NASA and non-NASA literature included 46 NASA formal reports, 15 conference publications, 60 technical memorandums, 158 contractor reports, 150 journal articles and book publications, 488 meeting presentations and 45 technical talks.

Significant Accomplishments in FY 1998

Aeronautics

Within the manufacturing sector, aerospace is the only industry with a positive contribution to the U.S. balance of trade. It provides a net annual contribution of more than $21 billion. However, the U.S. faces strong competition. Prior to 1974, the U.S. had more than 90 percent of the commercial transport market share. Today, the U.S. share is around 60 percent. To preserve our nation's economic health and the welfare of the traveling public, NASA has set bold research objectives and goals to sustain U.S. leadership in aeronautics and space. NASA Langley's leadership and technology advancements in aviation safety, advanced subsonic technology, airframe systems and high-speed research play a pivotal role in accomplishing these goals.

Safety

NASA Langley has the lead for the agency's Safety Program, which is working to achieve the national goal of reducing the accident rate by a factor of 5 within 10 years and by a factor of 10 within 20 years. In support of this goal, NASA Langley researchers have developed advanced technology to safely and economically extend the life of airplanes in the commercial transport fleet. The researchers developed advanced nondestructive evaluation (NDE) techniques for detecting disbonds, corrosion and cracks and structural integrity analysis methodologies for predicting fatigue crack growth and residual strength. New analysis methodologies have been verified and are in use in the airframe industry. New NDE prototype systems have been validated and the technologies have been licensed and commercialized by the NDE instrument manufacturers. These NDE technologies provide the capability for significantly decreasing the time and cost of inspections and have provided, in some cases, factors of 3-4 better resolution. As a result, cracks can be detected that previously could be found only through destructive tear-down inspections.

Environmental Compatibility

One of NASA's 10-year goals is to develop technology to reduce the noise impact from aircraft such that communities in the surrounding areas of airports hear one half of the noise that they heard in 1997. In technical terms, this means a 10 decibel (dB) reduction in noise. During landing, when airplanes are relatively close to the ground, the airframe noise from the flaps, slats and landing gear almost matches the level of engine noise.

In FY 1998, NASA Langley researchers and industry partners demonstrated advanced noise reduction technology to reduce flap noise, one of the three main airframe noise sources, by 4 dB. Results of a series of wind tunnel experiments, guided by newly developed noise and flow prediction models, developed at NASA Langley and Ames, successfully demonstrated that significant noise reductions could be obtained with innovative flap-edge devices. Research on technologies to reduce slat and gear noise, the other main airframe noise sources, is ongoing.

Affordable Air Travel

For aircraft manufacturers, a major challenge is to reverse the trend of increasing aircraft ownership and operating costs. To help achieve NASA's goal for more affordable air travel, NASA Langley researchers are developing advanced technologies to enable significant cost reductions in manufacturing metallic aircraft fuselage structures. In FY 1998, researchers built and tested an integrally (one-piece) stiffened fuselage structure that was less expensive to manufacture as well as equal in structural performance and weight of today's current structures. Analysis indicated a cost savings of 61% as compared with conventional structures. In addition, part counts dropped from 78 individual parts (not including rivets) on the baseline panel to just 7 on the integrally stiffened panel.

NASA Langley researchers are also developing smart devices to enable self-adaptive flight for revolutionary improvements in efficiency and affordability. Application areas include flow control, active noise reduction, aeroelastic and structural control as well as health monitoring. In FY1998, research results showed that the simulated actuators can stabilize a initially laterally directionally unstable aircraft. Flow control benefits of these novel actuators include low-observability maneuvering, drag reduction, increased lift-to-drag ratio, multi-point performance optimization and improved high-angle-of-attack maneuverability.

When incorporating new technologies into the design of a new aircraft, performance and control characteristics as well as manufacturing and operating costs must be considered and optimized for the full range of flight conditions. This process is known as multipoint design. In FY 1998, NASA Langley researchers successfully met a major milestone with the calibration of first generation multipoint wing design tools. Langley researchers, in partnership with industry, redesigned two existing aircraft configurations using the selected multipoint design methods that they had previously calibrated. Wind tunnel tests validated the data. This design method provides a means for aircraft designers to automate the wing design process and optimize the design over a range of flight conditions. This streamlined approach results in a decreased design time, thereby reducing the cost of the aircraft design process and ultimately the cost of the aircraft.

High-Speed Travel

In FY 1998, the High Speed Research Program made significant progress in developing airframe and propulsion technologies essential for an economically viable and environmentally compatible high-speed civil transport (HSCT). In early FY 1998, follow-on studies of the HSCT were conducted to determine design guidelines for actively suppressing structural vibrations. Desired levels of damping and feedforward cancellation (the ability to cancel the pilots' excitation of selected modes through the use of multiple control surfaces) were determined. These methods for reducing drag and predicting aeroelastic stability and control characteristics are necessary for the design of safe, controllable and economically viable HSCT configurations.

NASA Langley researchers also developed a design optimization synthesis system to optimize wing, planform and propulsion parameters to minimize the airplane take-off-gross-weight while satisfying the design mission. Researchers used this system to define the optimized technology baseline airplane in September 1998. The resulting optimized configuration offered a reduction in takeoff gross weight of nearly 10 percent, a level comparable to the vehicle design payload weight.

The recent completion of the Surface Operations Research/Evaluation Vehicle (SOREV) allowed Langley researchers to begin addressing the unique research issues associated with the taxi operations of a HSCT. SOREV is Langley's full-scale ground testing vehicle that emulates the landing gear footprint, turning performance and flight deck geometry for a HSCT. During FY 1998, NASA and industry researchers conducted surface operations testing with SOREV at Grant County Airport in Moses Lake, Washington. These initial experiments were used to assess the HSCT baseline geometry effects and evaluate front display integration issues with real side windows.

In an effort to reduce the community noise impact of the HSCT, acoustic trade studies have been performed to evaluate the benefits of alternative operational procedures. To be effective, the noise reduction must be balanced against any increase in vehicle weight or loss in overall performance. In FY 1998, Langley researchers completed some of these acoustics studies for the high-speed research technology concept configuration. While the studies showed that noise benefits can be achieved for most procedures, the options have to be assessed at a configuration level. Before selecting which of these procedures to use, the airplane configuration, certification standards and community noise requirements must be further defined.

Langley researchers have developed a special new composite material called PETI-5 to meet the temperature and durability requirements of the future transport. In FY 1998, several PETI-5 test articles were designed and fabricated by industry partners and tested at NASA Langley. One of these is a PETI-5 skin-stringer panel that was designed as part of the fuselage structure. This panel was subjected to more than 400,000 pounds of force before it cracked. Another PETI-5 fuselage panel was tested in the new Combined Loads Test System Facility at NASA Langley. It carried more than one million pounds of load before it failed. The third test article represented a single bay of the main wing box. It was tested at room and elevated temperature (300° F) conditions. All three test articles carried the required design ultimate loads before they failed (i.e., each article exceeded the expected flight loads by at least 50 percent).

GA Revitalization

In 1994, NASA, the FAA, industry and academia formed the Advanced General Aviation Transport Experiments (AGATE) Consortium—a unique partnership, to revitalize the general aviation industry. In FY 1998, a number of break-through AGATE technologies were successfully combined for the first time on a single aircraft. These technologies revolutionized the retrieval, processing of cockpit information with graphical, intuitive pilot displays and advanced avionics system architecture. A "Highway in the Sky" presentation of the flight path and integrated graphical weather, terrain and traffic data allowed the pilot to focus on critical decision-making information rather than reducing data, which increases safety, reliability and ease of use.

Dramatic changes in the training procedures of general aviation pilots can be achieved through computer-based learning aids. These new procedures have the potential to reduce training time by 50-75 percent. In 1998, the first student pilots in the AGATE Unified Private-Instrument Pilot Training Curricula completed their training using these procedures. Early results indicate significant reductions in total training time, total calendar time and total cost for achieving an Instrument Flight Rules (IFR) rating.

Another significant FY 1998 accomplishment for general aviation is the publication: *Material Qualification Methodology for Epoxy-Based Prepreg Composite Material Systems.* This publication documents the breakthrough process that allows airframe manufacturers to procure certified composite materials from vendors in the same manner that they procure metals. The publication outlines a materials qualification method that has been accepted by the FAA and eliminates the need for repeated qualification tests for composite materials. As a result, the cost of FAA certification of new composite airframes is reduced by more than $500,000 per material and the certification time is reduced by more than 2 years. These reductions in certification time and cost will make composite materials a viable choice for small and large companies and will help foster the revitalization of the general aviation industry.

Next-Generation Design Tools and Experimental Aircraft

NASA Langley researchers are working to develop fast, accurate and reliable analysis and design tools to significantly reduce development time and cost of aircraft designs. In support of this research, an automatic procedure for modifying existing complex aerodynamic codes for design variable gradients was developed in FY 1998. This procedure allows codes to be modified in one week as opposed to one year. When Boeing Phantom Works applied this procedure to their aerodynamic optimization code, the code ran 20 times faster than before. Future plans include extending this procedure from single discipline to multidisciplinary optimization methods for nonlinear problems.

High-performance aircraft require high-angle-of-attack flight for air-combat maneuvering. Under maneuvering conditions, powerful vortices form and then burst, creating extreme turbulence as the angle of attack is further increased. For configurations like the F/A-18, the structural response of the aircraft's twin vertical tails to the buffet loads leads to significantly reduced fatigue life. As a result, the aircraft requires frequent costly inspections and possible repairs. To increase the life

and decrease cost associated with these aircraft, NASA Langley researchers developed and tested an innovative buffet alleviation system. This system consists of accelerometers and strain gages in the vertical tails, piezoelectric actuators bonded externally to the tail skins and control laws to detect buffet and alleviate the structural response. Preliminary analysis indicates that the fatigue life can be improved by an order of magnitude, resulting in significant cost savings.

Langley researchers supporting a REVolutionary CONcepts (REVCON) project identify technology applications and vehicle concepts that offer revolutionary capabilities to meet and exceed NASA's long-term goals for aerospace. In FY 1998, NASA Langley researchers and industry partners completed systems analysis studies on various revolutionary aircraft concepts. Four of these concepts included configurations for box wing, strut-braced wing, intermodal transport and low-emissions transport aircraft.

Space Transportation Technology

Future aeronautics and space access systems must be able to accomplish their design missions while being affordable for both their initial acquisition and continuing operations. Likewise, for the United States to have affordable access to space and to remain competitive in launching spacecraft, a launch system that greatly reduces the cost to put payload into orbit is required. NASA Langley, working with industry and other NASA centers, is helping to address these technical challenges by using experimental aircraft to complement laboratory research.

Hyper-X Program

As a step toward opening the frontiers of atmospheric flight and reducing the cost of access to space, NASA has embarked on the Hyper-X program. This program will, for the first time ever, fly air-breathing scramjet-powered X-43 Hyper-X research vehicles at speeds up to 10 times the speed of sound (Mach 10). The first flight, at Mach 7, is planned for March 2000. NASA Langley has the lead for the program and is responsible for Hyper-X technology development. NASA Dryden Flight Research Center manages the Hyper-X flight project.

In early 1998, the X-43 critical design review and a major series of wind tunnel tests on the X-43 research-vehicle-to-booster-stage separation were successfully completed. The first Mach 5 engine ground tests were conducted in mid-1998. In August, the Hyper-X engine model, the high-speed scramjet model and the first Mach 7 flight engine were delivered to NASA for testing in 1999. In November, the first X-43 airframe was delivered to the MicroCraft facility in Tullahoma, TN, for systems integration. This vehicle will be delivered to Dryden in September 1999, followed by the Hyper-X launch vehicle in preparation for the first Mach 7 flight in early 2000.

NASA Langley contributions in 1998 include the detailed analysis of the Mach 7 airframe and scramjet (supersonic combustion ramjet) engine structure and performance, computational analyses of the stage separation, wind tunnel testing and design of the Mach 10 vehicle. Over 2,000 wind tunnel tests of 15 models were conducted at Langley in support of aerodynamic and propulsion design and database development. NASA Langley continues to provide extensive support for computational fluid dynamics and is currently working to solve challenging Hyper-X wing and tail leading-edge design issues for the Mach 10 vehicle.

X-33 Program

Fully reusable launch vehicles (RLVs) are essential to reducing the cost of putting payload into orbit. The X-33 Program is demonstrating the technologies necessary to develop these next-generation RLVs. During FY 1998, extensive aerodynamic testing of the X-33 configuration was performed to determine the vehicle's aerodynamic characteristics and provide data to support the design of the vehicle's structure and thermal protection system. Wind tunnel tests provided

information about the vehicle's low-speed aerodynamic characteristics, including the effects of ground proximity during approach and landing. Additional wind tunnel testing determined the dynamic stability characteristics of the X-33 during transonic and supersonic flight, and defined the X-33 aerodynamic performance during hypersonic (more than 5 times the speed of sound) flight.

Langley researchers also performed extensive computational fluid dynamic (CFD) analyses to validate the experimental results and define the aerodynamic characteristics for flight conditions that wind tunnels cannot adequately simulate. Additional wind tunnel tests provided data for designing the vehicle's load-carrying structure and the actuators which move the aerodynamic control surfaces in flight.

At the highest altitudes planned for X-33 flight test (above 250,000 feet), the air is too thin for the vehicle's aerodynamic control surfaces to be effective. At these altitudes, small rocket engines or jets will be used to provide attitude control. As the vehicle descends to lower altitudes, both the jets and the aerodynamic control surfaces will be used. In this flight regime, the gas plumes from the firing jets interact with the aerodynamic flow around the vehicle. These interactions influence the effectiveness of the jets and alter the aerodynamic characteristics of the vehicle. To understand these interactions, Langley researchers performed highly specialized wind tunnel tests. Data from these tests are being used to design the X-33 flight control logic for this phase of the flight.

Langley researchers also contributed to understanding of the aerodynamic heating environment that the vehicle will experience at hypersonic speeds. This data is critical for designing the vehicle's thermal protection system (TPS). Of particular importance during this stage is transitioning of the airflow over the vehicle's surface from a laminar to a turbulent state. Langley researchers performed extensive wind tunnel tests and complementary CFD modeling to understand and predict this phenomenon for the X-33. As a result, criteria and methodologies were established to predict the occurrence of boundary layer transition for the X-33 in flight. These methods are being used to design the thermal protection system and develop the X-33 flight test trajectories.

Researchers also performed flight environmental testing of the X-33's windward surface metallic thermal protection system. This testing subjected a full-scale array of seven X-33 metallic TPS panels to an environment simulating the aerodynamic pressure and surface temperature levels expected in flight. Additional testing was also performed on the leeward thermal protection configuration, which is comprised of flexible blanket TPS material bonded to a composite skin substructure. Successful completion of these tests was critical to "flight qualification" of the X-33 thermal protection system.

Evaluations of multiple options for insulating the X-33's aluminum oxygen tank and graphite-epoxy hydrogen tank were also performed. These tests subjected panels of candidate cryogenic insulation to experimental simulation of 50 complete mission mechanical and thermal load cycles representative of tank fill, launch, ascent and entry for a reusable launch vehicle. The tests validated the selection of the cryogenic tank insulation materials that will be used on the X-33. In addition, fiber-optic sensors developed at Langley will be used to monitor the flight thermal and structural performance of the X-33's liquid oxygen and hydrogen tanks and their cryogenic insulation.

X-34 Program

The X-34 Program will demonstrate reusable launch vehicle operations technologies that are essential to reducing the cost of access to space. The X-34 vehicle, which is capable of flying to Mach 8, is scheduled to fly repeatedly (some 25 times) within a one-year period. NASA Langley has been fully responsible for defining the aerodynamic performance and stability and control characteristics of the X-34 over its entire flight envelope. In FY 1998, wind tunnel testing was performed to define the vehicle's low-speed aerodynamic characteristics, including the effects of

ground proximity during approach and landing. Additional tests were performed to define the vehicle's hypersonic flight characteristics. The results of these tests, and others previously conducted at NASA Langley, provided the basis for the X-34 flight aerodynamic databook that will be used to develop the X-34's flight control system software.

Langley researchers also conducted a computational study to determine the aeroelastic effects (i.e., the effects of wing surface deflections due to aerodynamic pressure loads) on the aerodynamic characteristics of the X-34. This analysis was performed for the flight condition of peak dynamic pressure, which occurs at about Mach 1.35. The study was conducted jointly with the Structural Dynamics Research Corporation, which determined wing structural deformations, based upon wing pressure distribution information determined by Langley researchers. Aeroelastic deflections of the X-34's composite wing structure were found to be small, resulting in little change to the aerodynamic characteristics of the vehicle at this flight condition.

In addition to aerodynamic testing and analyses, Langley researchers also performed extensive wind tunnel tests and CFD analyses to define the aerodynamic heating characteristics of the X-34 configuration at hypersonic speeds. This information provided the basis for design of the vehicle's thermal protection system.

Atmospheric Sciences

NASA Langley leads several NASA activities in atmospheric sciences. Langley atmospheric scientists conduct an aggressive program of research focused on global change, working to improve our understanding of the Earth's atmosphere and of natural and human-induced changes to it. More specifically, they perform research to understand the fundamental processes of energy transfer, chemistry and transport mechanisms that determine the atmosphere's structure and composition. Researchers conceive, develop and use advanced instrumentation to observe, characterize and analyze regional and global atmospheric processes with emphasis on remote sensing. They develop advanced technologies and techniques to enable new science measurements and reduce mission life-cycle costs. They produce, analyze, interpret, archive and disseminate atmospheric data sets to understand atmospheric radiative, chemical, dynamical and meteorological processes and interpret trends. They identify critical atmospheric science issues and contribute to national and international assessments of the environment, utilizing theoretical models and analytical techniques to interpret atmospheric observations. NASA Langley's atmospheric science research significantly contributes to the U.S. Global Change Research Program.

Earth's Energy Budget

The Clouds and the Earth's Radiant Energy System (CERES) is the next generation of Langley atmospheric sensing instruments which have been measuring the Earth's energy system since 1984. The first CERES flight instrument, part of the joint NASA/Japanese Tropical Rainfall Measuring Mission (TRMM), was successfully launched in late 1997. After a successful on-orbit checkout, the CERES instrument has provided the most accurate measurements ever made of Earth's reflected and emitted radiation. The next set of CERES instruments have been built and delivered for launch in 1999 on the Earth Observing System (EOS) spacecraft to obtain global radiation measurements.

The PICASSO-CENA mission (Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations -- Climatologie Etendue des Nuages et des Aerosols) was successfully proposed to NASA's Earth System Science Pathfinders-2 program. The instruments on PICASSO-CENA are designed to address the role of clouds and aerosols and their impact on Earth's radiation budget. After its launch in 2003, PICASSO-CENA will provide, for the first time, the ability to construct the three-dimensional structures of the atmosphere to better understand the role of clouds and aerosols in Earth's climate. To be selected, the PICASSO-CENA proposal had to be judged

exceptional in each of five areas: scientific objectives and approach, technical implementation, management structure, binding cost definition, and public outreach/education program.

Students' Cloud Observations On-Line

The Students' Cloud Observations On-Line (S'COOL) Project is an education and outreach element of the Clouds and the Earth's Radiant Energy System (CERES) project. S'COOL involves K-12 students as ground truth observers for the CERES instrument, currently in orbit on the Tropical Rainfall Measuring Mission (TRMM) spacecraft. It will continue for a number of years with additional CERES instruments on EOS-AM and future missions. S'COOL currently has more than 150 participants in the United States and 15 other countries around the world.

Ozone

NASA Langley researchers use satellite, aircraft, balloon, ground-based, and laboratory experiments as well as theoretical and statistical models to study the atmosphere. The Halogen Occultation Experiment (HALOE), onboard the NASA Upper Atmosphere Research Satellite, has provided a 6-year record of measurements that proved chlorofluorocarbons (CFCs) were the dominant source of ozone-depleting chlorine in the lower stratosphere -- the cause of the Antarctic ozone hole. The HALOE observations are now indicating a slowdown in the production of hydrogen fluoride, a primary product of ozone destruction chemistry. This slowdown is consistent with the reduced release of CFCs at the surface of the Earth mandated by the Montreal Protocol.

Stratospheric Aerosols

NASA Langley is currently developing several new remote sensing instruments that will continue the significant achievements of their satellite forebears. The Stratospheric Aerosol and Gas Experiment III (SAGE III) is a continuation of the very successful SAGE I and SAGE II instruments for studying aerosols, small particles in the Earth's atmosphere, such as volcanic ash and liquid droplets. The SAGE III instruments will be flown aboard a Russian METEOR-3M satellite and the International Space Station.

Earth's Upper Atmosphere

The Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) project represents an extension of Langley's proven expertise in atmospheric sciences to a new region of the atmosphere. The SABER project is a new instrument that will provide global measurements of the key parameters needed to study the thermal structure, energy balance, ozone chemistry and dynamics of the upper atmosphere.

LASER Studies of the Atmosphere

The Lidar Atmospheric Sensing Instrument (LASE) is an advanced airborne water vapor differential absorption lidar (DIAL) system that was initially developed to operated on the high-altitude ER-2 aircraft as a precursor to a spaceborne water vapor DIAL system. LASE has been used in three previous field experiments, and during August-September 1998, LASE was flown on the NASA DC-8 aircraft for extensive measurements of water vapor and clouds in a study of hurricane characteristics over the Atlantic Ocean and Gulf of Mexico. These measurements will be used to improve the models used to predict hurricane behavior.

Global Data Center

NASA Langley provides one of the largest Earth Science Enterprise data centers--the Langley Distributed Active Archive Center (DAAC). The Langley DAAC processes, archives, and distributes Earth science data regarding the Earth's energy budget, clouds, aerosols and atmospheric chemistry. In 1998, data center holdings grew to over 250 data sets from 25 projects, and data products were distributed to over 750 customers from around the world. The DAAC processed over eight months of new data from the CERES TRMM experiment and provided access

to the data using a new world-wide-web ordering system. In addition, a set of "trading cards" explaining the Earth's radiation budget were provided to educational customers.

Passive Remote Sensing

The NPOESS Aircraft Sounder Testbed–Interferometer (NAST-I) is a high-spectral resolution infrared atmospheric sounder which was completed and flown in 1998. During the Convection and Atmospheric Moisture Experiment (CAMEX-3), NAST-I observed the three-dimensional thermodynamic structure of the eye of several hurricanes. The instrument also provided detailed measurements of the hurricane's environment moisture flux related to storm development and tracking. Future NAST-I field deployments will focus on obtaining data sets for the National Polar Orbiting Operational Environmental Satellite System (NPOESS) as well as the soon-to-be-launched EOS platform instruments.

Education Programs

NASA's Strategic Plan reflects our commitment to Executive Order 12999 encouraging federal agencies to make an important contribution to education in America. Langley's Office of Education has a core set of pre-college and university programs reaching out to a broad continuum, from kindergarten through post doctoral studies including students, teachers, faculty, other educators and education administrators. In FY 1998, Langley's education outreach provided programs such as summer internships, fellowships, visitations, workshops and distance learning. Langley and its many partners in academia, industry and other government agencies had many accomplishments.

NASA Langley contributed over $40M for over 500 research, training and education grants, cooperative agreements and contracts awarded to universities. The 1998 Langley Aerospace Research Summer Scholars (LARSS) program had a total of 122 participants, representing 57 universities from across the nation. The 1998 American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program provided 42 nationally selected professors the opportunity to do research with NASA. Almost 400 pre-service teachers from minority institutions engaged in a science, mathematics and technology workshop that exposed them to NASA scientists and engineers, curricula materials and facilities. In-service NASA educational workshops included 50 additional elementary school teachers.

NASA CONNECT is a series of 30-minute interactive instructional distance learning programs designed for elementary and middle school students. NASA CONNECT uses aerospace-focused programs, facilities and researchers to link concepts to the workplace by providing educators and students with examples of how math and science are used everyday by NASA scientists and engineers. A NASA CONNECT program, which focused on micro-gravity research entitled "Doing More In Less," was selected from over 1,000 entries for the 1998 Aurora Gold Award under the category of instructional and science education. Educators can register for NASA CONNECT and download lesson materials at http://edu.larc.nasa.gov/connect/

Langley's Students' Cloud Observations On-line (S'COOL) is a hands-on project that involves students in collaborative research with NASA scientists. Students in grades 3 through 12 act as ground truth observers by making observations of clouds at the time of an overpass by the Clouds and the Earth's Radiant Energy System (CERES) instrument. The major accomplishment in FY 1998 was the integration of this project in a joint NASA and Centre National d'Etudes Spatiales Trans-Atlantic educational cooperative effort. The American-French demonstration proceeded with the participation of First Lady Hillary Rodham Clinton in Paris and NASA Administrator Daniel Goldin in Washington. S'COOL currently involves over 180 schools in 17 countries on 5 continents.

DIRECT ECONOMIC IMPACT OF NASA LANGLEY ON VIRGINIA AND THE NATION

Economic Impact Study and Analysis[1]

Economic impact studies measure direct and indirect effects on an area economy. Direct impact refers to an agency's spending on goods and services, its various sources of income, and employment levels. Indirect impact is the effect of the agency's spending and employment on other sectors of the economy through the multiplied impact of spending and job creation. The indirect impact is an attempt to measure the impact on various businesses and industries that depend on the re-spending of income and other expenditures generated by an organization. NASA Langley is a very large economic generator. Its direct impact can therefore best be analyzed by evaluating its employment, payroll budget, contract and grant spending, taxes and revenue. The total economic impact is the combined direct and indirect effects in terms of total output, earnings and employment.

Methodology

Economic impact analysis considers the interrelatedness of industry within a local region and evaluates these relationships to determine the response of the regional economy to various changes in the economic base of the community. Input-Output tables are useful in this evaluation because they are a graphic presentation of the regional accounts of an economy system and illustrate the flows among various sectors of that economic system. Input-Output analysis divides the economy into two sectors: those that produce output (either final or intermediate) and those that use that final or intermediate output in the production of other goods or services. An Input-Output analysis is a simple yet highly effective picture of resource flows within an economic system. Input-Output analysis makes it possible to examine the impact of income generation or job generation as they *multiply* through the economy, creating additional income, expenditures and jobs. The economic multiplier for any sector of an economy measures the impact that an initial expenditure or income will have as the expenditure generates additional jobs and income and therefore generates additional expenditures and jobs, etc. In other words, a dollar spent is not simply a dollar spent. An income earned is not simply an income earned. They both get multiplied throughout the interrelatedness of the economy. For example, an employee making $50,000 plus benefits of approximately 28% spends a major portion of that income in the local economy. This generates jobs in that expenditure chain in industries such as food, housing, financial services, insurance, transportation, personal services, etc. These jobs then generate additional income and another round of spending as those recipients spend money on similar consumer goods and services.

This study utilizes regional Input-Output multipliers generated from the Regional Industrial Multiplier System (RIMS II) model as generated by the Bureau of Economic Analysis of the U.S. Department of Commerce and the IMPLAN Model used by the Virginia Employment Commission and adjusted for special local considerations by the Bureau of Business and Economic Research at Christopher Newport University. These methods, which concentrate on final demand multipliers to estimate an agency's impact, are widely used in both public and private sector analysis regarding economic impact analysis.

[1] Prepared for NASA Langley by Dr. Marshall Booker, Christopher Newport University

Spending Impact of NASA Langley

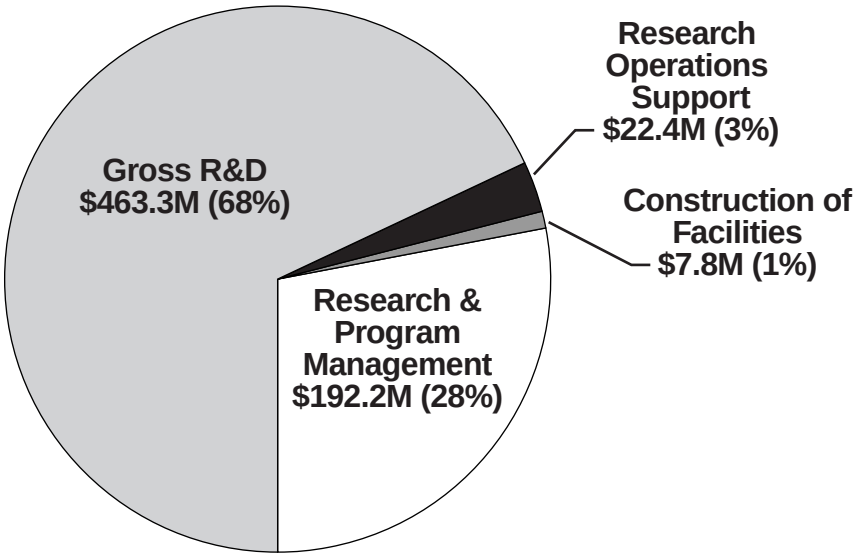
The output impact of NASA Langley spending for FY 1998 can be seen in the following table, which uses final demand multiplier to measure the output effects of spending by sector at NASA Langley. Total spending is calculated by sector and the appropriate multiplier is then applied to that sector to measure both direct and indirect economic impacts.

Spending Impact FY 1998

Sector	Direct Spending	Multiplier	Indirect impact
Engineering, business, & professional services	$271,516,000	2.4303	$659,865,000
Payroll/household earnings	188,200,000	1.6139	303,736,000
Data processing/equipment services	55,328,000	2.7015	149,469,000
Miscellaneous services	46,546,000	2.5073	116,705,000
Colleges, universities, schools	47,793,000	2.6178	104,919,000
New & repair construction	31,913,000	2.3624	75,391,000
Utilities services	14,032,000	1.8952	26,593,000
Fabricated products (metals)	16,831,000	2.4083	40,534,000
Instruments and related products	6,591,000	2.2153	14,601,000
Electronic and electrical equipment	3,289,000	2.3896	7,859,000
Transportation/travel	4,880,000	2.4792	12,098,000
Communications	1,472,000	2.0112	2,960,000
Machinery, non-electrical	691,000	2.5743	1,779,000
Health-related services	510,000	2.6566	1,355,000
Total indirect and direct	**$689,592,000**		**$1,542,810,000**
Total impact			**$2,232,402,000**

As the table indicates, NASA Langley's total outlay of $689,592,000 increases economic output in the region by a total of $1,542,810,000 for a combined impact of more than $2 billion.

Total Budget Program Year 1998



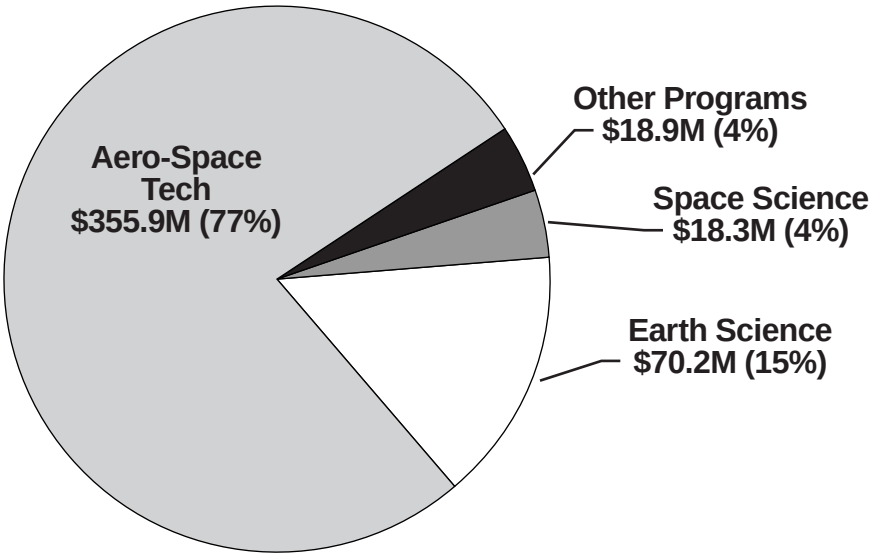
Total Budget = $685.7M

Budget Summary for Program Years 1997 and 1998 ($M)

	PY 97	PY 98
Salaries/Benefits	180.5	188.2
Travel	4.2	4.0
Research & Program Management	184.7	192.2
Research Operations Support	23.3	22.4
Construction of Facilities	7.2	7.8
Gross R&D	474.3	463.3
Total Budget	**689.5**	**685.7**

Note: Includes Langley Programs from other Centers

Gross R&D Funding Program Year 1998



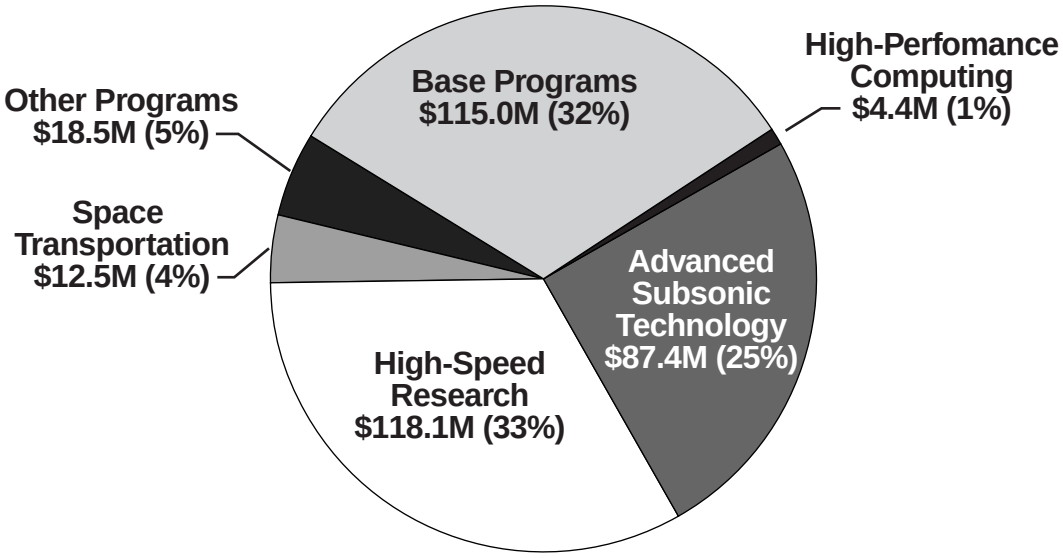
Total Gross R&D Budget = $463.3M

Gross R&D Funding for Program Years 1997 and 1998 ($M)

	PY 97	PY 98
Aeronautics & Space Transportation Technology……	362.2	355.9
Mission to Planet Earth……	86.1	70.2
Life & Microgravity Science & Applications……	2.0	0.6
Safety & Mission Assurance ……	1.2	1.2
Chief Engineer ……	1.4	3.2
Space Flight ……	2.0	7.1
Space Science ……	12.0	18.3
Advanced Concepts……...	0.0	0.1
Academic Programs ……	7.3	6.7
Total Gross R&D	**474.3**	**463.3**

Notes: Includes Langley Programs from other Centers

NASA Langley Gross R&D Funding
Office of Aeronautics & Space Transportation Technology
Program Year 1998



Total Aeronautics & Space Transportation Technology Budget = $355.9M

NASA Langley Gross R&D Funding Office of Aeronautics & Space Transportation Technology for Program Year 1998 ($M)

	PY 97	PY98
Airframe Systems	89.2	92.0
Interdisciplinary Technology	6.5	7.9
Information Systems	5.1	5.1
Propulsion Systems	0.4	0.0
Flight Research	3.5	0.7
Airspace Operations	3.9	5.4
Rotorcraft	3.7	3.9
Aeronautics Base	112.3	115.0
High Speed Research	119.7	118.1
Advanced Subsonic Technology	86.5	87.4
High Performance Computing	5.7	4.4
Space Transportation	13.6	12.5
Other Programs	24.4	18.5
Total Gross R&D	**362.2**	**355.9**

Construction of Facilities Program

FY 1992 - FY 1998 MAJOR PROGRAM AFPCE's*

FY 1992 -	15,100,000
FY 1993 -	2,200,000
FY 1994 -	57,000,000
FY 1995 -	0 (No projects)
FY 1996 -	0 (No projects)
FY 1997 -	0 (No projects)
FY 1998 -	0 (No projects)
TOTAL	**$74,300,000**

FY 1992 - FY 1998 MINOR PROGRAM AFPCE's

Revitalization

FY 1992 -	8,935,000
FY 1993 -	8,060,000
FY 1994 -	7,620,000
FY 1995 -	6,050,000
FY 1996 -	7,474,000
FY 1997 -	6,450,000
FY 1998 -	5,190,000
Total	**$49,779,000**

Minor Construction

FY 1992 -	1,630,000
FY 1993 -	1,140,000
FY 1994 -	1,252,000
FY 1995 -	665,000
FY 1996 -	665,000
FY 1997 -	0
FY 1998 -	700,000
Total	**$6,052,000**

Environmental Restoration

FY 1992 -	4,500,000
FY 1993 -	4,680,000
FY 1994 -	550,000
FY 1995 -	1,100,000
FY 1996 -	1,590,000
FY 1997 -	666,000
FY 1998 -	0
Total	**$13,086,000**

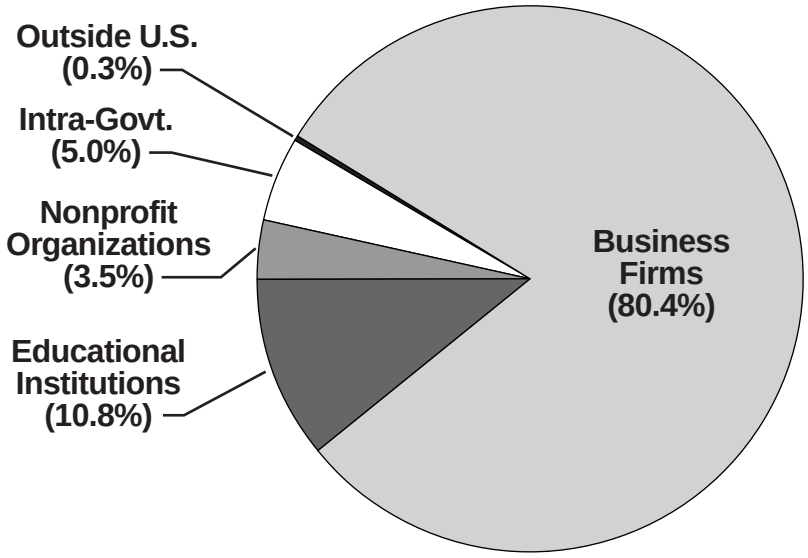
Total Major Programs FY 1992 - 1998 = $74,300,000

Total Minor Programs FY 1992 - 1998 = $68,917,000

Total Programs FY 1992 - 1998 = $143,217,000

* Approved Facility Project Cost Estimate (AFPCE)

Distribution of Procurements FY 1998 Obligations



Net Value of FY 1998 Obligations

Business Firms.....	$402,191,837
Educational Institutions	54,254,468
Nonprofit Organizations	17,494,520
Intragovernmental.....	24,849,980
Outside United States.....	1,506,823
Total	**$500,297,628**

Geographical Distribution Summary of Contracts, Grants and Purchase Orders for FY 1998

State	Total	State	Total
Alabama	$3,623,530	Montana	$289,244
Alaska	0	Nebraska	3,989
Arizona	8,949,097	Nevada	138,719
Arkansas	0	New Hampshire	758,296
California	56,047,054	New Jersey	3,764,031
Colorado	15,024,041	New Mexico	715,376
Connecticut	571,530	New York	6,003,033
Delaware	532,578	North Carolina	7,198,139
District of Columbia	3,130,500	North Dakota	48,045
Florida	5,477,740	Ohio	6,140,865
Georgia	6,328,914	Oklahoma	1,179,702
Hawaii	264,001	Oregon	1,02,666
Idaho	79,112	Pennsylvania	6,780,475
Illinois	1,222,420	Rhode Island	282,409
Indiana	419,525	South Carolina	188,753
Iowa	1,428,436	South Dakota	337,194
Kansas	2,395,396	Tennessee	2,831,082
Kentucky	100,202	Texas	7,437,705
Louisiana	10,836	Utah	9,504,165
Maine	0	Vermont	16,135
Maryland	6,503,023	Virginia	225,477,341
Massachusetts	11,526,919	Washington	89,546,833
Michigan	909,561	West Virginia	156,155
Minnesota	1,224,004	Wisconsin	1,058,402
Mississippi	1,101,437	Wyoming	335,082
Missouri	202,517	**Total**	**498,669,218**

Awards Made to Businesses and Institutions with Performance in Virginia

CATEGORY FY 1998	
Large business	$120,563,727
Small business	71,864,780
Educational institutions	15,534,706
Non-profit	13,582,545
Total	$221,545,758

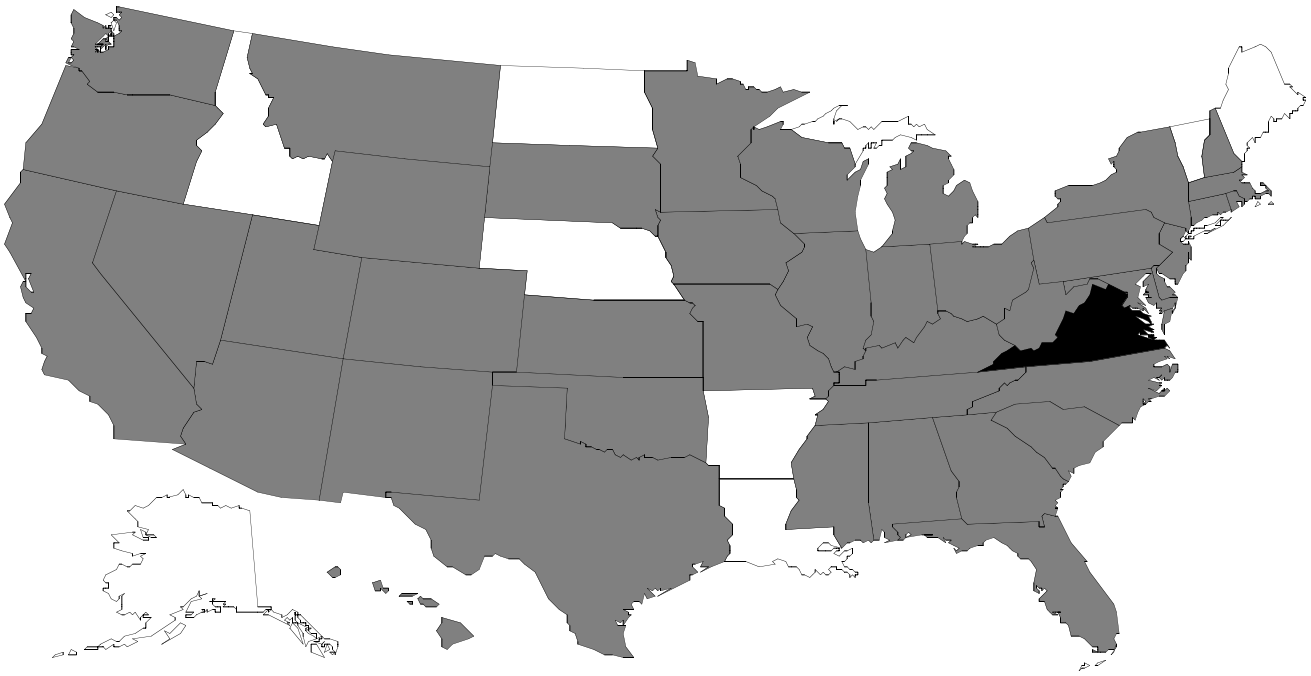
Note: Includes obligations for contracts, grants, and purchase orders.
Does not include approximately $3.8 million in intragovernmental obligations.

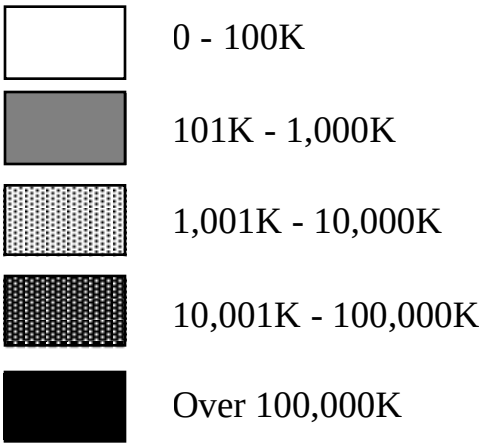
Obligations by Congressional District

Senator Charles S. Robb
Senator John W. Warner

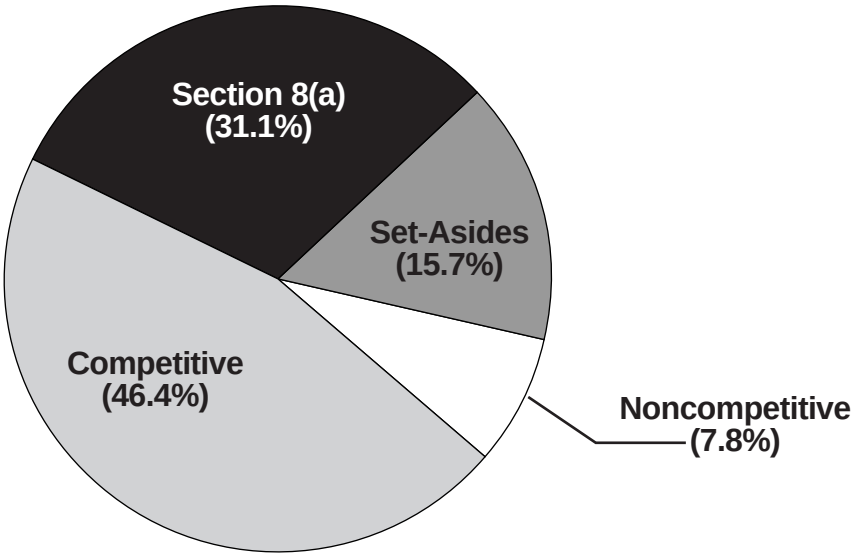
Congressional		NASA FY 1998 Obligations (K)	
District	**Representative**	**Agency**	**Langley**
1	Herbert H. Bateman	$218,641	$180,029
2	Owen B. Pickett	4,682	3,436
3	Robert C. Scott	10,208	9,254
4	Norman Sisisky	253	150
5	Virgil H. Goode, Jr.	8,328	3,507
6	Robert W. Goodlette	177	102
7	Thomas J. Bliley	926	195
8	James P. Moran	43,138	5,659
9	Rick Boucher	3,681	2,384
10	Frank R. Wolf	81,582	16,636
11	Thomas Davis	48,452	1,362
		$420,068	**$222,714**

Total Obligations By State FY 1998





Distribution of Small Business Awards FY 1998



Net Value of 1998 Obligations

Competitive.....	$42,313,544
Section 8(a)	28,942,704
Set Asides (competitive)	28,954,455
Noncompetitive	11,442,340
Total small business	**$111,653,043**

Top 25 Business Contractors FY 1998

	Company	*Dollars Obligated*
1	Boeing Commercial Airplane	$86,184,482
2	McDonnell Douglas Corp	31,950,840
3	Computer Sciences Corp	29,383,272
4	E G & G Langley	20,606,842
5	Science Application Intl Corp	19,663,930
6	GMR	15,740,424
7	Lockheed Martin Engineering	14,478,103
8	NCI Information Systems	13,835,631
9	Virginia Power	13,312,142
10	Ball Aerospace & Tech Corp	11,060,330
11	NYMA	10,931,874
12	TRW Inc	8,220,000
13	Wyle Laboratories	7,345,175
14	Honeywell Inc	6,865,530
15	Unisys Corp	4,621,399
16	Micro Craft Inc	3,468,144
17	Lockheed Martin Corp	3,200,707
18	Dynamic Engineering Inc	3,078,048
19	Aero Systems Engineering Inc	2,763,334
20	Raytheon Support Services	2,451,037
21	Sylvest Management	2,431,765
22	Technology Applications Inc	2,400,236
23	Advex Corp	2,390,900
24	G A S L	2,385,856
25	Calspan Corp	2,074,419

Top 20 Educational and Nonprofit Institutions Listed According to FY 1998 Total Obligations (N = Nonprofit)

Institution		Dollars	Percent
1.	Utah State University	$7,583,397	10.57%
2.	Research Triangle Institute (N)	4,825,231	6.73%
3.	University of Virginia	3,786,742	5.28%
4.	Hampton University	3,369,955	5.15%
5.	Old Dominion University	3,255,268	4.54%
6.	Universities Space Research (N)	3,129,978	4.36%
7.	Hampton City (N)	3,052,629	4.25%
8.	Logistics Management Institute (N)	2,971,717	4.14%
9.	Harvard University	2,238,845	3.12%
10.	Virginia Polytechnic Institute	2,036,481	2.84%
11.	Mass Institute Technology	1,427,766	1.99%
12.	North Carolina A & T	1,341,780	1.87%
13.	Georgia Tech Research Corp	1,277,443	1.78%
14.	Georgia Institute Technology	1,233,464	1.72%
15.	George Washington University	1,168,893	1.63%
16.	Wichita State University	1,053,422	1.47%
17.	University of Pittsburgh	1,050,000	1.46%
18.	North Carolina State University	963,604	1.34%
19.	Norfolk State University	921,150	1.28%
20.	Virginia Center Innovative Tech (N)	834,981	1.16%
	Subtotal	$47,846,746	66.69%
	All Others	$23,902,242	33.31%
	Grand Total	**$71,748,988**	**100.00%**

INDIRECT IMPACT OF NASA LANGLEY ACTIVITIES

Community Service

NASA Langley Research Center employees are committed “beyond the gates” to activities that benefit the educational and human service communities. A survey of Center employees confirmed that close to 1,000 employees donate over 4 hours each week to volunteer efforts to help neighbors, newcomers and those in need. Notable Center-supported initiatives include the following:

Combined Federal Campaign

Langley has the highest participation rate and average gift of any major federal group on the Virginia Peninsula. In all, 1,423 employees at NASA Langley contributed $315,000 to the Peninsula Combined Federal Campaign in 1998 for an average gift of $221. This amount does not include Langley retirees or contractors who contributed directly to the Peninsula United Way campaign.

Day of Caring

Just one of numerous Center-supported outreach activities, 179 Langley volunteers (one-third of all Peninsula volunteers) participated in the seventh annual community Day of Caring. Volunteers were posted at over 65 community sites. Whether they painted, pruned, plumbed or planted; sided, spackled, sorted or sawed; mowed, manicured or mended; cleaned, counted or cooked, the 1998 Day of Caring volunteers made the Peninsula a better place.

Holiday Projects

NASA Langley employees made the holidays warmer and sweeter for their neighbors in need. Seventy-six "angels" were adopted from Salvation Army Angel Trees in local stores. Warm clothing, socks and underwear, hats and gloves, shoes and boots were among the items chosen for the needy children. Many of the packages included a toy, a cuddly stuffed animal or candy as well. Another project, "Cookie Power," netted 160 dozen goodies for the Salvation Army's mobile kitchen during the holiday season.

Galaxy Of Gifts

The NASA Langley Alumni Association in partnership with the United Way of the Virginia Peninsula and the Association for Retarded Citizens (ARC) created *Galaxy of Gifts*, a community service project that distributes donated products to people in need. *Galaxy* has 138 member agencies. In FY 1998, membership expanded to non-profit organizations in Norfolk, Virginia Beach and Portsmouth.

Blood Drives

Giving the gift of life is one of the many ways NASA Langley employees reach out to the community. During the six blood drives sponsored by Langley in FY 1998, civil servants and contractors donated 1,372 pints of blood to the Hampton Roads Chapter of the American Red Cross, which supports the mid-Atlantic region.

Langley Speakers Bureau

NASA Langley civil servants, retirees, and contractors address civic, professional, educational, and other non-profit organizations that want to learn more about NASA Langley's research. Over 125 presentations were made in FY 1998, impacting a combined audience of almost 11,000 stakeholders.

VIP Tours

NASA Langley offers a limited number of tours for public, professional, military, governmental, and educational groups. Through these tours, our stakeholders are provided a first-hand look at how NASA research benefits them. In FY 1998, Center employees and volunteers hosted 72 tours for over 2,000 visitors to the Center. In addition, 33 tours were provided by the Center's educational staff, impacting 233 teachers and nearly 350 students.

Tourism: Visitor Center

NASA Langley's official visitor center is the Virginia Air and Space Center (VASC) located in Hampton, Virginia. Langley Research Center's programs and work are presented to the public through the VASC, which opened in 1992.

THEME: "From the Sea to the Stars"
The theme integrates the region's abundant history with Langley's aerospace legacy.

FEATURES: The Center features over 100 permanent exhibits that tell an exciting story of history, technology, aeronautics, and space exploration. A traveling exhibit hall features several interactive science exhibitions annually.

IMAX: The Center has an IMAX theater which features a five-story-high projection screen and state-of-the-art sound system.

ATTENDED: Over two million people have visited the VASC since it opened.

ORGANIZATION: The Center is a non-profit institution governed by a board of directors.

TOURS: The VASC conducts guided drive-through tours of the Langley Research Center during the summer months. These tours include a walk-through of a wind tunnel. In 1998, more than 1200 stakeholders took these tours. The VASC also offers many special exhibits, educational programs, camps and lectures year round.

Educational Outreach

University Programs

NASA Langley contributed over $45 million to universities across the country, awarding over 500 research and training grants, cooperative agreements and contracts to academic institutions in fiscal year 1998, almost $8 million going to Historically Black Colleges and Universities. The Center also provided summer internships and research opportunities to almost 300 students, teachers, and faculty.

Computers for Learning

Under the Stevenson-Wydler Act, Langley transferred over $27 million in education-related Federal equipment to schools and other educational facilities this fiscal year. Over 3,800 items were donated, including computers and related equipment as well as other research equipment for use in math, science and technology curricula. The total cost of all items donated by Langley in this 5-year-old program is now over $41 million.

Distance Learning Programs

Employing a variety of information technologies, NASA Langley uses distance learning to promote educational excellence. The initiatives, designed to support the national education standards in math science, geography and technology, utilize Langley's unique facilities and personnel. This year, the initiatives reached over 157,000 students and almost 6,200 teachers with programs including *EarthKAM*, NASA *CONNECT* series with guests such as John Glenn, and featured appearances on the WTKR-TV weekly children's program *Brain-Stew*.

NASA on Tour

Aerospace Education Services Program specialists visited 1,505 teachers and over 55,300 students in the five-state precollege service area: Kentucky, North Carolina, South Carolina, Virginia, and West Virginia. The specialists focus their efforts on teacher enhancement at the precollege level and provide workshops, demonstrations, and classroom visits.

Educator Resource Center Network

In FY 1998, the NASA Educator Resource Center Network (ERCN) distributed over 89,000 products and served almost 15,000 educators. NASA Langley's Educator Resource Center is located in Hampton, Virginia, and six Regional Educator Resource Centers are located within the five-state precollege service area.

National Engineers Week School Visitation

As part of NASA Langley's commitment to encourage and prepare young people for life in a technological world, the Center sponsors a number of electronic and Center- and school-based activities during the month of February. In 1998, 106 employees visited 44 local schools, reaching nearly 10,000 students in this single effort to reinforce student interest in math, science and technology careers. In addition, 530 high school students attended a careers program event hosted at Langley. A NASA CONNECT satellite broadcast enabled Langley's outreach beyond the immediate local area. Over 437 teachers and 7,672 students registered for the program.

Pre-Service Teacher Education Conference & Institute

NASA Langley, in collaboration with Norfolk State University, hosted a highly successful Pre-Service Teacher Education Conference and Institute. Almost 300 pre-service teachers were exposed to a variety of innovative techniques, educational technologies, and NASA aerospace materials that will be used in the classroom.

Partnership for Excellence in Math, Science and Technology

Langley's Partnership Programs have resulted in research and education activities at universities and precollege schools throughout America. These programs impact hundreds of businesses, industries and schools as well as hundreds of thousands of students.

NASA Educator Workshop (NEW)

NASA Langley hosted two NASA Educator Workshops. The first workshop, NEW K-6, was attended by 25 elementary teachers. NEW Rural was attended by 21 kindergarten through grade 12 teachers. The teachers were exposed to a variety of NASA materials, educational technologies and Langley researchers and classroom resources.

Cooperative Education Programs

In FY 1998, Langley Research Center provided employment and on-the-job educational experience for over 75 students. Work experience is provided for technicians, secretarial, administrative, and engineering students. Currently, 30 educational institutions throughout the United States and Puerto Rico participate in these programs. Five agreements are with Virginia schools and colleges. Selected participants may be offered full-time employment upon completion of the program.

Category	No. of Students	From No. Schools	Agreements* With Schools
Technician	0	0	0
Engineering	58	25	27
Administrative Professional	1	1	3
Secretarial	26	1	1

* Schools can be represented in more than one category and may not have students in the program at a given time.