



MARYLAND THE BUSINESS OF SPACE SCIENCE

A project of the Maryland Department of Business and Economic Development

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Maryland: The Business of Space Science

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Maryland Space Pioneer

John C. Mather – Dr. Mather is the senior astrophysicist at the NASA Goddard Space Flight Center and project scientist for the James Webb Space Telescope. He received the 2006 Nobel Prize for Physics for his work on the Cosmic Background Explorer Satellite which helped support the big-bang theory of the universe. In 2007 *Time* magazine named him one of the 100 Most Influential People in The World.

PREFACE

Maryland: The Business of Space Science is the second competitiveness research project initiated by the Maryland Department of Business & Economic Development. Modeled on *CyberMaryland: Epicenter for Information Security & Innovation*, the award-winning report on Maryland’s cybersecurity industry, *Maryland: The Business of Space Science* inventories the state’s space and satellite sector, identifies key assets and opportunities, and sets forth a policy to guide strategic planning and investments.

Maryland has an impressive array of space industry assets. NASA Goddard Space Flight Facility, which manages NASA’s observation, astronomy and space physics missions, has called Maryland home for more than 50 years. The Hubble Telescope, the first major optical telescope placed in space, was built, serviced and rebuilt in Maryland. The Space Telescope Science Institute (STScI) supports the Hubble Telescope as well as NASA’s optical/UV missions and the James Webb Space Telescope.

Supporting NASA’s mission are the Johns Hopkins University Applied Physics Laboratory, which built and launched the New Horizons mission to Pluto, and other flagship labs. Maryland colleges and universities perform cutting-edge aeronautics and space research, with Bowie State University, Morgan State University and the University of Maryland’s College Park, Eastern Shore and Baltimore County campuses at the forefront. The state’s private sector assets include ATK, Hughes Communications, Lockheed Martin, Northrop Grumman, Orbital Sciences, Raytheon and a host of other space industry giants.

The space sector is an important cog in Maryland’s economic engine. Each year, NASA contracts \$1.4 billion with Maryland companies. NASA’s 10,000 employees and thousands of other Marylanders work in space enterprises related to NASA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey and national security agencies.

Space industry partners in Maryland are adapting existing space science to explore and address climate change in the nation and the world. NASA Goddard scientists are expanding our understanding of the Earth and its life-sustaining environment, the sun, the solar system and the universe. In collaboration with NASA, NOAA develops systems that enhance our comprehension of the role oceans, coasts and the atmosphere play in the global ecosystem.

Maryland is poised to be the nation’s nerve center for “green science” and the scientific beachhead to monitor carbon emissions in any new system of cap-and-trade regulations. Already, the NASA Goddard’s high performance computing facility – the NASA Center for Computational Sciences – has evolved to become the NASA Center for Climate Simulation, in recognition of the importance of climate modeling. Given these unique industry assets and innovations, Maryland is strategically positioned to expand our leadership in the space industry even as the industry changes to meet 21st century challenges.

Maryland Space Pioneer

Riccardo Giacconi – Dr. Giacconi is an astrophysicist and Professor in the Department of Physics and Astronomy at JHU whose research in experimental astrophysics pioneered the field of X-ray astronomy, discovered the X-ray background. In 2002, he was awarded the Nobel Prize for Physics. Dr. Giacconi helped found the Space Telescope Science Institute and served as Director from 1981 to 1993, a period which included the launch and early years of operation of the Hubble Space Telescope.

SUMMARY

Maryland: The Business of Space Science seeks to increase the economic and innovation potential of Maryland’s space industry by advocating and implementing a series of policy recommendations and strategies in **Science Research & Development, Commercialization, Manufacturing, Satellite Servicing, Space Launch Services, and Workforce & Education**. Our recommendations require the participation and engagement of various state and federal agencies, our congressional delegation, the Maryland General Assembly, and entities such as the Federal Facilities Advisory Board, economic development organizations, educational institutions and the business community. In order to fully realize the opportunities of the space and science sector, the O’Malley-Brown Administration will:

- I. Create a **Space Development Authority** to coordinate space industry policies and initiatives.
- II. Establish a **Space-Related Business Incubator** with the Maryland Technology Development Corporation (TEDCO).
- III. Partner with congressional delegation to advocate for a proposed **National Center of Climate & Environmental Information** based in Maryland.
- IV. Engage the Greater Salisbury Committee to develop a **long-term program plan** for the Lower Eastern Shore to position the NASA Wallops Flight Facility as the premier spaceport for light- and medium-lift launches. Consider funding for the Mid-Atlantic Regional Spaceport (MARS) following the plan’s adoption.

POLICY RECOMMENDATIONS

1. Exploit and Enhance Maryland’s Leadership in Space and Earth Science Research & Development

The research and development that occurs in Maryland is the basic building block for any economic activity that follows and provides the raw materials for emerging disciplines like climate change policy. Our unique strengths in other fields can potentially benefit from the application of space science and earth science to contribute innovative solutions to global problems.

Maryland already has unrivaled expertise in space science and earth science. With expertise in earth sciences and with key research centers and other space industry assets – most notably, NASA Goddard Space Flight Center, NOAA, STScI and The Johns Hopkins University Applied Physics Laboratory (APL) – the state is poised to be the leader in climate change and the burgeoning climate information and services market.

Recommendations – Space Science

- Market Maryland as the *Space Science State* for study, discovery and technology transfer. Highlight Maryland’s leadership in astronomy, astrophysics, heliophysics and planetary science at space conferences and in industry publications.
- Leverage Maryland’s congressional delegation and the Federal Facilities Advisory Board to advocate for space science and earth science missions to be retained by NASA in the face of budget cuts, overseen by NASA Goddard and managed in Maryland.
- Develop space and earth science business cluster proposals to respond to funding opportunities from the U.S. Economic Development Administration and other agencies.

Recommendations – Earth Science

- Promote Maryland as the ideal location for climate information and research, building on an extensive network of operations, measurement, research and analysis across multiple agencies and research centers. Develop and brand the area around Goddard as a *Climate Corridor* for businesses engaged in climate research and the development of private sector products and services using climate data.
- Compete for the proposed national center of climate and environmental information to be located in Maryland. Work with local leaders and experts in climate change at the University System of Maryland (USM) and The Johns Hopkins University (JHU) to build a compelling case for the creation of such a center and to support its location in Maryland. Investigate models in related fields such as the National Weather Center at the University of Oklahoma.
- Building on the Memorandum of Understanding between Maryland and NASA Goddard, work with NASA, NOAA, USM, JHU and others to establish a Global Center of Excellence for climate research and product development to address environmental challenges using space-based resources (satellites, sensors and ground truth). Focus on the impact of climate change on the Chesapeake Bay as a model.
- Identify new capabilities for applying space and earth science knowledge which can benefit mankind and expand industries in agriculture, biotechnology, public health and other fields. Maryland has unique resources in these pursuits/areas, including the JHU Bloomberg School of Public Health, the National Institutes of Health (NIH), the USDA Beltsville Agricultural Research Center and the Food & Drug Administration (FDA).

2. Pursue Business Development Opportunities in Space and Earth Sciences and Technology Commercialization to Create New Products, Wealth and Employment

Federal assets are valuable in and of themselves, but the real opportunity lies in creating broader applications for the science they pursue and in generating new business.

Recommendations – Small Business & Commercialization

- Partner with NASA Goddard and TEDCO to establish a space-related business incubator adjacent to Goddard’s campus or the University of Maryland College Park (UMCP).
- Work with researchers and entrepreneurs from Maryland’s federal facilities and educational institutions to advance the commercialization of space industry technologies, products and services to foster innovation and startup companies.
- Support Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding from NASA and other space related agencies to Maryland’s small businesses.
- Work with the congressional delegation to explore a federally-chartered technology development authority to commercialize more NASA and other federally-owned technologies from federal laboratories.
- Identify opportunities for new space-related businesses and support their growth with seed funding, angel investors and venture capital. Utilize *InvestMaryland* to provide seed funding for emerging businesses that are developing products and services using climate data.
- Link small businesses to opportunities through the *Contract Connections* initiative.

Recommendations – Manufacturing, Robotics & Supply Chain Development

- Attract and extend NASA Goddard’s and NOAA’s supply chain related to space exploration, satellites, instruments and on-orbit services by increasing high-tech manufacturing in Maryland. Expand local awareness of supply chain requirements, making matches with Maryland companies. Encourage additional investment in production facilities by contractors to NASA and NOAA that are already located here. Maximize the manufacturing capability of existing private-sector production facilities in the state.
- Encourage Goddard to take a leadership role in the development of microsatellites in partnership with local education institutions. Leverage Goddard’s capabilities in this area to promote industry growth on the Lower Eastern Shore.
- Secure end-user lease agreements at NASA Goddard as a location for small manufacturers.
- Further develop the robotics expertise at Maryland’s academic and partner organizations – including JHU and APL – to serve as a model for future space and satellite servicing endeavors.

Recommendations – Satellite Servicing

- Build on the experience of servicing the Hubble Space Telescope and take advantage of growing opportunities to service and extend the life of existing and aging satellites.
- Promote hosted payloads that combine small loads and instruments in unified missions as a business opportunity for Maryland companies and universities.

3. Building on Wallops – An Opportunity for the Eastern Shore

The promising commercial space market presents a real opportunity for the Wallops Flight Facility and MARS. As one of the few U.S. spaceports licensed for commercial launch, MARS can compete for a share of the increasing market for commercial launches, representing a growth industry for the

Lower Eastern Shore. Other complementary activities at Wallops include the Research Range, FAA-certified runways, an experimental unmanned aerial vehicle (UAV) runway and a NOAA satellite receiving station.

Recommendations – Space Launch Services

- Develop the emerging Lower Eastern Shore cluster of space and defense businesses, emphasizing commercial launches from MARS, as well as the research range, mobile systems, UAVs and other aeronautical and space technologies.
- Aggressively market the assets and advantages of MARS to commercial space companies (for example, SpaceX and Bigelow Aerospace), capitalizing on planned launches to the International Space Station. Determine the necessary improvements to attract future launch capabilities at MARS. Double the annual number of launches from MARS by 2018.
- Lead regional economic development efforts on the Lower Eastern Shore to support Wallops. Engage the Greater Salisbury Committee and other local stakeholders in developing a long-term program plan to position Wallops as the premier spaceport for light- and medium-lift launches.
- Identify potential suppliers to the launch industry at MARS and work to attract the supply chain to the Lower Eastern Shore.
- Support local and regional efforts to invest in incubators, business parks or other facilities as the market for space-related contractor businesses develops.
- Encourage more linkages between Wallops and Maryland’s military facilities such as the Naval Research Laboratory and the Naval Air Station Patuxent River and academic institutions including the University of Maryland Eastern Shore (UMES).

4. Educate and Train People for Space and Earth Sciences Sectors

Consistent with STEM initiatives throughout Maryland’s technology sectors, build onto these existing efforts to prepare students for careers in space and Earth sciences.

Recommendations – Workforce and Education

- Support funding at USM institutions, the Historically Black Colleges and Universities and other Maryland-based institutions with an historic expertise in space science and earth science. Attract post-secondary degree scholars for space and satellite study and research.
- Coordinate state workforce development investments in STEM education with private sector initiatives of industry employers with the Governor’s Workforce Investment Board and the Maryland Space Business Roundtable.
- Develop a statewide middle and high school program to attract students to scientific fields related to the space industry. Partner with Maryland’s public schools system – the nation’s best – to develop a magnet high school focused on the space industry.
- Expand Maryland’s leadership role in space education through Goddard Space Flight Center, the STScI’s renowned Hubble Space Telescope education program, JHU’s Maryland Space Grant

Consortium, and not-for-profit entities such as the Association for Research in Astronomy and the Universities Space Research Association.

- Support the development of the proposed Maryland Science, Exploration and Education Center.

Maryland Space Pioneer

Robert Lee Curbeam, Jr. – A Baltimore County native and Naval Academy graduate, Curbeam received his B.S. in Aerospace Engineering and M.S. in Aeronautical Engineering from the Naval Postgraduate School and was selected as an astronaut in 1994. Over 13 years, this former naval captain completed three Space Shuttle flights and logged more than 900 hours in space. On mission STS-116, Curbeam became the first astronaut to complete four spacewalks during a single flight.

INTRODUCTION

For many people, the image of the space industry remains one of human space flight – the Space Shuttle and the International Space Station (ISS), or the Apollo program of the 1960s and 1970s. Large-scale spacecraft are highly visible, but represent only one part of the space industry. Today, satellites and unmanned exploration, scientific study of the Earth’s atmosphere, and satellite communications make up the majority of the government and commercial space industry.

The space industry comprises the products, services and technologies related to activity in outer space, as well as activities that occur on the ground and within the atmosphere that relate to outer space, such as propulsion systems, launch activities and ground stations.

For over 50 years, Maryland has been a hub for many of these operations – ground control systems and mission planning, systems engineering and network security – centered on Goddard Space Flight Center and NOAA. The Space Telescope Science Institute manages operations for the Hubble Space Telescope, carried into orbit by the Space Shuttle Discovery in 1990 and still going strong. STScI also manages operations for the Hubble’s successor, the James Webb Space Telescope. Scientists and engineers at JHU’s Applied Physics Laboratory have designed, built and launched 64 spacecraft and more than 150 instruments since 1959.

The foundation of Maryland’s space industry lies in its science. Researchers work with engineers, computer programmers and technologists to develop the cutting-edge technology needed for space-based research. Leading universities such as Johns Hopkins University, the University of Maryland, College Park, and the University of Maryland, Baltimore County (UMBC) have strong programs in scientific disciplines that support the space industry – astronomy, atmospheric sciences, physics and systems engineering. NASA Goddard is a major U.S. laboratory for developing and operating unmanned spacecraft, from the development of space systems and technologies to spacecraft design and building. Scientists at Goddard have developed more instruments for planetary exploration than any other organization, among them scientific instruments sent to every planet in the solar system.

Space science has become increasingly important in the quest for understanding the Earth and its life-sustaining environment. Maryland is growing center of activity in the growing realm of climate change research. NASA Goddard scientists advance understanding of the Earth and its life-sustaining

environment, the Sun, the solar system and the wider universe beyond. The research encompasses the global atmosphere, global oceans including sea ice, surfaces including snow and ice, and interactions among the atmosphere, oceans, land and ecosystems, including humans. NOAA collaborates with NASA to develop systems that help understand the role of the oceans, coasts and the atmosphere in the global ecosystem. NOAA also manages the nation's environmental satellite programs.

This report seeks to capture the primary activities in the space industry in Maryland and examine promising opportunities within the context of the national and international space industry.

INDUSTRY OVERVIEW

The space industry is still relatively young, having begun in the 1950s. For decades it was largely driven by government markets and manned space flight. While still substantial, government spending on space no longer accounts for the majority of economic activity. Commercial markets in communications and space-related services now drive the growth.

Size & Growth

As the world economy continued to emerge from the Great Recession, the space industry experienced steady growth in 2010. Worldwide economic activity attributed to the space industry reached \$276.52 billion in 2010, a 7.7% increase from 2009. The industry grew by 48% from 2005 to 2010, according to *The Space Report 2011* published by the nonprofit Space Foundation.

In 2010, U.S. government spending on space increased by only 0.3% over 2009, to \$64.63 billion, with the civilian market comprising approximately one-third (\$21.0 billion). The \$26.66 billion spent by the Department of Defense, coupled with spending estimates for the National Geospatial-Intelligence Agency, the National Reconnaissance Office and other agencies, bring the non-civilian total to \$43.66 billion – more than twice the civilian market.

Global Space Activity – Revenues & Budgets, 2010

| Activity | 2010 Revenues / Budget (\$B) | Percent |
|--|---|---------|
| Commercial Infrastructure and support industries | \$87.39 | 32% |
| Commercial Space Products and Services | \$102.00 | 37% |
| Commercial Transportation Services (personal spaceflight) | \$0.01 | <1% |
| U.S. Government Space Budgets | \$64.63 | 23% |
| <ul style="list-style-type: none"> • Department of Defense • National Reconnaissance Office • National Geospatial-Intelligence Agency • National Aeronautics and Space Administration • National Oceanic and Atmospheric Administration • All other agencies | <ul style="list-style-type: none"> \$26.66 \$15.00 \$2.00 \$18.72 \$1.40 \$0.86 | |
| International Government Space Budgets | \$22.49 | 8% |

Source: Space Foundation, *The Space Report 2011: The Authoritative Guide to Global Space Activity*, page 43, www.TheSpaceReport.org.

According to *The Space Report 2011*, nearly 260,000 were employed in the space industry in the U.S. in 2009. Salaries averaged \$92,553, more than double the average private sector salary of \$45,155. Maryland ranks third highest among states with an average space industry salary of \$110,614, more than double the private sector average.

Trends

- Growth in commercial space products and services
- Space technologies being utilized by other industries
- Program expansion by foreign governments
- Increasing activities in space by the military
- Space technologies adoption to support earth sciences
- Commercial human spaceflight

Perhaps no single development impacted the space industry as much as the recent shift in U.S. federal policy toward space. In February 2010 President Obama announced a proposal to cancel the Constellation program, NASA's latest human spaceflight initiative. That announcement, coupled with the Augustine Commission report in October 2009 and a new National Space Policy in June 2010, triggered tremendous uncertainty for an industry long used to predictability. With the FY2011 federal budget just enacted and FY2012 deliberations under way, private sector businesses are still reacting and adapting to a changing business landscape. The impact of these changes is being felt by several major contractors as well as certain states with traditional ties to NASA's launch and mission control flight centers – particularly Florida, Texas and Alabama.

MARYLAND'S SPACE INDUSTRY

Overview

Maryland's space industry is primarily based on science and research and, to a lesser degree, the defense, security and intelligence markets. The cancellation of the Constellation program had a lesser impact on the space sector in Maryland, as the state's space sector is less focused on these large-scale launch efforts. One noteworthy exception is the impact on ATK's Propulsion and Controls group in Elkton. ATK has manufactured solid rocket motors at the Elkton location for many years. As a result of the recent reduction in the number of launches by NASA and the defense and classified sectors, ATK laid off approximately 200 workers in 2010. A small number of NASA Goddard employees with direct responsibilities for the original Constellation program were moved to other projects.

Space Sectors in Maryland (as defined by the Space Foundation) with NAICS codes

- ✓ Search, Detection, Navigation, Guidance, Aeronautical and Nautical System and Instrument Manufacturing (334511)
- ✓ Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing (336415)
- ✓ Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing (335419)
- ✓ Satellite Telecommunications (517420)
- ✓ Space Research and Technology (927110)

Maryland Jobs & Wages

Using the Space Foundation's industry definition and 2009 data from the U.S. Bureau of Labor Statistics, Maryland's space industry employment and wages are estimated to be:

- 15,061 jobs
- \$1,626,940,997 in wages

By defining the space industry more broadly to include certain satellite communications and computer services companies, the total increases by several thousand jobs. Two notable examples include:

- Hughes Communications, which provides broadband satellite networks and services and employs 1,500 people in Maryland. Their primary industry classification is Broadcasting and Wireless Communications Equipment Manufacturing (NAICS 334220), which is not part of the Space Foundation definition.
- Integral Systems, which designs satellite command and control, data processing, flight simulation, integration and test, and signals analysis systems, employing 230 people at two locations in Maryland. Their primary industry classification is Computer Systems Designs Services (NAICS 541512), also not part of the Space Foundation definition.

Primary Space-Related Agencies

Among federal agencies with a Maryland presence are several with a direct interest in space including:

- National Aeronautic and Space Administration (NASA) Goddard Space Flight Center (Goddard)
- National Oceanic and Atmospheric Administration (NOAA)
- National Security Agency (NSA) – Fort George G. Meade

In addition, the NASA Wallops Flight Facility is located on Virginia's Eastern Shore, just outside the Maryland border.

NASA Goddard Space Flight Center (Goddard) – Established in 1959 as NASA's first space flight center, Goddard had a lead role in early stages of the manned flight program until certain functions moved to Houston. Goddard continued to provide computer tracking and radar tracking for manned missions. In the 1970s Goddard's focus turned to designing unmanned satellites and spacecraft for science research missions. Among its many accomplishments are the Hubble Space Telescope, the Earth Observing System (EOS) fleet of spacecraft, and the EOS Data Information System. Goddard has also developed more instruments for planetary exploration than any other organization, among them scientific instruments sent to every planet in the solar system. Goddard employs approximately 3,200 federal employees and 7,000 on-site contractors at its campus in Greenbelt. The campus covers 1,270 acres and contains over three million square feet of research and development and office space.

NASA Wallops Flight Facility is a rocket launch site and research center on the Eastern Shore of Virginia, approximately five miles south of the Maryland/Virginia border. Facilities include FAA-certified runways, an experimental UAV runway and a launch site with six launch pads, three blockhouses and assembly buildings. Wallops serves as NASA's premier suborbital research and launch center for sounding rockets, scientific balloons and aerostats. These activities support a variety of science experiments in heliophysics, earth science, atmospheric research, and microgravity science. Wallops has conducted 16,000 launches in its history. It is the only launch facility owned and managed exclusively by NASA.

National Oceanic and Atmospheric Administration – NOAA's campus in Silver Spring houses six offices, as well as the National Marine Fisheries Service, National Weather Service, Office of Oceanic and Atmospheric Research, National Ocean Service, Office of Marine and Aviation Operations, and the National Environmental Satellite, Data and Information Services (NESDIS). NESDIS is the largest civil operational environmental space agency and the most extensive holder of atmospheric and oceanographic data in the world. NESDIS provides timely access to global environmental data by managing 15 operational environmental satellites, providing data and information services and conducting related research. NOAA employs 5,300 people in Maryland, 3,200 of who work in Silver Spring.

Other facilities include the Satellite Operations Facility in Suitland (550 employees) and the Center for Weather and Climate Prediction in Camp Springs (800 employees), scheduled to move to a new 269,000 square-foot facility in Riverdale in 2012.

Other Notable Space Facilities

The Space Telescope Science Institute is a science operations center located at Johns Hopkins University in Baltimore. The Association of Universities for Research in Astronomy, a consortium of 37 U.S. and seven international organizations that operate world-class astronomical centers, operates STScI under contract to NASA. STScI's primary project is to manage operations for the Hubble Space Telescope and its successor, the James Webb Space Telescope. STScI currently employs over 400.

The U.S. Naval Research Laboratory Center for Space Technology supports a strong space technology base through the development and acquisition of space systems for naval missions. It has two facilities in Southern Maryland:

- Satellite Mission Analysis Facility, Pomomkey – High speed tracking antennae
- Blossom Point Satellite Tracking and Command Station – Provides engineering and operational support to several complex space systems for the Navy and other tenants

The United States Naval Academy is highly regarded for its engineering programs, ranking fifth overall in undergraduate engineering with programs in aerospace, electronics/communications and mechanical engineering. Over 50 U.S. astronauts graduated from the Academy – more than from any other undergraduate institution.

National security activities of the U.S. government in Maryland are not covered in this report.

Communications Cluster

Montgomery County is home to a vibrant cluster of satellite and communications companies including Comtech Mobile Datacom, DRS Signal Solutions, GE Satellite, GMV Space Systems, Hughes Communications, Intelsat General, IPX International Systems, Telesat, Vizada and XTAR. These companies sell products and services to federal agencies, defense and intelligence customers as well as to commercial markets.

MARYLAND'S STRENGTHS

Science & Research

The foundation of Maryland's space industry lies in its science. Leading universities such as Johns Hopkins University, the University of Maryland, College Park, and UMBC have strong programs in scientific disciplines that support the space industry – astronomy, atmospheric sciences, physics and systems engineering.

NASA Goddard Space Flight Center is a major U.S. laboratory for developing and operating unmanned spacecraft, from the development of space systems and technologies to spacecraft design and building. Goddard typically manages NASA's unmanned Earth observation missions and observatories. Goddard has developed more instruments for planetary exploration than any other organization, including scientific instruments.

Goddard's Sciences and Exploration Directorate is the largest earth and space science research organization. Its scientists advance understanding of the Earth, Sun, solar system and universe. Researchers work with engineers, computer programmers and technologists to develop the cutting-edge technology needed for space-based research. Instruments are also deployed on aircraft, balloons and Earth's surface. Their researchers share findings and data with the scientific community and public outreach programs communicate science to students and the general public.

Space Science at NASA Goddard

Goddard scientists developed the Wilkinson Microwave Anisotropy Probe (WMAP) to measure differences in the temperature of the Big Bang's remnant radiant heat, which quantified the age, content, history, and other key properties of the universe with unprecedented accuracy and precision. Recognized as the 2003 Breakthrough of the Year by *Science* magazine.

Astrophysics

The Astrophysics Science Division conducts a broad program of research in astronomy, astrophysics and fundamental physics. Individual investigations address issues such as the nature of dark matter and dark energy, which planets outside our solar system may harbor life, and the nature of space, time, and matter at the edges of black holes.

Observing photons, particles, and gravitational waves enables researchers to probe astrophysical objects and processes. Researchers develop theoretical models, design experiments and hardware to test theories, interpret and evaluate the data, archive and disseminate the data, provide expert user support to the scientific community, and publish conclusions drawn from research.

Heliophysics

The Heliophysics Science Division conducts research on the Sun, its extended solar-system environment (the heliosphere), and interactions of Earth, other planets, small bodies, and interstellar gas with the heliosphere. Division research also encompasses geospace – Earth's uppermost atmosphere, the ionosphere, and the magnetosphere – and the changing environmental conditions throughout the coupled heliosphere (solar system weather).

Scientists develop models, spacecraft missions and instruments, and systems to manage and disseminate heliophysical data. They interpret and evaluate data gathered from instruments, draw comparisons with computer simulations and theoretical models, and publish the results.

Planetary Science

The Solar System Exploration Division conducts theoretical and experimental research to explore the solar system and understand the formation and evolution of planetary systems. Laboratories investigate areas as diverse as astrochemistry, planetary atmospheres, extrasolar planetary systems, planetary geodynamics, space geodesy, and comparative planetary studies.

Division scientists develop theoretical models of how planetary systems form and evolve and design experiments and hardware to test them. They collect, interpret, and evaluate experimental data and publish research.

Selected Space Science Missions at NASA Goddard

Hubble Space Telescope (HST)

Goddard is responsible for HST project management, including mission and science operations, servicing missions, and all associated development activities.

James Webb Space Telescope (JWST)

JWST is a large, infrared-optimized space telescope, scheduled for launch in 2016. JWST will find the first galaxies that formed in the early Universe, connecting the Big Bang to our own Milky Way Galaxy. JWST will peer through dusty clouds to see stars forming planetary systems, connecting the Milky Way to our Solar System.

MESSENGER

Launched in 2004, the spacecraft was designed and built by The Johns Hopkins University Applied Physics Laboratory (APL) to answer key questions about Mercury. It successfully entered Mercury's orbit in March 2011.

New Horizons

Designed and built by APL and launched in 2006, NASA's New Horizons spacecraft will be the first to visit Pluto and its moon Charon in 2015.

[STEREO \(Solar TERrestrial RELations Observatory\)](#)

STEREO traces the flow of energy and matter between the Earth and Sun with two identically equipped spacecraft that provide revolutionary 3-D imaging.

[WMAP](#)

The Wilkinson Microwave Anisotropy Probe mission is designed to determine the geometry, content and evolution of the universe.

Research Centers for Space Science

[“The area between College Park, Greenbelt and Baltimore is the best area in the world for astronomy.” – Professor Stuart Vogel, Chair, Astronomy Department, University of Maryland, College Park.](#)

[University of Maryland, College Park](#)

- Constellation Universities Institutes Project (CUIP) – Led by Darryll Pines, Dean of the A. James Clark School of Engineering, CUIP is a consortium of 24 universities working a cooperative agreement with NASA to focus on addressing the technical challenges of the NASA Constellation program in six areas: thrust chamber assemblies, propellant storage and delivery, reentry aerothermodynamics, structures and materials for extreme environments, solids, and systems engineering and integration.
- Space Systems Laboratory – Centered around the Neutral Buoyancy Research Facility, the lab houses a deep water tank used to simulate the microgravity environment of space for undergraduate and graduate research. Research emphasizes space robotics, human factors, applications of artificial intelligence and the underlying fundamentals of space simulation.

[Johns Hopkins University](#)

- Scientists and engineers at JHU’s Applied Physics Laboratory have designed, built and launched 64 spacecraft and over 150 instruments since 1959. APL helped pioneer quick reaction spacecraft, invented many of the techniques now standard in today’s spacecraft, and developed entire space systems, such as the Navy Transit navigation system. Several important systems conceived and developed at APL have been transferred to industry for production. APL extended low-cost planetary mission methodology to such NASA missions as NEAR, ACE, MESSENGER and New Horizons. Programs in APL’s National Security Space business area focus on space solutions to critical military problems. APL develops and conducts innovative experimental missions, builds space instruments, and produces new applications to meet warfighter needs.

A nonprofit engineering, research and development organization, APL employs 5,000 people and generates \$1 billion in annual revenues. In addition to the space industry for both civil and national security clients, APL operates in business areas ranging from homeland protection and undersea warfare to missile systems and biomedicine.

- JHU is launching an initiative in space studies that will bring together its myriad efforts in space-related astrophysics, cosmology and planetary sciences, as well as climate and public health. The initiative will connect scientists, engineers and educators across the University, linking the Homewood campus (Arts and Sciences, Engineering), APL and the East Baltimore campus (Public Health, Medicine). Partner organizations will include the Space Telescope Science Institute, NASA Goddard, local space companies, the University System of Maryland and other universities.

Capitol College

The Space Operations Institute at Capitol College is a consortium of NASA, industry, government and education partners working to manage satellite operations and train students for space mission careers. SOI builds upon Capitol's established engineering foundation and works closely with NASA to understand the aerospace industry's changing skill requirements. Student-operated satellites are in extended mode operations; they have already met their primary objectives by NASA's terms, but are still healthy and capable of producing valuable scientific data. By allowing students to use "expired" satellites as learning tools, NASA saves millions of dollars by keeping projects going longer than anticipated while training the next generation of flight controllers and system engineers. SOI prolongs the satellites' operational life, provides data continuity and students receive hands-on training.

Morgan State University

Morgan State University's Center of Microwave, Satellite and RF Engineering (COMSARE) is a major research center in the School of Engineering that has an established legacy in the development of microwave and millimeter wave communication technology. COMSARE's research focuses on developing high frequency transistors, designing high-speed, low-power and high power monolithic microwave integrated circuits, and developing advanced CAD tools to strengthen device modeling capabilities and processes.

University of Maryland Eastern Shore (UMES)

Through its Maryland Hawk Corporation subsidiary for research and economic development, the University of Maryland Eastern Shore collaborates with local companies to create high-tech jobs on the Eastern Shore. UMES is planning to construct a new Aviation and Engineering Sciences building to support the aerospace industry. Future plans include a four-year program for unmanned air vehicles.

Joint Research Centers

- Bowie State University Satellite Operations and Control Center – A joint venture between Bowie, Goddard and Honeywell, this unique program features a training facility and mission control center for NASA spacecraft on the campus. Under the supervision of professionals, students participate in the daily satellite flight operation servicing and earn mission controller certification.
- Center for Research and Exploration in Space Science & Technology - Convenes Goddard researchers with scientists from UMCP, UMBC and the Universities Space Research Association (USRA) to strengthen minority and women student space science participation in neutron stars, black holes and extremely hot gas research.

- Joint Center for Astrophysics – A cooperative venture between UMBC and NASA’s Exploration of the Universe Division, faculty and students on both campuses conduct research, design and develop hardware and software, and calibrate instruments in a variety of astrophysical fields.

Earth Science at NASA Goddard

NASA conducts a research program to advance fundamental knowledge on the most important scientific questions about the global integrated earth system. NASA continues to lead the international scientific community to advance global integrated earth system science using space-based observations. The research encompasses the global atmosphere, global oceans including sea ice, surfaces including snow and ice, ecosystems, and interactions among the atmosphere, oceans, land and ecosystems.

The Earth Observing System (EOS) is a coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. EOS is a major component of NASA’s Earth Science Division. EOS enables an improved understanding of the Earth as an integrated system. Some of the EOS satellites such as GOES and POES are cooperative projects with NOAA.

Goddard recently introduced the NASA Center for Climate Simulation (NCCS), an integrated set of supercomputing, visualization and data interaction technologies that will enhance NASA’s capabilities in weather and climate prediction research. The new center more than doubles the computer capacity from just one year ago and expands other services to support NASA’s growing climate data needs.

Earth sciences budget

NASA’s earth sciences program is managed by the Goddard Space Flight Center. A renewed commitment to earth sciences with an emphasis on climate change increased NASA’s earth sciences budget from \$1.44 billion in FY2010 to \$1.8 billion in FY2011. This should generate greater economic activity at Goddard and represents an economic opportunity for Maryland.

Budget cutbacks have delayed earth science missions at Goddard, including:

- Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) – This mission combines two sensors that, taken together, provide observations important for solid-Earth (surface deformation), ecosystems (terrestrial biomass structure) and climate (ice dynamics).
- The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission will be a key component of the future climate observing system. NASA and NOAA share responsibility for CLARREO. The NOAA component involves measurements of incident solar irradiance and Earth energy. The NASA portion involves the measurement of spectrally resolved thermal IR and reflected solar radiation at high absolute accuracy. These measurements will provide a long-term data record for the detection, projection, and attribution of changes in the climate system.

Selected Earth Science Missions at NASA Goddard

EO-1

Earth Observing-1 mission developed techniques for space-based Earth observations.

GOES (Geostationary Operational Environmental Satellite)

GOES I-M satellites are the primary element of U.S. weather monitoring and forecast operations and are a key component of NOAA's weather service operations.

LandSat 7

LandSat 7 acquires images of the Earth's land surface and surrounding coastal regions.

Operation Ice Bridge

Six-year NASA field campaign is the largest airborne survey of Earth's polar ice ever flown and serves as a bridge between retiring satellite mission ICESat and its replacement ICESat-II is tentatively scheduled for launch in 2016.

Polar Operational Environmental Satellite (POES)

POES measures weather forecasts, monitoring severe storm movement, ozone levels, detecting forest fires and animal migrations patterns.

Tropical Rainfall Measuring Mission (TRMM)

TRMM is dedicated to examining rainfall in Earth's tropical and subtropical regions, which makes up two-thirds of Earth's total rainfall and is partly responsible for driving our weather and climate system.

Research Centers for Earth Science

- Earth System Science Interdisciplinary Center (ESSIC) – A collaborative effort between the UMCP's departments of Atmospheric & Oceanic Science, Geology and Geography and NASA's Earth Sciences Directorate. ESSIC scientists monitor and predict global climate changes by analyzing sophisticated satellite data that track sea surface temperatures, ozone levels, precipitation, infrared radiation, oceanic chlorophyll levels and more. The center's latest research focuses on predicting biological changes, such as emerging infectious diseases that result from complex interactions between the Earth's systems.
- Joint Global Change Research Institute (JGCRI) – The JGCRI, located at UMCP and affiliated with the Pacific Northwest National Laboratory (PNNL), brings together a multidisciplinary team of economists, social scientists, life and physical scientists, and business experts and engineers to assess the growth of atmospheric greenhouse gas and analyze technologies and policies for mitigating and reducing emissions. Its models are widely used by analysts and policymakers, including the Intergovernmental Panel on Climate Change, which shared the 2007 Nobel Peace Prize with former Vice President Al Gore.

- Joint Center for Earth Systems Technology (JCET) – The JCET operates under a cooperative agreement between UMBC and NASA Goddard. JCET meets the common interest of UMBC and Goddard to develop new technology for environmental remote sensing. Research focuses on themes which align with NASA's earth science interests: engineering, mesoscale atmospheric processes, climate and radiation, atmospheric chemistry and dynamics, hydrospheric and biospheric sciences, and solar system science including geodesy and geophysics.
- Goddard Earth Sciences and Technology Center (GEST) at UMBC – GEST is dedicated to furthering fundamental understanding of the coupled physical, chemical, and biological Earth systems and the effects of natural and anthropogenic changes upon the environment. This knowledge improves observations of, understanding of, and prediction capabilities for the Earth system, and fosters the development of sound environmental policy. GEST consortium institutions, led by UMBC, collaborate with Goddard's Earth-Sun Exploration Division to produce vital new knowledge and to attract and train the next generation of earth scientists.
- Goddard Earth Sciences Technology and Research (GESTAR) – Announced in 2011, GESTAR will facilitate experimental, analytical and theoretical research in support of NASA's earth and space science objectives. GESTAR will conduct research on all aspects of the Earth system, including its atmosphere, the biosphere, oceans and solid Earth. Led by the Universities Space Research Association of Columbia, other primary contractors include Johns Hopkins University, Morgan State University and I.M. Systems Group of Rockville.

National Carbon Monitoring System

The State of Maryland is leading the effort to provide the ability to scientifically collect, quantify, model and characterize greenhouse gas/carbon emissions and sequestration via the National Carbon Monitoring System (NCMS). Currently a pilot program, this effort brings together NASA Goddard Space Flight Center, the University of Maryland, College Park, and Greenbelt-based Stinger Ghaffarian Technologies (SGT), Inc. The NCMS project will provide the framework for implementing a timely certifiable forest-based carbon sequestration monitoring system that can deliver these data to the regulatory agency responsible for the monitoring, reporting and verification of carbon.

Greenhouse Gas Network

Over the next five years, Earth Networks will invest \$25 million to develop and implement networks that measure environmental factors such as air quality, water quality, wind and pollution. Based in Germantown, Earth Networks owns and operates WeatherBug.

Today, there are only a few dozen instruments dedicated to measuring greenhouse gas levels around the world. As a result, these emissions have largely been estimated rather than precisely measured. In contrast, by the middle of 2012 Earth Networks will have deployed 100 greenhouse gas measuring instruments, consisting of 50 in the United States, 25 throughout Europe and another 25 elsewhere around the world. These instruments will provide key data that can help explain the science behind carbon emissions and environmental patterns. Such data has the potential to:

- Create the first-ever baseline measurement of critical environmental factors
- Provide measurement, reporting and verification needed by the scientific community
- Permit governments and other organizations to be informed on current environmental observations
- Educate the general public about greenhouse gas emission levels

[“Maryland can lead the charge on climate change” – Eric Clemons, Vice President, SGT, Inc.](#)

NASA & NOAA

NOAA and NASA Goddard have enjoyed a close partnership for decades. Separated by only 13 miles of Maryland highway, NASA and NOAA collaborate to develop systems that help understand the role of the oceans, coasts and the atmosphere in the global ecosystem.

NOAA’s Silver Spring Campus includes the National Environmental Satellite, Data & Information Service (NESDIS), which operates and manages the nation’s environmental satellite programs. NASA Goddard develops the systems for these satellites – from research and development to manufacture and launch. Once launched, NESDIS operates the satellites by providing data and information services from these satellites. NESDIS also operates climatic, oceanographic and geophysical data centers, performs environmental assessments, and conducts related research. NOAA is considered to be NASA’s largest “outside customer” by a large margin.

NOAA operates two types of satellite systems:

- Geostationary Operational Environmental Satellites (GOES) circle the Earth in a geosynchronous orbit at the equator 22,300 miles above the Earth. This allows them to continuously hover over one position. GOES satellites support weather forecasting, severe storm tracking and meteorological research. NOAA currently operates five GOES satellites.
- Polar Operational Environmental Satellites (POES) circle the Earth in a north-south orbit, passing close to both poles at 540 miles above the Earth. They track atmospheric variables in support of

long-term forecasting. Data provided by polar orbiters include visible and infrared radiometer data, atmospheric data, ozone levels, and cloud images. NOAA currently operates five polar orbiters.

[“The United States will accelerate the development of satellites to observe and study the Earth’s environment, and conduct research programs to study the Earth’s lands, oceans and atmosphere.” – U.S. National Space Policy fact sheet, June 28, 2010.](#)

Next Generation of Satellites

Geostationary Operational Environmental Satellite R-Series (GOES-R) – A collaborative effort between NASA and NOAA, the GOES-R satellites will be comprised of improved spacecraft and instrument technologies. This will result in more timely and accurate weather forecasts, and improve support for the detection and observations of meteorological phenomena that directly affect public safety and protection of property.

The GOES-R ground system will be installed and operated at the NOAA Satellite Operations Facility in Suitland. Primary GOES-R contractors include Lockheed Martin, Harris and Raytheon. The first launch of the GOES-R series satellites is scheduled for 2015.

Joint Polar Satellite System (JPSS) – Another collaborative effort between NASA and NOAA is developing new polar-orbiting satellites. JPSS will continue to address NOAA’s requirements to provide global environmental data used in weather prediction models, as well as provide space weather observations. Like the current generation of POES satellites, NASA will partner with NOAA to develop and procure the new system. Goddard is now gearing up for JPSS, recently hiring 300 people. Due to a lack of space on the Goddard campus, a 120,000 sq. ft. building was leased for the JPSS program. When fully operational, JPSS will be managed from NOAA’s Satellite Operations Facility in Suitland.

Funding increases sought in FY2011 for JPSS were unsuccessful, and funding continued at the FY2010 level of \$382 million. For FY2012, the Administration’s request for JPSS is \$1.07 billion. NOAA believes the earliest it can launch the first satellite (JPSS-1) is September 2016 – not 2014 as originally planned – and possibly as late as 2018 if no funding increases occur. A delay in the launch of JPSS would likely lead to a gap in weather coverage of at least 18 months. Alternatively, NOAA now plans to launch a stopgap weather satellite in October 2011 with a five-year life span.

National Center of Climate & Environmental Information

A concept now under discussion is a federal climate service which would unite climate research elements from multiple agencies and departments in a single organization. One model favored by many in the scientific community calls for a not-for-profit, non-governmental research institute with NOAA as the lead agency providing oversight and control on behalf of other federal agencies such as NASA, Energy, USGS, Interior, EPA, and Agriculture. Future coordination could include Homeland Security, Defense, intelligence agencies, and the diplomatic corps.

A possible model for an interagency climate center is the National Weather Center at the University of Oklahoma. Located in a 5-story, 250,000 square-foot building on 22 acres, the center generates a \$45 million annual economic impact and employs 650 people, including research scientists, meteorologists and climatologists, engineers, technicians, support staff, and graduate and undergraduate students.

While this presents a significant opportunity for Maryland's earth and atmospheric sciences community, California, Colorado, North Carolina and other states are very interested in hosting such an organization. Maryland should pursue the non-profit, interagency research institute and make Maryland the center for research on climate and climate change.

Space Telescope Science Institute

One of NASA Goddard's most visible and successful undertakings is the Hubble Space Telescope (HST). Carried into orbit by the Space Shuttle Discovery in 1990, the HST is still going strong and is expected to continue at least through 2015 and possibly as long as 2020.

The operations center for the Hubble Space Telescope is located at the Space Telescope Science Institute (STScI) on the main campus of Johns Hopkins University in Baltimore. STScI was created in the 1950s by the Association of Universities for Research in Astronomy (AURA), a consortium of 37 U.S. and seven international organizations that operate world-class astronomical centers. AURA operates the STScI under contract to NASA. The Baltimore location was chosen in 1980. Total staff at STScI currently exceeds 400, many of whom are scientists holding Ph.D. degrees. STScI is considered the pre-eminent institution for science operations of major space observatories and scientific research.

The STScI conducts all activities required to select, schedule, and implement the science programs of HST. The Institute receives approximately 3,000 proposals annually for observing time on HST; only about 10% are selected for implementation. The HST project produces a strong return on investment for NASA, comprising 5% of NASA's science budget, but producing 30% of its science findings. Even after HST no longer transmits, its legacy archive of data will continue to have value to researchers.

The successor to the Hubble Space Telescope will be the James Webb Space Telescope (JWST). Scheduled for launch in 2016, the primary scientific goal of JWST is to observe the most distant objects in the universe beyond the reach of either ground-based instruments or Hubble. As with Hubble, STScI will function as the science and operations center. STScI will take on the additional responsibility for command and control functions of JWST, a function currently handled for Hubble by the Goddard Space Flight Center. As a result, STScI anticipates hiring approximately 100 people over the next few years as it gears up for JWST.

Wallops Flight Facility

“Inexpensive access to space is in the best interest of the scientific community and the nation. With that in mind, launches, particularly small to medium class launches from WFF, are a good thing for us. There is a tremendous opportunity for more science at lower costs.” – Nancy Abell, Associate Director, NASA Goddard Space Flight Center.

Wallops Flight Facility (WFF) is a rocket launch site and research center on the Eastern Shore of Virginia. Founded in 1945 by a predecessor agency of NASA, it is operated by Goddard. WFF is located near Wallops Island in Accomack County, Virginia, approximately 40 miles southeast of Salisbury, Md., and five miles south of the Maryland/Virginia border. WFF consists of three separate parcels: the Main Base, the Mainland and the Launch Site. The launch site is approximately seven miles south of the Main Base.

Facilities & Activities

The primary facilities include FAA-certified runways, an experimental UAV runway, and crash, fire and rescue services. WFF has facilities for the receipt, inspection, assembly, checkout, and storage of rocket motors and other hazardous pyrotechnic devices. The Wallops Island Launch Site includes six launch pads, three blockhouses for launch control, and assembly buildings to support the preparation and launching of suborbital and orbital launch vehicles.

The Wallops Research Range includes ground-based and mobile systems, and a range control center. Its radar facilities and systems are used for tracking and surveillance. Telemetry facilities include a variety of antennas, receivers, and display instrumentation systems. Command uplink and optical tracking facilities are included as part of the range. The range also provides premier digital photographic and video services including operation of numerous still cameras, high speed and video systems for Range Safety support, surveillance, and post-launch analysis (e.g., failure analysis); project documentation (e.g., fabrication and test; administrative documentation; and archiving for environmental studies. In addition, WFF has a variety of communications systems and facilities to route voice, video and data in support of launch processing, flight and test operations.

Wallops serves as NASA’s premier suborbital research and launch center. Launch activities include sounding rockets, scientific balloons and aerostats. These activities support a variety of science experiments in heliophysics, earth science, atmospheric research, and microgravity science. Wallops has conducted 16,000 launches in its history. It is the only launch facility owned and managed exclusively by NASA. Direct control by NASA means a high degree of certainty for scheduling commercial launches.

Other tenants and activities at Wallops Flight Facility include:

- NOAA Wallops Command and Data Acquisition Station (WCDAS) – The primary receiving station for data from NOAA’s environmental satellites, WCDAS also plans, designs and implements system modifications, and tests and evaluates new systems and techniques for satellite tracking and

communications. WCDAS has 16 satellite antennas at present, and by 2015 will add 10 more in support of NOAA's GOES-R program.

- Naval Surface Combat Systems Center (SCSC) – Includes the Advanced Electronic Guided Interceptor System (AEGIS) Engineering and Training Complex and the Ships Self Defense Systems Facility. Training center for combat systems of all operational cruisers, destroyers, aircraft carriers and landing ships.
- U.S. Coast Guard – Helicopter and airplane refueling base for Atlantic Ocean search and rescue operations.

Mid-Atlantic Regional Spaceport

One of four U.S. spaceports that are licensed for orbital access, the Mid-Atlantic Regional Spaceport (MARS) was created in 1997 on land leased from NASA at the southern end of the Wallops Flight Facility. Originally established by the Virginia Commercial Space Flight Authority, the spaceport was joined by the State of Maryland in 2002. A commercial space launch facility with two launch pads, MARS is capable of handling light and medium lift launches. MARS offers "one-stop shopping" space launch services for commercial, government and academic users. The ultimate goal of MARS is to promote commercial launch activities at Wallops. MARS conducted its first launch in December 2006.

Orbital Sciences

In 2006 NASA announced the Commercial Orbital Transportation Services (COTS) program to coordinate the delivery of cargo and crew to the International Space Station (ISS) following the conclusion of the Space Shuttle program. In 2008 NASA selected two companies – Orbital Sciences Corporation and Space Exploration Technologies Corporation ("SpaceX") to Commercial Resupply Services (CRS) to the ISS.

Orbital Sciences' contract is worth \$1.9 billion. The company will perform nine space shots over the next three years, launching from MARS at the Wallops Flight Facility. The first demonstration launch using Orbital's Taurus II rocket is scheduled for December 2011. Eight unmanned cargo launches will follow, beginning in 2012. The Taurus II is bigger than any of the thousands of rockets that have launched from Wallops.

Space X will perform 12 space shots using its Falcon 9 rocket, launching from Cape Canaveral in Florida.

A public-private partnership between NASA, the Virginia Commercial Space Flight Authority, the State of Maryland and Orbital Sciences is funding improvements to MARS. Approximately \$97 million is being invested in a new launch pad, a liquid fueling facility, and other capital improvements. Just completed at Wallops is the new Horizontal Integration Facility. Measuring 250' long, 150' wide, and 60' high and featuring 70-ton and 50-ton bridge cranes, it is capable of assembling two Taurus II rockets simultaneously.

Wallops Advantages

Rockets launched from Wallops head south over the Atlantic Ocean as they travel over the southern hemisphere. Launches from Florida must travel north and cross over Europe before reaching orbit. It is believed that the cost of insuring launches over water is less than over land, providing a cost advantage for Wallops.

The location of the Wallops Flight Facility is considered advantageous for reaching the International Space Station. At an orbit inclination of 51 degrees, the ISS can be reached with less fuel from Wallops than from Florida, a significant advantage for mid-sized scientific payloads.

Economic Impact

The Business, Economic and Community Outreach Network (BEACON) at Salisbury University recently released an economic impact study of the activities at Wallops Island. BEACON found a total economic impact of \$188.3 million and 2,341 total jobs for the Lower Eastern Shore region. The total fiscal impact to the region was of \$7.1 million state and local, and \$5.8 million federal.

This cluster of high technology jobs is the largest on the Delmarva Peninsula between Wilmington, Delaware, and Norfolk, Virginia – a stretch of 235 miles. The growth and development of MARS as a viable launch site for commercial launches is now giving rise to a growing cluster of support services around Salisbury, Pocomoke City and Princess Anne in Maryland.

In addition to the University of Maryland Eastern Shore, notable assets for the continued growth and development of this cluster include:

- Hawk Institute for Space Sciences – Hawk provides aerospace engineering services for space applications, with focus areas that include launch services, small satellite design, unmanned aircraft systems, and workforce development training.
- Mid-Atlantic Institute for Space and Technology (MIST) – MIST is a nonprofit organization dedicated to growing the aerospace industry in the region’s vision of low cost, rapid response, space access and utilization. Funded through a cooperative agreement with the Wallops Flight Facility, MIST undertakes projects that contribute to its objectives in technology development, workforce development and regional economic development. Active with STEM initiatives, MIST has won awards from NASA for both its “Reach for the Stars” program targeting middle school students, and the STEP-UP (Science, Technology and Engineering Pipeline for Underserved Populations) intern program for local high school and college students.

Columbia, Maryland-based LJT & Associates recently won a \$117 million contract to provide support services to Wallops Flight Facility. LJT will provide personnel, equipment, tools, materials, vehicles and other services to support operations and maintenance at Wallops.

Opportunities

The promise of a developing commercial market is an opportunity for the Wallops Flight Facility. The potential growth of commercial markets also could provide a means of diversifying away from the

government markets which currently dominate Maryland's space industry. Maryland should continue to work with space industry stakeholders and help facilitate the growth and development of commercial and other new market opportunities at Wallops.

- More cargo launches to the ISS – The International Space Station is expected to continue through 2020. Successful launches by Orbital from the Mid-Atlantic Regional Spaceport over the next three years should position MARS to continue as a launch site to the ISS beyond Orbital's initial contract.
- Other launch service providers – As one of the few commercial launch facilities in the United States, MARS may hold interest for Space Exploration Technologies (SpaceX), United Launch Alliance (a joint venture of Boeing and Lockheed Martin), and other companies as a potential launch facility.
- Bigelow Commercial Space Station – A private space station being developed by upstart Bigelow Aerospace is scheduled for launch in 2014. While Bigelow has used launch sites in Florida, California and Russia, Bigelow is said to have interest in the MARS launch site for its space station.
- Operationally Responsive Space Office (ORS) – A joint project of several agencies within the U.S. Department of Defense, ORS was established in 2008 and focused on smaller satellites and quick-response launch vehicles. ORS has launched three spacecraft from Wallops Flight Facility, with a fourth scheduled for the summer of 2011. This could be a growth market for Wallops.
- Space Tourism – With larger rockets being launched from Wallops/MARS, there is growing interest cultivating tourists to view launches. Tourism officials from Maryland and Virginia are jointly working on strategies to attract tourists to the area.

Emerging Space Industries

“Maryland is already well-positioned in space, between NASA Goddard, NOAA, JHU/APL and major research universities. But by carefully adding other regional assets – like the Department of Agriculture and the Bloomberg School of Public Health -- Maryland could take things to a whole new level in monitoring and addressing the problems resulting from climate change.” – Dr. John Sommerer, Chief Technology Officer, Johns Hopkins University Applied Physics Laboratory

While Maryland's space industry is centered on NASA and NOAA, future growth in the industry is expected to come from the commercial market. New industries are poised to emerge as data and knowledge from space and earth science is applied to other disciplines.

Given the proximity of NASA and NOAA to major universities and federal labs, opportunities to make connections abound in a variety of fields:

- Agriculture – Explore synergies with the USDA Beltsville Agricultural Research Center and the Food and Drug Administration.
- Biotechnology – Research and drug development in a weightless environment.
- Public health – Explore synergies with the JHU Bloomberg School of Public Health and the National Institute of Health.

Weather & Climate Data

“The challenge and opportunity for Maryland is for the many current and potential contributors to work together to take things to a whole new level in monitoring and addressing the problems resulting from climate change — we could make Maryland the ‘capital’ of Earth Science.” – Dr. John Sommerer, Chief Technology Officer, Johns Hopkins University Applied Physics Laboratory.

Nowhere is this more evident than with earth sciences and climate change. With a renewed emphasis on earth sciences and increasing concern over global climate change, Maryland’s position as the hub for climate data research – including carbon monitoring and greenhouse gas measurements – presents an opportunity for new businesses to emerge to translate this data into commercial products and services.

One success story using weather and climate data is Global Science & Technology in Greenbelt. After working primarily as a NASA contractor, Global has developed a niche converting weather and climate data from satellites to images for commercial customers and other national governments. Global has annual revenues of approximately \$200 million and employs 60 people.

“The University of Maryland, College Park, is a top school in atmospheric sciences. Our partnership with them and NASA Goddard provides NOAA the ability to provide timely weather data to the country.” – Charles S. Baker, Deputy Assistant Administrator, NOAA NESDIS.

Satellite Servicing

The Hubble Space Telescope (HST) is one of NASA Goddard’s most visible and successful undertakings. Goddard is responsible for overall HST project management, including mission and science operations, servicing missions and all associated development activities. Five servicing missions from 1993 to 2009 developed Goddard’s expertise in servicing an observatory in low Earth orbit.

With hundreds of government and commercial satellites in orbit, there is growing interest in extending the life of satellites through in-orbit servicing, repairing and refueling. NASA Goddard recently completed an On-Orbit Satellite Servicing Study Project Report on the feasibility and cost of in-orbit satellite servicing. The study concluded that “viable plans can be put in place to develop a meaningful on-orbit satellite servicing capability...using today’s technology with current and projected launch systems.”

Some companies are already planning for this market. Intelsat is working with MacDonald, Dettwiler and Associates on a Space Infrastructure Servicing vehicle that could be ready to launch in 2015.

Satellite servicing is increasingly viewed as an emerging industry and – with Maryland being well positioned by virtue of Goddard’s experience with Hubble -- this could represent an opportunity for the state. Maryland should also work with this industry to encourage standardization that would allow for the establishment and growth of the satellite repair/services industry.

Hosted Payloads

Hosted payloads are modules on a commercial satellite that are made available to third parties but share the satellite's power supply and transponders. Instead of individual launches for specific payloads, satellite operators can specialize in launching a "constellation" of satellites and make modules available to customers, both commercial and government. The U.S. National Space Policy in 2010 called for federal departments and agencies to "work jointly to acquire space launch services and hosted payload arrangements that are reliable, responsive to United States Government needs, and cost-effective."

Iridium Communications is planning a constellation of 66 low-Earth orbiting satellites and reserving space on each for third-party payloads. Launches are planned beginning in 2015. Seeing an opportunity to develop a global Earth-observation network, the geosciences community is organizing a "GEOscan" network for consideration by the National Science Foundation. Just recently a GEOscan workshop in Maryland was organized by APL to gather ideas, proposals and feedback for selecting scientific goals and the sensors and measurements to accomplish them.

Communications Cluster

Montgomery County is home to a vibrant cluster of satellite and communications companies that sell to federal agencies, defense and intelligence customers, as well as to commercial markets.

The largest of these is Hughes Communications and its wholly owned subsidiary Hughes Network Systems, both headquartered in Germantown. With 1,500 employees in Maryland, Hughes is the world's leading provider of broadband satellite networks and services for large enterprises, governments, small businesses, and consumers. Hughes bridges satellite and terrestrial technologies and has shipped 2.2 million systems to customers in over 100 countries. The company operates on multiple satellites globally, including its award-winning SPACEWAY® satellite, the world's first with on-board switching and routing, which is used to deliver the highest speed satellite Internet plans available in North America. Hughes is currently building its next-generation JUPITER™ high throughput satellite – a platform with over 100 times the capacity of today's conventional satellites – for launch in 2012.

Satellite communications plays a critical role in the lives of people affected by disasters such as the 2010 earthquake in Haiti. Non-profit medical rescue organizations equipped Haiti's State University Hospital with a Hughes emergency communications satellite system. To this day, the hospital continues to use the Hughes telemedicine solution to enable consultation with specialists.

Hughes was awarded \$58.7 million in funds as the only national provider of high-speed satellite internet service under the American Recovery and Reinvestment Act of 2009. The award was part of the U.S. Department of Agriculture's Rural Utilities Service that will expand broadband access to rural communities. The high-speed Internet infrastructure will help bridge the technology divide in rural communities and support improvements in education, health care and public safety.

Selected Satellite & Communications Companies in Montgomery County

- Comtech Mobile Datacom – Asset tracking, messaging solutions, network services; integrates network services, platform products, features and capabilities for military, government and commercial customers
- DRS Signal Solutions – “Open architecture” tuners, receivers, recorders and geolocation systems
- GE Satellite – International fixed satellite services
- GMV Space Systems – Ground control systems for commercial telecommunications operators
- Hughes Communications – World’s leading provider of satellite networks and services
- Intelsat General – Provides leading-edge, fixed and mobile, end-to-end communications solutions for military, commercial and government customers; operates a fleet of 50 satellites, eight teleports and extensive fiber infrastructure; major supporter of U.S. armed forces.
- IPX International Systems – Global satellite, IT and applications service provider delivering and supporting turnkey total telecommunications and IT solutions for voice, data and video
- Telesat – Fixed satellite services operator providing reliable and secure satellite-delivered communications solutions to broadcast, telecom, corporate and government customers; global state-of-the-art fleet of 12 satellites and two additional satellites under construction, and manages the operations of 13 additional satellites for third parties; a subsidiary of Loral Space & Communications
- Vizada – Global satellite communications with more market share on more satellite networks than any other satellite communications provider in the world
- XTAR, LLC – commercial services in the X-band frequency (7.25-8.4 GHz) through two owned and operated satellite payloads; exclusively dedicated to serving the long-haul communications needs of U.S. and Allied military and government organizations.

To encourage the continued growth and development of the satellite-based communications industry, Maryland should:

- Support and engage in the National Export Initiative and Export Control Reform process to promote federal policies to enhance the global competitiveness of the industry;
- Support activities and funding for federal agencies that rely on and procure bandwidth from commercial satellites; and
- Support the development and implementation of neutral policies for communications technologies across multiple platforms (satellite; broadband).

Workforce & Education

"Maryland has a highly educated and trained workforce responding to many high performance challenges and exciting programs in the space industry." – John Mace Grunsfeld, Deputy Director, Space Telescope Science Institute

Maryland has more than 10,000 jobs in occupations traditionally associated with the space industry. With the highest concentration of astronomers in the country – 11 times the number of astronomers as compared to the national average – it is easily the top state on a per capita basis. The state ranks second in the concentration of physicists - 3.5 times the national average.

Maryland Employment in Space Industry Occupations, 2009

| Occupation | Employment | Mean Salary |
|---|---------------|------------------|
| Aerospace and Operations Technicians | 250 | \$60,980 |
| Aerospace Engineers | 2,690 | \$115,310 |
| Astronomers | 270 | \$128,520 |
| Atmospheric and Space Scientists | 400 | \$109,530 |
| Avionics Technicians | 340 | \$54,070 |
| Chemical Engineers | 660 | \$98,750 |
| Materials Engineers | 560 | \$108,840 |
| Materials Scientists | 210 | \$92,670 |
| Mechanical Engineers | 5,090 | \$89,410 |
| Postsecondary Atmospheric, Earth, Marine and Space Science Teachers | 70 | \$100,780 |
| TOTAL | 10,290 | \$100,103 |

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics, May 2009.

Several Maryland companies in the space industry expressed concern over the aging workforce. Data from The Space Foundation show significantly higher-than-average concentrations of NASA civil servants in the age range between 45 and 54 years. The private sector space workforce peaks in the age range between 50 and 59 years. This will result in a large number of retiring workers by the early-to mid-2020s. To address this concern, many companies have adopted/instituted STEM (Science, Technology Engineering and Mathematics) initiatives as a means of ensuring their future workforce. Maryland should insure that state-led STEM initiatives complement these private sector efforts.

On the Horizon: Maryland Science, Exploration and Education Center (SEEC)

To be located at Goddard, SEEC is envisioned as a state-of-the art venue that will serve as a national and regional destination attracting 350,000 visitors annually. The Center will be developed in partnership with the non-profit Maryland SEEC at Goddard Inc. SEEC is planned as a 120,000 square-foot facility offering visitors the experience of exploring NASA's work and building and testing spaceflight hardware. SEEC will also include a 4-D theatre, creating an immersive and authentic "you are there" experience. Key milestones include a capital campaign beginning in 2011, groundbreaking in 2014 and opening in 2016. Total capital costs are estimated at \$173 million. Once opened SEEC will have a staff of 60.

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