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Aerospace in Virginia: An Opportunity for Economic Growth (HJR 97/SJR 97, 2016)

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AEROSPACE IN VIRGINIA:

An Opportunity for Economic Growth

Committee on the Commonwealth's Aerospace Industry

of the

Virginia Academy of Science, Engineering, and Medicine

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The Virginia Academy of Science, Engineering, and Medicine

The Virginia Academy of Science, Engineering, and Medicine is a nonprofit organization consisting of members of the National Academy of Science, National Academy of Engineering and Institute of Medicine who reside or work in Virginia.

VASEM's mission is to assist the Commonwealth of Virginia by serving as an intellectual resource to inform and educate agencies on issues for which science, engineering, and medicine affect decisions on policy, on the economy, and on quality of life. The organization will promote research, foster interchange between individuals and organizations, and recognize and honor individuals in the Commonwealth who have made major achievements in science, engineering, and medicine.

Preface

The Virginia General Assembly Joint Commission on Technology and Science (JCOTS), which is made up of House and Senate members, asked the Virginia Academy of Science, Engineering, and Medicine (VASEM) to conduct a study of the aerospace industry in Virginia and identify areas with potential for economic development. VASEM formed the Committee on the Commonwealth's Aerospace Industry to identify growth areas, document important assets in each one, and highlight best practices of competitor states, all with the aim of informing Virginia's economic development efforts.

The committee is grateful for the support it received from the MITRE Corporation, Virginia Commonwealth University, and the University of Virginia, which allowed the committee to host meetings in their facilities. The committee would also like to thank participants from the following organizations who shared their views: Accomack County, Advanced Aircraft Company, Aerojet Rocketdyne, Blue Origin, Hampton Roads Military and Federal Facilities Alliance, KPMG, Mid-Atlantic Aviation Partnership, National Institute of Aerospace, Offices of the Secretaries of Technology and Transportation, OmniEarth, Orbital ATK, Peninsula Technology Incubator, Rolls-Royce, Virginia Commercial Space Flight Authority, Virginia Department of Transportation, Virginia Economic Development Partnership, Virginia Tech, and Wallops Island Regional Alliance (see Appendix B for a list of presentations and interviews).

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Executive Summary

SECTION 1. OPPORTUNITIES IN AEROSPACE

Aerospace represents a promising avenue for economic development in Virginia. The area is currently a source of well-paying jobs that pay substantially more than the average state wage, and it directly and indirectly supports close to 30,000 Virginia workers. Aerospace is also an industry that is growing, particularly in two areas—commercial space and unmanned aerial systems (UAS).

Commercial transportation of cargo and crew to the International Space Station (ISS), direct-to-home television services, communications, Earth observation, geo-location services, and global navigation services—and possibly space tourism—are the primary drivers of growth in commercial space. This growth, in turn, is leading to demand for launch facilities, ground stations and equipment, satellite manufacturing, and a host of services. SpaceX, Blue Origin, Virgin Galactic, Orbital ATK, and Bigelow Aerospace are examples of approximately two dozen companies working in this area. There is considerable discussion of the commercialization of low-earth orbit after the retirement of the ISS and extensive operations in cislunar space, the region between the Earth and the moon.

> **Finding 1.1. Commercial space and related support services present an opportunity for high-quality jobs and substantial economic growth. Commercial space involves high-value products that require a well-educated, specialized workforce. It encompasses such activities as crew and cargo transportation services, space stations, launch services, spacecraft, ground systems, and information technology.**

The UAS industry is in an earlier stage of its lifecycle, but the prospects here are excellent as well, pending the effective integration of UAS into the National Airspace System, a process that is under way at the Federal Aviation Administration (FAA). Opportunity lies with high-end vehicles, which the FAA projects will grow dramatically from 1,300 units in 2016 to 52,000 units in 2020, and systems and services for low-end UAS. Demand for these units will come from companies like Google and Amazon as well as from users in sectors like infrastructure monitoring and inspection. In addition, the military is expected to continue investing heavily in various UAS, from UAS swarms to massive aircraft like the Navy's MQ-4C Triton. There will be opportunities to service and support this diverse and complex fleet.

> **Finding 1.2. The UAS manufacturing market and the market for services built upon them is at a point of explosive growth. States that emerge as centers for commercial UAS development and application will reap the benefits of high-paying jobs, additional tax revenue, and economic growth far into the future.**

At the same time, the military market for drones and their services is evolving rapidly, creating significant opportunities for support and supply chain services.

Virginia is not the only state that has recognized these two aerospace areas. States like Alabama, Colorado, Florida, and Texas have focused on commercial space, and there are centers for UAS development in states like California, Florida, New York, North Dakota, Ohio, and Texas. For Virginia to capture the benefits of this growth, it must act quickly.

Finding 1.3. A number of other states are already investing heavily in commercial space and UAS across the country. Virginia must act quickly before the window of opportunity closes.

Recommendation 1.1. Virginia must act immediately to establish the two most promising growth areas in aerospace—commercial space and unmanned aerial systems (UAS) and their applications—as a primary focus of economic development. This is essential to positioning Virginia as an aerospace state, one that is high on the list of locations for aerospace companies.

SECTION 2. VIRGINIA AEROSPACE INFRASTRUCTURE AND ECONOMIC DEVELOPMENT

a) Virginia Aerospace Assets

Over the last decade, there has been a dramatic increase in commercial space activity, fueled in large part by the opportunities private industry sees in space-based services, from Internet access to data generation. The initiatives founded by billionaire entrepreneurs—SpaceX (Elon Musk), Blue Origin (Jeff Bezos), and Virgin Galactic (Richard Branson)—are only the most visible manifestations of broad-based response to this demand.

Two areas of particular potential are providing NASA with commercial launch services to the ISS and low-earth orbit systems of the future. There are several companies competing to serve these markets, including such stalwarts as the United Launch Alliance (a joint venture between Lockheed Martin and The Boeing Company), SpaceX, Sierra Nevada Corporation, and Orbital ATK. In the future, cislunar space can be a major market.

The current lineup of companies serving the commercial space market creates the false impression that the opportunities in space have all been taken. Nothing could be further from the truth. As the industry matures, it is likely to grow as companies focus on niche markets while others consolidate in an effort to offer a broad range of service, orbits and transport specialties. A critical bottleneck is availability of suitable launchpads. With its Mid-Atlantic Regional Spaceport (MARS) on Wallops Island, Virginia has a foundation that could position it to capture a substantial share of these opportunities.

Virginia also has a considerable number of high-end commercial space assets, which range from NASA facilities to major commercial companies to universities with space-related

research and education programs, but coordination occurs at best on a local level or on an *ad hoc* basis. There is no Commonwealth-wide master plan for strengthening commercial space assets.

> **Finding 2.1. Virginia possesses a number of distinct advantages to support the development of commercial space initiatives. These include the Virginia Commercial Space Flight Authority and the Mid-Atlantic Regional Spaceport, two major NASA facilities, Department of Defense (DoD) and intelligence agencies with active space programs, major commercial space corporations, and leading universities and public/private consortia engaged in space-related R&D and education. However, these advantages are not coordinated in a way to maximize their potential.**

Unmanned vehicles and systems are in the early stages of their development. The FAA, NASA, and universities are working in tandem with private industry to overcome hurdles to widespread deployment. For instance, FAA's UAS Focus Area Pathfinders initiative is exploring how UAS might be safely used in populated areas and addressing some of the command-and-control challenges of using UAS beyond visual line of sight (BVLOS) in rural areas.

As these challenges are solved and regulations allow for BVLOS operations as well as the control of multiple unmanned aerial vehicles by a single pilot, demand for commercial UAS will soar. Attention will turn to improvements in platforms and to meeting demand for supporting services such as software applications, sensors, advanced manufacturing, data services, and cybersecurity.

Currently, Virginia has assembled a number of assets that it could use to position itself, during this critical phase leading up to UAS industry maturity, as a center for UAS development and application. In 2015, the Commonwealth established the Virginia Unmanned Systems (UMS) Commission to identify the state of the UMS industry in Virginia, pinpoint challenges and needs of the industry that may be met with Virginia assets, provide recommendations that will encourage its development, and establish a value proposition that will position Virginia for emerging needs and applications.

> **Finding 2.2. Virginia has a number of facilities and initiatives required to develop a commercial UAS industry and support military UAS. These include NASA Wallops Flight Facility, NASA Langley Research Center, the Mid-Atlantic Aviation Partnership (MAAP), a new UAS test strip at Wallops Island, the 4,800-square-mile Beyond Visual Line of Sight (BVLOS) test range, established UAS companies and startups, and UAS-related university and government R&D activities. Virginia has also been the site of several UAS test programs. Most of these efforts, however, are in their formative phases and have not been well coordinated.**

b) Virginia Economic Development

In 2008, Orbital Sciences (now Orbital ATK) selected the Mid-Atlantic Regional Spaceport (MARS) as the base of operations for its Antares II rockets, creating approximately 125 new jobs. That year, Orbital subsequently secured a commercial orbital transport services (COTS) contract and a series of commercial resupply services (CRS) contracts for delivery of cargo and supplies to the International Space Station. Orbital invested approximately $45 million to support this effort. Virginia has invested approximately $95 million in making MARS a reality and has continued to fund MARS at a level of $15.8 million per year. Since that time, despite a proliferation of commercial space opportunities, Virginia has secured no major additional customers for its MARS services.

A similar picture emerges for commercial UAS. When the FAA chose the Mid-Atlantic Aviation Partnership (MAAP) as one of its six UAS test sites in 2013, there were high expectations for Virginia to emerge as a leader in the field. Virginia invested $2.6 million for the development of MAAP; as this funding is consumed MAAP has been required to focus on research rather than on growing the nascent industry as a way of being self-sufficient. In FY16, Virginia allocated $950,000 for radar equipment to enhance its UAS BVLOS test range and will invest $850,000 in FY17 for the establishment of a UAS Commercial Center of Excellence and business accelerator in collaboration with MAAP and the Virginia Commercial Space Flight Authority (Virginia Space).

In 2015, Virginia allocated $5.8 million for the development of the UAS runway at Wallops Island. Virginia Space will invest $500,000 for FY17 to develop a UAS hangar and maintenance complex.

> **Finding 2.3. For most of the last decade, aerospace economic development efforts have been unsuccessful. The state has not secured a commitment from a major commercial space company since it signed its first agreement with Orbital ATK in 2008. The selection of MAAP as one of six UAS test sites nationwide has created visibility of Virginia in the UAS arena but has not led to a significant increase in UAS economic development success.**

One reason the state has been unsuccessful in capitalizing on its commercial space and UAS assets lies with the structure of the Virginia Economic Development Partnership, which leads economic development activities in the Commonwealth. In recent years, it has had a regional focus that has proven to be ineffective in pursuing opportunities that transcend single localities.

> **Finding 2.4. There is no one leadership position, with authority stemming directly from the governor, that is responsible for leading the Commonwealth's economic development efforts for aerospace.**

SECTION 3. STATE BEST PRACTICES AND COMPANY CASE STUDIES

a) State Best Practices

The Aerospace Committee examined methods employed by other states to strengthen their aerospace sector. It performed an initial scan of all states, which led it to identify key states that have successfully attracted aerospace companies—Alabama, California, Colorado, Florida, Georgia, Nebraska, New York, North Carolina, North Dakota, South Carolina, and Texas. The committee selected Florida and North Dakota for detailed analysis. These states represented success in two areas of interest: Florida in commercial space and North Dakota in UAS.

Florida: Commercial Space

Because of its long history with space, Florida is recognized as a space state. Florida's aerospace infrastructure is well developed. In addition to its spaceport at Cape Canaveral, Florida is the home of many academic and research institutions with an aerospace focus, virtually every major aerospace company, a fully articulated supply chain, and an extensive talent pool.

> **Finding 3.1. Commercial space infrastructure in Florida is exceptionally comprehensive, encompassing launch facilities at Cape Canaveral, virtually all major aerospace companies, a talented workforce, and a university research enterprise.**

Florida does an excellent job capitalizing on these advantages thanks to Space Florida. With the shuttle program closing down, then-Gov. Jeb Bush convened the Commission on Space & Aeronautics to determine Florida's way forward. The entity it proposed, Space Florida, serves as the state's central organization for coordinating and communicating all space-related matters within the state and reports to a board of directors chaired by the governor. In its economic development role, Space Florida has a substantial budget as well as direct access to a full suite of financial tools used to assist space-oriented businesses attracted to Florida.

> **Finding 3.2. Florida has a single dedicated aerospace economic development agency, Space Florida, with a senior leader with the authority to negotiate on behalf of the governor. A special district, Space Florida has the power to negotiate on behalf of the state, a board chaired by the governor, an extensive variety of financial tools, and an annual budget of approximately $40 million to incentivize aerospace companies to locate in Florida. It also can offer incentives through related agencies: Enterprise Florida and Workforce Florida.**

North Dakota: UAS

North Dakota harnessed its oil revenues and the presence of Grand Forks Air Force Base, which since 2013 has predominantly flown UAS, to create a hub for UAS development. In the process, it has built a partnership with the FAA to advance commercial UAS policy. For instance, its Northern Plains UAS test site recently secured a block of the electromagnetic spectrum from the Federal Communications Commission for transmitting commands and data during drone flight. This partnership only increases the attractiveness of North Dakota for companies eager to be among the first to conduct BVLOS operations.

> **Finding 3.3. North Dakota's UAS infrastructure, though small, is well balanced and concentrated around a Grand Forks hub. Its UAS assets include an FAA test site, an Air Force base focused on UAS flight, a UAS business park, and a university conducting UAS research and offering a degree in unmanned systems.**

The North Dakota Department of Commerce, with substantial backing from the governor, drives North Dakota's UAS economic development effort. State officials at the highest level—including the governor and all members of its Congressional delegation—are engaged in recruiting UAS corporations. North Dakota has also invested in building UAS infrastructure and intellectual property. It has spent a total of about $34 million to establish a national UAS test site, to launch the Grand Sky UAS Business Park, and to advance North Dakota's position as a hub for the nation's growing UAS industry. In addition, the state's Research-ND program disburses $5 million biannually in grants for research and development to organizations and companies involved in UAS research.

> **Finding 3.4. North Dakota's UAS initiative is housed in its Department of Commerce, which aggressively promotes the state's UAS industry and its ability to offer a "one-stop-shop" for companies wishing to locate in the state. The state has provided a total of $34 million to promote UAS development. The lieutenant governor chairs the authority overseeing its test site. Advocates have included the governor, the state's Congressional delegation, and the executive director of the UAS test site.**

Thanks to these efforts, North Dakota is known as a UAS state just as Florida is known for space. North Dakota is widely referred to as the Silicon Valley for Drones, and the area around Cape Canaveral and the Kennedy Space Center is called the Space Coast.

> **Finding 3.5. One indication of a state's success at space and/or UAV economic development is that it is widely recognized as a space- or UAS-focused state. States like Florida and North Dakota have made aerospace a signature priority, devoting time and resources to supporting existing space and UAS endeavors and welcoming newcomers. The Commonwealth of Virginia is not considered an aerospace state.**

b) Company Case Studies

The Aerospace Committee compiled a number of case studies to highlight the strengths and weaknesses of Virginia's aerospace economic development efforts. They are based on interviews with corporate personnel and other knowledgeable sources.

Blue Origin

In 2015, Blue Origin, the privately funded aerospace manufacturer and spaceflight services company founded by Amazon's Jeff Bezos, conducted an extensive search for a location for its launchpad and manufacturing facility. Twelve states were chosen for initial consideration, a list that was quickly trimmed to six including Virginia. Virginia, however, was not included in the final three: North Carolina, Georgia, and Florida. The company ultimately chose to locate in Florida. One reason for this may have been the failure of the Orbital ATK Antares ISS supply mission before this decision was announced. At that point, Virginia leadership had publicly adopted an antagonistic relationship to Orbital ATK and NASA.

> **Finding 3.6. Virginia lost the competition for Blue Origin because it lacks a single authority with negotiating power, it couldn't accommodate larger rockets, and the Wallops Island launch site was viewed as too isolated for workforce availability and as too distant from a deepwater port.**

Orbital ATK

Orbital ATK is headquartered in Dulles, Virginia, with locations in 20 U.S. states as well as in several other countries. In 2015, its annual revenue was approximately $4.5 billion. Orbital ATK's Space Systems Group in Dulles builds satellites and advanced space systems. It offers a broad portfolio of products for commercial, military, scientific, and international customers.

When the company made a successful bid for the NASA Space Station Resupply contract in 2008, it did so using Wallops as its launch site. The company felt that Wallops would be a better collaborative partner when it came to controlling such issues as launch time, and it had excellent relationships with the governor and secretary of commerce.

> **Finding 3.7. Even though siting its International Space Station resupply mission at the NASA Wallops Flight Facility required Orbital ATK to invest heavily in launchpad upgrades, it chose Wallops because of the knowledge and flexibility of its management and the good relationships it had with the governor and his administration.**

Aerojet Rocketdyne

Aerojet Rocketdyne is a leading supplier of space propulsion system products and services. In addition, it provides services for architecture and mission design, systems engineering,

design and development, manufacturing, and testing. Its customers include U.S. military and both U.S. and foreign civil and commercial customers.

Although Aerojet Rocketdyne has three locations in Virginia, it chose to locate a new research facility in Alabama in 2014 even though it has good relationships with Virginia universities.

> **Finding 3.8. Aerojet Rocketdyne chose to locate a research facility in Alabama because it felt that the state made a coordinated and substantial effort to secure the facility, an installation that Virginia might not have thought a substantial enough target for economic development.**

Rolls-Royce

Rolls-Royce, a power systems provider that designs, manufactures and supports a range of products and services for air, sea, and land applications, had several criteria for locating a new advanced manufacturing facility. It determined that it required a large tract of land, which would give it room to expand and provide the buffer necessary to build a jet engine test facility on the site. It was also looking for a pro-business state with a trained workforce where it could have a close relationship with state leadership. In 2007, Rolls-Royce decided to build this new facility near Petersburg, Virginia.

> **Finding 3.9. Rolls-Royce chose Virginia because it is a right-to-work state, Virginia aggressively pursued their business, and Virginia's universities were proactive in meeting its needs. It is concerned about shortages of trained workers.**

Advanced Aircraft Company

Advanced Aircraft Company (AAC) is an aeronautical engineering and manufacturing start-up located in the Peninsula Technology Incubator in Hampton, Virginia. AAC has designed and is now prototyping an octorotor UAS it calls Hercules. Powered by a hybrid system consisting of a two-stroke gas engine turning an electrical generator, Hercules offers a level of endurance that battery-powered multirotor UASs cannot equal, as well as an improved aerodynamic design. AAC has also licensed the Greased Lightning (GL-10) vertical takeoff and landing (VTOL) UAS, which was developed at NASA Langley Research Center.

> **Finding 3.10. To flourish, UAS startups need a suite of services, the most pressing of which are incubators, funding for prototyping and testing, and access to capital.**

OmniEarth

Established in 2014, OmniEarth is a privately funded aerospace manufacturer and spaceflight services company in Arlington, Virginia, that specializes in advanced geoanalytics. The company exploits data from aerospace systems—satellites, UAS and

other sources of information—to develop solutions as a service (SaaS) for multiple users, including insurance companies, municipalities, natural resource managers, and other clients.

OmniEarth chose to locate in Crystal City for its access to transportation (METRO, Virginia Railway Express), availability of skilled workforce, and proximity to large aerospace companies, such as Orbital ATK, Boeing, and Lockheed Martin. Virginia tax incentives did not influence its decision.

Finding 3.11. OmniEarth demonstrates the potential of an active aerospace sector, including commercial space and UAS, to promote the development of companies that provide data analytics and other services.

Recommendation 3.1. Virginia must create a senior, high-level aerospace economic development position with direct access to the governor and the authority to negotiate with aerospace companies considering investing in Virginia.

Recommendation 3.2. Virginia must commit significant existing and new resources, including budget and tax incentives, to be used in attracting new aerospace investments to Virginia.

Recommendation 3.3. Virginia must support, strengthen, and market its current aerospace assets including its governmental, commercial, and academic assets.

Recommendation 3.4. Virginia must coordinate its existing set of government, commercial, and academic institutions within the state to achieve an effective economic development capability.

SECTION 4. OUTLOOK FOR FEDERAL AEROSPACE SPENDING

The Commonwealth of Virginia's aerospace industry is now, and will likely remain for many years, heavily dependent on federal spending. Federal spending for aerospace programs, in total, will most likely remain relatively flat for the next few years. This covers DoD and intelligence agency spending for space and UAS as well as non-defense discretionary spending by agencies like NASA and the NSF.

Finding 4.1. Defense and civil aerospace spending is uncertain but is likely to be flat in the near term. As a result, federal spending on aerospace initiatives, programs, and research will face increased competition from other spending priorities.

This is not to say that there will not be federal funding opportunities in commercial space and UAS. Recent opportunities include the East Coast home for the Navy's MQ-4C Triton, an envisioned Department of Homeland Security science technology testing ground for

unmanned vehicle systems (operating in the air and underwater), and the White House small satellite initiative. Aggressive support from the state's federal representatives will be necessary to secure these opportunities.

> **Finding 4.2. Despite anticipated flat federal spending, there nonetheless are large federally funded opportunities like the Triton program, which would result in 400 jobs.**
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> ***Recommendation 4.1. Virginia must aggressively search for new opportunities in the financially constrained federal sector and secure these opportunities for the Commonwealth.***

SECTION 5. CONCLUSION

The findings and recommendations in this report show that Virginia has a limited window of opportunity to become a national leader in the commercial space and UAS industries. These fields provide high-paying jobs and, perhaps more importantly, create many additional good jobs by attracting supporting industries. These include supply chain businesses, contractors, and new technology development groups. New markets in UAS and in services based on commercial satellite data and drone data are emerging. However, if Virginia is to realize the potential of its substantial assets and its opportunities, it must act now.

Section 1. Opportunities in Aerospace

Definition of Aerospace

The aerospace industry has two distinct sectors—space and aviation. In 2011 and 2012, the Performance Management Group at Virginia Commonwealth University issued two companion reports, one on Virginia's space industry and the other on its aviation industry. For purposes of consistency, this report takes its definitions of these two sectors from these studies.

According to *Competitive Analysis of Virginia's Space Industry*, "the space industry is most often defined as any activity involving flight above the internationally accepted 100-kilometer altitude. A more comprehensive and appropriate definition of the space industry refers to the research, development, manufacturing, or operation of rockets and/or launch vehicles. This includes the provision of communications, navigation, remote sensing, intelligence/surveillance/reconnaissance, launch, recovery, and other services that employ spacecraft or launch vehicles."[1]

In lieu of a commonly accepted definition of aviation, the authors of its companion report, *Competitive Analysis of Virginia's Aviation Industry*, adopted the Federal Aviation Administration (FAA) definition: "Aviation . . . is defined as activities related to mechanical flight, which include the operation, maintenance, design and production of fixed and rotary wing aircraft." [2]

Economic Opportunity: Aerospace

The latest report to estimate the economic impact of the aerospace industry in the Commonwealth is *Virginia's Aerospace Industry: An Economic Impact Analysis*.[3] Although it was prepared for the Virginia Department of Aviation, it covered space as well as aviation. In 2011, the authors of this report estimated that Virginia's aerospace industry contributes $7.6 billion in annual direct economic output and directly and indirectly supports 29,638

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[1] Performance Management Group, Virginia Commonwealth University, *Competitive Analysis of Virginia's Space Industry*, 2011.

[2] Performance Management Group, Virginia Commonwealth University, *Competitive Analysis of Virginia's Aviation Industry*, 2012, available at http://www.doav.virginia.gov/Downloads/Studies/Competitive%20Analysis/DOAVAviationCompetitiveAnalysisRevised.pdf.

[3] Performance Management Group, Virginia Commonwealth University, *Virginia's Aerospace Industry: An Economic Impact Analysis*, 2011, available at http://www.doav.virginia.gov/Downloads/Studies/Workforce/Aerospace%20Impact%202010%20ADA.pdf.

jobs. Aviation and space jobs in Virginia are well paying, according to the 2012 report *Virginia Aviation and Space Workforce Analysis and Strategy Development*. The average wage for aviation and space workers in 2009 was $65,579 per year, 38 percent higher than the Commonwealth's average annual wage of $47,672.[4] The aerospace industry creates the potential for substantial economic growth in a host of related activities, such as the analysis of aerial information, composites development and manufacture, and flight simulation.

Economic Opportunity: Commercial Space

According to The Space Foundation's *Space Report 2016*,[5] the global space economy has grown strongly over the last decade, with a compound annual growth rate of 7 percent from 2005 to 2014. In 2015, its growth continued, although the ever-increasing levels of activity outside the United States and the strong U.S. dollar caused the appearance of a decline to $323 billion from $329 billion in 2014.

The Space Foundation divides the space industry into four areas:

- Commercial Infrastructure and Support Industries: $120.09 billion (Ground Stations and Equipment, Satellite Manufacturing, Satellite Launch Industry, etc.)
- Commercial Space Products and Services: $126.33 billion (Direct-to-Home Television, Satellite Communications, Satellite Radio, Earth Observation)
- US Government Space Budget: $44.57 billion (Department of Defense, National Oceanic and Atmospheric Administration, etc.)
- Non-US Government Space Budget: $31.95 billion (Non-US Military Space, European Space Agency, China, Russia, Japan, France, etc.)

The Space Foundation pointed to a long-term decline in the number of people employed in the civilian U.S. space workforce. In 2013, the latest full year for which data is available, there was an estimated loss of nearly 6,000 employees. From 2006 to 2013, the U.S. space workforce declined about 14 percent, losing nearly 40,000 space specialists.

Wages for those remaining in the U.S. space industry, however, remain high. The average annual salary was $108,000 for a U.S. civilian space employee in 2013. Employees working in the guided missile and space vehicle manufacturing sector averaged the highest salary, nearly $120,000.

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[4] Performance Management Group, Virginia Commonwealth University, *Virginia Aviation and Space Workforce Analysis and Strategy Development*, 2012, available at http://www.doav.virginia.gov/Downloads/Studies/Workforce%20Development%20Study/WorkforceADA4.17.12.pdf.

[5] The Space Foundation, *Space Report 2016*, 2016, available at https://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2016_OVERVIEW.pdf

The Space Foundation's report highlighted ongoing growth in commercial space activities, which accounted for 76 percent of the total space economy. In 2014, global navigation satellite system receivers, such as the ones integrated with smartphone microchips, were the primary driver behind a nearly 18 percent increase in revenue for commercial space infrastructure and support industries. Direct-to-home television services, communications, Earth observation, and geo-location—and possibly space tourism—are other drivers of growth. Industries such as launch facilities, ground stations and equipment, and satellite manufacturing were stimulated by this demand.

Another indication of the ascendency of commercial space operations can be seen in the launch profile. High-value military satellite launches decreased in 2014, but the number of launches conducted increased significantly, rising to levels not seen in more than a decade. These nonmilitary launches—and now launches for NASA and other space agencies—are being conducted by private companies. SpaceX, Blue Origin, Virgin Galactic, Orbital ATK, and Bigelow Aerospace are the best known of approximately two dozen companies working on crew and cargo transport vehicles, space stations, launch vehicles, and landers, rovers, and probes. There is considerable discussion of the commercialization of low-Earth orbit after the retirement of the ISS and extensive operations in cislunar space, the region between the earth and the moon.

> **Finding 1.1. Commercial space and related support services present an opportunity for high-quality jobs and substantial economic growth. Commercial space involves high-value products that require a well-educated, specialized workforce. It encompasses such activities as crew and cargo transportation services, space stations, launch services, spacecraft, ground systems, and information technology.**

Economic Opportunity: Unmanned Aerial Systems

According to the Federal Aviation Administration,[6] the commercial aviation industry recorded its fifth consecutive year of profitability in 2015—and the reasons are not hard to find. Over the last decade, the air carriers fine-tuned their business models to minimize losses by lowering operating costs, eliminating unprofitable routes, grounding older, less fuel-efficient aircraft, and stressing ancillary revenues. During the same period, commercial aviation has also undergone dramatic consolidation. In 2005, there were 12 major carriers. In 2017, there are four. These characteristics—cost-cutting and consolidation—are those of a mature industry, one that is growing incrementally, whose structure is generally fixed, and whose market participants are well-entrenched and protected by high barriers to entry.

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[6] Federal Aviation Administration, FAA Aerospace Forecast: Fiscal Years 2016-2036, 2016, available at https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf.

One segment of the aviation industry, however, is poised for dramatic growth: civil and military unmanned aerial systems (UAS). In *The Economic Impact of Unmanned Aircraft Systems Integration in the United States*,[7] the Association for Unmanned Vehicle Systems International notes that the economic impact of the integration of UAS into the National Airspace System (NAS) will total more than $13.6 billion in the first three years of integration and will grow sustainably for the foreseeable future, totaling more than $82.1 billion in the following 10 years. Integration will create more than 34,000 manufacturing jobs and more than 70,000 new jobs in the first three years, and after 10 years, total job creation is estimated at 103,776. The manufacturing jobs created will be high paying and require technical baccalaureate degrees. Tax revenue to the states will total more than $482 million in the first 11 years following integration. In August 2016, the FAA published Part 107, the first operational rules for routine commercial use of small unmanned aircraft systems, opening a pathway towards fully integrating UAS into the nation's airspace.

The Teal Group, an aerospace and defense market research firm that provides forecasting services for the FAA, notes that the market for civil UAS "promises to be one of the most dynamic growth sectors in the next decade," reaching $65 billion by 2026. It notes that the fastest growth comes from commercial systems, which it expects to surpass consumer and hobbyist systems in 2022.[8]

In its forecasts, the FAA divides the small UAS sector into higher-end units with an average sales price of $40,000 and lower-end units with a price of $2,250. Most of these lower-end units will be produced overseas, mainly in China. There remains an opportunity for the United States to focus on the more complex higher-end vehicles. Working with the Teal Group, the FAA estimates that the higher-end sector will grow rapidly from 1,300 units in 2016 to 52,000 units in 2020. Demand for these units will come from companies like Google and Amazon as well as from users in sectors like infrastructure monitoring and inspection. There is also potential in providing systems and services for low-end UAS.

Unlike the commercial UAS industry, the military UAS industry is highly concentrated and relatively mature. General Atomics, Northrop Grumman (headquartered in Virginia), Textron, and Boeing account for 66 percent of the industry. Nonetheless, it is an industry characterized by rapid technological change and new UAS range from UAS swarms to massive aircraft like the MQ-4C Triton, which Northrop Grumman is introducing for the Navy. Despite the war drawdown and sequestration, the military spent almost $14 billion between 2010 and 2015 on UAS development. This represented a 6 percent CAGR, a

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[7] Association for Unmanned Vehicle Systems International, *The Economic Impact of Unmanned Aircraft Systems Integration in the United States,* 2013, available at https://higherlogicdownload.s3.amazonaws.com/AUVSI/958c920a-7f9b-4ad2-9807-f9a4e95d1ef1/UploadedImages/New_Economic%20Report%202013%20Full.pdf

[8] Teal Group, "Executive Overview," *World Civil Unmanned Aerial Systems: Market Profile and Forecast*, 2016, available at http://tealgroup.com/index.php?option=com_rokecwid&view=ecwid&Itemid=100020&ecwid:mode=product&ecwid:product=0&ecwid_product_id=68070034#!/2016-World-Civil-Unmanned-Aerial-Systems-Market-Profile-&-Forecast-CD-ROM/p/68070034.

growth rate that Govini, the defense analyst, believes will continue. This creates ample opportunity for support and supply chain services.

> **Finding 1.2. The UAS manufacturing market and the market for services built upon them is at a point of explosive growth. States that emerge as centers for commercial UAS development and application will reap the benefits of high-paying jobs, additional tax revenue, and economic growth far into the future. At the same time, the military market for drones and their services is evolving rapidly, creating significant opportunities for support and supply chain services.**

Virginia is not the only state that has recognized these two aerospace areas. States like Alabama, Colorado, Florida, and Texas have focused on commercial space, and there are centers for UAS development in states like California, Florida, New York, North Dakota, Ohio, and Texas. For Virginia to capture the benefits of this growth, it must act quickly.

> **Finding 1.3. A number of other states are already investing heavily in commercial space and UAS across the country. Virginia must act quickly before the window of opportunity closes.**

> ***Recommendation 1.1. Virginia must act immediately to establish the two most promising growth areas in aerospace—commercial space and unmanned aerial systems (UAS) and their applications—as a primary focus of economic development. This is essential to positioning Virginia as an aerospace state, one that is high on the list of locations for aerospace companies.***

Section 2. Virginia Aerospace Infrastructure and Economic Development

a) Virginia Aerospace Assets

Virginia's aerospace infrastructure includes a number of assets that differentiate it from other states. This includes one of four spaceports with FAA approval to launch into space, one of just six FAA UAS test sites, the NASA Wallops Flight Facility and the NASA Langley Research Center, the presence of every major aerospace company in the nation, proximity to the nation's capital, and top-rated universities. These assets could provide the foundation for Virginia leadership in commercial space and UAS.

Commercial Space Assets

Over the last decade, there has been a dramatic increase in commercial space activity, fueled in large part by the opportunities private industry sees in space-based services, whether it is Internet access or data generation. The initiatives founded by billionaire entrepreneurs—SpaceX (Elon Musk), Blue Origin (Jeff Bezos), and Virgin Galactic (Richard Branson)—are only the most visible manifestations of broad-based response to this demand.

An area of particular importance is providing NASA with commercial launch services to the International Space Station. There are several companies competing to serve this market, including such stalwarts as the United Launch Alliance (a joint venture between Lockheed Martin and The Boeing Company), SpaceX, Sierra Nevada Corporation, and Orbital ATK. In the future, cislunar space can be a major market.

The current lineup of companies serving the commercial space market creates the false impression that the opportunities in space have all been taken. Nothing could be further from the truth. As the industry matures, it is likely to grow as companies focus on niche markets while others consolidate in an effort to offer a broad range of services, orbits and transport specialties. A critical bottleneck is availability of suitable launchpads. With its Spaceport on Wallops Island, Virginia has a foundation that could position it to capture these opportunities.

<u>Virginia Commercial Space Flight Authority/Mid-Atlantic Regional Spaceport</u>

There are several elements that provide Virginia with a competitive advantage in commercial space. The first is the Virginia Commercial Space Flight Authority (VCSFA, also known as Virginia Space). In 1995, the Virginia General Assembly created VCSFA to promote the development of the commercial space flight industry, economic development, and aerospace research as well as science, technology, engineering, and math (STEM)

education throughout the Commonwealth. The VCSFA has a full suite of legal abilities, including the ability to hire staff; buy, sell or lease real estate; plan and execute projects; borrow money; sell bonds; sue and be sued; and other matters necessary or convenient to carry out its mission. Funding for VCSFA comes from the Transportation Trust fund, providing $15.8 million in funding each year for operations, personnel, site maintenance, and infrastructure. After covering these expenses, little is available for economic development. The funding is committed at five-year intervals.

VCSFA administers all commercial spaceflight operations within the Commonwealth, including launch activities at the Mid-Atlantic Regional Spaceport (MARS), which is operated jointly by Virginia and Maryland. Located at the southern tip of the NASA Wallops Flight Facility on the Eastern Shore, MARS is one of only four spaceports currently licensed by the FAA to launch into orbit and only one of two on the East Coast.

Virginia Space began its lease from NASA at Wallops Island in 1997 and has continually expanded and improved MARS. MARS now has two launch facilities (one medium-lift and the other small-lift). It also has access to support infrastructure through agreements with NASA. These include vehicle and payload processing integration facilities, support instrumentation, and emergency facilities. MARS also provides internships to students at regional universities and the Eastern Shore Community College to encourage the development of the local workforce.

MARS' unique location and capabilities offer advantages that position Virginia as a strategic player in commercial spaceflight. The launch trajectory from MARS is primarily over ocean and avoids populated areas. This lowers the cost of insurance. Virginia is also one of three states to possess a medium-lift and small-lift launchpad that services low-Earth orbit (LEO) launches (the others are California and Florida). MARS is also within driving distance of several major cities and Washington, DC.

These advantages were attractive to Virginia-based Orbital Sciences (now Orbital ATK), which began commercial resupply service (CRS) missions from MARS to the International Space Station (ISS) in 2014. This project was halted after a launch failure during its third mission in October 2014. In January 2016, NASA awarded a new multiyear CRS contract to Orbital ATK from spaceports including MARS. In 2016, the company conducted tests of its Antares rocket at the MARS Pad 0A, which led to a resumption of CRS missions in October.

Virginia's relationship with Orbital ATK has also given MARS a cubesat capability. Orbital ATK has agreed to carry cubesats on its launches at no cost to the Commonwealth.

The $15.8 million that Virginia Space receives from the Transportation Trust fund is not sufficient in itself to sustain MARS. As a result, MARS charges users launch fees and other charges to make up the difference (an issue in Virginia's efforts to attract Blue Origin). Even with these fees, MARS cannot make necessary improvements that increase its attractiveness to business. However, over the years, Virginia has made a $95 million capital investment in MARS facilities. In addition to the MARS UAS runway, this investment has been allocated to Pad 0A and Pad 0B, the rebuilding of Pad 0A, removal of overhead power

lines, and Wallops Research Park development. The MARS facility currently lacks a dedicated payload processing facility capable of handling advanced classified and scientific missions, a permanent hangar at the runway, and deepwater dock access.[9]

Virginia Space has also invested in UAS. It recently completed an unmanned aerial systems runway at the northern end of NASA's Wallops Flight Facility to test UAS vehicles. This strip was financed with $5.8 million from the Commonwealth's General Fund.

NASA Wallops Flight Facility/NASA Langley Research Center

The National Aeronautics and Space Administration (NASA) has an extensive and long-term presence in Virginia. NASA Wallops Flight Facility, established in 1945, is one of NASA's primary suborbital research program management and implementation facilities. It supports missions for suborbital and orbital rocket vehicles by providing range safety, surveillance, vehicle tracking and communications, command systems, meteorological services, optical systems, a range control center, payload processing, and launch vehicle integration facilities. In addition, the range's mobile assets can be deployed to support rocket launches at Wallops and other worldwide locations.

Wallops is NASA's only rocket launch range. It supports a variety of projects that include launching first-time vehicles as well as those with a proven track record. During its 70-year history, Wallops has launched more than 16,000 rockets carrying aircraft models, space and earth science experiments, technology development payloads, and satellites.

Virginia is also home to the NASA Langley Research Center, established in 1917 by NASA's precursor, the National Advisory Committee for Aeronautics. NASA Langley is a leader in innovative technologies and research in aeronautics, atmospheric sciences, and exploration. For instance, NASA Langley has been instrumental in the development of the Orion crew capsule, helping to create the heat shield, the parachute system, and the launch abort system. Its research activities cover a wide variety of fields related to aerospace. In 2016, for instance, Langley received the NASA Government Invention of the Year Award for a promising new approach for producing boron nitride nanotubes that produces a material that is lightweight, stable, heat resistant, and strong. It conducted this research in conjunction with the National Institute of Aerospace (see below).

In addition, NASA Langley has been a pioneer in making big data acquired from NASA satellites accessible to small businesses. In the late 1990s, it first offered solar-energy data from satellites in a user-friendly form called Surface Solar Energy (SSE), which can be used to evaluate solar and wind energy projects as well as building design. NASA Langley also licenses the technology it develops to business. This year, it entered into a partially exclusive license agreement with United Equipment Corporation of Richmond, Virginia, for two technologies with applications in vibration control in aerospace structures. The

[9] Secretary of Transportation Aubrey Layne, *Presentation to VASEM Aerospace Committee*, October 11, 2016.

company plans to integrate the NASA technologies into their build-to-order aircraft windows. NASA Langley is also an active participant in the Small Business Technology Transfer program. Among other programs funded this year, it will work with a Virginia-based team consisting of Prime Photonics LC and Virginia Tech to develop technology in advanced structural health monitoring. The technology will provide ground-based tests and flight evaluations of aircraft structures.

The economic impacts of NASA Langley and Wallops in Virginia are substantial. In 2015, they supported over 10,700 jobs in Virginia, with a total economic impact of $1.3 billion annually. Additionally, Virginia received approximately $100 million in direct state funds as a result of the concentration of these civil space entities.[10]

Department of Defense/National Reconnaissance Organization

Virginia is also the focal point for extensive defense-related space activities, conducted under the supervision of the Department of Defense (DoD) for military space and the National Reconnaissance Office (NRO) for intelligence-related operations. These initiatives are carried out with the assistance of hundreds of corporations located primarily in Northern Virginia. The DoD space program includes the development, launch, and maintenance of different launch and satellite vehicles. Although difficult to quantify, the budget for the DoD space program is significantly larger than NASA's budget.

Although California benefits most from DoD space-related funding, Virginia is the primary state for intelligence-related space activity—and much of this originates from the NRO, whose budget is roughly equivalent to NASA's budget. All national intelligence space programs are managed from NRO offices in Virginia. The NRO's key customers and mission partners include policy makers, the Armed Services, the Intelligence Community, the Departments of State, Justice, and Treasury, and civil agencies.

All of them depend on the unique capabilities NRO systems provide:

- Monitoring the proliferation of weapons of mass destruction
- Tracking international terrorists, drug traffickers, and criminal organizations
- Developing highly accurate military targeting data and bomb damage assessments
- Supporting international peacekeeping and humanitarian relief operations
- Assessing the impact of natural disasters, such as earthquakes, tsunamis, floods, and fires

Virginia: Aerospace Advisory Council

The Aerospace Advisory Council is part of Virginia's Department of Aviation. Its purpose, powers, and duties are to advise the governor on policy and funding priorities to promote

[10] National Aeronautics and Space Administration, Langley Research Center, *Earth, Mars, and Beyond*, 2015, available at https://www.nasa.gov/sites/default/files/atoms/files/larcreport_2015c.pdf

the aerospace and space exploration industry in the Commonwealth. It also advises the Joint Commission on Technology and Science as well as the Secretaries of Commerce and Trade, Technology, and Education on policy and funding priorities with respect to aerospace economic development, workforce training, educational programs, and educational curriculum. In addition, it suggests strategies to attract and promote the development of existing aerospace companies, new aerospace companies, federal aerospace agencies, aerospace research, venture and human capital, and applied research and technology that contribute to the growth and development of the aerospace sector in the Commonwealth.[11]

The council is composed of nineteen members, including four legislators as well as representatives of state universities, aerospace companies, the Department of Aviation, the National Institute of Aerospace, the Virginia Tourism Authority, and the Virginia Space Grant Consortium. Representatives from NASA Wallops Flight Facility and NASA's Langley Research Center serve as nonvoting, ex officio members.

Business Sector

Virginia is home to approximately 270 businesses that are active in a variety of commercial, civil, and military space ventures.[12] The largest employers are Raytheon Company, Orbital ATK, Northrup Grumman, Lockheed Martin, and Rolls-Royce. Recently, Alcoa Howmet, AAI, Boeing, Goodyear Tire & Rubber, and Orbital ATK have made major new announcements.[13]

With cooperation from NASA and funding from state and local sources, Accomack County has opened the Wallops Research Park adjacent to the flight facility. Businesses meeting the criteria to locate in the park have assured access to the airfield and the controlled and experimental airspace surrounding it.[14]

University Research and Development

Besides NASA Wallops and NASA Langley, the majority of Virginia's space research is conducted by universities and public institutions. A number of universities—including the University of Virginia, Virginia Tech, and Old Dominion University—have aerospace engineering programs and laboratories devoted to aerospace research. These include the Aerospace Research Laboratory at the University of Virginia and the Virginia Modeling, Analysis, and Simulation Center at Old Dominion University. With funding from the

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[11] (Code Reference: § 2.2-2698)
[12] Performance Management Group, Virginia Commonwealth University, *Virginia's Aerospace Industry: An Economic Impact Analysis*, 2011, available at http://www.doav.virginia.gov/Downloads/Studies/Workforce/Aerospace%20Impact%202010%20ADA.pdf.
[13] Aerospace Industry Overview, Virginia Economic Development Partnership, available at http://www.yesvirginia.org/KeyIndustries/Aerospace
[14] Steven B. Miner, Presentation to the VASEM Aerospace Committee, August 22, 2016.

National Science Foundation, all three institutions are building cubesats for launch at Wallops Island.

Virginia's universities are also active in university consortia and public/private partnerships that support aerospace research. These include the National Institute of Aerospace (NIA), the Virginia Space Grant Consortium (VSGC), and the Commonwealth Center for Advanced Manufacturing (CCAM).

The NIA, for instance, is a not-for-profit Virginia corporation established a decade ago in Hampton, Virginia, as a strategic partner for NASA Langley. Five of NIA's member institutions are Virginia universities (Virginia Tech, the University of Virginia, Old Dominion University, Hampton University, and William & Mary). NIA has grown to be a $30 million per year research, graduate education, and outreach institute with 100 employees. Research is underway at NIA in such fields as analytical and computational methods, advanced sensing, and optics. It is currently located in the newly established Hampton Research and Science Park less than a mile from NASA Langley. Approximately 65 percent of its funding comes from NASA; 35 percent comes from other groups including the FAA, the Air Force Office of Strategic Research, and Airbus.[15]

One of NIA's missions is to develop and commercialize aerospace technologies. It does this by developing joint intellectual property with NASA Langley, such as the boron nitride nanotubes cited above in the section on NASA Langley. It also hosts the Peninsula Technology Incubator (PTI), established in 2012 with a grant from the City of Hampton. PTI is located in NIA's new 58,000-square-foot Research and Innovation Laboratories, which was partially funded by a grant from the Commonwealth to Virginia Tech in 2008. To date, PTI has provided incubation services to 15 technology companies and has been responsible for more than a score of high-tech jobs. Two of these companies have recently won contracts exceeding $1 million.[16]

The Virginia Space Grant Consortium (VSGC) is a coalition of five Virginia colleges and universities, two NASA centers, state educational agencies including the State Council of Higher Education for Virginia and the Virginia Community College System, Virginia's Center for Innovative Technology, and other institutions representing diverse aerospace and high technology education, workforce development, and research interests. It has collaborated with over 400 partners to undertake a wide range of higher education and college preparatory programs and initiatives to seed research in areas of interest to NASA.

The Commonwealth Center for Advanced Manufacturing (CCAM) is a public–private collaborative research center that undertakes research critical to the surface technology and advanced manufacturing industries. By pooling resources to pursue university

[15] Douglas Stanley, National Institute of Aerospace, Presentation to VASEM Aerospace Committee, October 10, 2016.
[16] Daniel Morris, Peninsula Technology Incubator, Presentation to VASEM Aerospace Committee, October 10, 2016.

research authorized by member companies, CCAM increases the value of its members' research-and-development dollar. R&D risks and costs are shared by members and research results are shared, allowing members to capitalize on new, breakthrough developments that emerge from CCAM research. CCAM was part of the package that enabled the Commonwealth to successfully attract Rolls-Royce to build a manufacturing facility in the state. CCAM's 62,000-square-foot-facility, completed in late 2012, is adjacent to Rolls-Royce's Crosspointe aerospace manufacturing campus,and features computational and engineering research labs, high bay production space for commercial scale equipment, and tools required for research in surface engineering and manufacturing systems.

Coordination of Assets

Virginia has a considerable number of commercial space assets, but coordination among them occurs at best on a local level or on an *ad hoc* basis. A great deal of productive coordination, for instance, is driven by NASA, but it is not NASA's mandate to promote commercial space in Virginia. Nor has there been any systematic attempt to go beyond inventorying Virginia's commercial space assets and to evaluate how these assets can be supplemented and expanded to form a commercial space ecosystem. There is no Commonwealth-wide master plan for strengthening commercial space assets.

> **Finding 2.1. Virginia possesses a number of distinct advantages to support the development of commercial space initiatives. These include the Virginia Commercial Space Flight Authority and the Mid-Atlantic Regional Spaceport, two major NASA facilities, Department of Defense (DoD) and intelligence agencies with active space programs, major commercial space corporations, and leading universities and public/private consortia engaged in space-related R&D and education. However, these advantages are not coordinated in a way to maximize their potential.**

Unmanned Aerial Systems Assets

Unmanned vehicles and systems are in the early stages of their development. The FAA, NASA, and the academic community are working in tandem with private industry to overcome hurdles to widespread deployment. For instance, the FAA's UAS Focus Area Pathfinders initiative is exploring how UAS might be safely used in populated areas and addressing some of the command-and-control challenges of using UAS beyond visual line of sight (BVLOS) in rural areas.

As these challenges are solved and regulations more easily enable BVLOS operations as well as the control of multiple unmanned aerial vehicles by a single pilot, demand for UAS will soar. Attention will turn to improvements in platforms and to meeting demand for supporting services such as software applications, sensors, advanced manufacturing, data services, and cybersecurity.

Currently, Virginia has assembled a number of assets that it could use to position itself, during this critical phase leading up to UAS industry maturity, as a center for UAS development and application. In 2015, the Commonwealth established the Virginia Unmanned Systems (UMS) Commission to identify the state of the UMS industry in Virginia, pinpoint challenges and needs of the industry that may be met with Virginia assets, provide recommendations that will encourage its development, and establish a value proposition that will position Virginia for emerging needs and applications. This section of this study draws, in part, on the interim report of the commission[17] and its related publication, *Unmanned Vehicle Systems in Virginia*.[18]

The Mid-Atlantic Aviation Partnership

In 2013, the Federal Aviation Administration chose the Mid-Atlantic Aviation Partnership (MAAP), led by Virginia Tech with 70 partners from Virginia, Maryland, and New Jersey, to operate one of only six UAS test sites in the country.[19] MAAP conducted its first operational test flight at the Virginia Tech Transportation Institute in August 2014. Since that time, a number of private companies have conducted flights that move them toward certification and authorization for airframes and operations of UAS. These include Hazon, Textron, and UAV Pro. MAAP offers unique ground test facilities and laboratories that can be used to support the entire UAS product lifecycle, from R&D to customer training to operations. It also has a working relationship with other Virginia UAS centers at Wallops, Farmville, and Wise. Among other accomplishments, MAAP oversaw the first delivery of medical supplies by UAS (see Test Flights, below).

On the whole, however, MAAP has not proven to be as effective a source of economic development for Virginia as originally planned. At inception, Virginia, Maryland and New Jersey agreed to provide $250,000 each year to MAAP for salaries. Virginia followed through but Maryland provided salary support for just one year, and New Jersey did not provide any funding at all. Thus, the responsibility for keeping MAAP afloat shifted to Virginia and to Virginia Tech specifically. For instance, additional money was required for insurance should a UAS crash, which Virginia Tech supplied.

As a stopgap, MAAP successful secured a federal FACT grant, which expired in 2013. In the meantime, the organization, which is housed in the Institute for Critical Technology and Applied Science at Virginia Tech, has positioned itself as a test site for research conducted by Virginia Tech faculty. Approximately 75 percent of its budget is sustained by research grants. This has been enough to keep the organization self-sufficient. MAAP is currently in the process of developing a new business model that it hopes will enable it to increase its

[17] Virginia Unmanned Systems Commission, *Interim Report of Recommendations*, 2016, available at http://vus.virginia.gov/media/5262/ums-interimreport-01-12-2016-dah-2.pdf.
[18] Virginia Unmanned Systems Commission, *Unmanned Vehicle Systems in Virginia*, 2016, available at http://vus.virginia.gov/media/5279/2016-ums-report-web.pdf.
[19] A seventh, New Mexico, was added subsequently.

revenue from private sources and, with a larger portfolio of private clients, to play a greater role in partnering with the FAA in developing UAS policy.[20]

MARS UAS Runway

With $5.8 million from the General Fund, MARS has recently expanded its UAS test strip, originally created in 2003 for remotely piloted aircraft. Located at the northern end of Wallops Island, the test strip is now 3,000 feet long, making it the longest UAS-specific test runway in the nation. It has the added benefits of being exempt from FAA restrictions, free from external traffic, and possessing easy terminal escape points into the Atlantic Ocean. The stated goal is to become the premier UAS test flight facility in the world, providing a much-needed site for UAS manufacturers and operators for data collection.

The Beyond Visual Line of Site Test Range

The Beyond Visual Line of Site Test Range is an example of the Commonwealth's commitment to the UAS industry and to public-private partnerships. The vision is for it to be the best place for training and operational validation for oil and gas, rail, and power line management companies. Infrastructure inspection and monitoring is considered to be among the top three most important uses of UAS technologies.

Through MAAP and authorization from the FAA through a certificate of authorization (COA), Virginia devoted a 4,800-square-mile test range in central Virginia, covering 10 percent of the land area of the Commonwealth, for UAS research in critical infrastructure inspection and Beyond Visual Line of Sight operations. To advance that research, the governor proposed, and the 2016 General Assembly adopted, $950,000 in funding for equipment for the new test range.

This airspace includes a unique set of critical infrastructure such as airports, power plants, over 200 miles of electric transmission lines and rail lines, and over 100 miles of liquid transmission pipelines and natural gas transmission pipelines. Quarries, interstate I-64, highway 460 (four lane), the James River, open farmland, and forested areas also underlie this COA. UAS operations throughout this area have been conducted from the Farmville airport.

A multi-industry research consortium is also forming to utilize Virginia's extensive resources for unmanned systems research, according to industry representatives. The consortium is organized through Pipeline Research Council International, Inc., and American Aerospace Technologies, Inc., and includes companies from industries spanning oil and natural gas, electric power, and telecommunications. The consortium will explore and develop sensors, analytics, and operational concepts that can enhance the efficiency and safety of aerial inspections of critical infrastructures.

[20] Theresa Mayer, Vice President for Research and Innovation, Virginia Tech, Interview with VASEM Aerospace Committee, October 10, 2016.

Business Sector

Although major defense contractors headquartered in Virginia like Northrop Grumman are deeply involved in UAS development and production, Aurora Flight Sciences is the largest UAS specialty company in Virginia. It is headquartered in Manassas, though the bulk of its employees are in Mississippi where it has an aerostructures manufacturing and final assembly facility. It recently opened a satellite office in Dayton, Ohio, to take advantage of UAS activity at the universities there and nearby Wright-Patterson Air Force base.

The company manufactures the composite fuselage and V-tail for the Northrup Grumman Global Hawk and is developing Orion, a medium-altitude, long-endurance UAS. The company recently announced its intention to begin operational testing of its Centaur Optionally Piloted Aircraft (OPA) system at the Lonesome Pine Airport in Wise County, Virginia. Aurora will initially use the Centaur OPA system, a large UAS, to collect a variety of critical data for the state using advanced sensor technologies, and support the Mountain Empire Community College in developing the first-of-its-kind *Aerial Drone Geo-Spatial Mapping and Surveyors* course.[21]

The Peninsula Technology Incubator (PTI), housed in the National Institute of Aerospace, is gradually shifting its emphasis to UAS companies. Inspired by the work of the Virginia Unmanned Systems Commission, it hopes to establish itself a UAS Center of Excellence and Business Accelerator. To succeed, it would need affordable access to flight test ranges and funding for tests, as well as access to low-cost design, prototyping, and fabrication services. Ideally, such an incubator would exist in an environment in which intellectual property flows from government and academic institutions to the business, there is a trained UAS workforce, and there is capital available for investment.[22]

University Research and Development

Virginia Tech's College of Engineering houses the Virginia Center for Autonomous Systems, a research center facilitating interdisciplinary research in autonomous systems technology in water, land, air, and space. Its Kentland Experimental Aerial Systems Laboratory includes approximately 2,000 square feet of UAS hangar space and a 300-foot by 70-foot paved airstrip for small (R/C scale) aircraft. Virginia Tech's Unmanned Systems lab, in the Mechanical Engineering Department, has worked with sponsors such as Pacific Northwest National Labs, Savannah River National Labs, the Defense Threat Reduction Agency, the Air Force Research Lab, and AAI Corp. Other assets include Liberty University in Lynchburg and Averett University in Danville, both of which have aviation programs.

Researchers in the University of Virginia School of Engineering and Applied Science have developed system-aware cybersecurity technology to detect and respond to cyberattacks

[21] Jack Kennedy, Member of Board of Directors, Virginia Commercial Space Flight Authority, Presentation to VASEM Aerospace Committee, October 11, 2016.
[22] Daniel Morris, Peninsula Technology Incubator, Presentation to VASEM Aerospace Committee, October 10, 2016.

on unmanned aerial systems. The university recently licensed the technology to Mission Secure Inc., which is in the process of commercializing its security solutions for the military, intelligence, and civil sectors.

Test Flights

With the support of the Secretary of Technology, Virginia has been the site of several test flights for healthcare and emergency response applications for UAS. In July 2015, the first FAA-approved medical package delivery in the United States took place during the Remote Area Medical (RAM) Clinic, a free annual medical clinic in Wise County, Virginia. The partnership, led by Flirtey (an Australian firm), included MAAP, the RAM Clinic, and NASA. It produced data to support the development of medical package delivery application standards. Flirtey chose Wise County in part due to support from the Commonwealth, flight opportunities, and the research environment.

Albemarle County, Piedmont Virginia Community College, the Virginia Department of Emergency Management, and MAAP have begun a training program to enable public safety officials to operate UAS during incident response. The program includes a certification that allows private entities with an FAA Section 333 exemption[23] to operate and participate with emergency response personnel. Potential program benefits include enhanced public safety and lifesaving; encouragement for UAS service provision and innovation; increased public awareness of beneficial uses of UAS; and fostering of technology and procedures that could provide a foundation for other UAS applications, including precision agriculture and critical infrastructure inspection.

Coordination of Assets

The development of Virginia's UAS assets has been hampered by initial leadership issues with MAAP, lack of funding, and a comprehensive statewide vision for UAS. MAAP is now under new leadership and establishing a business model, but the relationship among UAS institutions in the Commonwealth that have a stake in the future of UAS in Virginia have been opportunistic and *ad hoc*. There has been no effort to develop a comprehensive, coherent ecosystem of assets to support UAS development.

> **Finding 2.2. Virginia has a number of facilities and initiatives required to develop a commercial UAS industry and support military UAS. These include NASA Wallops Flight Facility, NASA Langley Research Center, the Mid-Atlantic Aviation Partnership, a new UAS test strip at Wallops Island, the 4,800-square-mile Beyond Visual Line of Sight (BVLOS) test range, established UAS**

[23] By law, any aircraft operation in the national airspace requires a certificated and registered aircraft, a licensed pilot, and operational approval. Section 333 of the *FAA Modernization and Reform Act of 2012* (FMRA) grants the U.S. Secretary of Transportation the authority to determine whether an airworthiness certificate is required for a UAS to operate safely in the National Airspace System. Going forward, Part 107—the small UAS rule, which went into effect on August 29, 2016—supersedes Section 333.

companies and start-ups, and UAS-related university and government R&D activities. Virginia has also been the site of several UAS test programs. Most of these efforts, however, are in their formative phases and have not been well coordinated.

b) Aerospace Economic Development in Virginia

In 2008, Orbital Sciences (now Orbital ATK) selected MARS as the base of operations for its Antares II rockets, creating approximately 125 new jobs in the state at Orbital's Dulles headquarters and at Wallops Island. That year, Orbital subsequently secured a commercial orbital transport services (COTS) contract and a series of commercial resupply services (CRS) contracts for delivery of cargo and supplies to the International Space Station. Orbital invested approximately $45 million to support this effort.[24] Virginia invested approximately $95 million in making MARS a reality and continues to fund MARS at a level of $15.8 million per year.

Since that time, despite a proliferation of commercial space opportunities, Virginia has secured no major additional companies for its MARS services. This stagnation has had its effects. PwC's 2016 Aerospace Manufacturing Attractiveness Rankings results showed the Commonwealth in 13th position among all states, down from fifth the year before.[25]

A similar picture emerges for UAS. When the FAA chose MAAP as one of its six UAS test sites in 2013, there were high expectations for Virginia to emerge as a leader in the field. Virginia invested $2.6 million for the development of MAAP; as this funding is consumed, MAAP has been required to focus on research rather than on growing the nascent industry as a way of being self-sufficient. In FY16, Virginia allocated $950,000 for radar equipment to enhance its UAS BVLOS test range.

Virginia has also been investing in UAS at Wallops Island. In 2015, Virginia allocated $5.8 million for the development of the UAS runway there, and Virginia Space will invest $500,000 for FY17 to develop a UAS hangar and maintenance complex. Also in FY17, Virginia will invest $850,000 for the establishment of a UAS Commercial Center of Excellence and business accelerator in collaboration with MAAP and the Virginia Commercial Space Flight Authority (Virginia Space).

Finding 2.3. For most of the last decade, aerospace economic development efforts have been unsuccessful. The state has not secured a commitment from a major commercial space company since it signed its first agreement with

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[24] Office of the Governor, Governor Kaine Announces 125 New Jobs for Virginia, June 9, 2008, available at http://www.yesvirginia.org/AboutUs/NewsItem/945

[25] PwC, 2016 Aerospace Manufacturing Attractiveness Rankings, July 2016, available at http://www.pwc.com/us/en/industrial-products/publications/assets/pwc-aerospace-manufacturing-attractiveness-rankings-2016.pdf

Orbital ATK in 2008. The selection of MAAP as one of six UAS test sites nationwide has created visibility of Virginia in the UAS arena but has not led to a significant increase in UAS economic development success.

One reason that the state has been unsuccessful in capitalizing on its commercial space and UAS assets lies with the structure of the Virginia Economic Development Partnership (VEDP), which leads economic development activities in the Commonwealth. In recent years, it has had a regional focus that has proven to be ineffective in pursuing opportunities that transcend single localities. Furthermore, VEDP does not participate in framing the Commonwealth's four-year comprehensive economic development policy.

Created by the General Assembly as an authority in 1995,[26] VEDP acts as a political subdivision of the Commonwealth, and is neither a legislative nor an executive branch agency. While the secretary of commerce and trade is responsible to the governor for VEDP and for guiding economic development policy generally, VEDP does not answer directly to the secretary or the governor. Instead, VEDP is governed by a 24-member board, consisting of the lieutenant governor, the secretaries of agriculture and forestry, commerce and trade, finance, and technology, the chancellor of the Virginia Community College System, 12 citizens appointed by the governor, four citizens appointed by the speaker of the House, and two citizens appointed by the Senate Committee on Rules. The board elects a chairman from its membership and appoints a chief executive officer to run VEDP.

The Code of Virginia spells out a number of powers and duties of VEDP. At a high level, it was established to "encourage, stimulate and support the development and expansion of the economy of the Commonwealth through economic development."[27] A number of general duties related to the provision of economic development services are set forth in § 2.2-2238 of the Code of Virginia, including carrying out effective marketing and promotional programs, encouraging the coordination of economic development initiatives at all levels of government, and advancing programs to attract new business and retain and expand existing businesses. All statutory powers and duties are set out in general terms and do not reference any specific business or industry sector (such as aerospace).

In addition to the general authority granted to VEDP to administer economic development programs, subsection B of § 2.2-205 of the Code of Virginia directs that the secretary of commerce and trade develop, at the start of each gubernatorial administration, a comprehensive economic development policy for the Commonwealth. The code directs the formation of a committee to assist the secretary in policy development and notes that it shall include other secretariats, as well as any members of regional or local economic development groups or members of the business community as may be appointed by the governor. There is no specific requirement that the secretary consult with or include in the discussions any representatives of VEDP. The most recent policy adopted in 2014, at the

[26] See Chapter 638 of the 1995 Virginia Acts of Assembly. The statutory authority for the Virginia Economic Development Partnership Authority is found at Article 4 (§ 2.2-2234 et seq.) of Chapter 22 of Title 2.2 of the Code of Virginia.
[27] See subsection B of § 2.2-2234 of the Code of Virginia.

start of the McAuliffe administration, lists general goals to develop project-ready infrastructure, diversify high-growth industries, establish and maintain a preeminent business climate, create an environment that promotes innovation and entrepreneurship, and align education with workforce needs. The report specifically highlights plans related to the diversification and growth of the energy sector. The only reference to aerospace is a mention of the industry as one of fifteen potential high-growth industries in the Commonwealth. It does not appear that a single person is responsible for understanding and promoting the aerospace industry as a whole.

Furthermore, Virginia's efforts to attract aerospace companies have been undercut by the VEDP's regional economic development strategy. While VEDP employs an economic development professional with background and expertise in the aviation and aerospace industries, this professional's job was regionally focused and had broader responsibilities than just this industry sector.

Prospective businesses must talk to a different point of contact at VEDP depending on the region in which the company will locate. If a company is considering multiple regions, it must duplicate its interactions with multiple different contacts. This situation leads to regions competing for individual companies rather than coordinating their efforts.

In measuring results of economic development efforts and initiatives, VEDP utilizes a number of metrics. Traditional metrics, adopted in a variety of economic development initiatives in the Commonwealth over the past few decades, focus on the number of jobs created, the capital investment made by private entities in the Commonwealth, and average wages.

VEDP administers 10 incentive grant programs and awarded $384 million to companies over the past decade. These include the Commonwealth's Development Opportunity Fund, the Virginia Investment Partnership, and the Virginia Economic Development Incentive Grant. During this time period, many projects supported through VEDP-administered incentive programs did not meet their performance requirements.

Another issue is poor coordination of funding and incentives. The Commonwealth boasts a number of different funds, grants, tax benefits, and programs that benefit economic development and economic development-related activities such as research and development. For instance, GAP Fund grants and loans for entrepreneurs seeking to bridge the commercialization gap and the Commonwealth Research and Commercialization Fund are administered by a wholly separate authority, the Innovation and Entrepreneurship Investment Authority (the governing body for the Center for Innovative Technology). There is no formal coordination with VEDP for awarding these grants.

The same is true of newer potential sources of funding, such as the GO Virginia awards and Virginia Research Investment Funds, that are awarded by other entities with limited or no coordination with VEDP. Additionally, while aerospace-related endeavors would potentially be eligible for grants and awards from any of the aforementioned programs, no grant program exists in the Commonwealth related specifically to the development of the

aerospace sector. Aerospace-related initiatives compete with a wide array of other areas of industry and research for relatively small amounts of money spread around multiple sources of funding.

Finding 2.4. There is no one leadership position, with authority stemming directly from the governor, that is responsible for leading the Commonwealth's economic development efforts for aerospace.

Over the last two years, the VEDP's economic development efforts have been subject to increasing scrutiny and criticism. In 2015, a *Roanoke Times* investigation revealed that a Chinese-owned company, which received $1.4 million in Governor's Opportunity Fund incentives to entice the company to locate in Virginia and an additional $1.7 million pledged to renovate a facility in Appomattox, did not in fact exist. As a result, in January 2016 state lawmakers demanded a review of the VEDP's handling of the deal, and in late spring 2016 the VEDP CEO stepped down.

In November 2016, the Joint Legislative Audit and Review Commission (JLARC) produced a scathing report on the VEDP.[28] In addition to noting serious administrative failures and a lack of accountability, the report noted that:

> State, regional, and local economic development entities in Virginia operate mostly independently of one another and do not systematically coordinate their activities and spending—limiting their ability to share best practices, align activities, and leverage the resources of others. Coordination that does occur is generally unstructured, reactive, and limited to specific projects or one-time events.

Among other recommendations, JLARC proposed that the General Assembly amend the Code of Virginia to establish a Board of Economic Development to provide systematic planning, advice, and direction for the state's economic development system to improve coordination of activities and improve their effectiveness. It also suggested that the General Assembly amend the Code of Virginia to establish a:

> State, Regional, and Local Advisory Team tasked with advising the Board of Economic Development on opportunities to improve the coordination, efficiency, and effectiveness of the state's economic development system. The State, Regional, and Local Advisory Team should provide advice to the Board of Economic Development on how to adapt economic development strategies to reflect changes in Virginia's regions and industries.

[28] *Management and Accountability of the Virginia Economic Development Partnership*, Joint Legislative Audit and Review Commission, November 14, 2016, available at http://jlarc.virginia.gov/pdfs/reports/Rpt488.pdf.

Section 3. State Best Practices and Company Case Studies

The committee examined methods employed by other states to strengthen their aerospace sector. It performed an initial scan of all states, which led it to identify key states that have successfully attracted aerospace companies—Alabama, California, Colorado, Florida, Georgia, Nebraska, New York, North Carolina, North Dakota, South Carolina, and Texas. The committee selected Florida and North Dakota for detailed analysis. These states have several characteristics in common with Virginia (for instance a spaceport and a FAA UAS test site) and represented success in two areas of interest: Florida in commercial space and North Dakota in UAS. The goal of this analysis is to spotlight best practices and lessons learned that could inform recommendations for strengthening Virginia's aerospace strategy.

a) State Best Practices

Florida: Commercial Space

Commercial Space Assets

Because of its long history with space, Florida's aerospace infrastructure is well developed. It is the home of many academic and research institutions with an aerospace focus, including the Florida Institute of Technology, University of Florida, Everglades University, Embrey Riddle University, and the University of Central Florida and its Florida Space Institute. Other research ventures include the Florida Space Research Initiative (a joint program between the University of Central Florida and the University of Florida) and the Florida Center for Advanced Aero-Propulsion.

Many of these institutions belong to Florida's Center of Excellence for Commercial Space Transportation (COE-CST), a consortium of academic, industrial, and governmental entities developed to address current and future challenges in the commercial space industry.[29]

In addition, Florida has a fully articulated supply chain and extensive talent pool. There are over 2,000 aviation and aerospace establishments employing 82,500 workers. Aerospace industry leaders including Boeing, Embraer, General Dynamics, Lockheed Martin, Northrop Grumman, Pratt & Whitney, and Sikorsky, among others, have significant operations in Florida.[30]

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[29] "Competitive Analysis of Virginia's Space Industry," The Performance Management Group, L. Douglas Wilder School of Government and Public Affairs, Virginia Commonwealth University, December 2011.

[30] Enterprise Florida, https://www.enterpriseflorida.com/industries/aviation-aerospace/.

All these advantages contributed to Florida's ability to develop a spaceport at Cape Canaveral. Located at low latitude for efficient orbital launches, Cape Canaveral has an added advantage in that rockets can be launched over open ocean to avoid populated areas. Cape Canaveral is served by Florida's strategic intermodal system (SIS), a network of key roadway, rail, airport, seaports, and spaceport infrastructure identified by the Florida Department of Transportation.[31] It is also in close proximity to NASA's Kennedy Space Center and Cape Canaveral Air Force Station.

> **Finding 3.1. Commercial space infrastructure in Florida is exceptionally comprehensive, encompassing launch facilities at Cape Canaveral, virtually all major aerospace companies, a talented workforce, and a university research enterprise.**

Authority Structure: Space Florida

Florida is distinguished by having created a single dedicated aerospace economic development agency, Space Florida, with the power to negotiate on behalf of the state. After the Federal government announced the end of the shuttle program, then-Gov. Jeb Bush convened the Commission on Space & Aeronautics to determine Florida's way forward. The commission's report, finalized in 2006, outlined the potential benefits of realigning the structure and functionality of Space Florida's three predecessor organizations—Florida Space Authority, Florida Space Research Institute, and Florida Aerospace Finance Corporation—into a single organization. The entity would have a high level of visibility within the state, encourage a high level of industry participation in setting strategic direction, and would also provide a single point of contact for businesses.

Specifically, the Governor's Commission recommended an organization that would:

- Serve as the central organization for coordinating and communicating all space-related matters within the state and thus enhance customer service
- Ensure a focus on mission-critical activities through clear lines of authority and accountability that flow from a single, strongly managed coordinating office
- Be the face and voice of space and aeronautics in Florida
- Be responsible for representing the state and tracking all related legislative issues at the state and federal levels
- Be structured as a private-public partnership like Enterprise Florida or Visit Florida (the equivalent of the Virginia Economic Development Partnership and the Virginia Tourism Authority)
- Report to a board of directors chaired by the governor. This board would include representatives from all areas of the state's space industry, including business, finance, marketing, spaceport operations, research and development, and education. The board

[31] "Florida Spaceport System Plan 2013," Space Florida, April 2013, http://www.spaceflorida.gov/docs/spaceport-ops/florida-spaceport-systems-plan-2013_final.pdf?sfvrsn=2.

would also include members appointed by the governor, the speaker of the House, and the Senate president.

In May 2006, the Florida legislature passed the Space Florida Act, consolidating the three entities into a single new organization. Space Florida was established by the legislature on September 1, 2006, as a special district, dedicated explicitly to "fostering the growth and development of a sustainable and world-leading space industry in Florida."[32]

Its standing as a special district makes it the equal of Florida's Office of Tourism, Trade, and Economic Development (OTTED) in the state hierarchy. As a result, the Space Florida organization chart shows Space Florida with a same level, solid line relationship with OTTED. There is a dotted line relationship between Space Florida's Business Development and Finance Office and Enterprise Florida, the state's equivalent to the Virginia Economic Development Partnership.

Economic Development Funding

In its economic development role, Space Florida has direct access to a full suite of financial tools used to assist space-oriented businesses attracted to Florida. Space Florida has $40 million annually from the state legislature to incentivize aerospace companies to locate in Florida and authority to negotiate arrangements with commercial aerospace companies. Frank DiBello, President and Chief Executive Officer of Space Florida, serves as a single point of contact for aerospace companies seeking to locate in Florida and coordinates the effort across the state. Space Florida can also draw on Enterprise Florida's general economic development funding of $23.5 million annually.[33] It also works hand-in-hand with Workforce Florida. Space Florida has a separate budget for operations and maintenance (O&M) of its space capabilities.

Space Florida has a mix of financing tools[34] at its disposal. They include:

- Conduit Financing. A financing technique that creates a special purpose entity (SPE) that holds title to the assets that are financed. By 2014, Space Florida had facilitated over $480 million in conduit debt financing to help deliver critical infrastructure and equipment to industry partners
- Space Florida Financing Fund (SFFF). A $7 million fund to support financing of facilities, machinery and equipment for aerospace companies that are expanding or creating new operations

[32] www.spaceflorida.gov
[33] "HB 5001, General Appropriations Act," 2016 Bill Summary, Florida Senate, https://www.flsenate.gov/Committees/billsummaries/2016/html/1402.
[34] Space Florida, June 2013 – Florida Economic Development Financing and Incentives applicable to Aerospace companies. Accessed July 5th, 2016 from: http://www.spaceflorida.gov/docs/fact-sheets/florida-economic-development-incentives-update-6-4-2013.pdf?sfvrsn=2

- Space Florida Spaceports Infrastructure Fund (SFSIF). Annual allocation of funding from the Florida Department of Transportation to support infrastructure rehabilitation and development within the designated Florida Spaceport Territory. Funding is capped at $5 million per project
- Space Business Incentive Act. A corporate income tax credit, capped at $1 million, equivalent to up to 50 percent of liabilities. To be eligible, companies must create 35 jobs and invest $5 million.

In addition to funding through Space Florida, aerospace businesses have access to funds available to all other technology-related businesses under Enterprise Florida.

- Capital Investment Tax Credit (CITC). Eligible companies create 100 jobs and invest $25 million in eligible capital costs. It is an annual credit (up to 20 years) against corporate income
- Qualified Defense & Space Contractor Tax Refund (QD&SCTR). A tax refund of $3,000 for each net full-time equivalent (FTE) job created or retained
- Qualified Target Industry Tax Refund (QTI). For companies that create high-wage jobs and target high value-added industries. This incentive includes refunds on corporate income, sales, intangible personal property, etc.
- Quick Action Closing Fund (QACF). For projects that have a positive economic benefit ratio of at least 5 to 1 and pay at least 125 percent of the average annual area-wide or state-wide wage
- High Impact Performance Incentive (HIPI) Grant. For companies that cumulatively invest $50 million and create 50 jobs in Florida in a three-year period or for R&D facilities that cumulatively invest $25M million and create 25 jobs during the same time period.

Aerospace companies are also eligible for funding under Workforce Florida:

- Incumbent Worker Training Program (IWT). Assists existing Florida businesses seeking to provide their employees with the training necessary to keep Florida's workforce competitive in a global economy
- Quick Response Training Program (QRT). An employer-driven training program designed to assist new value-added businesses and provide existing Florida businesses training for expansion
- U.S. Department of Labor Training Grant. A National Emergency Grant to aid businesses hiring and training transitioning aerospace workers displaced from companies significantly affected by changes to the space program at NASA-Kennedy Space Center.

Over the years, Florida has used a combination of incentives. The most common is the Megadeal,[35] a subsidy package worth $75 million or more, which it has used to great

[35] Megadeal Definition - Goodjobsfirst: Accessed July 5, 2016 from: http://subsidytracker.goodjobsfirst.org/prog.php?parent=&statesum=&fedsum=&company_op=starts&company=&major_industry=aerospace+and+military+contracting&free_text=

advantage. Besides the megadeal, Florida has consistently used grants and low-cost loans and, somewhat less frequently, tax credits and training reimbursement. In 2014, Northrop Grumman received incentives totaling $471 million.

Table 1 - Type of Incentives - Florida

Years	2010	2011	2012	2013	2014	Total
Grant/low-Cost loan	$4,909,696	$11,112,196	$6,000,000	$13,000,000	$12,100,000	$47,121,892
MEGADEAL					$471,005,000	$471,005,000
Tax credit/rebate	$3,167,000	$7,198,810		$48,000	$1,400,000	$11,813,810
Training reimbursement	$195,664	$1,372,326	$296,388			$1,864,378
Total	**$8,272,360**	**$19,683,332**	**$6,296,388**	**$13,048,000**	**$484,505,000**	**$531,805,080**

Finding 3.2. Florida has a single dedicated aerospace economic development agency, Space Florida, with a senior leader with the authority to negotiate on behalf of the governor. A special district, Space Florida has the power to negotiate on behalf of the state, a board chaired by the governor, an extensive variety of financial tools, and an annual budget of approximately $40 million to incentivize aerospace companies to locate in Florida. It also can offer incentives through related agencies: Enterprise Florida and Workforce Florida.

North Dakota: Unmanned Aerial Systems

UAS Assets

The UAS industry is in a much earlier part in its lifecycle than commercial space, with the result that North Dakota's UAS assets are much less developed than Florida's commercial space infrastructure. They do, however, have the advantage of being concentrated. These assets include the Northern Plains UAS Test site, one of six FAA UAS test sites nationwide. The test site is seeking to fly UAS up to 29,000 feet above ground without the use of a chase planes.[36] Recently, the test site was successful in securing a block of the electromagnetic spectrum from the Federal Communications Commission for transmitting commands and data during UAS flights. This partnership only increases the attractiveness of North Dakota for companies eager to be among the first to conduct BVLOS operations.

The test site is part of a hub of business, research, and education institutions, all located within an hour drive of Grand Forks. The University of North Dakota in Grand Forks has a vibrant aerospace program, including the John D. Odegard School of Aerospace Sciences,

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&subsidy_level=&subsidy_op=%3E&subsidy=&face_loan_op=%3E&face_loan=&subsidy_type=&sub_year=&state=&order=subsidy_level&sort=desc

[36] Brandi Jewett, North Dakota Drone Effort Lauded at White House Workshop, August 8, 2016, available at http://www.grandforksherald.com/news/local/4089522-north-dakota-drone-effort-lauded-white-house-workshop.

which offers a four-year B.S. in aeronautics with a major in unmanned systems. Two hundred students are enrolled in the program, which recently added a class in UAS business. Other academic programs include aerospace studies, space studies, atmospheric science, and computer science, as well as flight training programs and a nonengineering degree in unmanned aircraft systems operations.

The university also hosts an incubator, the Center for Innovation, to promote local entrepreneurship. A number of startup companies that have emerged from the incubator have established Grand Forks as a center for UAS development. These include Field of View (aerial sensing equipment), SkySkopes (aerial infrastructure inspections), and Smart C2 (aircraft management software). UAS companies in North Dakota include Botlink (drone software), Packet Digital (high-speed power electronics and solar power technology for UAS) and Involta (aerial inspections and information).[37] ComDel Innovation and Altavian manufacture UASs and UAS components at their facility in Wahpeton.[38]

To attract new UAS companies to North Dakota and to publicize the state's growing UAS presence, the Red River Valley Research Corridor (RRVRC) sponsors an annual UAS Summit. The most recent summit, held August 22-24, 2016, featured remarks by top-level officials from the Air Force and NASA, representatives from Northrop Grumman, General Atomics, Insitu, and Textron, as well as addresses from one of North Dakota's senators, its representative in Congress, and the president of the University of North Dakota.[39] Almost 40 exhibitors, including Virginia's Advanced Aircraft Company, set up booths.

The RRVRC is a non-profit corporation committed to catalyzing and promoting science, technology, and engineering initiatives that create new opportunities in the region. Through its coordinating center, it tracks and works to acquire federal research funding, provides basic support that will attract such work, and identifies gaps in technology infrastructure and works to fill them. The Center also provides links between state colleges and universities, companies, and investment capital.[40]

Grand Forks Air Force Base is another important asset. Since 2013, Grand Forks Air Force Base has flown nothing but UAS for the United States military and Customs and Border Protection. It is now home primarily to the Global Hawk and Reaper drones.

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[37] Quentin Hardy, A Silicon Valley for Drones, in North Dakota, New York Times, Dec. 25, 2015, available at http://www.nytimes.com/2015/12/26/technology/a-silicon-valley-for-drones-in-north-dakota.html

[38] North Dakota Governor's Office, Dalrymple Announces $5.6 Million in Additional State Funding for Grand Sky UAS Park, July 6, 2015, available at https://www.commerce.nd.gov/news/DalrympleAnnounces56MillioninAdditionalStateFundingforGrandSkyUASPark/

[39] UAS Summit & Expo, Agenda, August 22-24, 2016, Grand Forks, North Dakota, available at http://www.theuassummit.com/ema/DisplayPage.aspx?pageId=Agenda1

[40] Red River Valley Research Corridor, Coordinating Center, available at http://www.theresearchcorridor.com/content/008-red-river-valley-research-corridor-coordinating-center

Grand Sky, a 200-acre UAS business and aviation park, is located inside the Grand Forks Air Force Base. Created by Grand Forks County, Grand Sky is billed as the nation's first UAS research and industrial park. In late 2015, Northrop Grumman broke ground on a $10 million 36,000-square-foot facility that will support its UAS operations.[41] General Atomics subsequently began work on a 19,400-square-foot UAS academy to train UAS pilots and crew members.[42]

> **Finding 3.3. North Dakota's UAS infrastructure, though small, is well balanced and concentrated around a Grand Forks hub. Its UAS assets include an FAA test site, an Air Force base focused on UAS flight, a UAS business park, and a university conducting UAS research and offering a degree in unmanned systems.**

Authority Structure: Northern Plains Unmanned Systems Authority

North Dakota's economic development effort is organized by industry sector, but aerospace is not listed as a target. However, the governor is very proactive, energetic, and passionate about bringing aerospace companies to North Dakota. The North Dakota Department of Commerce takes the lead, aggressively highlighting the state's nascent UAS industry and providing a "one-stop-shop" for companies wishing to locate in the state.

Within the North Dakota Department of Commerce, the Northern Plains Unmanned Systems Authority (NPUSA) in Grand Sky, North Dakota, is responsible for UAS operations and economic development. Roughly the equivalent of MAAP in Virginia, the authority was established in 2013. Its first goal was to secure an FAA designation as an unmanned aircraft systems national test site. It currently oversees the Northern Plains UAS Test Site. After securing the test site, it received additional funding for test flight operations, allowing it to serve as the "one-stop-shop" for those seeking to test and develop unmanned aerial vehicles. NPUSA is chaired by the lieutenant governor and includes representatives from the University of North Dakota School of Aerospace Sciences, the North Dakota Aeronautics Commission, the North Dakota Department of Commerce, and the Office of the Adjutant General.

Although there is no single state spokesperson for UAS, Robert J. Becklund, the executive director of the Northern Plains UAS Test Site, often joins the governor in advocating for

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[41] North Dakota Governor's Office, Dalrymple, Northrop Grumman Officials Break Ground on Grand Sky UAS Facility, October 5, 2015, available at http://www.commerce.nd.gov/news/DalrympleNorthropGrummanOfficialsBreakGroundonGrandSkyUASFacility/

[42] Brandi Jewett, General Atomics breaks ground on a $2.5 million drone academy in Grand Forks, November 9, 2015, available at http://www.grandforksherald.com/news/business/3878979-general-atomics-breaks-ground-25-million-drone-academy-grand-forks

UAS development. Becklund was the former 119th North Dakota Air National Guard commander.

It is worth bearing in mind that this less structured approach is appropriate for a state like North Dakota. Though it is physically large, its population is under 800,000. Virginia has 8.3 million residents, while Florida has 19.9 million—and their governments are sized commensurately.

Economic Development Funding

The state's Research-ND program has set aside $5 million biannually in grants for research and development to organizations and companies involved in UAS research through cooperation with University of North Dakota (UND) and North Dakota State University (NDSU). In addition, North Dakota has spent a total of about $34 million to establish a national UAS test site, to launch the Grand Sky UAS Business Park (more than $5.6 million), and to advance North Dakota's position as a hub for the nation's growing UAS industry.[43] The North Dakota Department of Commerce estimates that the economic impact of UAS development totaled $59 million through 2016.[44]

State officials at the highest level are engaged in recruiting UAS corporations. Then-Lt. Gov. Dalrymple invited Northrop Grumman's sector vice president of operations to visit North Dakota and learn more about the state's aviation and aerospace offerings. This led to the company building its Grand Sky facility. Dalrymple is now the governor. Both U.S. senators and the governor attended the groundbreaking ceremony. The state's senators and congressman also met with General Atomics executives in a successful bid to persuade the company to build a facility at Grand Sky.

> **Finding 3.4. North Dakota's UAS initiative is housed in its Department of Commerce, which aggressively promotes the state's UAS industry and its ability to offer a "one-stop-shop" for companies wishing to locate in the state. The state has provided a total of $34 million to promote UAS development. The lieutenant governor chairs the authority overseeing its test site. Advocates have included the governor, the state's Congressional delegation, and the executive director of the UAS test site.**

[43] Quentin Hardy, A Silicon Valley for Drones, in North Dakota, New York Times, Dec. 25, 2015, available at http://www.nytimes.com/2015/12/26/technology/a-silicon-valley-for-drones-in-north-dakota.html

[44] Sally French, There's a new Silicon Valley of drones, and it isn't California, Market Watch, June 23, 2015, available at http://www.marketwatch.com/story/theres-a-new-silicon-valley-of-drones-and-it-isnt-in-california-2015-06-22?page=2

Best Practices Lead to Recognition

Thanks to these efforts, Florida is known for commercial space and North Dakota for UAS. The area around Cape Canaveral and the Kennedy Space Center is called the "Space Coast and North Dakota is widely referred to as the "Silicon Valley for Drones."

> **Finding 3.5. One indication of a state's success at space and/or UAV economic development is that it is widely recognized as a space- or UAS-focused state. States like Florida and North Dakota have made aerospace a signature priority, devoting time and resources to supporting existing space and UAS endeavors and welcoming newcomers. The Commonwealth of Virginia is not considered an aerospace state.**

b) Company Case Studies

The following case studies highlight the strengths and weaknesses of Virginia's aerospace economic development efforts. They are based on interviews with corporate personnel and other knowledgeable sources.

Blue Origin

Blue Origin is a privately-funded aerospace manufacturer and spaceflight services company that Amazon founder Jeff Bezos incorporated in 2000. The company is developing technologies that dramatically lower the costs and increase the reliability of spaceflight, setting the stage for private citizens to travel into space. Blue Origin is developing a variety of technologies, with a focus on rocket-powered vertical takeoff and vertical landing (VTVL) vehicles for access to suborbital and orbital space.

Blue Origin's engineering, manufacturing, and business teams work in a 260,000-square-foot facility on 26 acres in Kent, Washington, just 20 minutes south of Seattle. In 2003, Bezos bought land in West Texas two hours east of El Paso and established an engine-test and suborbital test-flight facility. In September 2015, Blue Origin leased Launch Complex 36 in Cape Canaveral, Florida, to build a launchpad for its orbital launch vehicle. It also plans to manufacture its new BE-4-powered orbital launch vehicle at the nearby NASA property at Exploration Park. Groundbreaking for the facility occurred in June 2016. In 2015, the company had approximately 400 employees, just 50 of whom were in Texas.

Florida was chosen as the launchpad and manufacturing facility after an extensive search. Twelve states were selected for initial consideration. The list was quickly trimmed to six. These six states were Virginia, North Carolina, Georgia, Texas, Nevada, and Florida. The list was again trimmed to three states: North Carolina, Georgia, and Florida. These three states were asked to provide a proposal for the facility.

Blue Origin considered five factors when making its decision about placing the facility:

1. A location that would allow rockets to achieve the necessary flight trajectory
2. A launchpad that could accommodate large rockets safely
3. A workforce that could provide the 300 to 500 engineers and technicians the project would require.
4. Proximity to a deepwater port
5. Attractive tax incentives and contributions of property.

Virginia did not make the final consideration round for several reasons. The Virginia Commercial Space Flight Authority had proposed placing the facility at Wallops Island. Blue Origin reviewers determined that the location was too isolated, making it difficult to attract a talented workforce. They felt that existing launchpads could not accommodate larger rockets safely and estimated that modification of the pads and related infrastructure would require an investment of $100 million. Furthermore, they found that the site was too far from a deepwater port. In addition, Blue Origin was not pleased that Virginia intended to charge a flight fee. A final reason may have been the failure of the Orbital ATK Antares ISS supply mission before this decision was announced. At that point, Virginia leadership had publicly adopted an antagonistic relationship to Orbital ATK and NASA.

On a positive note, the reviewers appreciated Virginia's efforts to provide them with direct contact with state decision-makers, in this case the secretary of commerce and trade. They also felt it was helpful that Virginia had created a single entity – the Virginia Commercial Space Flight Authority – staffed by knowledgeable and responsive personnel, an advantage over other states with the exception of Florida. The crucial difference was that, unlike its counterpart in Florida, the Virginia Commercial Space Flight Authority had no negotiating power, a fact that the Blue Origin reviewers felt was a disadvantage.

> **Finding 3.6. Virginia lost the competition for Blue Origin because it lacks a single authority with negotiating power, it couldn't accommodate larger rockets, and the Wallops Island launch site was viewed as too isolated for workforce availability and as too distant from a deepwater port.**

Orbital ATK

Orbital ATK, Inc., formed in 2015 from the merger of Orbital Sciences Corporation and ATK, is an aerospace and defense systems company. Its customers include the U.S. government, allied nations, and prime contractors. Its main products are launch vehicles and related propulsion systems; satellites and associated components and services; composite aerospace structures; tactical missiles, subsystems, and defense electronics; and precision weapons, armament systems, and ammunition. Orbital ATK is headquartered in Dulles, Virginia, with locations in 20 U.S. states as well as in several other countries. It employs 4,000 engineers, 7,000 manufacturing and operational specialists, and 1,000 management

and administration personnel. As of 2015, Orbital ATK had annual revenue of approximately $4.5 billion.

The company has three major divisions. Orbital ATK's Flight Systems Group, headquartered in Chandler, Arizona, provides systems and products that span the space launch, strategic missile and missile defense, and aerospace structures markets. Orbital ATK's Defense Systems Group, headquartered in Baltimore, Maryland, produces precision weapons, tactical rocket motors and warheads used in air-, sea- and land-based systems, missile-warning products, and advanced gun systems. Finally, Orbital ATK's Space Systems Group in Dulles builds satellites and advanced space systems. It offers a broad portfolio of products for commercial, military, scientific, and international customers.

Orbital ATK is headquartered in Northern Virginia because its predecessor company, Orbital Sciences Corporation, was formed there in 1982 to take advantage of proximity to the federal government and agencies such as NASA. The company subsequently added personnel to its Dulles facility while expanding its presence around the nation and the world via acquisitions. Although the Commonwealth was not a player in most of this growth, the Virginia Center for Innovative Technology did make a minor co-investment in the company in 1990.

A relationship between Orbital Sciences Corporation and NASA Wallops Flight Facility began during the 1990s when the two organizations collaborated on the launching of the Pegasus rocket. Although Orbital Sciences conducted some small ground launches from Wallops during the same period, there was a pause in the relationship until 2008 when the company won the NASA Space Station Resupply contract. It bid the contract based on using Wallops as its launch site. The company felt that Wallops would be a better collaborative partner when it came to controlling such issues as launch time, and it had excellent relationships with the governor and secretary of commerce and trade. Using Wallops required a $140 million launchpad renovation, to which the Commonwealth contributed approximately $95 million. Launches for Space Station resupply continue to take place from the Wallops Facility.

> **Finding 3.7. Even though siting its International Space Station resupply mission at the NASA Wallops Flight Facility required Orbital ATK to invest heavily in launchpad upgrades, it chose Wallops because of the knowledge and flexibility of its management and the good relationships it had with the governor and his administration.**

Aerojet Rocketdyne

Aerojet Rocketdyne is a leading supplier of space propulsion system products and services. It offers a full spectrum of flight-qualified propulsion products ranging from chemical and electrical propulsion systems to individual monopropellant, bipropellant, and electric propulsion engines. In addition, it provides services for architecture and mission design,

systems engineering, design and development, manufacturing, and testing. Its customers include U.S. military and both U.S. and foreign civil and commercial customers. Aerojet Rocketdyne is a $1.7 billion company.

Aerojet Rocketdyne has numerous locations in the United States, including California, New Jersey, Alabama, Tennessee, Washington, Arizona, Utah, New Mexico, Mississippi, and Florida. It has three locations in Virginia. Its Arlington office focuses on governmental relations and liaison with its government and corporate customers base. Orange County is the home of its Manufacturing Center for Strategic Solid Post Boost Propulsion, its Technology Development Center, its Laboratories for Solid Propulsion, and its test facilities for rocket motors and air-breathing propulsion. Finally, Aerojet Rocketdyne's Gainesville facility houses engineering design and analysis for tactical rocket, strategic solid post-boost, and ramjet propulsion and innovative advanced product technologies. The Gainesville office also provides development and production program management as well as administrative support for East Coast Aerojet Rocketdyne facilities.

In the process of acquiring and integrating five companies over the last 15 years, Aerojet Rocketdyne has interacted with the economic development organizations and key decision-makers in numerous states. In an interview, Aerojet Rocketdyne noted that a number of the states offered more meaningful incentives than Virginia, and that the Commonwealth seems to concentrate its economic development efforts on a few big prizes rather than the incremental growth of established companies. However, the company emphasized that it had good relationships with the state's universities, an important consideration given its needs for a highly skilled workforce and research support.

The weakness of Virginia's approach to economic development was underscored by Aerojet Rocketdyne's 2014 decision to add a major research program to its Huntsville, Alabama, facilities. It chose Alabama rather than many other suitable sites because Alabama made a coordinated effort to secure the program. Alabama deployed its governor, local officials, and educational leaders at opportune moments in the negotiating process to demonstrate its commitment. The company appreciated this team effort, something it found lacking in Virginia.

> **Finding 3.8. Aerojet Rocketdyne chose to locate a research facility in Alabama because it felt that the state made a coordinated and substantial effort to secure the facility, an installation that Virginia might not have thought a substantial enough target for economic development.**

Rolls-Royce

Rolls-Royce, a power systems provider that designs, manufactures, and supports a range of products and services for air, sea, and land applications, has been in North America for over 100 years and employs more than 7,000 workers in the United States. Over the last decade, it has invested over $1 billion in the United States, enabling it to expand and develop

several new state-of-the-art facilities including its Crosspointe advanced manufacturing and research campus in Prince George County, Virginia. The plant is located on 1,000 acres 30 miles south of Richmond, and includes two production factories. The first plant at Crosspointe, the Rotatives Factory, began production in 2011. The second, the Advanced Airfoil Machining Facility, began production in 2014. The Crosspointe facility is the first advanced manufacturing facility that Rolls-Royce has built from the ground up in the United States. Rolls-Royce decided to build this new facility near Petersburg, Virginia, in 2007.

Rolls-Royce's goal for Crosspointe was two-fold: to expand its presence in the United States and to build the most advanced and most efficient manufacturing facility in the world. Rolls-Royce did significant research before deciding what to build and where to build. As part of this process, it studied the manufacturing processes of its competitors and other large manufacturing companies such as Airbus, Boeing, and Caterpillar, as well as considered its own needs. It determined that it required a large tract of land, which would give it room to expand and provide the buffer necessary to build a jet engine test facility on the site. Because it needed access to a trained workforce, Rolls-Royce preferred a state with an excellent education system including institutions of higher education as well as trade schools. It was also looking for a pro-business, right-to-work state where it could have a close relationship with state leadership. Ultimately, it wanted to feel that its activities would be important to the state.

Rolls-Royce decided to study the assets of a number of states before approaching any single state with its plans. Its philosophy was to involve only those states with the assets it needed in order to limit the loser pool. It determined early in its search process to focus on the Southeast, already a center for aerospace manufacturing.

The final three states under consideration were Georgia, South Carolina, and Virginia. There were two primary reasons that Rolls-Royce chose Virginia. It is a right-to-work state and it was aggressive in securing its business. Prince George County provided 1,000 acres of land in a good location, as well as tax incentives based on the jobs created. The Commonwealth also allocated funds to the University of Virginia and Virginia Tech to enhance their research and educational capabilities in areas that supported the mission of the new facility. This allowed Rolls-Royce to establish collaborative relationships with them early in the negotiation process, an important factor for creating such an advanced facility. In addition, Virginia was willing to provide the company access to state decision-makers. Rolls-Royce interacted with the governor and the relevant cabinet secretaries, not just with the economic development community.

One reservation that the company had, however, was the need for a trained workforce, prepared at the community college and trade school level to operate the company's advanced equipment. This issue has persisted. Rolls-Royce is currently concerned that it cannot continue to expand unless this issue is addressed.

Finding 3.9. Rolls-Royce chose Virginia because it is a right-to-work state, Virginia aggressively pursued their business, and Virginia's universities were

proactive in meeting its needs. It is concerned about shortages of trained workers.

Advanced Aircraft Company

Advanced Aircraft Company (AAC) is an aeronautical engineering and manufacturing start-up located in the Peninsula Technology Incubator in Hampton, Virginia. Bill Fredericks, the company's CEO and founder, created the company in 2016 to license the Greased Lightning (GL-10) vertical takeoff and landing (VTOL) UAS developed at NASA Langley Research Center.

This 62-pound UAS has a 10-foot wingspan and was flight-tested successfully at NASA Langley in June 2015. The design improves on the speed, range, and endurance of existing multirotor VTOL UAS thanks to the aircraft's ability to transition from hovering to winged flight. This development alone generates more than a seven-fold improvement in aerodynamic efficiency. Linear inspection, package delivery, and Department of Defense Group 2 Tactical UAS applications are initial target markets for the GL-10.

Developing GL-10 is a capital-intensive effort. While it is raising funds, AAC has designed and is now prototyping an octorotor UAS it calls Hercules. Powered by a hybrid system consisting of a two-stroke gas engine turning an electrical generator, Hercules offers a level of endurance that battery-powered multirotor UAS cannot equal as well as an improved aerodynamic design. Hercules will have a $60,000 price tag.

To date, AAC has raised small start-up funding from family and friends and hopes to complete its first round of angel investment by the end of 2016. It plans to fly its Hercules #3 by first quarter 2017 and produce two per month by first quarter 2018.

AAC's primary reason for being in Virginia is the proximity to NASA Langley, where the GL-10 was developed. However, North Dakota economic development officials have shown interest in AAC moving to Grand Forks, and Fredericks is considering the option. In addition to capital, AAC needs free or low-cost access to FAA-approved flight test facilities, especially facilities that support beyond visible line of sight (BVLOS) flight.

Finding 3.10. To flourish, UAS start-ups need a suite of services, the most pressing of which are incubators, funding for prototyping and testing, and access to capital.

OmniEarth

OmniEarth illustrates the potential of space and UAS platforms and the data they generate to support information enterprises. Established in 2014, OmniEarth is a privately funded aerospace manufacturer and spaceflight services company in Arlington, Virginia, that

specializes in advanced geoanalytics. The company exploits data from aerospace systems—satellites, UAS and other sources of information—to develop solutions as a service (SaaS) for multiple users, including insurance companies, municipalities, natural resource managers, and other clients.

The company has 34 staff members, scientists, and engineers and serves more than 35 customers. It has five patents, either issued or pending, on automated derivation of information for aerial and satellite imagery as well as proprietary algorithms and trademarks in remote sensing. It has content partnerships with national data providers including aerial imagery as well with virtually all commercial satellite companies.

OmniParcel™ is an example of the kind of product OmniEarth develops. OmniParcel applies artificial intelligence and machine learning to aerial and satellite imagery and property data to automate the verification and identification of infrastructure and commercial and residential parcel features, currently a time-intensive process. Its parcel-by-parcel analysis is available by state, county, or zip code. The OmniParcel platform is cloud-based and easily scalable to encompass as much, or as little, territory as required. The data are updated several times per year.

OmniParcel can be customized for different industry segments. OmniParcel™ for Water Resource Management is delivered to nearly 90 California water agencies, either directly or through their wholesalers, to help identify lost revenue due to water leakage. In this case, OmniEarth creates additional water efficiency analytics by fusing weather, image, property, and water-meter data.

OmniEarth chose to locate in Crystal City for its access to transportation (METRO, Virginia Railway Express), availability of skilled workforce, and proximity to large aerospace companies, such as Orbital ATK, Boeing, and Lockheed Martin. Virginia tax incentives did not influence its decision.

Finding 3.11. OmniEarth demonstrates the potential of an active aerospace sector, including commercial space and UAS, to promote the development of companies that provide data analytics and other services.

Recommendation 3.1. Virginia must create a senior, high-level aerospace economic development position with direct access to the governor and the authority to negotiate with aerospace companies considering investing in Virginia.

Recommendation 3.2. Virginia must commit significant existing and new resources, including budget and tax incentives, to be used in attracting new aerospace investments to Virginia.

Recommendation 3.3. Virginia must support, strengthen, and market its current aerospace assets including its governmental, commercial, and academic assets.

Recommendation 3.4. Virginia must coordinate its existing set of government, commercial, and academic institutions within the state to achieve an effective economic development capability.

Section 4. Outlook for Federal Aerospace Spending

The Commonwealth of Virginia's aerospace industry is now, and will likely remain for many years, heavily dependent on federal spending. The overall outlook is that federal spending for aerospace programs, in total, will remain relatively flat for the next few years, with potential future increases tied, in part, to the expiration of Budget Control Act caps in 2021.[45] Therefore, continued success will depend on enhancing the state's competitive positioning.

Federal spending that supports the aerospace industries is channeled through many agencies and programs. A few examples include:

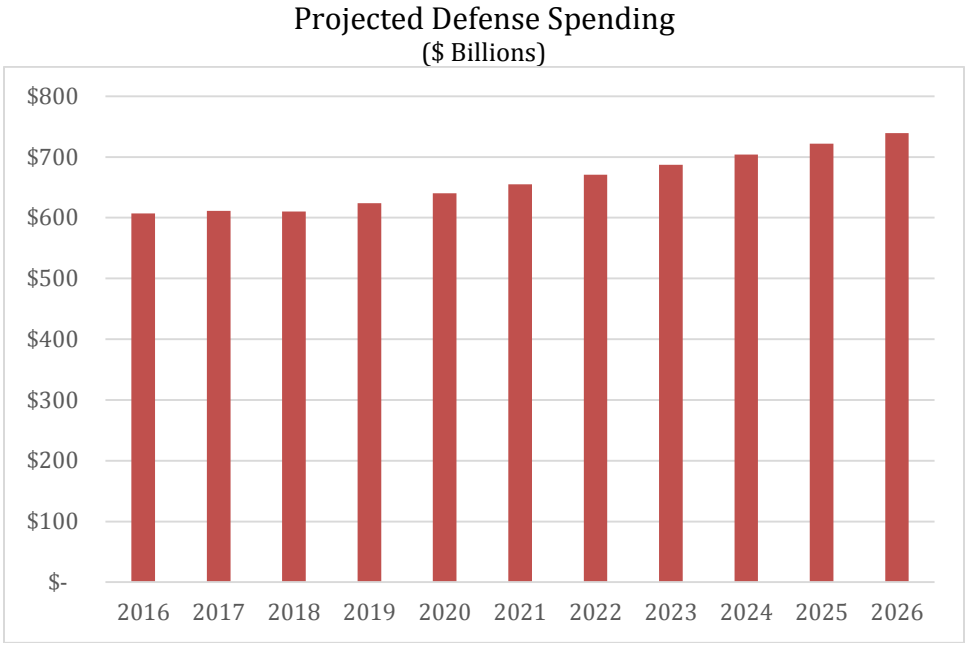
- Department of Defense (DoD)
    - DARPA/National Institute for Aerospace
    - Air Force Office of Science and Research/National Center for Hypersonic Combined Cycle Propulsion
    - Procurement spending related to:
        - Weapons systems
        - Intelligence systems
        - Other R&D
    - Military bases
- National Aeronautics and Space Administration (NASA)
    - Langley Research Center
    - Wallops Flight Facility
- National Science Foundation
    - University grants
        - Community college curricula for UAS operations technicians
    - Research Center grants
        - National Center for Coatings, Application, Research, and Education
        - Other
- Other federal agency research and procurement spending

The Budget Control Act of 2011 and the subsequent failure of the Joint Select Committee for Budget Reduction to reach a mandated agreement sparked budget sequestration cuts that lowered DoD spending by $131 billion in FY2015 compared to FY2010. More positively, DoD total spending budgeted for FY2016 rose by $20 billion. Assuming no significant changes in budget caps, and if Congress passes budgets that do not invoke future sequestration provisions,[46] the CBO January 2016 baseline budget projections show

[45] This assessment does not include specific assumptions about changing spending priorities related to the outcome of the November 2016 elections.

[46] OMB's August 2016 report on the proposed federal budget shows that the Senate budget for FY2017 meets all specified budget caps, while the House budget would trigger a relatively modest $17 million sequester in defense spending if passed as presented.

defense spending staying relatively flat for the next few years until Budget Control Spending Caps expire in 2020, and then slowly increasing over the next several years (see figure below).



Source: Congressional Budget Office

Shifting priorities in DoD spending have not been favorable for space-related activities. Based on data from the Center for Innovative Technology (CIT),[47] spending for space-based systems in the defense budget declined by 4.1 percent between FY2015 and FY2016, a drop of $7.1 billion. While not drawing specific conclusions about future spending priorities, spending for space is likely to be affected by increased spending for aircraft and related systems due in part to higher demand for maintenance, repair, and overhaul (MRO) spending to support an aged military aircraft fleet. According to CIT, the overall average age of Air Force aircraft is 31 years, with the refueling fleet now averaging more than 50 years old. Recently awarded contracts for new tankers and other aircraft will likely result in shifts in spending, with space systems being a *potential* target for future cuts.

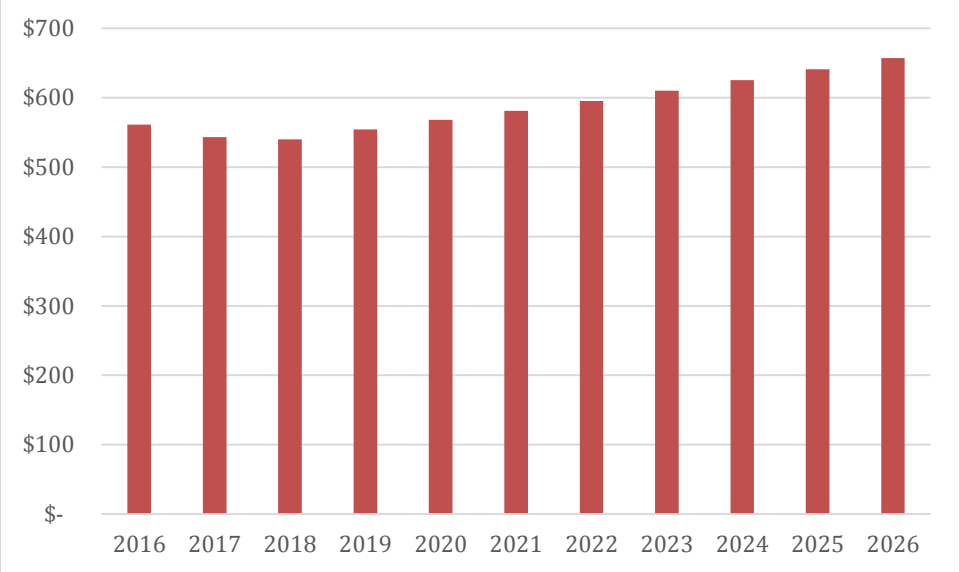
Over the past several years, one of the fastest growing segments of aerospace spending has been in unmanned aerial systems (UAS), at least in terms of percentage increases. *Business Insider* estimates that the global UAS market totals roughly $9.5 billion in 2016,[48] with the vast majority of that market being defense-related purchases. Its outlook for sales trends in the defense segment of this industry generally tracks with overall U.S. defense budgets. However, as U.S. services have met their fleet targets for UAVs, spending is projected to drop in the near term. An analysis conducted by the Center for the Study of the Drone at Bard College reports that the President's FY2017 budget reduces UAV spending by $1.2

[47] https://www.cit.com/thought-leadership/us-defense-spending-industry-outlook/
[48] http://www.businessinsider.com/uav-or-commercial-drone-market-forecast-2015-2

billion compared to FY2016.[49] Companies supplying drones for military uses will likely attempt to build the nonmilitary segments of their business.

The near-term story is bleaker for non-defense discretionary federal spending that may impact aerospace. Over the next few years, non-defense discretionary spending, which includes NASA, NSF, and other departments and programs that support aerospace-related research and activities, is projected to decline compared to FY2016 (see figure below). Spending will rise as budget control caps expire in 2021. As of August 2016, the OMB estimates that the FY2017 budget prepared by the U.S. House of Representatives would trigger $775 million in nondefense sequestration cuts, while the Senate version would not trigger sequestration cuts. As this report is written, there has been no budget agreement reached in Congress for FY2017.

Non-Defense Discretionary Spending
($ Billions)



Source: Congressional Budget Office

NASA is also experiencing budget pressure. According to industry group presentations, the president's FY2017 budget reduces NASA's $19 billion 2016 budget by about $300 million. More importantly, this reduction targets deep space exploration programs with a proposed 19 percent cut to Exploration Systems Development, possibly reflecting a shift in administration priorities. Of course, the enacted budget could see some of these cuts restored, but there is a clear preference in the current administration's last year to shift space exploration funding to other priorities.

The general outlook for the federal budget over the next few years suggests that aerospace-related spending will remain, at best, relatively flat with opportunities for growth starting in FY2021, assuming that Budget Control Act spending caps are allowed to expire. The

[49] http://dronecenter.bard.edu/drones-in-the-fy17-defense-budget/

budget outlooks coincide with widely accepted economic forecasts that the U.S. economy will continue to grow, but at a historically modest pace. However, given the need to replace or modernize a wide range of systems (weapons, command/control, cybersecurity) and facilities within the defense budget, some aerospace industry initiatives will be challenged in maintaining their existing spending levels.

> **Finding 4.1. Defense and civil aerospace spending is uncertain but is likely to be flat in the near term. As a result, federal spending on aerospace initiatives, programs, and research will face increased competition from other spending priorities.**

This is not to say that there will not be federal funding opportunities in commercial space and UAS. For instance, in September 2016 the U.S. Navy awarded Northrop Grumman a $255.2 million contract to build the first three MQ-4C Tritons, its new intelligence, surveillance, and reconnaissance UAS designed for oceans and coastal regions. A few days later, the Navy ordered $95 million in spare parts and $49.4 million to procure long-lead components. Triton is designed to fly for 24 hours at a time, at altitudes in excess of 10 miles, and for distances as far as 8,200 nautical miles.

The Navy plans to purchase 68 aircraft at an estimated cost of $130 million each. It is deciding on the location of the program's East Coast home base, which would host launch and recovery operations as well as a maintenance facility. Initially, the base would be home to four Tritons with room for up to four more undergoing maintenance and will bring with it more than 400 jobs. Wallops Flight Facility as well as two installations in Florida—the Naval Station Mayport in Jacksonville and the Naval Air Station in Key West—are in the running for the base.

The Wallops Island Regional Alliance has been a leading proponent for locating the facility in Virginia. It has faulted Virginia for being slow to recognize the potential of this contract. Among Wallops Island's strengths are its proximity to Naval Air Station Patuxent River, where the Triton aircraft were first developed and tested, as well as to Navy facilities in the Hampton Roads vicinity. They also cited Wallops' experience with similar unmanned aerial vehicles, including NASA's RQ-4 Global Hawk, and the fact that Virginia is less adversely impacted by hurricanes and other severe weather events. Finally, they noted that the 400 jobs associated with the initiative would have a much greater impact on the Wallops-area economy than on the areas surrounding the Florida sites. [50,51] Similar arguments are being proposed to persuade the Department of Homeland Security to base a new science and

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[50] Jeremy Cox, *delmarvanow*, 3 Governors, 1 Mission: Bring Drones to Wallops, available at http://www.delmarvanow.com/story/news/local/virginia/2016/06/24/navy-triton-drones-wallops/86332348/

[51] Peter Bale, Wallops Island Regional Alliance, Presentation to VASEM Aerospace Committee, October 10, 2016.

technology testing ground for unmanned vehicle systems (operating in the air and underwater) in Virginia.[52]

The recently announced Harnessing the Small Satellite initiative, created by the White House Office of Science and Technology Policy, represents an opportunity for commercial space. A collection of programs from NASA, the National Geospatial-Intelligence Agency, the Department of Commerce, and the Intelligence Advanced Research Projects Activity, the small satellite initiative is designed to promote government and private use of small satellites for remote sensing, communications, science, and the exploration of space. It includes a $30 million NASA program to support data buys derived and purchased from nongovernmental small spacecraft constellations and to advance small spacecraft constellation technologies; $20 million to Planet, a startup currently building out a constellation of imagery smallsats in low-Earth orbit; and a NOAA contract to two smallsat-constellation operations, GeoOptics and Pire Global, to provide space-based radio-occultation data for the purpose of demonstrating data quality and the potential value to NOAA's weather forecasts and warnings.[53]

There is no doubt that numerous other opportunities will arise if close collaboration is maintained between the Commonwealth and federal facilities located in Virginia. One example is the Air Force Air Combat Command, headquartered at Joint Base Langley-Eustis and the primary provider of air combat forces to America's warfighting commanders. Replacement and upgrades for such equipment as the MQ-9 Reaper, a long-endurance remotely piloted aircraft, are always issues for the command. Other opportunities may arise from the growing interest in the X-plane and the related increase in NASA's budget to support aeronautics research.

Finding 4.2. Despite anticipated flat federal spending, there nonetheless are large federally-funded opportunities like the Triton program, which would result in 400 jobs.

Recommendation 4.1. Virginia must aggressively search for new opportunities in the financially-constrained federal sector and secure these opportunities for the Commonwealth.

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[52] Michael Martz, *Richmond Times Dispatch*, Virginia Looks at New Opportunities for Wallops Spaceport, available at http://www.richmond.com/news/virginia/government-politics/general-assembly/article_24351021-ee16-5e65-8df0-aff600fae3ef.html

[53] The White House, "Harnessing the Small Satellite Revolution to Promote Innovation and Entrepreneurship in Space, October 21, 2016, available at https://www.whitehouse.gov/the-press-office/2016/10/21/harnessing-small-satellite-revolution-promote-innovation-and

Section 5. Conclusion

Commercial space and UAS are two of the fastest growing segments of the aerospace industry, generating thousands of well-paying jobs, both directly and indirectly, and producing substantial growth for states supporting economic development in these areas. In commercial space, companies like SpaceX, Blue Origin, Virgin Galactic, Orbital ATK, and Bigelow Aerospace are taking over many activities formerly conducted by NASA, including supplying the International Space Station. The UAS industry is at an earlier stage of its life cycle, but the Federal Aviation Agency has begun to move forward with a series of regulations that will accelerate the use of high-end drones for commercial activities like pipeline inspection and logistics. At the same time, the military continues to invest in drones, like the MQ-4C Triton, with ever more advanced capabilities.

Virginia has assets in both commercial space and UAS that could position it for leadership. This includes one of four spaceports with FAA approval to launch into space, one of just six FAA UAS test sites, the NASA Wallops Flight Facility and the NASA Langley Research Center, the presence of every major aerospace company in the nation, proximity to the nation's capital, and top-rated universities.

Despite these advantages, a number of other states have outpaced the Commonwealth, particularly Florida in commercial space and North Dakota in UAS development and application. Florida's assets are the result of almost sixty years of space flight, but North Dakota has amassed a flourishing UAS sector in less than a decade. The difference between these two states and Virginia is the focus with which they coordinate existing assets to maximize their value and the single-mindedness with which they support economic development in aerospace.

Florida has a dedicated aerospace economic development agency that has power to negotiate on behalf of the state, a board chaired by the governor, an extensive variety of financial tools, and an annual budget of approximately $40 million to incentivize aerospace companies to locate in Florida. North Dakota, because of its size, takes a simpler but no less focused approach. North Dakota's UAS initiative is housed in its Department of Commerce, which aggressively promotes the state's UAS industry and its ability to offer a "one-stop-shop" for companies wishing to locate in the state. The lieutenant governor chairs the authority overseeing its UAS test site, and UAS advocates have included the governor and members of its Congressional delegation.

By contrast, the Virginia Economic Development Partnership has limited authority to negotiate with private companies and a limited number of incentives to offer them. In addition, it has pursued a regional economic development strategy that has proven itself to be unequal to the challenge of conveying the totality of Virginia's aerospace assets or of encouraging coordination among these regions. As a result, the Commonwealth has not secured a commitment from a major commercial aerospace company since it signed its first

agreement with Orbital ATK in 2008. Today, Florida and North Dakota are known as aerospace states; Virginia is not.

The findings and recommendations in this report show that Virginia still has an opportunity to become a national leader in the commercial space and UAS industries, but that window is limited. If Virginia is to realize the potential of its substantial assets and its opportunities, it must act now.

Appendix A. Committee Member and Staff Biographies

Committee Leadership

A. Thomas Young, Chair

Thomas Young is the former Director of NASA's Goddard Space Flight Center, former President and COO of Martin Marietta, and former Chairman of SAIC. He retired from Lockheed Martin in 1995. During his NASA career, he served as Deputy Director of the Ames Research Center, Director of the Planetary Program, and Mission Director of the Viking Mars Project.

Mr. Young has been a member of the Board of Directors of the Goodrich Corporation, SAIC, Martin Marietta, Cooper Industries, Dial Corporation, Salomon Corporation, and Potomac Electric and Power Company. He is a member of the National Academy of Engineering and a member of the Virginia Academy of Science, Engineering and Medicine.

He received a B.S. in aeronautical engineering and a B.S. in mechanical engineering from the University of Virginia and an M.S. in management from the Massachusetts Institute of Technology as a Sloan Fellow.

James H. Aylor, Vice Chair

Dr. James Aylor served for 11 years as the dean of the School of Engineering and Applied Science at the University of Virginia, having previously served as associate dean of academic programs and chair of the Department of Electrical Engineering. He is currently Louis T. Rader Professor and Dean Emeritus.

His research focuses on computer system design, including computer technology for persons with disabilities. His accomplishments include participating in the development of the VHSIC Hardware Description Language (VHDL), the development of a new "mixed-level" modeling technology to support the early phases of the computer systems design process, and the development and implementation of automatic test pattern generation techniques. Dr. Aylor was instrumental in the founding of the Engineering School's Center for Semicustom Integrated Systems, which focuses on the design and implementation of complex electronic systems.

Dr. Aylor has also been extremely active in professional activities both in technical and administrative capacities. He served as the president of the Institute of Electrical and Electronic Engineers (IEEE) Computer Society and served as a division director (and a board of directors member) of IEEE. He is a past Editor-in-Chief of *IEEE Computer*, received by the more than 100,000 IEEE Computer Society members. He served as president of the Electrical & Computer Engineering Department Heads Association. He is a fellow of IEEE

and a fellow of the American Association for the Advancement of Science. He is a member of the Virginia Academy of Science, Engineering and Medicine.

Dr. Aylor received the B.S., M.S., and Ph.D. degrees in electrical engineering from the University of Virginia.

Committee Members

David Bowles

Dr. David Bowles, director of NASA's Langley Research Center, Hampton, Virginia, has been an active member of the NASA Langley community for more than 35 years. He began his career conducting research in advanced materials for use on aerospace vehicles and then focused on materials to be used in space. He has published many research papers on the effects of materials degradation on structural and thermal properties.

As the director of Langley's Exploration and Space Operations Directorate from 2007 to 2012, he had overall management responsibility for identifying opportunities, defining implementation strategies, and delivering on mission commitments. He supported NASA's Human Exploration and Operations Mission Directorate along with the Space Technology Program in the Office of the Chief Technologist. He has been the recipient of numerous awards, including NASA's Outstanding Leadership Medal in both 2005 and 2015.

Dr. Bowles earned his bachelor's, master's and doctoral degrees in engineering mechanics from Virginia Tech.

Terry Clower

Dr. Terry Clower is Northern Virginia chair and professor of public policy at George Mason University. He is also director of GMU’s Center for Regional Analysis. The center provides economic and public policy research services to sponsors in the private, nonprofit, and public sectors.

Prior to joining GMU, Dr. Clower was director for the Center for Economic Development and Research at the University of North Texas. Dr. Clower also spent 10 years employed in private industry in logistics and transportation management positions.

Dr. Clower has authored or co-authored over 150 articles, book chapters, and research reports reflecting experience in economic and community development, economic and fiscal impact analysis, transportation, land use planning, housing, and economic forecasting.

Dr. Clower received a B.S. in marine transportation from Texas A&M University as well as an M.S. in applied economics and a Ph.D. in information sciences from the University of North Texas.

Senator John Cosgrove

Senator John Cosgrove was elected to the Virginia Senate in 2013, representing the 14th Senate District, which includes parts of Chesapeake, Virginia Beach, Suffolk, Portsmouth, Southampton County, Isle of Wight County, and Franklin. Previously, he served on the Chesapeake City Council and then as vice-mayor before being elected to the House of Delegates in 2001. He represented the citizens of the 78th House District for over 12 years.

In the Virginia Senate, Senator Cosgrove serves on five committees: Commerce and Labor, Transportation (as vice chair), Education and Health, Rehabilitation and Social Services (as vice chair), and Local Government. In his 15 years as a state legislator, he has received numerous awards and accolades.

Senator Cosgrove is a graduate of Tidewater Community College and Old Dominion University where he received his B.S. in engineering.

Antonio Elias

Dr. Antonio Elias is executive vice president and chief technical officer of Orbital ATK, posts he held at its predecessor company, Orbital Sciences. During his career at Orbital, Dr. Elias led the technical team that designed and built the Pegasus air-launched booster, Orbital's APEX and SeaStar satellites, and the X-34 hypersonic research vehicle.

Prior to joining Orbital, Dr. Elias held various teaching and research positions in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology. During the 1970s, he worked on the design of the Space Shuttle Orbiter avionics system at Draper Laboratory, where he originated the Shuttle's Terminal Area Energy Management (TAEM) guidance concept.

Dr. Elias is a member of the National Academy of Engineering and the Virginia Academy of Science, Engineering, and Medicine, and a fellow of the American Institute of Aeronautics and Astronautics, the American Astronautical Society, and the International Academy of Astronautics. His awards include the 1991 AIAA Engineer of the Year, AIAA Aircraft Design Award, and AAS Brouwer Award. He is a co-recipient of the 1991 National Medal of Technology and the 1990 National Air and Space Museum Trophy and holds FAA Airline Transport Pilot and Flight Instructor certificates.

Dr. Elias holds B.S., M.S., E.A.A., and Ph.D. degrees from the Massachusetts Institute of Technology.

Donald M. Kerr

Dr. Donald M. Kerr has had a long and distinguished career in government and private industry. He has served as principal deputy director of National Intelligence, director of the National Reconnaissance Office, assistant to the secretary of the Air Force for Intelligence

space technology, and deputy director for science and technology at the CIA. He was also director of the Los Alamos National Laboratory.

In the private sector, Dr. Kerr has held several executive positions, including executive vice president and director at Information Systems Laboratories, Inc., corporate executive vice president and director at Science Applications International Corporation, and president and director of EG&G, Inc. He is vice chairman of the Board of Trustees of The MITRE Corporation and a director of Areté Associates, Michael Baker International, LLC, and Orbis Operations, LLC.

Dr. Kerr has received several awards for his public service. They include the National Intelligence Distinguished Service Medal, the CIA Distinguished Intelligence Medal, the NRO Distinguished Service Medal, and the DOE Outstanding Service Award. He is a fellow of the American Physical Society and the American Association for the Advancement of Science.

Dr. Kerr holds a B.S. in electrical engineering, an M.S. in microwave electronics, and a Ph.D. in plasma physics and microwave electronics from Cornell University.

Scott Kordella

Dr. Scott Kordella is a director within MITRE's National Security Engineering Center, with responsibility for MITRE programs that support the National Reconnaissance Office and the Department of Defense Principal Defense Space Advisor Staff.

Dr. Kordella is a radio frequency systems engineer with over 30 years of experience in intelligence, surveillance, and reconnaissance system design, addressing space, missile defense, measurement, signal intelligence, and communications domains. In his current role, he leads MITRE's support to the Department of Defense and intelligence community national space programs, developing and implementing strategies that improve the posture of U.S. space-based capabilities. He has served as a subject matter expert on several intelligence community-wide studies, chief engineer for MITRE's NRO support, chief radar engineer for several DoD major system acquisitions, and researcher in multiple intelligence science and technology studies.

Prior to joining MITRE, Dr. Kordella was a senior fellow for Computer Sciences Corporation, leading support to the Missile Defense Agency, the Navy's Aegis Navy Theater-Wide development, and the Joint Theater Air and Missile Defense Organization. He is a registered professional engineer in the Commonwealth of Virginia and a senior member of the IEEE.

Dr. Kordella holds a B.S. in physics from the University of Maryland, an M.S.E.E. in electrophysics and a D.Sc. from George Washington University.

John Langford

Dr. John Langford is chairman and CEO of Aurora Flight Sciences Corporation, which he founded in 1989. He also co-founded Athena Technologies in 1998 and served as its CEO and chairman. While a student at MIT, Langford organized and led a series of human-powered aircraft projects, culminating in the Daedalus Project, which in 1988 shattered the world distance and endurance records for human-powered flight with a 72-mile flight between the Greek islands of Crete and Santorini.

Dr. Langford has served on the Board of Directors of the National Aeronautics Association (NAA) and is a member of the Executive Committee of the Aerospace Industries Association (AIA). He serves on the NASA Advisory Council (NAC) and chaired the Subcommittee on Unmanned Air Systems. He has also served on academic advisory boards at MIT, the University of Maryland, and Mississippi State University, and on several study committees for the National Research Council. He was named by the governor of Virginia to chair the Virginia Commission on Unmanned Systems and is a fellow of the American Institute of Aeronautics and Astronautics (AIAA) and the Royal Aeronautical Society (RAeS).

Dr. Langford's awards include the Cliff Henderson Trophy from the NAA, the Kremer Speed Prize from the RAeS, the Barry M. Goldwater Educator Award from the AIAA, Virginia's Outstanding Industrialist award from the Commonwealth of Virginia, and the President's Award for Exceptional Service and the Howard Galloway Award from the National Association of Rocketry. He recently accepted the prestigious *Aviation Week* 2016 Laureate Top Innovation Achievement Award for Aurora's record setting UAS Orion.

Dr. Langford received his B.S. in aeronautics, M.S. in aeronautics and astronautics, M.S. in defense policy, and Ph.D. in aeronautics and public policy from MIT.

General Lester Lyles

General Lester Lyles retired as a four-star general from the U.S. Air Force following a distinguished career that included posts as vice chief of staff of the Air Force, director of the Ballistics Missile Defense Organization, commander of the Space and Missile Systems Center, and Commander of Ogden Air Logistics Center. He completed his active duty career in 2003 as Commander of the Air Force Materiel Command at Wright-Patterson Air Force Base.

Since his retirement from the Air Force, he has served as a company director for General Dynamics, KBR Incorporated, Battelle Memorial Institute, and USAA among others. Among the many accolades General Lyles has received are the NASA Distinguished Public Service Medal and the Thomas D. White Award from the United States Air Force Academy. He is a member of the National Academy of Engineering and the Virginia Academy of Science, Engineering and Medicine.

General Lyles has a B.S. in mechanical engineering from Howard University and an M.S. in mechanical engineering from New Mexico State University.

Billie Reed

Billie Reed served as executive director of the Virginia Commercial Space Flight Authority (Virginia Space) from its inception in 1995 until October 2012. During his tenure as executive director, he led the development of the only FAA-licensed commercial spaceport co-located on a NASA facility. It includes Launchpad 0A, the only new mid-to-heavy-class launch facility to be built in the United States in over 30 years. Currently, he is a private consultant to the aerospace sector and serves as the senior advisor to Virginia Space.

Before retirement, he was an assistant professor of Engineering Management at Old Dominion University for 22 years. In addition, Dr. Reed was an active member of the Commercial Space Transportation Advisory Committee (COMSTAC) to the Federal Aviation Administration's Office of the Associate Administrator for Commercial Space Transportation for 12 years and served on the Virginia Governor's Aerospace Advisory Council for four years.

Dr. Reed holds a B.S. in mechanical engineering, an M.S. in engineering management, and a Ph.D. in engineering management.

Kathryn Thornton

Dr. Kathryn Thornton is a former astronaut and veteran of four space flights between 1989 and 1995. She has logged over 975 hours in space, including more than 21 hours of extravehicular activity. Among other achievements, she was a crew member on the maiden flight of the Space Shuttle Endeavour and performed space walks on the first Hubble Space telescope service mission.

Dr. Thornton left NASA in 1996 to join the mechanical and aerospace engineering faculty at the University of Virginia's School of Engineering and Applied Science, where she served as associate dean for graduate programs for 12 years. In addition, Dr. Thornton participated on several NASA review committees and task groups, including the Return to Flight Task Group that evaluated NASA's work in meeting goals set by the Columbia Accident Investigation Board. She has testified before Congress and served as a member or co-chair of several National Research Council studies.

She is the recipient of numerous awards including NASA Space Flight Medals, the Explorer Club Lowell Thomas Award, the National Astronautics Association Robert J. Collier Trophy, the Freedom Foundation Freedom Spirit Award, and the National Intelligence Medal of Achievement. She was inducted into the Astronaut Hall of Fame in 2010.

Dr. Thornton received a B.S. in physics from Auburn University and an M.S. and Ph.D. in physics from the University of Virginia.

William Wrobel

William Wrobel is the director of the NASA Goddard Space Flight Center's Wallops Flight Facility. He also serves as the director of Suborbital and Special Orbital Projects and is responsible for Goddard Space Flight Center's suborbital and low-cost orbital flight projects. He was the recipient of NASA's Agency Honor Outstanding Leadership Medal in 2015.

Before coming to NASA in 2006, he worked for Orbital Sciences Corporation, working a variety of programs including TOS, Pegasus, X-34, APEX, and SeaStar. In 1999, Mr. Wrobel was named the program director for the Taurus Launch Vehicle Program at Orbital. He also supported the company's Advanced Programs Group, providing satellite development support for Department of Defense customers.

Mr. Wrobel earned his B.S. in aeronautics and astronautics from the Ohio State University.

Study Staff

Andrew Densmore, Study Codirector

Andrew Densmore has been the executive director of the Virginia Academy of Science, Engineering, and Medicine since 2015. Prior to VASEM, Mr. Densmore served for six years as a congressional staffer to U.S. Senator Mark R. Warner of Virginia, where he handled legislative work related to water resources development and the U.S. Army Corps of Engineers. He also worked as an outreach staffer on issues such as the Patient Protection and Affordable Care Act, the Dodd Frank Wall Street Reform and Consumer Protection Act, and the Startup Acts among others.

Mr. Densmore received a B.A. in history and a B.A. in international business from Virginia Tech.

Charles Feigenoff, Writer

Dr. Charles Feigenoff is a freelance marketing consultant, publisher, and writer whose clients have included Capital One Bank, Metropolitan Life, General Electric, and Marriott International. He has also worked extensively for academic institutions such as Georgetown University, Washington and Lee University, the University of Colorado, and the University of Virginia. Most recently, he wrote UVA's strategic plan as well as its four-year financial plan.

Dr. Feigenoff received a B.A. in English from Cornell University, an M.A. in English from the University of Colorado, and a Ph.D. in English from the University of Virginia.

Lisa Wallmeyer, Study Codirector

Lisa Wallmeyer is a senior attorney at the Virginia Division of Legislative Services, and serves as the executive director of the Joint Commission on Technology & Science (JCOTS), a permanent, 12-member legislative commission. JCOTS' work focuses on examining and developing policy on a wide variety of technology-related issues, such as nanotechnology, traffic safety technology, and science and math education.

Ms. Wallmeyer also serves as counsel to the Senate Finance Committee. She previously served as counsel to the House Committee on Militia, Police, and Public Safety, and as the assistant director of the Virginia Freedom of Information Advisory Council.

She earned a B.A. in print journalism from Washington and Lee University and concurrently earned an M.A. in mass communications and a J.D. from the University of Florida.

Appendix B. Presentations/Interviews

Peter Bale, Chairman, Wallops Island Regional Alliance

Mark Blanks, Director, Mid-Atlantic Aviation Partnership

Philip Duke, Managing Director, Aerospace and Defense Risk Advisory Practice, KPMG

William Fredericks, CEO and Founder, Advanced Aircraft Company

Jon Greene, Associate Director, Mid-Atlantic Aviation Partnership

David Hinton, Senior Advisor for Unmanned Systems, Office of the Secretary of Technology

Jack Kennedy, Member of Board of Directors, Virginia Commercial Space Flight Authority

Brian Kroll, Senior Economist, Virginia Economic Development Partnership

Aubrey Layne, Secretary, Virginia Department of Transportation

Frank McKenna, Member of Advisory Board, OmniEarth

Theresa Mayer, Vice President for Research and Innovation, Virginia Tech

Steven B. Miner, Administrator, Accomack County

Daniel Morris, Director, Peninsula Technology Incubator

Dale Nash, Executive Director, Virginia Commercial Space Flight Authority

Craig Quigley, Executive Director, Hampton Roads Military and Federal Facilities Alliance.

Douglas Stanley, President and Executive Director, National Institute of Aerospace

John Tylko, Chief Information Officer, Aurora Flight Sciences