

UNMANNED SYSTEMS INDUSTRY IN VIRGINIA

2018



INTRODUCTION

Combining world-leading technology infrastructure with a pro-business agenda, the Commonwealth of Virginia is the place to be in the Unmanned Systems (UMS) industry. Virginia is a national leader in the development, manufacture, and use of unmanned systems and continues to push the boundaries of innovation because of the strong national and federal support structures in the state. Home to the eighth largest concentration of unmanned system firms in the nation, Virginia leverages a unique competitive advantage to create an ecosystem of innovation that not only serves as a foundation for continued development, but also promotes rapid advancement in the application and use of technologies.

The Commonwealth of Virginia has aggressively pursued the long-term success of automated vehicle systems with an approach that emphasizes inclusion, diversity, and investment. By taking a major leadership position early in the UMS industry lifecycle and providing the regulatory and legislative support requisite to promote sustained growth, Virginia is now a recognized international leader in the field. The key to success has been three-fold: (1) the designation of one of only seven test sites for unmanned aircraft system testing in the country, (2) the extensive state and federal support for all domains of automated vehicle systems, and (3) the ability for private companies to leverage the regional and geographical assets that only Virginia can claim.

Virginia continues to support the core domains of autonomous vehicles and has incentivized programs in ground, air, sea, and space robotics to foster a strong and diversified portfolio of homegrown markets. The most competitive and accessible support structure and logistical pathways for UMS find their home in Virginia, including world-leading education institutions, research and development programs, testing and safety compliance initiatives, maintenance training and facilities, and access to capital with investors who are open to taking risks.

As a national leader in advanced technology, Virginia is defining the direction for all the unmanned vehicle systems in the United States

as well as the international community by drawing from incredible resources (natural and produced), including a well-educated and technologically proficient workforce, diverse geography, proximity to decision-makers in Washington, existing technology infrastructure and companies, and an extremely strong military and law enforcement presence. By recognizing the value of the myriad application of this new technology, Virginia has positioned itself as the best place to be for the UMS industry.

The Commonwealth's geography provides not only proximity to Washington, D.C. and unparalleled engagement with stakeholders and leaders, but also direct relationship opportunities at the state and federal level in advanced technologies for both public and private programs. Government, higher education, and business work together to develop training and workforce development programs. The Commonwealth leverages leading edge research performed at universities and local federal laboratories by approaching education from two goals: workforce development and research and development. For the UMS industry, these assets are further complemented by unique and incomparable natural resources, including dense urban areas, open rural spaces, and advantages for air, land, and sea.

The purpose of this report is to highlight the ways Virginia is pushing the limits of the UMS industry, and how the Commonwealth provides the resources, support, expertise, and structure needed to succeed in this rapidly evolving environment. By creating an ecosystem of innovation that leverages its geographical assets and proximity to Washington, D.C., engages regulators and industry representatives in one of only seven national test sites, and complements research with investments in infrastructure like the Beyond the Horizon Corridor, Virginia has quickly become the best place to be for successful development in the unmanned system industry.

VIRGINIA IS THE PLACE TO BE FOR THE UMS INDUSTRY

Virginia's commitment to the UMS industry is unflinching and far ranging, exemplified by the direct involvement from both government and private industry partners. It has become the epicenter for automated vehicles in land, air, sea, and space. The Commonwealth boasts numerous advantages for any firm looking to start up, relocate, or expand.

PRO-BUSINESS ADVANTAGES FOR COMPANIES

- *Strategic east coast location and excellent infrastructure provide easy access to national and global markets*
- *Stable, low tax costs for corporations and individuals and a 6% corporate income tax that is well below the U.S. median of 6.75%*
- *Minimized payroll costs with low worker's compensation rates and a low unemployment tax*
- *Favorable business environment that protects "at will" and "right-to-work" employment practices*
- *One of the highest-ranked states in high-technology employment*
- *38 established Technology Zones*
- *3 of top 10 Public Universities in the nation per niche.com*
- *A vibrant and diverse multi-cultural community where employees can live and work*
- *An experienced, educated and productive workforce*
- *Recruitment and training programs to help businesses become operational faster and maintain their competitive advantage*
- *More than 2,300 qualified buildings and sites located across the Commonwealth*

Advantages include: a general business climate that is advantageous to any industry, a specific commitment to unmanned vehicle systems, unparalleled geographic advantages, a high-tech workforce, top-tier education and workforce development, and a bevy of economic incentives.

Virginia's asset-rich portfolio of defense facilities like Norfolk Naval Base, Langley, Quantico, Dahlgren, and Pickett; major research institutions and Centers of Excellence like the Mid-Atlantic Aviation Partnership, George Mason University, James Madison University, Virginia Tech, University of Virginia, and Old Dominion University; and science collaboratives in all regions of Virginia such as NASA Wallops, NASA Langley, and 4-VA provide countless opportunities for partnership and testing that meet the highest standards internationally requisite for product development and growth of a new industry.

A PRO-BUSINESS CLIMATE

Virginia's government leadership is second to none in the United States, providing programs that innovate the local, regional, and state levels and supportive of public-private partnerships that bring together investors with early-stage start-ups like those found at VT Knowledge Works. Year to year, Virginia consistently ranks near the top of Forbes' annual list of Best States for Business. By providing "low business costs, educated workforces and pro-business

regulatory climates," Virginia placed in the top states in the country again in 2017.¹ A ranking by CNBC further identified Virginia as one of the top five states in the nation for "workforce," "business friendliness," and "education."² The key to success for Virginia has been in investing in future-oriented industries such as UMS and cyber security, providing leadership that truly understands the importance of maintaining the best business environment for economic prosperity, and enabling public-private partnerships to flourish to meet the needs of the new economy.

From the robust economy to competitive taxes and incentives, Virginia's pro-business climate has few, if any, peers. For more than 40 years, Virginia's commitment to business growth and prosperity has been evidenced by its unchanging and attractive 6% corporate income tax rate. Virginia has one of the lowest average worker's compensation costs in the nation. Depending on the region of the Commonwealth, building costs range from 8–22% lower than the national average. The unemployment insurance tax rate is the second lowest in the nation.

As a strong recruitment and retention tool, Virginia has invested in its economic future by creating incentives that meet the needs of new and expanding employers. From tax credits to tax exemptions, Virginia continues to demonstrate its willingness to partner with those who invest and reinvest in the Commonwealth.

¹ <https://www.forbes.com/forbes/welcome/?toURL=https://www.forbes.com/sites/kurtbadenhausen/2016/11/16/the-best-and-worst-states-for-business-2016/&refURL=&referrer=#4804ef2147764>

² <https://www.cnbc.com/2016/07/12/americas-top-states-for-business-2016-the-list-and-ranking.html>



Virginia Leads the Way

#1 Best School System in the Mid-Atlantic and Southeast, Wallet Hub (2014) #1 Regulatory Environment, Forbes (2015) #1 Highest Concentration of Computer Specialists, National Science Foundation (2012) #1 State for Higher Education, Smart Asset (2017) #2 Highest STEM Job Concentration, Enterprising States Report (2014) #2 State with the Highest Concentration of Tech Workers as a Percentage of the Private Sector Workspace, Cyberstates (2015) #2 Highest Concentration of Scientists and Engineers, National Science Foundation (2012) #2 State or Nation with most companies (39) on the Cybersecurity 500 list in the World, Cybersecurity Ventures (2015, Q3) #3 Business Friendliness, CNBC (2015) #3 Best State for Small Business, Business Insider (2014) #5 Top State for Technology and Entrepreneurship, Enterprising States Report (2014).

The Commonwealth of Virginia features world-class assets that serve as a foundation of economic strength. Virginia's unparalleled education system, highly talented workforce, competitive business climate, central location, and premium infrastructure have earned the Commonwealth years of well-deserved recognition as a preeminent state for business and economic growth. Virginia's rich

history of collaborative partnerships and commitment to maintaining and increasing its competitive advantages in the workforce is a boon for any high-tech company.

While the foundational pro-business environment enables generic business growth, support, and investment there are several unique competitive advantages for the UMS industry in Virginia. The Commonwealth provides one of the most stable, pro-UMS regulatory environments in the nation with the understanding that UMS technologies are to be approached not out of fear, but of appreciation for their applications. Virginia is gifted with a unique geography that provides extensive, open, and diverse training and testing locations that enable manufacturers and developers to demonstrate proof-of-concepts, acquire the data needed for Federal Aviation Administration (FAA) certifications and approvals, and to push the envelope of automated vehicles capabilities in a controlled, data-focused method. Coupled with the advanced educational opportunities targeted to the UMS industry and boasting one of only seven FAA designated test sites in the nation through the Mid-Atlantic Aviation Partnership (MAAP) at Virginia Tech, Virginia's students, current and future workforce, are well-trained and capable of taking on the biggest challenges in the field.

VIRGINIA'S REGULATORY AND POLICY COMMITMENT TO UMS

Virginia went from being a state once looking to limit drone markets to becoming an active supporter—and national advocate—for unmanned systems.

The Commonwealth has surged to the forefront by providing resources, support, infrastructure, and personnel unparalleled by any other state, a journey lauded by industry advocacy groups, state legislators, and executive officers of major companies.

In comparison to other states, Virginia's pro-UMS, business-friendly approach is clear. The top leadership in Virginia agree that "capitalizing on Virginia's advantages in the unmanned systems industry is key to building a new Virginia economy."³ This includes creating a regulatory and policy framework that allows innovation and strategic partnerships for unmanned vehicles in the air, on the ground, and on/under the sea.

Virginia enables free access to airspace in accordance with the FAA, limiting only the use of Unmanned Aerial Systems (UAS) by law enforcement to continue to put the public's mind at ease and to protect long-term interest in the market. Virginia leads the way as a friendly partner to the FAA and other federal organizations, and became a main safety testing program partner through the Mid-Atlantic Aviation Partnership in 2017.

The Commonwealth allows the testing of any automated vehicle on Virginia roads under the guidance of the Virginia Tech Transportation Institute (VTTI), and Virginia is the first state to pass legislation (SB 1207) allowing delivery robots to operate on sidewalks and crosswalks across the state. Aquatic and sub-sea drones are supported by the creation of the Virginia Tech Department of Aerospace and Ocean Engineering, where both the air and sea come together in design, analysis, and production of aerospace and ocean systems.

Legislatively, Virginia maintains its leadership among UMS friendly states having passed three bills in 2016 focused on the unmanned systems industry—HB 412, HB 29, and HB 30—all developed to support the drone community while giving appropriate deference to the rules and regulations as published by the FAA. HB 412 simply states that "no locality may regulate the use of privately owned, unmanned aircraft systems...within its boundaries."⁴ The difference is striking; Virginia is bluntly stating that only the state can determine UAS flights and only in deference to the federal government. It is this type of clear, concise,

regulatory development that UAS business operators and investors need to feel comfortable. HB 29 and HB 30 were passed to appropriate funds to Virginia Tech for UAS research and development. Again, rather than pass a restrictive, negative, over burdensome, or unnecessary patchwork of laws,

Virginia continues to promote the open use of drones while increasingly investing in the new economy at the highest levels of government.



A Virginia First: Flirtey and Let's Fly Wisely

On June 17, 2015, Flirtey conducted the first FAA approved drone delivery during research flights at Wise, Virginia.⁵ Flirtey, a startup with origins in Australia, originally sought out the test site at the University of Nevada, but found Virginia was a preferable landscape for developing, innovating, promoting, and completing their first mission.

Flirtey teamed with Virginian leaders the Mid-Atlantic Aviation Partnership (who partnered with NASA), and the Remote Area Medical free clinic, to take advantage of a once per year event that brings out underserved citizens for medical analysis and treatment in rural Wise County. Wise County can be difficult to service for delivery trucks and take a long time for delivery. The goal for Flirtey was to deliver 24 packages of medicine for 24 people, separated between six UAS delivery flights. The flights, a proof-of-concept for the delivery industry, cut delivery of much needed medicines from "more than a day to half an hour."⁶ While this event seems like an easy-to-recognize fit for Flirtey and for Wise County, a great amount of effort is involved in ensuring a pathfinder project like this one is allowed to take place. These flights could not have happened without the support from government and partnerships available in Virginia—a significant reason that Flirtey chose the Virginia test site team over Nevada's. Under the supervision of the Mid-Atlantic Aviation Partnership and in conjunction with NASA counterparts, the "Let's Fly Wisely" was a huge success for Flirtey, the FAA, NASA, and Virginia.

³ <http://vus.virginia.gov/ums-commission/>

⁴ <http://lis.virginia.gov/cgi-bin/legp604.exe?161+ful+CHAP0451+pdf>

⁵ Ibid.

⁶ <https://newatlas.com/flirtey-drones-deliver-medicine-in-us-first/38102/>

UNMANNED SYSTEMS ASSOCIATION OF VIRGINIA

Industry leadership and representation is extremely important for any nascent and developing industry. Unmanned Systems—ground, air, and sea—require funding, investments, strategic partnership, and fair treatment from government leaders to ensure legislation does not unfairly target it. The Unmanned Systems Association of Virginia, a nonprofit trade association founded in October 2016, strives to promote Virginia's UAS test site, unmanned systems research, and other resources; share information about grant opportunities for expansion of existing businesses or attracting new unmanned systems businesses; support legislation that fosters a business environment that is favorable to innovation and development of technology; support public and private programs that promote STEM education, workforce training and workforce development that may be beneficial to the unmanned systems industry; and promotes collaboration among entrepreneurial, existing technology and academic research entities.

By bringing together varied parties interested in the unmanned sector—ground, air, and sea—the association provides leadership and guidance on legal and regulatory problems as well as industry support and representation. Through advocacy efforts, USAV works with the Virginia General Assembly and Governor's Administration on state matters involving unmanned systems and coordinates with members of the Virginia Congressional delegation on federal issues. With the active support of USAV, Virginia became the first state in the nation to pass legislation to allow unmanned vehicles (robots) on sidewalks. The legislation, which was advanced by USAV member Starship Technologies, is designed to transform the last mile of delivery and will help open the door to other advanced delivery technologies in the Commonwealth. USAV also directly cooperates with the Secretaries of Technology, Commerce and Trade, and Transportation, as well as the Governor's Office, to establish and promote industry opportunities available in the Commonwealth.



- Nicole Barranco, *Volkswagen Group of America*
- Bob Burkholder, *Clark Nexsen*
- Joel Campbell, *Avineon*
- Sean Cushing, *Hazon Solutions*
- Robert E. Dehnert, Jr., *Raytheon*
- Steven A. Eisenrauch, *Dominion Virginia Power*
- Robert Grant, *Lyft*
- John Lamb, *Newport News Shipbuilding*
- Charles Mondello, *Property Drone Consortium*
- Guy Sanitate, *Science Applications International Corp. (SAIC)*

Virginia's government, local medical organizations, and the FAA UAS Program Office made this happen by developing relationships and building support. Flirtey's "Kitty Hawk-like" proof of concept is an example that illustrates the need for the partnerships Virginia cultivates daily. By bringing together lawyers representing Continuing Legal Education (CLE), local government, and entrepreneurial leaders, Virginia showed how it leads the nation through collaboration.⁷

Autonomous Systems Center of Excellence

Virginia established the Autonomous Systems Center of Excellence to champion the expansion of this important industry in the Commonwealth. The Center, which will be operated by Virginia's Center for Innovative Technology (CIT), is in direct response to recommendations made by

the Commonwealth's Unmanned Systems Commission and roundtable discussions with industry leaders from across the Commonwealth. The newly established center will serve as the ombudsman and advocate for this industry in the Commonwealth and will act as a champion for the development and deployment of all aspects of the autonomous systems industry. In addition to advocacy, the center will also serve as a clearinghouse and coordination point for related information, assets, and programs throughout Virginia.

Virginia Unmanned Systems Commission

The regulatory framework that sets Virginia apart came, in part, from the forward-thinking and nationally recognized Virginia Unmanned Systems Commission, created with the intent to "lay the foundation...to make

⁷ <http://www.courtbar.org/cle/>

this Commonwealth the world's leader in unmanned systems and seize the enormous economic opportunities that accompany growing this industry." An example of Virginia's excellent working relationship and partnership between the state and private industry, the VUS Commission consisted of the Secretaries of Technology, Commerce and Trade, Transportation, Education, Veterans and Defense Affairs, Congressional members (both Senate and House), and many members from private industry, such as: Aurora Flight Science, MITRE Corporation, Virginia Tech Transportation Institute, Raytheon, Veracity Engineering, Glen Allen, Digital Harvest, Newport News Shipbuilding, SAIC, National Air Traffic Controllers Association, and the Farlead Boat Works, Inc. Importantly for the unmanned vehicle systems industry, this commission embraced a public-private representation that is now a national model for friendly, but safe and regulated, autonomous systems growth.⁸

The VUS Commission had four essential tasks when it began to determine the future positive impact that unmanned systems may have on Virginia: 1. Identify the state of all unmanned systems industries 2. Identify challenges and needs of the unmanned system industry that may be met with Virginia assets 3. Provide recommendations that will encourage the development of the unmanned systems industry 4. Develop the value proposition that will provide a basis for marketing Virginia to the current unmanned systems industry and position the Commonwealth for the industry's emerging needs and applications.

The Virginia Unmanned Systems Commission should be recognized as an important indicator of the collaboration between public and private entities looking to promote research in the field. In collaboration with NASA at the Wallops Flight Facility, Virginia Community Colleges investigated sea level rises through data acquisition with various UAS. On April 18, 2016, students and faculty could design, manage, and execute missions in support of important environmental research.⁹ Beyond the strict study and research of UAS applications, the UMS Commission indirectly supported local entities and private companies involved in The Flying Circus FPV Festival in Covington, Virginia. This three-day festival September 14–17, 2017, enabled flying and racing for quads and planes as well as various other contents for recreation, hobby, and competition and brought more than 400 participants, spectators, and vendors to the area for the fun. As education and promotion to the public is a key concept in the promotion of the UMS industry, this event was a

massive success and the 5th annual event is planned for 2018. The City of Covington received \$100,000 in federal funds from the Appalachian Regional Commission (ARC) to promote the unmanned systems industry in Alleghany County, matched with another \$100,000 locally.

While the UMS industry is receiving support, partnership, and attention throughout the highest levels of government, so too are tangential industries that will enable UMS to flourish. Recognizing the need for strong and secure connectivity, an ability to maintain data without fear of breaches, and a need to ensure to privacy for all, Virginia is heavily investing in cyber security and other information data management programs. Commonwealth leaders understand these industries do not evolve in a vacuum and that success will only come as enabling technologies grow in partnership and support from government. This was the understanding behind the development of the Virginia Cyber Commission; resulting in a nationally leading cyber industry that focuses on educational opportunities, attracting cyber students and business, and promoting homegrown protections against international threats.

LOCATION LOCATION LOCATION: REGIONAL ADVANTAGES UNIQUE TO THE COMMONWEALTH

We often hear where you are matters. Never has this been more obvious than thinking about how economic performance shifts and evolves in collaboration with what's around. The geographical advantages of Virginia are second to none; Virginia boasts proximity to decision-makers and defense industries in Washington, D.C., and is home to the Pentagon, Quantico, and Norfolk Naval Base. With educational groups, labor advocates, and pro-business firms, the unmanned systems industry finds a network of politically savvy partners right at their doorstep.

Boasting geographical advantages "from mountain to sea," Virginia has high-density urban areas, populous and diverse suburbs, and low-population rural stretches with both mountains and meadows. Central and Southern Virginia offer a Beyond Visual Line of Sight testing environment of nearly 5,000 square miles. In October 2016, then-President Obama announced a \$2.2 million grant to go toward positioning Southwestern Virginia as a "national destination for the development of a drone-operator workforce to support the emerging drone industry."¹⁰ And the Chesapeake Bay provides a shallow, protected estuary fed by winding creeks and marshes and rivers with deep, wide mouths that open to the vast

⁸ <http://vus.virginia.gov/ums-commission/ums-commissioners/>

⁹ <http://vus.virginia.gov/media/5810/stf-wf-gis295-service-learning-pressrelease-final.pdf52>

¹⁰ <https://www.recode.net/2016/10/28/13450480/obama-2-million-train-coal-miners-pilot-drones-jobs-federal>

Atlantic Ocean. For whatever use, case, or need, Virginia has something to offer.

Virginia is not just one contiguous population with the same advantages across the state. As the Center for Innovative Technologies (CIT) puts it, “the Commonwealth is home to a variety of market players: sources of government UAS demand in Northern Virginia and Hampton Roads; tourist videography demand in the Neck region; innovation hubs in Danville and Blacksburg, and skilled technicians, wide open test grounds with an accepting populace in the southeast. All the elements of a marketplace are already in the Commonwealth.”¹¹

These catalysts act together to create an ecosystem that supports partnerships in innovation and, when coupled with Virginia’s pro-business philosophy, provide the best place to be for UMS industry participants.

Proximity to Decision-Makers

Geographical advantages abound not only in the natural resources, but in access to industry leaders and public stakeholders all looking to help drive the growth of this new technology industry. State and federal leaders have seen the importance of the UMS field through engagement and communication, making Northern Virginia the home to leading aerospace companies for generations. Virginia has also seen the importance of testing environments that are highly innovative in and of themselves, leading to the development of the Beyond the Horizon Corridor—a testing environment for manufacturers, operators, and regulators to see how Beyond Visual Line of Sight Operations can aid in the energy, rail, and urban environments.

In fact, the leading unmanned aircraft system voice in the world, the Association for Unmanned Vehicle Systems International, which boasts the largest UMS association membership in the world, is headquartered in Arlington, Virginia and hosts universities, businesses, financiers, and legislators throughout the state. In addition, AUVSI has local member chapters throughout Virginia that provide more regional support and relationships for municipal and state representatives.

¹¹ Center for Innovative Technology, Draft Report 12/27/2016.

¹² <http://www.ncsl.org/research/military-and-veterans-affairs/military-s-impact-on-state-economies.aspx6>

NASA and the Defense Industry

Virginia has long been a producer of high-tech drones for the military and defense contractors here are now exploring potential commercial applications for their technologies. The National Aeronautics and Space Administration (NASA) and the defense industry are a unique provider of opportunity in Virginia. While the defense industry is spread throughout the nation, Virginia benefits from a disproportionate breadth of contracts and relationships available through the Department of Defense (DoD).

As of FY 2015, Virginia accounted for more than \$53 billion in defense contracts alone, making it the number one state for total revenue driven by DoD investment.¹² This success is not driven simply by the geographical access to Washington, D.C., but is driven by the long-term investments made by leading aerospace companies and government agencies in the region, an investment that continues with a business-friendly environment and partnership developments in UMS technologies.

Twelve defense contractors are headquartered in Virginia, including Alliant Techsystems, Atlantic Diving Supply, Booz Allen Hamilton, CACI, CSC, DynCorp, General Dynamics, Huntington Ingalls, ITT Exelis, Leidos, ManTech, Northrop Grumman, and Spatial Integrated Systems. Of those, two—Northrop Grumman and General Dynamics—are among the top four leading UMS companies in the world.

Raytheon Intelligence, Information and Services (RIIS), a Dulles-based business unit of Raytheon Co., has been involved in unmanned technologies since the early 1990s. The company provides unmanned systems support and training to the military in addition to manufacturing drones. Today one of its major programs is producing control systems for the Global Hawk, a high-altitude plane used for intelligence, surveillance and reconnaissance.

While Raytheon’s focus will continue to be making drones for the Department of Defense, the company is looking at potential commercial applications, “specifically in the area of precision agriculture,” says Bob Dehnert, senior director for command control and awareness at RIIS. “We could possibly capitalize on the nation’s huge investment in defense capabilities and with some slight adjustment of technologies have some new applications. We’ve built the capability to modify some imaging algorithms to be able to count kernels on an ear of corn. We can predict a field yield more precisely than a human can.”

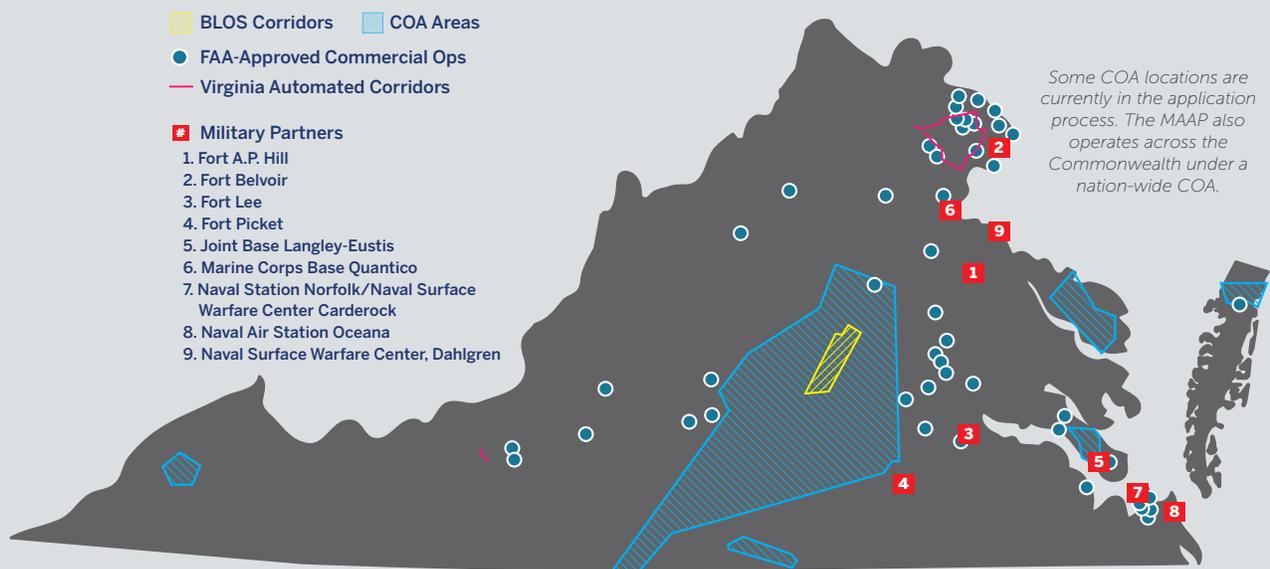


By being co-located in the Virginia area, new companies gain access to corporate entrepreneurial initiatives that enable cross collaboration, increased likelihood of buyout, and a “Silicon Valley” like atmosphere focused in their field. These defense contractors have seen the value in access to national leaders in Washington, D.C., as well as a proximity to the Pentagon and nineteen defense installations. With the federal government focusing on investing in startup companies by making access to venture capital easier for government-related tech firms, localizing a business in Virginia has never been more important.¹³

These nineteen defense installations have cultivated programs to enable service members and procurement officers to engage with communities in the UMS industry. By collaborating locally, diminishing the need for travel expense, and increasing face-to-face communication and discussion, UMS companies gain a leg up on any non-local competition. These defense installations, defense contractors, and smaller firms have developed partnerships and projects much more easily than with other organizations, leading directly to research and development capabilities throughout the state.

Research and development is the first fundamental step toward innovation. By collaborating with competitors and developing private partnerships that enable potential customers to outline their needs directly to engineering production, the interactive process of innovation comes faster and with greater return. Virginia has made these partnerships its focus over the last five-years, and the area is reaping the rewards of those efforts.

¹³ <https://www.whitehouse.gov/startup-america-fact-sheet>



The Commonwealth now boasts significant partnerships between NASA, DoD, and private companies. The Virginia Modeling and Simulation Center (VMASC) applies simulation techniques to solve problems and provides training for industry, military, and governments. The Commonwealth Center for Aerospace Propulsion Systems (CCAPS) is a partnership between UVA, Virginia Tech, and Rolls Royce research teams that let students gain first-hand experience with advanced engineering principles and manufacturing directly with leading aerospace firms. Virginia's unique partnerships also include the Defense Advanced Research Projects Agency (DARPA) that enables private companies and universities to respond to military proposals and start-up oriented engineering labs all over the country.

Three of NASA's ten field centers and NASA Headquarters are in the mid-Atlantic region and offer their support to the users of the Mid-Atlantic Partnership UAS Test Range. NASA Langley (Virginia) is the original NASA center with a long legacy in aeronautics research and autonomous systems. NASA Wallops Flight Facility (Virginia) is the oldest launch facility in the nation and has been a NASA flight test range for many years. NASA Goddard Space Flight Center (nearby Maryland) has extensive experience developing innovative solutions to remote sensing challenges.¹⁴

NASA conducts research at the Langley Research Center (LaRC) and at the Wallops Flight Facility (Wallops). The importance for NASA programs and projects in aiding the UMS field cannot be overstated. NASA is leading the true integration of UAS into the National Airspace (UASNA) projects at the national level by enabling new

technology developed at the state and local level. The Unmanned Traffic Management initiative (UTM) is being developed in conjunction with NASA Ames and NASA Langley and in cooperation with the Virginia Tech Test Site at MAAP. NASA Langley also operates CERTAIN(City Environment for Range Testing of Autonomous Integrated Navigation), which is a new 100-acre test range.



Figure 1 NASA unmanned aircraft

Langley Research Center (LaRC), located in Hampton, Virginia, is home to the most important autonomy incubators for new technologies in the country. LaRC has more than 75 registered unmanned aircraft that provide test beds for autonomous hardware and software and began participation with the Unmanned Aircraft Systems Traffic Management (UTM) program in early 2015. To provide ample test flight area, LaRC maintains and hosts a 400-acre urban flight test range run by the NASA Langley Research Services Directorate and is accessible to anyone interested in testing their autonomous vehicle. Their goal is to create a "UAS Friendly Campus," the first opportunity of its kind to test UMS usage in a relevant, urban environment in, over, and around buildings and infrastructure.

¹⁴ <http://www.maap.ictas.vt.edu/>

ADVANCED AIRCRAFT COMPANY (AAC)

Advanced Aircraft Company (AAC) is an aeronautical engineering and aircraft manufacturing company based in Hampton, Virginia. AAC produces vertical takeoff and landing (VTOL) unmanned aerial systems (UAS) targeting commercial and military markets. The HAMR (Hybrid Advanced Multi-Rotor) UAS is the first aircraft product of AAC, which is a long-endurance multi-rotor UAS incorporating aerodynamic improvements and hybrid electric propulsion to achieve six times greater endurance than battery-powered multi-rotors.



Existing Industry

New applications for UAS, and manufacturers of diverse and unique UAS, are finding Virginia the best place to do business. Among these successful companies are: Aurora Flight Sciences, who build advanced unmanned aircraft in Manassas, Virginia and UAV Pro, who conduct UAS training and research in Blackstone, Virginia, at the Fort Pickett Army National Guard Maneuver Training Center. Fort Pickett's unique "shared space" for commercial and military UAS, in addition to organizational approval for drone flight airspace and procedures, means that the entire industry can learn through sharing an airstrip.

While Virginia has in place forward thinking economic solutions that provide a robust environment of investment, workforce development, and performance it also has unique regional competitive advantages to the aerospace industry. More than 19,300 high-tech establishments operate in Virginia; more than 70 firms with annual revenue topping \$500 million are headquartered in Virginia, with 37 Fortune 1000 Firms. In providing federal funding, Virginia ranked 3rd

among all states in federal R&D funding and among the top 10 states "best prepared to navigate the changing economy, in terms of being knowledge-based, globalized, entrepreneurial, IT-driven and innovation-based."¹⁵

These elements combine to provide an environment where entrepreneurs and well-established companies can attain nationally recognized and important, first-of-a-kind mission success such as the first burrito delivery by drone in collaboration with Google Project Wing and the first FAA approved delivery of medicine to rural areas by Flirtey. There is no wonder why so many companies are deciding to relocate to Virginia, and why the Unmanned Systems industry is finding a permanent home in the Commonwealth.

The Beyond Horizons Corridor is just one of the many public-private partnerships envisioned by Virginia leaders and made manifest by the cooperation of private companies investing in the future of UMS and the Commonwealth. Virginia Tech, MAAAP, American Aerospace Technologies, Inc., Dominion Resources, the Pipelines Research Council International (PRCI), Black & Veatch, and the law firm William Mullen are all partners in the development of this unique environment demonstrating how involvement from throughout industry overcomes even the most challenging goals.¹⁶

Meanwhile, the era of precision agriculture through technological innovation has arrived and Virginian farmers, vintners, and ranchers are beginning to take advantage of unmanned aircraft systems. By applying cutting edge precision soil sampling, variable rate GIS mapping, data management with traditional farming expertise, conventional soil testing, and on-farm research, companies such as Tellus™ are realizing the successes in application of UAS and other advanced technologies.¹⁷ Livestock management is also a key industry ready for disruption in Virginia's productive economy. Using UAS technologies and other automated robotics for the entire food and water production verticals will be vital in meeting the societal challenges to come.

Using drones for perimeter maintenance, livestock monitoring, chemical monitoring, environmental and vegetation analysis, and imaging for heat and exhaust will ensure the effective and efficient health of the overall system for chickens, eggs, hogs, aquaculture, sheep, lambs, soybeans, and turkey; all major products in Virginia.¹⁸ Though the livestock production lifecycle

¹⁵ <http://www2.itif.org/2014-state-new-economy-index.pdf>

¹⁶ <http://www.doav.virginia.gov/Downloads/Studies/UAVs%20in%20Virginia/TheFutureOfUAVSInVirginia2014.pdf>

¹⁷ <http://www.agronomics.farm/services/>

¹⁸ http://www.netstate.com/economy/va_economy.htm#14

makes up two-thirds of the agricultural receipts for Virginia, crops such as soybeans, barley, hay, cotton, tomatoes, tobacco, apples, and grapes comprise roughly 9% of the total receipts. These are all crops that have had great success adapting UAS technologies into their programs, and will continue to find automated robotics an important part of the productive system.¹⁹

One industry often overlooked by the UAS community, because agriculture, energy, and videography have captured the most media attention and are perhaps the easiest applications to realize due to their proximity away from hazardous environments or dense population centers, is construction and mining operations. By including UAS technologies in coal mining and in construction management throughout the state, volumetric analysis, soil erosion monitoring, environmental protection, worker safety, and long-term planning can be better realized. A bird's-eye view partnered with the latest computer technology provides greater efficiency, safety, and return on investment for mining and construction. UAS can be used for pit and dump management, haul route surface optimization, drill and blast planning and monitoring, hydrogeology management, feasibility studies, mineral resource calculation, geophysical and watershed modeling, game counting, inundation tracking, slurry pipeline stability, property right definitions, security, impact reporting, and even equipment inspections.²⁰ For Virginia, this is vital, as the coal mining industry, along with stone, sand, gravel, lime, kyanite, and clay play a vital role in economic health.

Virginia and Aerospace

Virginia's role in the aerospace industry started in 1917 when the nation's first civil aeronautics laboratory was established in Hampton. This facility is now known as the NASA Langley Research Center, a world-leading center for unmanned systems research, development, and operations. Privately owned global leaders Rolls-Royce produce components in its Crosspointe campus in Prince George County, also home to a world-class applied research collaborative—the Commonwealth Center for Advanced Manufacturing (CCAM). Alcoa Howmet, Airbus, General Dynamics, Dynamic Aviation, L-3, Lockheed Martin, Moog, Orbital ATK, and The Aerospace Corporation have seen Virginia as one of the best places to do business and continue to develop their operations here, creating 67 industry projects and more than 7,268 jobs with investments worth \$1.79

billion over the last 10 years.²¹ In total, the aerospace industry employs roughly 28,200 workers at 287 firms.

Aerospace companies continue to grow rapidly in Virginia, taking full advantage of the superior support industries including manufacturing, transportation, and well-established and maintained infrastructure with access to all regions via rail, air, and marine. Virginia is a right-to-work state with the sixth-lowest unionization rate in the United States. The Port of Virginia allows companies to export and import through a facility capable of handling post-Panamax ships and has no overhead obstructions between it and the Atlantic Ocean, allowing manufacturing and trade of heavy, large, and high-yield payloads, lowering costs and maximizing return. Interstate and rail networks in Virginia provide access to the Northeast, Southeast, and Midwest.

In the Air

Becoming a major partner in the development of Unmanned Aerial Systems was not an easy task, as Virginia had to compete against nearly every other state in the nation to be chosen as only one of six test sites following the 2012 FAA Modernization and Reform Act (FMRA). Virginia had to demonstrate it was pro-business, pro-UAS, and able to foster the type of research and investment requisite for success in the new economy. The Commonwealth continues to meet and exceed those great expectations at Virginia Tech. Leaders at the state and federal levels continue to surround Virginia Tech and the Mid-Atlantic Aviation Partnership with supportive institutions and programs throughout the state that bolster the important drone work conducted there.



¹⁹ http://www.netstate.com/economy/va_economy.htm#14
²⁰ Center for Innovative Technology, Draft Report 12/27/2016

²¹ Yesvirginia.org

Mid-Atlantic Aviation Partnership

The Virginia Tech Mid-Atlantic Aviation Partnership is moving the UAS industry forward and helping to make Virginia a nexus of activity in this booming market by accelerating their customers' ability to find innovative solutions and enable new applications for unmanned aircraft.

MAAP is one of seven FAA-designated test sites for UAS, and combines operational and engineering expertise with a deep understanding of the most critical challenges facing the industry. Those assets are nurtured by the dynamic research environment at Virginia Tech, a top-25 public university where student and faculty talent fuels next-generation technology.

Since its beginning in 2013, MAAP has moved quickly to make Virginia a national destination for UAS. With support from the Commonwealth, MAAP has attracted major industry partnerships and conducted groundbreaking research, training a spotlight on Virginia as a center of innovation with projects including the first FAA approved UAS delivery and Project Wing's first U.S. tests of its delivery system. NASA, Intel, Ligado Networks, and other public and private organizations populate MAAP's growing list of partners.

Companies wanting to pursue innovative UAS applications can face steep barriers to demonstrate new operations can be done safely. MAAP helps bridge the gap, working closely with regulating authorities and industry members to facilitate collaboration and productive dialogue. A unique risk-based approach to operational approvals responds directly to FAA interests and concerns, increasing the likelihood of success for the customer and streamlining the process for the FAA. The result has consistently been leading-edge research that informs evidence-based policies and standards and establishes a framework for advancing the industry safely.

This powerful blend of technical knowledge, operational experience, and innovative thinking, in a setting that facilitates efficient prototyping, yields comprehensive solutions that help the growing UAS industry reach its potential.

MAAP's Key Research Areas

MAAP focuses on foundational technologies and operations to enable a broad range of applications. Full UAS integration will require robust solutions in these areas, where MAAP's resources provide unmatched capability.

Operations Over People

Virginia Tech is home to the world's largest injury biomechanics group. Research, coupled with MAAP's active involvement in industry standards, makes the organization ideally positioned to lead work on safe operations of UAS over people. MAAP is developing strategies to enable a majority of these operations in the near term, and working on long-term solutions to maximize efficiency and performance.

Beyond Visual Line of Sight (BVLOS)

Unique operational approvals and infrastructure allow MAAP to explore BVLOS operations across a gamut of applications. A radar-equipped, 5,000 square mile "Beyond the Horizons" test range in central Virginia allows flights up to 7,000 feet AGL, in an infrastructure-rich area ripe for testing a variety of use cases. MAAP also has access to unique test beds for urban BVLOS operations.

UAS Communications

MAAP collaborates with leading companies and world-renowned Virginia Tech research programs to develop and test solutions for secure, long-range, high-quality communications—in particular, low-altitude, long-distance C2 and payload datalinks.

What MAAP Offers Industry

MAAP has a track record of delivering flexible, effective solutions for industry partners ranging from established companies seeking to integrate UAS, to traditional aviation firms, to UAS startups.

Collaboration on Innovative Technical Solutions

Unparalleled experience in UAS operations, combined with the strength of Virginia Tech's research programs, mean that MAAP is equipped to tackle the most daunting technical challenges facing UAS integration, from detect-and-avoid technology to trustworthy automation.

Custom Safety Cases for New Missions Beyond Existing Authorizations

MAAP excels at developing industry-leading safety cases for operations that extend beyond Part 107. Its staff has broken new ground in UAS type certification, Section 333 exemptions, and broad-area COAs by collecting the extensive, careful documentation necessary to articulate a safety case that pushes the limits of current regulations.

Flight Operations Support

With decades of combined experience operating UAS and manned aircraft, the MAAP team is well-prepared to handle a wide range of operations and can provide pilots, engineers, maintainers, observers, and safety officers to support almost any mission.

Strategic Partnerships

MAAP excels at connecting partners with similar needs and complementary capabilities who can accelerate each other's progress. The organization has also built coalitions of industry members to engage collectively with government, which can lead to obtaining approvals more quickly.

Comprehensive Aircraft Testing

MAAP has flown and tested UAS from quadcopters weighing a few ounces to some of the largest fixed-wing aircraft available. With access to facilities across Virginia and along the east coast offering access to diverse geography and infrastructure, and mobile assets to support testing at custom locations, MAAP can help design and execute virtually any operation.

Beyond Horizon Corridor

On May 11, 2016, the Commonwealth continued to push the limits of the industry by providing a Beyond Visual Line of Sight (BVLOS) testing environment of nearly 5,000 square miles in Central Virginia, consisting of 27 miles of pipeline infrastructure, 24 miles of power line, 13 miles of rail line, and a variety of agricultural assets all to be used for operational training, business proposition validation, and reliability standardization.²² The BVLOS



autonomous flight corridor, known as the Beyond Horizon Corridor, however, is not just an example of setting aside remote environments for enthusiasts to play around in. The area includes 10% of the land area in the state and includes a unique set of "critical infrastructure such as airports, power plants, electric lines, energy assets, and rail lines."²³

This area has been specifically tailored and set aside for developing best practices and testing for energy inspections, funded by 2016 General Assembly with \$950,000 for equipment. Funds were used to purchase a high-performance mobile radar system from Gryphon Sensors, the state of the art in commercially viable radar technology. The system combines radar with optical and spectrum sensors, providing multiple ways to detect aircraft and other objects. The Gryphon radar system enables the test site to offer even more capability to the UAS industry. Companies pursuing BVLOS applications need access to the most advanced technology as well as the expertise and knowledge to conduct innovative operations safely.

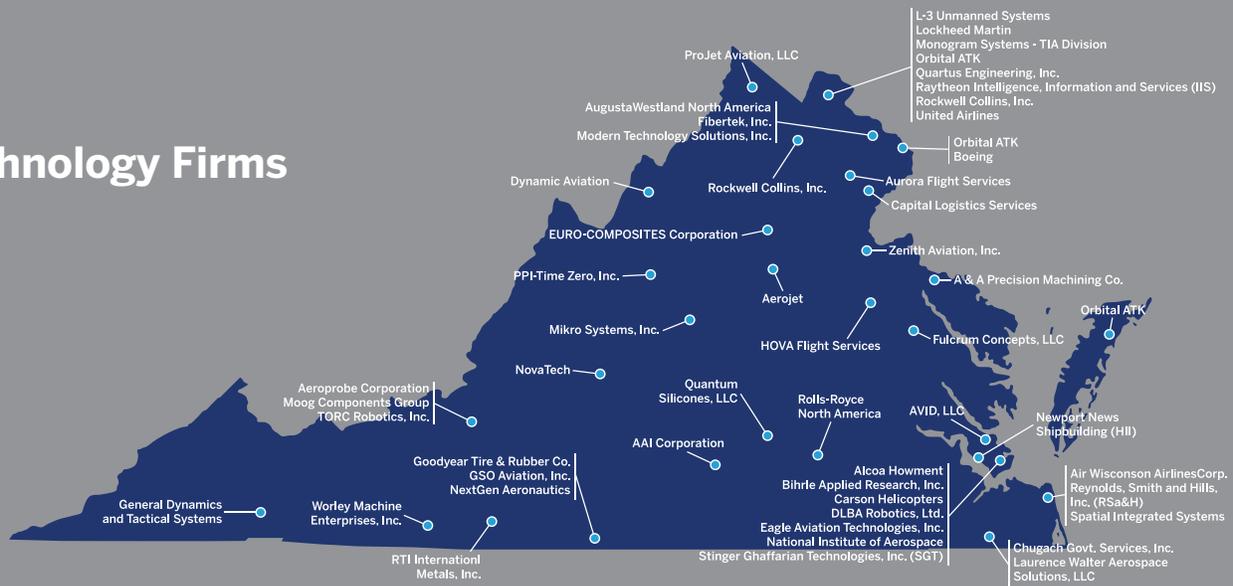
While states across the nation struggle to fund their promises to the unmanned systems industry and other test sites struggle to find specific applications for their set asides, Virginia has a clear direction, with funding mechanisms and leadership with a passion for next generation development.

For UAS manufacturers, operators, and service providers, this test environment provides a unique opportunity to test Beyond Visual Line of Sight capabilities in a simulated, real world manner. As the FAA is currently reluctant to provide 14 CFR 107 waivers without clear and accurate test data, this opportunity may be the missing element of the success equation. The vision for the Beyond Horizon Corridor is to provide the best place for training, testing, and operational validation for the oil and gas, rail, and energy production industry's unmanned system initiatives. By enabling companies to test and operate in a safe, monitored, well regulated, and documented area they build their case for full integration into the National Air Space. This is an environmentally safe, robust, accessible, and effective area to prove a company's ability to perform their function as well as to gain first-hand experience for UAS operations.

²² <https://governor.virginia.gov/newsroom/newsarticle?articleId=15330>

²³ *Ibid.*

Technology Firms



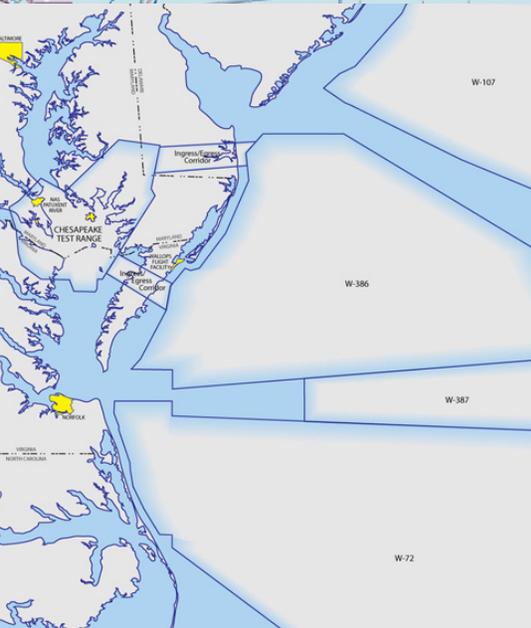
NASA Wallops Flight Facility

Virginia is flush with resources to support innovation, collaboration, and the involvement of industry participants throughout the nation. One such resource towers above the rest in its uniqueness and success for UAS companies and government sponsorship.

NASA's Wallops facility is one of the UAS industry's greatest assets and shows the forward-thinking position of Virginia as well as its unique place in aerospace history.

Originally named the Pilotless Aircraft Research Stations in 1945, the Virginia Commercial Space Flight Authority (VCSFA) became the premier UAS flight test facility in the world by building a purpose-built UAS airfield. The Commonwealth invested \$5.8 million dollars to build this UAS-only test facility on the northern tip of Wallops Island that includes a 3,000 feet long by 75 feet wide runway, 130 feet by 120 feet concrete Vertical Take-off and Landing (VTOL) pad, and a complete hangar and ground support facility. This expansion creates the longest UAS test specific runway in the nation, with easy terminal escape points into the Atlantic Ocean and free of commercial or recreational air traffic.

The VCSFA UAS Airfield is located within Special Use Airspace (SUA) R-6604 providing more than 300 square nautical miles of restricted airspace from the surface to space with direct access to the adjacent Virginia Capes (VACAPES) Warning Areas extending from Rhode Island to South Carolina and eastward more than 200 nautical miles. W-386, 387 and 72 controlled by the Fleet Area Control and Surveillance Facility, Virginia Capes (FACSFAC/ VACAPES) located in Virginia Beach, Virginia offers endless capabilities over the Atlantic Ocean well clear of obstructing FAA civilian air traffic operating within the National Airspace System (NAS). These Warning Areas are located directly above the Virginia Capes Operating Area (VCOA) a surface and subsurface operating area offering various surface, subsurface, and air-to-surface exercise capabilities.



Left Above: VCSFA/MARS UAS Airfield is located on the Mid-Atlantic seaboard allowing access from locally controlled Restricted Area R-6604 to the VACAPES operating area for both surface and air events. Warning Areas W-386, 387 & 72 are all controlled by FACSFAC VACAPES. "Giant Killer" out of Virginia Beach, Va. VCSFA/MARS Airfield personnel can provide logistical support for scheduling needs.

Left Center: Ingress/Egress corridors also allow access from inshore to off via COA connecting the Chesapeake Bay and western shore to the Atlantic operating areas.



The Virginia Tech Transportation Institute (VTTI)

VTTI provides cutting edge technological leadership to driverless vehicle organizations choosing to partner with it and was recently announced as a national safety center by the U.S. Department of Transportation.²⁴ By combining core research in autonomous vehicle development with real-world simulation environments, students and partner companies rapidly iterate and evolve their autonomous projects. As Senator Tim Kaine put it, “It is clear why VTTI is a national leader, and I’m proud the U.S. Department of Transportation recognized its work with this federal funding and national center designation.” As a Center of Excellence, VTTI will build upon its already extensive portfolio. VTTI has been responsible for providing significant investments in education, infrastructure, and innovation through scholarships, study support, funding from federal and state resources, and leadership in new programs such as a \$75 million plan to emphasize intelligent infrastructure in Virginia and \$2.5 million for studying trucker safety.

VTTI, VDOT, and others also came together to create the Virginia Connected Corridors (VCC) which tests and produces the next generation of Smart Roads that will enable rapid response and information for travelers, enhanced transit operations, lane closure alerts, and work zone and incident management. Collaboration between these groups and MAAP has provided extensive research into Smart Roads by looking at the integrating pathways for high-occupancy toll lanes, high-definition mapping capabilities, real-time traffic and incidents, intelligent routing, location cloud technology, and pavement markings.²⁵

The Virginia Connected Corridor (VCC) and the Virginia Automated Corridor (VAC) provide researchers, manufacturers, and developers access to more than 70 miles of interstates and arterials in the Northern Virginia region and provide car companies and suppliers of

automated vehicles the ideal, real-world environments they need to test complex scenarios prior to putting their vehicles on more roadways. The proximity of the Virginia Automated Corridors to Washington, D.C. facilitates access to the northern Virginia technology corridor and decision makers in DoD and federal agencies.

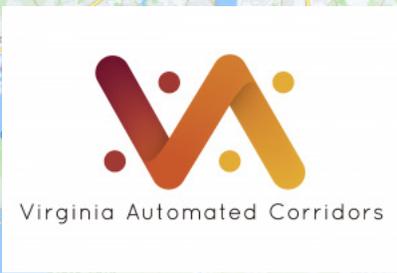
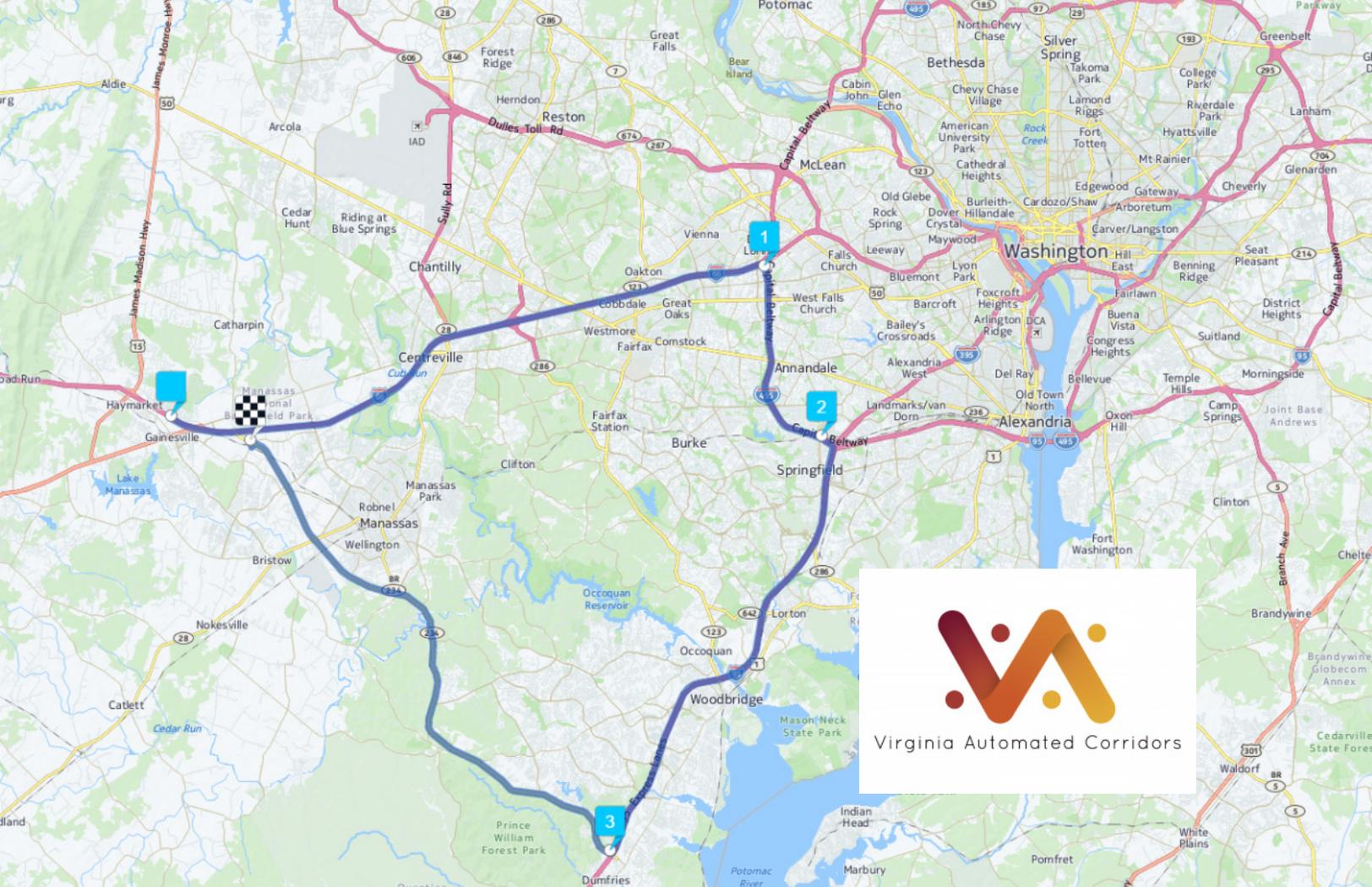
These corridors integrate access to dedicated high-occupancy toll lanes, high-definition mapping capabilities, real-time traffic and incidents, intelligent routing, location cloud technology, pavement markings maintained by VDOT for completeness and retro-reflectivity, accurate localization via high-precision global navigation satellite systems, dedicated short-range communications and cellular technology, and sophisticated, unobtrusive data acquisition systems.

In November 2017, the Virginia Tech Transportation Institute launched its new urban test track, the first in a string of expansions planned to grow its research capabilities. In Blacksburg, VA, The Smart Road has offered scientists a closed, 2.2-mile stretch of highway since 2002, but now that’s flanked by two new test tracks: an urban environment, which opens Tuesday, and a rural road, which is still under construction. This 3.5-mile road will be intentionally built to outdated 1965 safety standards, with narrower lanes and fewer roadway markings. The whole track will be connected to U.S. 460, allowing scientists to begin experiments on a closed road before seamlessly driving onto public roads around Blacksburg. When it’s all complete, VTTI Smart Road Director of Operations Jared Bryson said he can’t think of any roadway scenarios his team won’t be able to simulate. There will be mock neighborhoods, roundabouts, bus stops, foggy highways and blind curves on country roads. The idea is to create a testbed where industry leaders can bring their self-driving cars to see how they perform in the variety of unpredictable environments they’ll find in the real world—all in one place.

The Commonwealth’s dedication to ground based automation goes beyond these two corridors of course, and many startups, innovators, and entrepreneurs will find access to leading research and investment groups vital for their success. Virginia enables easy access to leaders in the field of safety, testing, and automation management at the Global Center for Automotive Performance Simulation (GCAPS), the National Surface Transportation Safety Center for Excellence, and several University Transportation Centers all eager to collaborate and fund the future of autonomous automotive research.

²⁴ <http://www.me.vt.edu/extreme/>

²⁵ <http://vus.virginia.gov/land/>



VIRGINIA AUTOMATED CORRIDOR FEATURES

- *Multiple testing environments, including more than 70 miles of urban interstates and rural arterials in the Northern Virginia area, the Virginia Smart Road and Virginia International Raceway test tracks, and Town of Blacksburg roadways*
- *Access to dedicated high-occupancy toll (HOT) lanes in conjunction with Transurban, which develops and manages more than 40 miles of express lanes located along the VAC*
- *Pavement markings implemented in conjunction with the Virginia Department of Transportation (VDOT), which will maintain standards for both completeness of markings and retro-reflectivity properties*
- *High-definition mapping, real-time traffic and incidents, intelligent routing, and location cloud technology for automated and connected vehicles supported by HERE, a Nokia company*
- *Ubiquitous 1 cm accurate localization facilitated by a multichannel, high-precision global navigation satellite system with real-time kinematic corrections, an inertial navigation system providing dead-reckoning, and an update rate up to 100 Hz*
- *Sophisticated, unobtrusive data acquisition systems that record time-synchronized data to the nearest millisecond using multiple (i.e., two to six) cameras and sensors*
- *Remote monitoring and data streaming*
- *Existing connected-vehicle infrastructure and systems installed along the Virginia Connected Corridors (VCC)*
- *No bond required for automation testing in Virginia; licensing and insurance provided through the Commonwealth, with Institutional Review Board approval and certification for safe human research involvement facilitated via VTTI*
- *More than 2,300 qualified buildings and sites located across the Commonwealth*

On the Land

Virginia is not just focused on the success of unmanned aircraft to foster the future of UMS technologies. Ground-based autonomous vehicles are being supported and nurtured in a way unparalleled throughout the rest of the United States.

As Time Magazine put it when writing about the work started in Virginia in 2015, “This State is Becoming a Self-Driving Car Haven.”²⁶

While some states are debating the positives and negatives of automated vehicles on their infrastructure, Virginia’s leaders have taken the bold steps of establishing programs with extensive funding to promote the theoretical and applied research requisite to full deployment of driverless cars, and other automated ground robotics. The Commonwealth allows testing of any automated vehicle on Virginia roads under the guidance of the Virginia Tech Transportation Institute (VTTI), and the Virginia Department of Motor Vehicles (DMV) will support research efforts performed by VTTI.

Virginia Automated Corridors

The Virginia Department of Transportation (VDOT) and the Department of Motor Vehicles took the first steps toward integrating driverless vehicles in 2015 by entering a long-term partnership with the Virginia

Tech Transportation Institute (VTTI), Transurban, and HERE—Nokia’s mapping business—to create the Virginia Automated Corridors. The Virginia Automated Corridors (VAC) provide an automation-friendly environment that government agencies, original equipment manufacturers, and suppliers can use to test and certify their systems, providing a system migration path from test-track to real-world operating environments. The leverages extensive experience in on-road safety research to provide efficient solutions to automated-vehicle testing.

The varying roadway environments of the VAC promote multiple use case scenarios, including the testing of automated cars, trucks, and buses on freeways and express highways, as well as testing along urban routes. Automated capabilities can also be developed and deployed in two test-track environments that feature intersections, connected-vehicle communications, operations at higher speeds, a reconfigurable track, complex curves, and markings.

The distribution of the roadways that compose the VAC were designed to be representative of the Nation’s Highway System, as described in the Nation’s Highways, Bridges, and Transit: Conditions and Performance report made to Congress and published by the Federal Highway Administration (FHWA). The percentage of road miles in the VAC is consistent with the percentage of National Road Miles. Specific roadways of the VAC were also selected that had existing naturalistic driving data available to support comparative research.

Virginia Automated Corridors Roadway Environment	Use Case(s)	SAE Level(s) of Automation	Connected via DSRC, Cellular & HD Mapping
Northern Virginia Highways & Arterials	Freeway Platooning Highway Autopilot Operation in Urban Setting	2–3	Yes
Town of Blacksburg	Urban Chauffeur Automated Taxi	4	No
Virginia Smart Road	Closed Test Track	1–5	Yes
Virginia International Raceway	Closed Test Track	1–5	No
All Virginia Roads	Many	1–5	No

²⁶ <http://time.com/3907036/driverless-cars-virginia/21/>

Collaboration in Focus: TORC Robotics

By leveraging these unique centers of excellence, transportation institutes dedicated to providing go-to market strategies for all levels of R&D, and enabling students and faculty to retain intellectual property throughout their relationships with new companies have flourished in Virginia. One such example is the amazing success story of TORC Robotics. It was founded in 2006 by a team of graduate students who, while at Virginia Tech, competed in one of the X Challenges developed and hosted by DARPA. This collaborative evolved from a group of graduate students to a team of professionals who are even now expanding further into a new 3,000 square foot warehouse in the Blacksburg Industrial Park.²⁷

TORC Robotics developed a self-driving car and introduced it to the rest of the country by sending it on a cross country, coast-to-coast drive. The self-driving car and its test team crossed 13 states on the westward drive to Seattle, Washington. For the eastward trip home, the car took a more southern route and drove autonomously through seven additional states. With more than 4,300 autonomous miles, TORC Robotics is leading the way in autonomous vehicle development for military, construction, agriculture, and automotive technologies promising fully self-driving vehicles in the not-so-distant future. TORC Robotics is another example as to how collaborations at the academic, professional, and government levels provide the perfect support structure for making technological concepts a reality.

Under the Sea

While air- and ground-based unmanned systems seem to dominate the discussion when examining new automated vehicle technologies, Virginia's commitment to advanced technologies and the pursuit of a protected and high-quality environment come together in the support and application of unmanned technologies on and under the sea. Early on, Virginia recognized the importance of UUVs as an extension of all automated technological applications and as vital to the long-term future of the waterways in and around the nation. Instead of allocating funds and focusing solely on UAS, Virginia's leaders decided to adopt all UMS technologies to support, and has therefore provided the leading environment for UUV development in collaboration with ground and air vehicles development.



By leveraging the unique qualities of the region, businesses and educators gain access to universities, small companies, and large firms that are advancing maritime vehicles, autonomy, manufacturing, and servicing. Virginia's profound advantages geographically provide access to waterways, swamps, shallow rivers, bays, and the open ocean unlike many others. Virginia boasts several massive, historic, and infrastructure-rich bays and wide-open oceans that simulate any number of aquatic environments sought by the defense industry, unmanned system manufacturers, and consumers eager to apply their working conditions to test and apply their systems.

Joint Atlantic & Chesapeake Ranges Cooperative

The Hampton Roads waters and the Joint Atlantic & Chesapeake Ranges Cooperative (JACRC) is a hub of maritime systems testing from shallow rivers to deep ocean waters and are already attracting test customers from Pennsylvania to Massachusetts. JACRC is an alliance of Department of Defense test and training ranges and facilities in Maryland, Virginia and Rhode Island. JACRC members collaborate in supporting the research, development, test and evaluation (RDT&E) requirements, as well as interoperability requirements of Department of Defense acquisition managers. They support and cooperate in all phases of Warfighter Readiness Training and Joint Forces Warfare Experimentation.

Through a Memorandum of Agreement, JACRC members collaborate in support of research, development, test, and evaluation (RDT&E) to facilitate interoperability requirements within DoD. The JACRC provides a useful mechanism for many large-scale initiatives, small-scale events and medium-scale exercises in water and on land. The JACRC partnership boasts the following members, enabling a variety of outlets for any business interested in working with the Department of Defense to engage:

²⁷ http://www.roanoke.com/business/news/blacksburg/torc-robotics-to-expand-in-blacksburg-with-room-for-more/article_fc68811c-e5bd-50ec-a763/

- *NASA Wallops Flight Facility, Wallops, VA*
- *U.S. Army Fort A.P. Hill, Bowling Green, VA*
- *U.S. Fleet Forces Command (N73), Norfolk, VA*
- *Fleet Forces Atlantic Exercise Coordination Center (FFAECC)*
- *Fleet Area Control & Surveillance Facility, Virginia Capes (FACSFAC VACAPES), NAS Oceana, VA*
- *NAVSEA Naval Surface Warfare Center (NSWC)*
- *Carderock Combatant Craft Division, Little Creek, VA*
- *NAVSEA NSWC Dahlgren Division, Dahlgren, VA*
- *NAVSEA NSWC, Dam Neck, VA*
- *NAVSEA Surface Combat Systems Center (SCSC), Wallops Island, VA*
- *Army National Guard Fort Pickett, Blackstone, VA*

The JACRC works together to support service-specific test and training events and exercises—from small-scale, unit-level events, to medium- and large-scale exercises. Recent activities have included U.S. Navy tests of the Boston Engineering-developed GhostSwimmer unmanned underwater vehicle (UUV) at the Joint Expeditionary Base Little Creek-Fort Story in Virginia. The Navy's Autonomous Swarmboats conduct tests at the Reserve Fleet.

Joint missions with the Mid-Atlantic Aviation Partnership (MAAP) or NASA Wallops exist to enable swarm or nodal communication between ground, air, and underwater vehicles without human intervention. These areas facilitate new companies to work with leading institutions to rapidly develop new solutions to global challenges with local area firms all seeking to provide needed support.

Virginia Tech Department of Aerospace and Ocean Engineering

At the Virginia Tech Department of Aerospace and Ocean Engineering, both the air and sea come together in design, analysis, and production of aerospace and ocean systems. The department offers a unique blend of two disciplines that takes advantage of commonality in the analysis and design of aerospace and ocean systems. The adjacent Virginia Tech Corporate Research Center (VTCRC) is a growing, prestigious research park for high-technology companies that advance the research, educational, and technology transfer missions of the university. Together with the developing VTCRC Newport News, Virginia location, the expertise and technology available at Virginia Tech will be collated in the heart of the Hampton Roads maritime environment.

On October 4, 2016, the National Science Foundation announced it had awarded Virginia Tech researchers nearly \$900,000 to “improve emergency response by developing methods to coordinate teams of aerial and surface vehicles.”²⁸ These teams are putting the funding to good use, examining how aquatic emergencies such as oil spills and radiation leaks can utilize autonomous vehicles to assess the extent of the contamination and transmit that critical information to first responders so they can categorize and prioritize their response.

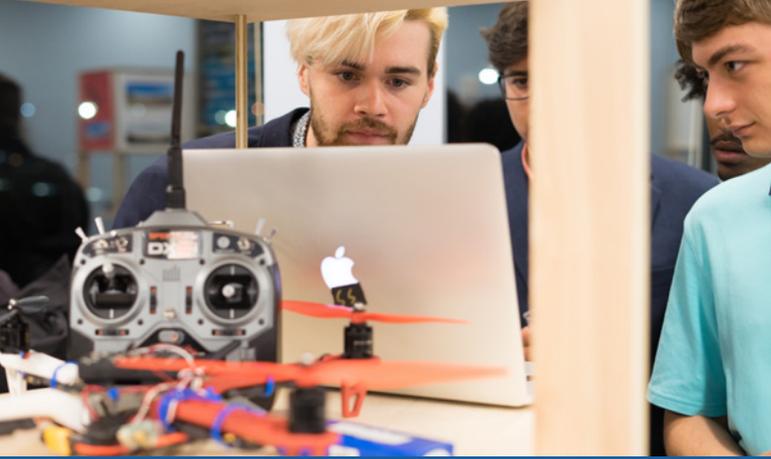
These systems will use unmanned aircraft and water vehicles equipped with cameras and multispectral imaging, and require two types of domains to interact as one to problem-solve and respond. When the research and debugging is complete, the faculty and students will then field-test their prototypes with the Virginia Tech Rescue Squad, a student group that handles around 1,200 calls per year, illustrating Virginia’s approach to providing partnerships to enable new ideas and companies to flourish in an unparalleled way.

By combining the engineering and technology expertise of the major educational institutions and private companies with the resources and needs of the state and federal governments, Virginia has developed an ecosystem for innovation unmatched. From the need sets of the Virginia Institute of Marine Science to the Chesapeake Bay and Hamptons Roads test facilities, and the various research institutes in between, the Commonwealth provides both the investment for growth and the demand for new solutions.

Virginia Institute of Marine Science

One other important asset that combines both the air and sea for unmanned systems is the Eastern Shore Laboratory of the Virginia Institute of Marine Science (VIMS). The Virginia Institute of Marine Science’s Eastern Shore Laboratory (ESL) serves as both a field station in support of research and teaching and as a site for resident research in coastal ecology and aquaculture. By virtue of its access to unique coastal habitats, excellent water quality, and an extensive seawater laboratory, the ESL affords educational and research opportunities not available elsewhere within the region. Over its 40-year history, the laboratory has become internationally recognized for shellfish research, with important contributions to molluscan ecology and culture. This facility has recently been a base for the mapping of shoreline using autonomous vehicles.

²⁸ <https://vtnews.vt.edu/articles/2016/10/ictas-schmaletokekar.html>



EDUCATION & WORKFORCE: VIRGINIA'S NOT-SO-SECRET SAUCE

Virginia is known the around the world for the way government, higher education, and business work together to create training and workforce development programs. The highly trained, tech savvy workforce that already exists in Virginia, coupled with a commitment to education and workforce development by the state, colleges and universities, and K-12 education system, are a major advantage for firms looking to thrive.

More than 15,000 graduate students pursue advanced degrees in science and engineering and approximately 18,000 people leave Virginia military bases seeking civilian employment annually. New initiatives such as the Aviation Academy in Newport News prepares high school students for aerospace careers. Maintaining a highly skilled workforce ensures future success in advanced manufacturing, engineering, and design fields.

Aerospace industry leaders have long recognized Virginia's workforce as readily recruitable, highly productive, and characterized by a strong work ethic and reasonable cost. Technology companies have been busy expanding in Virginia to take advantage of the largest concentration of high-tech workers in the U.S. (9.8% of the state's private sector workforce is in tech).²⁹

Workforce

The Unmanned Aerial System industry is directly engaged with, and finding a home in, the Commonwealth of Virginia. Private companies in Virginia already employ more than 2,000 individuals working at 41 UAS-related companies.³⁰ Virginia's population of more than 8.3 million and a workforce of more than 4.3 million boasts the fourth highest graduate education rate in the nation at 15.4%.³¹

An educated and well-trained workforce is fundamental to building a resilient, globally competitive Commonwealth ready to meet the demands of the 21st century. Virginia's higher education system is the 11th largest in the nation with more than 80,000 graduates annually receiving associate, bachelor, master and doctoral degrees a year. Currently, more than 500,000 students are enrolled in more than 90 in-state institutions of higher education. With at least one community college located within approximately 30 miles of almost every resident, Virginia's workforce development programs are strategically positioned to provide workforce solutions in an efficient and effective manner.

²⁹ TechAmerica Foundation's annual Cyberstates Report

³⁰ <http://yesvirginia.org/Content/pdf/Industry%20Profiles/VA%20Aerospace%20Profile%202016.pdf>

³¹ American Community Survey

OPPORTUNITY IN SOUTHEASTERN VIRGINIA

Southeastern Virginia has a small cluster of private firms specializing in the use of unmanned and autonomous technologies in the maritime environment. For example, industry leaders in Unmanned Surface Vessels are based in Hampton Roads, where they are ideally positioned to leverage technology from NASA (e.g., Mars Rover) and research partnerships with DARPA, ONR, and NASA Langley Research Center (LaRC).

Approaching the opportunities from a different angle, the leadership of RISE Resilient efforts continue to incentivize the development of new technologies that can be integrated into "Smart Cities." As part of 100 Resilient Cities, this effort based in Norfolk will be central to overcoming the challenges sea level rise presents to coastal communities around the world. Private companies, such as the fully-integrated architecture and engineering firm Clark Nexsen in Virginia Beach, have established efforts focused on sea level resiliency.

Additionally, the Virginia Modeling, Analysis, and Simulation Center (VMASC), located adjacent to the Tri-Cities Center and the Portsmouth Economic Zone, is working hand-in-hand with Huntington Ingalls Industries (NYSE:HII) to explore the potential of unmanned systems, to include augmented reality in ship repair. Further, HII acquired Camber Corporation and established a Technical Solutions Segment. From Wallops Island, to Williamsburg, to the Isle of Wight County, Hampton Roads is well-positioned to lead the commercialization of unmanned and autonomous maritime technologies well into the 21st Century.

VIRGINIA HAS ONE OF THE MOST WELL-EDUCATED WORKFORCES TO SUPPORT THE UNMANNED SYSTEMS INDUSTRY

As target industries continue to seek highly skilled, highly trained professionals to fill critical gaps, postsecondary education is key to building the New Virginia Economy. There is a strong correlation between educational attainment and job opportunities with higher incomes. In 2012, only 12.1% of Virginia adults did not have a high school diploma, which was better than the national average of 13.7%. Virginia also boasts the greatest number of scientists and engineers of any state. Additionally, Virginia has the highest concentration (1 in 10) of private sector high-tech workers in the country.³²

An educated and well-trained workforce is fundamental to building a resilient, globally competitive Commonwealth ready to meet the demands of the 21st century. This workforce includes the high-tech skills found in our northern Virginia Technology Corridor, highly skilled veterans returning to civilian life for our many defense installations, and leading-edge research performed at our universities and local federal laboratories. While Virginia has the quality of education and workforce required, the demand in this growing industry exceeds the supply in some areas, including the cyber security aspects of unmanned physical systems. With constant growth in this new economy, it is up to government, private industry, and new workforce entrants to meet and exceed the challenges ahead. These challenges will be fought and won in Virginia.

The Commonwealth Center for Advanced Manufacturing (CCAM) was developed to address this important need, enabling applied research to accelerate the transition of products from laboratory to commercial use. While developing the workforce, CCAM also develops immediate technologies, allowing its member companies to own all funded IP developed in the CCAM institution or partner universities. The National Institute of Aerospace (NIA) conducts research and awards advanced degrees in aerospace engineering through a partnership with nine universities to grow a workforce with commercialization and engineering experience necessary for today's lean startup oriented small businesses and large firms.

New Virginia Economy

Launched in 2014, the New Virginia Economy Initiative seeks to build upon the Commonwealth's position among the nation's best globalized, entrepreneurial, IT-driven, and innovative economies and capitalize on opportunities in various high-growth industries. By making smart investments in education, transforming the approach to

- *Virginia currently supports the third highest concentration of technology jobs as a share of overall private-sector employment.*
- *More than 37% of Virginians have at least a bachelor's degree, the 6th highest rate in the country.*
- *More than 1,400 doctorate degrees in science and engineering are awarded annually from Virginia universities.*
- *More than 15,000 science and engineering graduate students pursue advanced degrees in Virginia.*
- *Approximately 18,000 people leave Virginia military bases each year and enter the civilian workforce.*

high school education, and strengthening the workforce training pipeline, the goal is to create new opportunities for Virginia students and businesses to thrive.

The New Virginia Economy focuses on five priorities:

1. *Enhance economic development infrastructure*
2. *Diversify and grow strategic industry sectors*
3. *Solidify and promote the existing competitive business climate*
4. *Nurture a sustainable entrepreneurial environment*
5. *Equip Virginia's workforce with in-demand skills to meet the needs of business and industry*

Virginia also established the New Virginia Economy Workforce Initiative, which challenged Virginia's education and workforce development programs to produce 50,000 STEM-H Workforce Credentials a year by the end of 2017. Virginia's agencies are now producing 46,230 STEM-H workforce credentials a year.

³² <https://commerce.virginia.gov/media/3501/new-virginia-economy-12052014.pdf>

Education

The Commonwealth leverages leading edge research performed at universities and local federal laboratories by approaching education from two goals—workforce development and research and development. Virginia's university system can provide the industry with knowledgeable, well-trained, technology-focused students ready to enter the labor market while also publishing and producing meaningful research that can be directly leveraged for industrial use today.

Education and Workforce Development

The Commonwealth boasts 575,000 students enrolled in more than 230 campuses around the state including 23 community college campuses with 40 total campuses around the state. Virginia has 15 public comprehensive institutions, eight of which are doctoral institutions complemented by 45 accredited private four-year institutions (including three of the top 10 public institutions in the country). With at least one community college located within approximately 30 miles of almost every resident, Virginia's workforce development programs are strategically positioned to provide workforce solutions in an efficient and effective manner.

For firms looking to find the best students in the nation to start on Day One, Virginia leads the list. Virginia Tech, the University of Virginia, and Old Dominion University all perform world-class advanced aerospace research and have mechanisms for funding that include state and federal grants, as well as private partnerships.

UMS programs in policy, law, entrepreneurship, and innovation are also major vocations at Virginia Commonwealth University, Liberty University, George Mason University, Hampton University and Averett University. These higher education institutions work together through collaborative agreements and leadership at the state level to provide all students, regardless of university or college, the opportunity to work on world-class projects.

The education of the UMS workforce, from the researchers and engineers to the operators, maintainers, programmers, software developers and lawyers is performed in Virginia's institutions. All verticals in this growing industry are developed to the highest standards in the Commonwealth producing a workforce ready for next generation challenges.



Figure 2: Geo-TEd-UAS 2016 Summer Training Institute

Mountain Empire Community College

Mountain Empire Community College (MECC) in southwestern Virginia offered the first UAS class in the Virginia Community College System in the Summer of 2015, led by instructor Fred Coeburn. MECC was, shortly afterward, also asked to join in on a National Science Foundation grant application being submitted by Old Dominion University to develop a UAS train-the-trainer program for the college instructors in the region. The goals were to bring together UAS industry experts in order to develop a DACUM chart (skills set chart) with which to design classes, to bring together and train the region's college instructors on how to integrate UAS technologies into their existing classes, and to help with the development of new classes and programs. This included the provisions of a weeklong training session (Geo-TEd-UAS 2017 Summer Training Institute) to 22 Virginia community college instructors interested in providing UAS training at their respective schools.

Mountain Empire has continued to be a leader in pioneering new classes and applications, including both assisting with a UAS-based multispectral site scan on a mine reclamation project in conjunction with Senselize, an Israeli company and presenting a two year AAS degree in Unmanned Aircraft Systems to the VCCS for approval.

In the Spring of 2016, the Appalachian Regional Commission announced a \$300,000 grant to Aurora Flight Sciences, the Wise County IDA, and MECC for the development of a UAS Geospatial Mapping course. ARC funds were awarded through the federal Partnership for Opportunity and Economic Revitalization (POWER) initiative, a multi-agency effort to help economically stressed coal communities reinvent their economies, which provided additional funds totaling \$2.2 million dollars to the Wise County Industrial Authority for the Virginia Emerging Drone Industry Cluster Project, intended to position five Southwest Virginia counties as "an epicenter" for drone R&D work.



Figure 3: The first UAS Class in the Virginia Community College System

Geospatial Technician Education Through Virginia's Community Colleges (GTEVCC)

Thanks to a grant from the National Science Foundation's Advanced Technological Education program, the Virginia Space Grant Consortium (VSGC), the Virginia Community College System (VCCS), three community colleges (John Tyler Community College-JTCC, Tidewater Community College-TCC, and Virginia Western Community College-VWCC), and the Virginia Geospatial Extension Program (VGEP) at Virginia Tech have partnered to establish sustainable academic pathways in geospatial technology (GST) to provide Virginia employers with a larger pool of skilled geospatial technicians.

These pathways will serve as models for other community colleges as the GTEVCC project team spreads the implementation of geospatial pathways and curriculum through faculty professional development and mentoring. The GTEVCC project includes educational materials development, adaptation, and implementation, and will provide professional development and mentoring for faculty. Curriculum is based on principles of authentic learning and driven by the needs of business and industry in the Commonwealth. Project activities target community college students and faculty as well as precollege students and faculty.

James Madison University and 4-VA

Virginia and its united universities are redefining the very foundation of college education by promoting an interconnected system where students can leverage unique institutions from around the state without leaving their campus. By supporting unprecedented partnerships between faculty and departments to generate significant, innovative solutions to educational and real-world problems, and sponsoring advancements in research, pilot courses, redesigned courses, shared courses, online programs, industry-focused adult degrees, new technologies, interventions, workshops, conferences, and other programs, 4-VA enables students from throughout the state to take part in a community of innovation.

In the spring of 2015, Dr. Kevin Giovanetti taught the first

undergraduate drone course in the Commonwealth of Virginia—a feat that put JMU on the map in ways never imagined. What began as a pilot course has surged into multiple iterations of a collaborative, interdisciplinary course and events shared across the Commonwealth. The initial course focused primarily on the technical components of unmanned aerial vehicles (UAVs) and JMU continues to offer this upper-level physics course. In the spring of 2016, ODU successfully joined the course via telepresence technology.

In the fall of 2015, 4-VA at JMU launched an expanded and applied version of the UAV course, addressing global problems with drone technology: aerial imaging, ecology topics of pollution and riverbeds, first response for providing medicine to remote locations, and land mine detection and destruction. In the fall of 2016, both ODU and GMU joined the expanded UAV course through telepresence hosted by JMU. With a variety of interests across the class, students chose a few additional global issues to explore and solve using drones: augmented communication, fire rescue, increasing honeybee populations, and modeling city walls in Cartagena, Colombia (the latter team journeyed to Colombia in January 2017 to test their prototype and work directly with the PhD candidate there who requested the project).

The success of the UAV courses propelled 4-VA at JMU to host the first Virginia RoboTics and Unmanned systems Education Summit (VIRTUES) in August 2016. This working meeting brought UAV experts from industry, research, curriculum, ethics, and policy from across the Commonwealth and along the east coast together to discuss actionable ways to collaborate. Much like the interdisciplinary opportunity for UAV students, professionals reached beyond their regions and organizations to discover collaborative solutions to the many challenges facing unmanned vehicles in a burgeoning field.

Back by popular demand, VIRTUES II was held just six months later to focus on strategic coordination between curriculum and industry.

Liberty University's Unmanned Aircraft Systems Program

Partnerships in the Commonwealth stimulate the economy, drive innovative solutions to challenging problems, and provide opportunities for students and workers to achieve greater heights in diverse ways. Liberty University took on the challenge of aerial flight by first identifying the need for skilled, educated, and certified operators of unmanned aircraft just as the industry was becoming more mainstream. In

VIRGINIA DGIF PARTNERS WITH 4-VA AT JMU ON DRONE PROJECTS

During one of JMU graduate Nick Sipes's recent drone surveys, a man named David Kocka approached him, curious about drones. Nick agreed to give him a tour of JMU X-Labs to share more about his background in UAVs. As a wildlife biologist who works for the Virginia Department of Game and Inland Fisheries (DGIF), David saw a huge opportunity for collaboration. After meeting with 4-VA Executive Director Nick Swayne, David reached out to his regional peers across Virginia to determine where they could use drones to facilitate their projects. They drew up a list of statewide drone projects, including searching for bear den locations, surveying peregrine falcon sites, shorebird research, and surveying wildfire areas. 4-VA at JMU plans to delegate these projects to interdisciplinary student teams through the Virginia Drones Project at JMU X-Labs to give them real-world experience using drone technology.

2013, Liberty University graduated their first class of unmanned aircraft systems operators as a concentration within the School of Aeronautics. The program was so visionary that Virginia's Region 2000 Technology Council recognized it as Innovator of the Year.³³

Today, students have an opportunity to train with Textron's (the owner of Cessna and Aerosonde) UAS equipment and gain a certification for Aerosonde UAS operations. This certification can then be used for immediate hiring as a UAS operator for flight test and commercial operations in conjunction with the CFR 107 Remote Pilot in Command certification.³⁴ These trainings allow flexibility in coursework, enable long-term success as a part of the bachelor's degree process, and provide immediate skilled pilots for the flourishing UAS industry in Virginia.

Germanna Community College's Approach to Drones

The Commonwealth of is not just focused on theoretical research being conducted at four-year universities, but engaged with and supportive of all colleges and universities eager to participate in the transformative autonomous economy. Germanna Community College

is providing another gateway for students and faculty to interact with drone operations. Germanna now offers a Drone-UAV FAA Pilot Class that helps prepare students for the 14 CFR 107 test. They recognize "companies are utilizing UAVs for services in real estate, construction, surveying and mapping, agriculture, utilities inspections, and more."³⁵ When combined with the FAA Private Pilot Ground School course, it is clear Germanna is encouraging safe, secure, and productive student education in manned and unmanned aviation.

Education and Research

Private companies who manufacture, promote, and use unmanned systems and the government that fosters productive development and use of these systems are not the only stakeholders directly engaged in Virginia. Academic stakeholders in Virginia lead the nation in direct involvement with the industry as well. University researchers and educators are pushing the limits of UMS technology trends and producing results that are having immediate effect in legislative efforts, regulatory requirements, and manufacturing. Virginia has cultivated an approach for education that is being copied now around the world.

Higher education in Virginia is a key component in the Commonwealth's dominance in the industry. While Virginia Tech's UAS leadership as a test site and important participation with the UAS Center of Excellence (CoE) is vital to pushing the drone industry forward, the rest of its robotics programs continue to define the UMS field in the sea and on the ground. Virginia universities and colleges boast one of the most advanced and diverse portfolios for unmanned systems in the world and is greatly supported by and engaged with the technology stakeholders. The following programs, laboratories, and collaboratives offer great examples of how students, government, and private firms interface to innovate and excel in UMS technologies, in addition to the Mid-Atlantic Aviation Partnership (referenced extensively in "In the Air").

Institute for Advanced Learning and Research

The Precision Agriculture Program at the Institute for Advanced Learning and Research (IALR) is focused on developing technology and analytic-based programs to support applied agricultural research and the regional farming community. The program incorporates the use of several commercial grade small unmanned aerial vehicles highlighted by Aerial Technology International's AgBot, an industrial quadcopter drone equipped with multispectral and thermal payloads. The AgBot is fully autonomous and flies preprogrammed missions over a

wide range of crops in Southern Virginia, including corn, grapevines, and strawberries. Data gathered is analyzed by IALR researchers in partnership with growers to focus on field-specific issues during the entire plant life cycle, from planting to harvest. By comparing images through layering, site-specific action plans are developed for the next season, with the overall goal of increasing productivity while reducing costs. IALR is currently partnering with farmers to collect data on over 20 fields in the region.

TREC – Terrestrial Robotics Engineering & Controls Laboratory

The TREC laboratory was founded to study cutting-edge mechanics and controls in order create robotic platforms to change the way the world is perceived. Located in the Signature Engineering Building at Virginia Tech, the institute is able to combine cutting edge research and all of the assets and support found throughout the university. Command and control, as well as human-machine-interface problems, are core issues that this open laboratory solves. TREC's projects allow students to operate along a wide swath of the vertical stack, from fundamental research to engineering, manufacturing, and operations.³⁶

Perhaps the most important project focuses on the deployment of robots to novel field applications through a tightly integrated cross-disciplinary team. TREC's Team VALOR created and is fielding ESCHER, the Electric Series Compliant Humanoid for Emergency Response. ESCHER is a full-sized humanoid robot designed, fabricated, and assembled by Virginia Tech in cooperation with industry stakeholders in response to the DARPA Robotics Challenge. The TREC team competed as one of the only Track-A University teams at the DARPA Robotics Challenges Finals and are now developing what will be the world's first fully balancing exoskeleton as part of the National Robotics Initiative.

ESCHER was designed to support disaster relief response and search and rescue tasks, allowing robots to command interfaces and transportation designed for humans. In collaboration with software development group Team ViGiR—Virginia-German Interdisciplinary Robotics—TREC and ESCHER are a great demonstration of how Virginian universities and companies work at an international level to create technologies needed by government, military, or the public.

Extreme Environments, Robotics & Materials Laboratory (ExtReMe) & Robotics and Automation (R&A) Laboratory

The ExtReMe laboratory allows students and researchers to focus on using robotic systems in extreme environments

and to study the impact of those environments on materials.³⁷ This includes research that involves fires, firefighting, and spaces with low visibility conditions. This lab is in high demand by disaster relief and government contractors for partnerships. One such project is the Shipboard Autonomous Firefighting Robot (SAFFiR) program sponsored by the U.S. Navy. This robotic platform was showcased at the Laboratory for Autonomous Systems Research (LASR) located at the Naval Research Laboratory (NRL). Portions of this platform were created in the ExtReMe laboratory led by Professor Lattimer of Virginia Tech as the principal investigator of the program.

SAFFiR was developed to showcase how humanoid robots can be integrated with artificial intelligence to perform firefighting tasks such as turning valves, identifying and grasping a fire nozzle, and tracking fires with the nozzle using an advanced vision system. This project directly led to several follow up robotic technology programs used in the 2013 DARPA Robot Challenge in Florida.

The R&A Lab at Virginia Tech is considered one of the leaders in research and instructional labs in the country. By providing support to undergraduate and graduate courses while engaging NSF funding through grant development, the R&A lab allows students incredible insight into developing UMS technologies that require automation development and application.³⁸ Their most recent undertakings include two National Science Foundation projects related to automated path planning and passive assembly, an industry project for guidance and control of driverless linked vehicles, and a NASA project for automated fiber-composite structure manufacture.

INVESTMENT

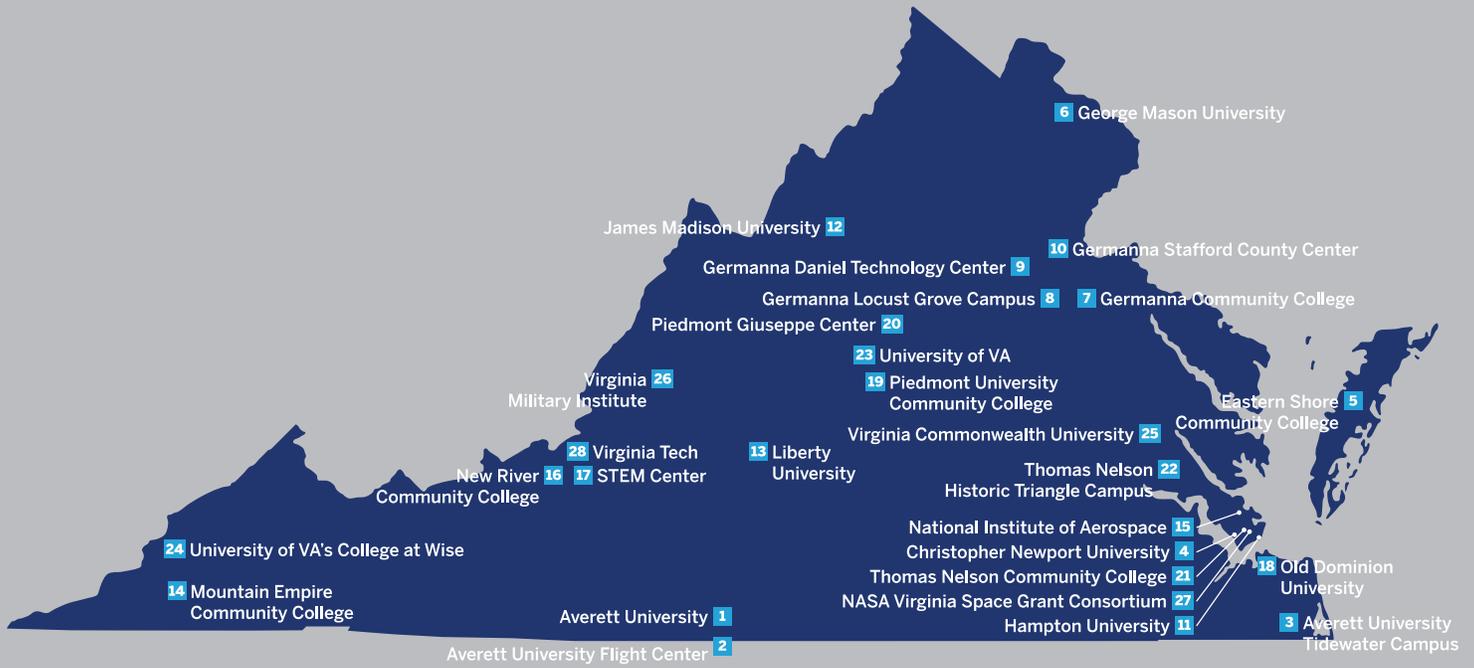
Within the field of UMS, entrepreneurs and startup firms vie for funding and to be the next big company in the space. The competition is fierce as international companies account for nearly 70% of the consumer market and new entrants must learn to provide new characteristics and functions. This is a focus in Virginia and a challenge that is eagerly being taken on. As entrepreneurs explore any number of various business models and systems that can be provided at low cost to consumers, the industry in Virginia is also well suited to engage with military and paramilitary organizations needing systems for their unique challenges. Virginia affords an ideal place for all manufacturing and nonmanufacturing focused businesses in the UMS field.

³⁶ <http://www.me.vt.edu/research/laboratories/trec/>
³⁷ <http://www.me.vt.edu/extreme/>

³⁸ <https://www.ise.vt.edu/facilities/labs/robotics-automation.html>

School	Academic Programs	Overview	Number of Students
Averett University	<i>Aerospace Management, BS</i>	Averett University operates an FAA-approved Part 141 flight school as part of its Aeronautics degree, offering classes for various aircraft and pilot certificates. Its Bachelor of Science in Aerospace Management has two concentration options: Aviation Business and Flight Operations, in addition to a joint Aerospace Management/Criminal Justice degree program for students interested in law enforcement related aviation careers.	10-20
Christopher Newport University	<i>Computer Engineering, BS; Electrical Engineering, BS; Computer Foundations, BS; Information Science, BS</i>	CNU's Department of Physics, Computer Science and Engineering features an Unmanned Aerial Systems team of 10-12 students. About six more students are working on unmanned systems as their capstone projects, and the department features two computer science professors conducting research in ground-based, unmanned robotics.	10-20
Eastern Shore Community College		Eastern Shore Community College is located near Wallops Flight Facility, part of Virginia Tech's UAS test site program. In October 2014, ESCC hosted an Unmanned Aircraft System Technical Interchange between policy makers and industry executives. An Aerosonde aircraft donated to the school was the first unmanned aircraft to fly into a hurricane in 2005.	10-20
George Mason University	<i>Systems Engineering and Operations Research Department; Applied and Engineering Physics, MS</i>	George Mason University's Department of Systems Engineering and Operations Research has 150 students in bachelors, masters, and doctorate programs, 19 of whom have declared a concentration in Aviation and UASs. GMU's Center for Air Transportation Systems Research, chartered in 2003, also features several white papers, dissertations, and student projects dedicated specifically to UAS and UASs.	20-30
Germanna Community College		In October 2015, Germanna Community College's Center for Workforce and Community Development partnered with Cedar Mountain Stone, allowing Germanna to track progress at the company's quarry in Culpeper County. The school purchased two \$6,200 UASs, and is launching two noncredit classes in UASs at the Daniel Technology Center and Germanna's Fredericksburg Area Campus.	10-25
Hampton University	<i>Department of Aviation (Air Traffic Control, Aviation Management, Flight Education programs); Aviation Computer Science, BS; Aviation Electronic Systems, BS; Electrical Engineering, BS; Computer Science, BS</i>	Hampton University's Department of Aviation, housed within its School of Engineering and Technology, offers programs in Air Traffic Control, Aviation Management, and Flight Education. According to the most recent figures from the school's registrar, 19 students were enrolled in the department as of Fall 2012. The department is the only one of the 105 Historically Black Colleges and Universities in America with a FAA-approved Air Traffic Collegiate Training Initiative program.	20-30
James Madison University	<i>Engineering, BS; Integrated Science and Technology, BS; Interdisciplinary Minor in Robotics; Information Systems Security Professionals Certificate; Information Security - INFOSEC, MS</i>	JMU's UAS Project in Fall 2015 brought together students from seven majors and four professors to use "collaborative learning, design thinking, social entrepreneurial skills, and a variety of technologies to develop prototype uses for six UASs that were custom-built by JMU students." The project was sponsored by 4-VA, and hosted in their X-Labs facility on the JMU campus. Entrepreneurs from NOVALabs participate throughout the course.	10-20
Liberty University	<i>Aeronautics: Unmanned Aerial Systems, BS</i>	Liberty University currently has over 50 students that have declared the UAS program as their major and many more undeclared students that have mentioned UAS as a path of choice. They offer courses on UAS fundamentals, small UAS operations and medium UAS ground and flight courses which offer students the possibility of certification on the Aerosonde UAS with a partnership through Textron's UAS division. Liberty is growing their program to include courses that will teach students how to apply professional aviation concepts to UAS flights as well as provide them with the knowledge of the systems common to all types of UAS.	50-75

Mountain Empire Community College	<i>Electromechanical Technology Specialization, Industrial Electronics Specialization</i>	Mountain Empire Community College began offering the region's only college credit course in UAS technology in the fall of 2015. The class covers the "principles of building, programming, and flying UASs," and students receive "hands-on training in quadcopter design and construction as well as learn to fly both assisted and unassisted FPV (First Person View) quadcopters."	10-20
National Institute of Aerospace	<i>M.S. and Ph.D. degrees available from nine member universities</i>	NIA was formed by a consortium of leading research universities, including Hampton University, the University of Virginia, Virginia Tech, Old Dominion University, the College of William & Mary and the AIAA Foundation. NIA serves as a strategic partner with NASA Langley Research Center and the aerospace community to enable research creativity and expand technology development opportunities. The Institute integrates research and graduate education while creating new government/academia/industry partnerships.	n/a
New River Community College	<i>NRCC Engineering Design</i>	New River Community College students have worked in conjunction with many companies and universities on industry projects, including concept designs of UAV, UCAV, and UGVs. This year's concept design projects, which include three NRCC transfer engineering students on each team, are a fifth generation Unmanned Air Superiority Fighter and a modular tactical, reconnaissance, and crowd control UGV.	5-10
Old Dominion University	<i>Aerospace Engineering, Engineering, MS/ME; Aerospace Engineering, Engineering, Ph.D./D.Eng.; Electrical & Computer Engineering, Engineering, Ph.D.</i>	ODU's College of Engineering & Technology features the Unmanned Autonomous Systems and Robots (UAS) Cluster, a group of leading engineering researchers promoting research and developing curricula in unmanned systems, autonomy, and robotics. The Unmanned and Autonomous Vehicle Laboratory was created in Fall 2015 "to support ongoing work in ground and flight based unmanned and autonomous vehicle design. The laboratory provides a work space and tools for two major undergraduate competitions, SAE Aero Design East and AUVSI RoboBoat. In addition, the laboratory is used for design and support of air and surface vehicles used for graduate research projects." ODU also features an Unmanned Aerial Vehicle club, "currently geared toward the development of a fully autonomous aerial vehicle for International Competition" and is open to all majors and grade levels at the university.	80-100
Piedmont Virginia Community College		PVCC features an all-day introduction to UAS technology class covering "current local, state and federal regulations governing commercial and recreational use of UAVs, as well as what industries currently use them and what the future holds for other industries." Students are briefed on maintenance and safety requirements before an afternoon flight demonstration.	10-20
Thomas Nelson Community College	Mechanical Engineering Technology: Specialization in Marine Engineering, Mechanical Engineering Technology: Specialization in Mechanical Design, Computer-Aided Drafting and Design Technology, Electronics Technology: Specialization in Electrical Engineering Technology	In November 2015, TNCC Workforce Development hosted the Peninsula Entrepreneurship Forum, featuring keynote speakers from DividedSky. The company specializes in aerial emergency response, agriculture, mapping, and videography with small unmanned aerial systems. TNCC also hosted the Hover Games in August 2015 for middle and high school students, "a rodeo style competition that highlighted the work of four teams that had the opportunity to build, program, and fly quadcopters throughout the week... David North, Aerospace Engineer at NASA Langley Research Center volunteered throughout the week to introduce flying terms, and the basics of the aircraft to campers."	n/a
University of Virginia	Electrical Engineering (Graduate), Mechanical and Aerospace Engineering (Graduate), Aerospace Engineering (Undergrad), Electrical Engineering (Undergrad), Cyber Security Management (Certificate)	"U.Va.'s System-Aware Cybersecurity concept and Secure Sentinel technology was part of a research project led by U.Va. engineers to detect and respond to cyber attacks on unmanned aerial systems...U.Va. 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." U.Va. professor David Sheffler has also developed a 3D-printed, hand-launchable, fully autonomous UAV called The Razor in partnership with the Mitre Corporation, and the U.Va. Vision Group conducts theoretical and experimental research on computer vision, image processing, autonomous robotics, and planning. U.Va.'s School of Engineering has also launched a multi-million dollar initiative in "cyber-physical systems," which will include an international search for eight additional faculty members.	40-50



Virginia Commonwealth University	Mechanical Engineering, Computer and Information Systems Security	VCU's Department of Electrical and Computer Engineering conducts research in nanoelectronics, controls and communication, and computer engineering, with one of its nine laboratories specifically focused on Unmanned Aerial Vehicles. VCU students have participated in the Association for Unmanned Vehicle Systems (AUVSI) Foundation's Small Unmanned Systems Competition since 2003.	10-20
Virginia Military Institute	Aerospace Engineering Concentration, Mechanical Engineering Program, Electrical and Computer Engineering Program	VMI's Mechanical Engineering Department features the Cooperative Engineering Center, in which senior students are placed on teams and tasked with solving an engineering design problem submitted by local industrial clients. Students draft formal reports and present their findings to faculty and the client.	5-10
Virginia Space Grant Consortium	Umbrella organization, offers scholarships	The Virginia Space Grant Consortium (VSGC) is a coalition of five Virginia colleges and universities, NASA, state educational agencies, Virginia's Center for Innovative Technology, and other institutions representing diverse aerospace education and research. The VSGC acts as an umbrella organization, coordinating and developing aerospace-related and high technology educational and research efforts throughout the Commonwealth and connecting Virginia's effort to a national community of shared aerospace interests.	n/a
Virginia Tech	Aerospace and Ocean Engineering Program, Electrical and Computer Engineering Program, Materials Science and Engineering Program, Mechanical Engineering Program	Virginia Tech's College of Engineering houses the Virginia Center for Autonomous Systems (VaCAS), a research center facilitating interdisciplinary research in autonomous systems technology in water, land, air, and space. Its Kentland Experimental Aerial Systems (KEAS) Laboratory includes approximately 2000 sq ft of UAV hangar space and a 300 ft by 70 ft paved airstrip for small (R/C scale) aircraft. In August 2014, the FAA granted Virginia Tech authorization for its Mid-Atlantic Aviation Partnership's Unmanned Aircraft System test site program, headquartered within the school's Institute of Critical Technology and Applied Science. VT's Unmanned Systems lab also operates under the Mechanical Engineering Department, and has worked with sponsors such as Pacific Northwest National Labs (PNL), Savannah River National Labs (SRNL), the Defense Threat Reduction Agency (DTRA), the Air Force Research Lab (AFRL), and AAI corp.	100-200

VIRGINIA TECH HUME CENTER FOR NATIONAL SECURITY & TECHNOLOGY

CACI, an information solutions and services provider in support of national security missions, and Virginia Tech's Ted and Karyn Hume Center for National Security and Technology have an established and dynamic partnership that focuses on developing the next generation of technology leaders in cyber-physical system security with a focus on cyber security for unmanned aerial vehicles (UAV). The Hume Center at Virginia Tech is a leading research institution, sponsoring cutting-edge research into the biggest threats facing America's national security.

As part of the partnership CACI provides industry mentoring and research support for Virginia Tech undergraduate and graduate students, and helps to underwrite research and the Hume Center's CPSS Lab.

Working together, CACI and Hume Center academic experts and students develop curriculum, research initiatives, and support projects focused on cyber security threats to platforms, specifically including UAVs. Research projects concentrate on the cyber vulnerabilities of hobbyist UAVs and the security of the wireless link between the drone and the user.

As part of the research projects that are aimed at advancing technologies and developments for UAVs, the team is directly working on a government UAV-related contract, event-driven probabilistic anomaly detection for UAV security, and UAV physical security vulnerabilities remediation.

This partnership helps both organizations meet the pressing demand for highly trained, highly skilled national security professionals, with the potential of creating and filling these types of positions in the state of Virginia.



REaKTOR

The Peninsula Technology Incubator recently changed its name to the REaKTOR Business Technology Innovation Center (RBTIC), and is comprised of three primary programs focused exclusively on unmanned vehicle systems. Located in Hampton at the National Institute of Aerospace, REaKTOR was most recently awarded the Donna Nobel Business Incubation Client Award from the Virginia Business Incubation Association in recognition of exemplary advocacy and innovation.

The anchor program is the REaKTOR Unmanned Systems Accelerator (RUMSA)—a non-profit, mentor-driven startup accelerator program tailored specifically for companies creating products and services in the unmanned systems (UMS) industry. RUMSA provides an intense 4-month program to connect founders with experienced mentors, investors, support services, working space and lean startup education to move from idea to viable high growth venture. REaKTOR guides them through the early stages of technology startup and help them grow their startup—whether through capital raises, bootstraps, or crowd funding. Services are delivered based on a “technology pull” approach believing that real customer needs validate companies' business approach and help them validate their business model and value.

If companies aren't quite ready to launch, REaKTOR has a number of resources to help them pre-accelerate their startup—primarily REaKTOR's second program—the REaKTOR pre-acceleration workshops offered twice per year. These workshops are based on the Strategyzer's best-selling books, Business Model Generation (utilizing the Business Model Canvas) and Value Proposition Design. The workshops are scheduled during a 4-week span between cohort cycles and consist of basic business model canvas development and business validation, as well as basics of accounting, legal, intellectual property, marketing, and sales.

The third program is the REaKTOR Landing Zone—an office and co-working space with business support services (copies, Wi-Fi, conference room, mail room etc.) that provide cost-effective space for growing companies to flourish. The offices are on the third floor of the 1100 Exploration Way Building in Hampton (the former location of PTI). The intent is to provide these spaces to cohort graduates that intend to continue the growth of their companies and thrive in an energetic positive and empowering environment. The Landing Zone office spaces and services are available to other Hampton-based businesses seeking co-working space and a collision-collaboration environment.

State Investment

Beyond simply pledging support and being engaged at all levels of this new ecosystem of innovation, Commonwealth leadership has followed through with the very performance-based incentives that help promote strong business and keep them competitive across the globe. These incentives range dramatically from local, state, and federal government relationship building to tax credits and tax exemptions that ensure continued investment in Virginia's future. Being recognized as one of the most pro-business states in the nation is no easy task, however the on-going dedication to providing long-term and real investment in business is a paramount focus, especially in the UMS industry. This focus allows the Commonwealth with new and expanding powers who demonstrate a willingness to invest in those who invest in Virginia, create a high standard of living for all Virginians, and enhance local and state economies through a healthy economy.

With the Commonwealth of Virginia taking a leadership role in UMS industry, and that industry gaining support, investment, and interest internationally, it is important to recognize Virginia's successful approach and vision moving forward. Between 2011 and 2015, Virginia saw \$5.3 billion of international investment from 29 countries.³⁹ The top foreign nations investing in Virginia were China with \$2 billion, Germany with \$650 million, Japan with \$577 million, and the UK with \$406 million. As Chinese company DJI is the clear leader in consumer and the newly developing prosumer grade UAS models, with an estimated 60%-80% of all commercial operations including the DJI line of drones and the first \$1 billion drone company in the world, it is important for UMS fields to operate with a global mindset.⁴⁰ While it is the goal of all Virginian industries to support homegrown manufacturing and engineering—in fact there exists incentives to purchase and use Virginian made technology—foreign investment plays a crucial role in these developing, interrelated economies.

The Commonwealth Research Commercialization Fund and the Center for Innovative Technologies (CIT) are both key players in promoting homegrown innovation for any investment opportunities. The CIT, developed as a flagship for the new Virginian economic development planning, thrives in recognizing that the availability of early-stage capital is a critical need of many emerging technology companies and making connection with

private, public, and international funding is a difficult step in the start-up lifecycle.⁴¹ The CIT portfolio of GAP funds also provides specific industry participants with funding. CIT GAP Funds is a family of seed- and early-stage investment funds placing near-equity and equity investments in Virginia-based technology, life science, and clean tech companies. CIT GAP Funds invests in companies with a high potential for achieving rapid growth and generating significant economic return for entrepreneurs, co-investors and the Commonwealth.

CIT has created for any early-stage start-up the Commonwealth Innovation and Entrepreneurship Measurement Systems (IEMS), a web-based portal using key metrics to track the performance of Virginia's innovation economy, allowing angel investors and private equity firms and other stakeholders a unique insight into the life-cycles and stages of start-up companies in Virginia along with opportunities to get involved very easily. This reduces the hurdles of engagement for investment for companies and investors alike.⁴²

Small businesses are rewarded significantly by beginning their journey in Virginia. The Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program offer similar incentives for small business that partner with nonprofit U.S. research institutions. Virginia-based firms, because of the local and supported access to nonprofit organizations such as universities, military and non-military government groups, and R&D laboratories received a total of \$106.3 million in SBIR/SBTT funds in 2015, the third highest amount of any U.S. state and well above the average when adjusting for state size.⁴³

By focusing on all levels of a company's life cycle, Virginia provides the perfect environment to start, grow, and commercialize any UMS related firm. By taking advantage of the unique characteristics and government support provided in Virginia, companies make a smart decision for their future. New Virginian companies can be supported by several unique incentives geared toward enabling technologies in sub-markets. While this has created a friendly environment for all business development within the state for new or expanding firms, there are number of UMS technology focused programs of which to be aware.

INCENTIVES

New Virginia companies can be supported by a number of unique incentives geared toward enabling technologies in sub-markets. While this has created a friendly environment for all business development within the state for new or expanding firms, there are number of UMS technology focused programs of which to be aware.

Commonwealth's Opportunity Fund

The Commonwealth's Opportunity Fund (COF) is a discretionary incentive available to secure a business location or expansion project for Virginia. Grants are awarded to localities on a local matching basis with the expectation that the grant will result in a favorable location decision for the Commonwealth.

General Eligibility Thresholds:

- 50 new jobs / \$5 million capital investment; or
- 25 new jobs / \$100 million capital investment

The average annual wage for the new jobs must be at least equal to the prevailing average annual wage in the locality, excluding fringe benefits.

If the average annual wage is twice the prevailing average annual wage, the Governor may reduce the new jobs threshold to as low as 25.

<http://www.yesvirginia.org/ProBusiness/BusinessIncentives>

Virginia Investment Partnership Act/Major Eligible Employer Grant

The Virginia Investment Partnership (VIP) Grant and the Major Eligible Employer (MEE) Grant are designed to encourage continued capital investment by Virginia companies. This is intended to add capacity, modernize, and increase productivity, creation, development, and utilization of advanced technology. UMS technologies are specifically being targeted for this type of investment.

To be eligible for a VIP grant, a minimum of \$25 million in capital investment is required by an eligible existing Virginia manufacturer or research and development service.

<http://www.virginiaallies.org/assets/files/incentives/VIPGuidelines.pdf>

The Virginia Economic Development Incentive Grant

The Virginia Economic Development Incentive Grant (VEDIG) is designed to assist and encourage companies to invest and create new employment opportunities by locating significant headquarters, administrative, or service sector operations in Virginia.

The VEDIG program has two separate eligibility requirements. Companies located in a Metropolitan Statistical Area with a population of 300,000 or more in the most recently preceding decennial census, must: (A) create or cause to be created and maintained (i) at least 400 jobs with average salaries at least 50% greater than the prevailing average wage, or (ii) at least 300 jobs with average salaries at least 100% greater than the prevailing average wage; and (B) make a capital investment of at least \$5 million or \$6,500 per job, whichever is greater. For all companies located elsewhere in Virginia, the company must create or cause to be created and maintained at least 200 jobs with average salaries at least 50% greater than the prevailing average wage, and make a capital investment of at least \$6,500 per job.

<http://www.virginiaallies.org/assets/files/incentives/VEDIGGuidelines.pdf>

Governor's Agriculture and Forestry Industries Development Fund

One of the most important incentive programs for UMS technologies focuses on agriculture as an industry best positioned for development. AFID grants are made at the discretion of the governor awarded to a political subdivision that will result in a new or expanded processing/value-added facility for Virginia grown agricultural or forestry products, and with the expectation that the grant will be critical to the success of the project.

AFID grants are made at the discretion of the Governor with the expectation that grants awarded to a political subdivision will result in a new or expanded processing/value-added facility for Virginia grown agricultural or forestal products

Grants are made upon an application by both the locality and the business beneficiary for a project under the following conditions:

- The business beneficiary is a facility that produces "Value-added agricultural or forestal products"
- A minimum of 30% of the agricultural or forestry products to which the facility is adding value are produced within the Commonwealth of Virginia on an annual basis in normal production years
- The grant request does not exceed \$250,000 or 25% of qualified capital expenditures (whichever is less)
- The applicant provides a dollar-for-dollar matching financial commitment (cash or qualified in-kind)
- A performance agreement is executed between the applicant and the company to ensure fulfillment of promised job creation, capital investment and purchase of Virginia grown agricultural or forestry products
- Public announcement of the project is coordinated with the Governor's Office

<http://www.vdacs.virginia.gov/agribusiness/afid.shtml>

Tobacco Region Opportunity Fund

Tobacco producing regions assist with specific projects that result in the creation of new jobs and investment. Grants are made to the community at the discretion of the Tobacco Region Revitalization Commission. The goal of the Fund is to attract competitive projects expected to have a regional impact due to the magnitude of new employment and investment, and the possibility of follow-on industry.

- Evaluation of award amount is consistent throughout the region and is based on the following criteria: local unemployment rates, prevailing wage rates, number of new jobs, capital investment levels, industry type and the possibility of related economic multiplier effect
- TROF is the only Tobacco Commission grant program paid at the beginning of the project to help tobacco region localities be competitive in attracting new investment and jobs resulting in increased tax revenue and opportunity for quality employment in the tobacco region
- Intended to support the goal of the Commission to "revitalize the economies of tobacco dependent regions and communities." This goal is measured by job creation, workforce participation rate, wealth, diversity of economy, and taxable assets. All measurements listed are increased when a new or expanding business in the tobacco region creates new jobs that pay more than prevailing wage and adds taxable assets to the local tax rolls.

<http://www.tic.virginia.gov/tobregionoppfund.shtml>

Port of Virginia Economic and Infrastructure Development Grant Program

UUV and UAS focused companies should look to The Port of Virginia Economic and Infrastructure Development Grant Program (POV Grant), as it provides a grant to Qualified Companies to incentivize them to locate new maritime-related employment centers or expand existing centers in specified localities in order to encourage and facilitate the growth of the Port of Virginia.

POV Zone Grants are made at the discretion of the Executive Director of the Virginia Port Authority (VPA) with the expectation that grants awarded will be used to assist a Qualified Company to locate a new operation or expand an existing operation within the Commonwealth of Virginia

Subject to appropriation, a POV Grant is available from January 1, 2014 until June 30, 2020. The maximum amount of grant allowable per Qualified Company is \$500,000 and the maximum amount of POV Grants allowable among all Qualified Companies in any given fiscal year is \$5 million. For Fiscal Year 2015, the maximum amount of POV Grants allowable among all Qualified Companies is \$2 million

<http://www.portofvirginia.com/stewardship/economic-development/ed-infrastructure-grant-program/>

CENTER FOR INNOVATIVE TECHNOLOGY INCENTIVES

Commonwealth Research Commercialization Fund

The Commonwealth Research Commercialization Fund (CRCF) accelerates innovation and economic growth in Virginia by advancing solutions to important state, national, and international problems through technology research, development, and commercialization. UMS has been identified as a critical field of study.

Proposals submitted to CRCF undergo a multi-stage review process, which includes award recommendations made by the Research and Technology Investment Advisory Committee (RTIAC) to the CIT Board of Directors and culminates with award decisions made by the Board. CRCF awards contribute to the Commonwealth's overall plan to enhance economic development through technology research and commercialization and, as such, CRCF awards must further the goals set forth in the Commonwealth Research and Technology Strategic Roadmap. In addition to identifying research areas worthy of economic development and institutional focus, the Roadmap provides a framework for aligning key industry sectors within the state, as prioritized by the research community, which includes but is not limited to the private sector, academia, and economic development professionals

<http://www.cit.org/initiatives/crcf/>

GAP Tech Fund

CIT GAP Tech Fund makes seed-stage equity investments in Virginia-based technology companies with a high potential for achieving rapid growth and generating significant economic return.

CIT GAP Funds invests exclusively in companies headquartered, and with an express desire to grow in, the Commonwealth of Virginia.

Sectors (includes UMS)

- Software, Telecommunications
- Semiconductors
- Security
- Information and Communication Technologies
- E-Commerce
- Networking and Equipment
- Electronics/Instrumentation
- Computers and Peripherals
- Sensors
- Materials

<http://www.cit.org/services/gap-tech-fund/>

GAP Venture Funds

CIT GAP Funds is a family of seed- and early-stage investment funds placing near-equity and equity investments in Virginia-based technology, life science, and clean tech companies. CIT GAP Funds invests in companies with a high potential for achieving rapid growth and generating significant economic return for entrepreneurs, co-investors and the Commonwealth of Virginia.

CIT's family of funds includes:

- GAP Fund I – A vintage 2004 fund fully invested in a broad array of seed-stage technology companies
- GAP BioLife Fund – A seed fund investing exclusively in life science companies
- GAP Tech Fund – A seed fund investing in IT and technology companies
- Commonwealth Energy Fund (CEF), a seed fund investing in energy efficiency and renewable energy companies

<http://www.cit.org/service-lines/cit-gap-funds/>

TAX CREDITS

Enterprise Zone Tax Credit

Provides state and local incentives to businesses that invest and create jobs within Virginia's enterprise zones, which are located throughout the state.

<http://www.tax.virginia.gov/content/tax-credits#enterprise>

Major Business Facility Job Tax Credit

Qualified companies locating or expanding in Virginia receive a \$1,000 income tax credit for each new full-time job created over a threshold number of jobs.

- Companies locating in Enterprise Zones or economically distressed areas are required to meet a 25-job threshold; all other locations have a 50-job threshold. The threshold number of jobs must be created within a 12-month period.
- The \$1,000 credit is available for all qualifying jobs in excess of the threshold and is taken in equal installments over two years (\$500 per year) through 2014. Credits earned after 2014 will be taken in equal installments over three years.
- Non-qualifying jobs include seasonal positions shifted within Virginia, building and grounds maintenance, security, and other positions ancillary to the principal activities of the facility.
- Credits are available for taxable years before January 1, 2020. Unused credits may be carried over for up to 10 years.

http://www.tax.virginia.gov/content/tax-credits#Major_Business_Facility_Job_Credit

Qualified Equity And Subordinated Debt Investments Credit

The Qualified Equity and Subordinated Debt Investments Tax Credit offers angel investors a 50% tax credit for pre-qualified small business ventures involved in technology fields. The state also offers individual and corporate income tax subtractions for long-term capital gains attributable to qualified investments in early stage technology, biotechnology, and energy start-ups, technology, nanotechnology, or any similar technology-related field, which includes UMS.

The credit is equal to 50% of the qualified business investments made during the taxable year. If total annual requests for the credit exceed \$5 million for tax year 2015, the Department of Taxation will prorate the credit for each taxpayer

The credit a taxpayer may claim per taxable year may not exceed the credit authorized by the Department of Taxation, \$50,000, or the income tax liability on that year's return, whichever is less. The credit is nonrefundable. Unused credits may be carried forward up to 15 years

http://www.tax.virginia.gov/content/tax-credits#Qualified_Equity_And_Subordinated_Debt_Investments_Credit

Telework Expenses Tax Credit

Allows a tax credit to employers for eligible expenses incurred for allowing employees to telework pursuant to a signed telework agreement for taxable years beginning on or after January 1, 2012, but before January 1, 2017. An employer may be eligible for a credit of up to \$1,200 per teleworking employee and/or a maximum of \$20,000 for conducting a telework assessment.

The amount of credit shall not exceed \$50,000 per employer for each calendar year. The telework assessment can only be allowed once. The aggregate amount of tax credits that will be issued is capped at \$1 million annually. An employer shall be ineligible for a tax credit pursuant to this section if such employer claims a credit based on the jobs, wages, or other expenses for the same employee under any other provision of this chapter. Additionally employers are not allowed to deduct expenses that are deducted for federal purposes.

<http://www.tax.virginia.gov/content/tax-credits#TeleworkExpensesTaxCredit>

Worker Retraining Tax Credit

This credit allows an employer to claim a tax credit for the training costs of providing eligible worker retraining to qualified employees for taxable years beginning on or after January 1, 1999.

The credit may be applied against individual income tax, estate and trust tax, corporate income tax, bank franchise tax, and taxes imposed on insurance companies and utility companies.

Eligible Worker Retraining

Eligible worker retraining includes noncredit courses that are approved by the Virginia Economic Development Partnership. For information on noncredit course approval, call (804) 545-5706. It also includes credit or non-credit retraining courses undertaken through an apprenticeship agreement approved by the Commissioner of Labor and Industry.

How Much is the Credit?

Virginia employers will be eligible to receive an income tax credit equal to 30% of all expenditures made by the employer for eligible worker retraining. If the eligible worker retraining consists of courses at a private school, the credit is equal to the cost per qualified employee, up to \$200 per qualified employee annually, or \$300 per qualified employee annually if the eligible worker retraining includes retraining in a STEM or STEAM discipline.

Credits taken may not exceed your tax liability in any one taxable year. Unused credits may be carried forward for three years.

http://www.tax.virginia.gov/content/tax-credits#WorkerRetraining_Credit

Agricultural Best Management Practices Credit

This credit is available to individuals and corporations that are engaged in agricultural production for market and have a soil conservation plan in place to provide significant improvement to water quality in Virginia's streams, rivers, and bays. To be eligible for the credit, your plan must be certified in advance by your local Soil and Water Conservation District.

The credit is 25% of the first \$70,000 you spend for approved agricultural best management programs. The maximum credit is \$17,500 or the taxpayers' tax liability, whichever is less. Unused credits may be carried forward for five years

<http://www.tax.virginia.gov/content/tax-credits#agricultural>

Research and Development Tax Credit

Businesses may claim a tax credit equal to 15% of the first \$234,000 in Virginia qualified research and development expenses incurred during the taxable year or they may claim a tax credit equal to 20% of the first \$234,000 in Virginia qualified research and development expenses if the qualified research was conducted in conjunction with a Virginia college or university.

<http://www.tax.virginia.gov/content/tax-credits#ResearchandDevelopmentTaxCredit>

- There is a \$6 million cap on the total amount of credits allowed in any fiscal year

Fertilizer and Pesticide Application Equipment Credit

Individuals and corporations may claim this credit for equipment purchased to provide more precise pesticide application. You must be engaged in agricultural production for market and have a nutrient management plan approved by your local Soil and Water Conservation District in place.

The credit is 25% of the cost of the certified equipment, or \$3,750, whichever is less. The allowable credit may not exceed your tax liability. Unused credits may be carried forward for five years

<http://www.tax.virginia.gov/content/tax-credits#fertilizer>

Credit for Tax Paid to Another State

The Code of Virginia makes out-of-state tax credit provisions for income that is taxed by more than one state. The credit is restricted to certain types of income. The intent of the law is to address double taxation when income is generated in more than one state; however, the credit does not eliminate double taxation in all cases. For example, taxes paid to another state on non-qualifying income would not be subject to the credit provisions.

Generally, Virginia will allow taxpayers filing resident individual income tax returns to claim credit for income tax paid to another state on qualifying income derived from sources outside of Virginia, provided the income is taxed by Virginia as well as the other state. If the income is from one or more of the following states, you should claim the credit on the nonresident income tax return of the other state instead of the Virginia return: Arizona; California; District of Columbia; Oregon

[credits#Credit_for_Tax_Paid_to_Another_State](#)

Recycling Equipment Tax Credit

An income tax credit is available to manufacturers for the purchase of certified machinery and equipment used for processing recyclable materials in taxable years. The credit is equal to 20% of the purchase price paid during the taxable year for the machinery and equipment.

Green Job Creation Tax Credit

A “green job” means employment in industries relating to the field of renewable, alternative energies, including the manufacture and operation of products used to generate electricity and other forms of energy from alternative sources that include hydrogen and fuel cell technology, landfill gas, geothermal heating systems, solar heating systems, hydropower systems, wind systems, and biomass and biofuel systems.

PROGRAMS

SSBCI Virginia Capital Access Program

This program provides loan loss insurance to a bank to cover a portfolio of enrolled loans. It is designed to be a quick, efficient means of obtaining a credit enhancement from the VSBFA. Under most circumstances, the bank determines whether a loan will be enrolled in the program without VSBFA's involvement.

<http://www.vabankers.org/ssbci-virginia-capital-access-program>

The Program is designed to assist financial institutions in making small business loans by mitigating some of the risk associated with the loan. The Program offers lenders a flexible, non-bureaucratic tool to expand their market base and enhance their ability to meet the financing needs of Virginia's businesses

Small Business Microloan Program

This is a direct loan from the VSBFA to the business client that does not require a bank's participation in the transaction. It is an ideal tool for bankers who are faced with business loan requests for very small amounts where the bank would prefer to refer the client to an alternative source of funds.

The Virginia Small Business Financing Authority (VSBFA) is the Commonwealth of Virginia's economic development and business financing arm. We help banks make loans to businesses that can demonstrate repayment ability, but where the bank needs additional collateral support or a more robust secondary repayment source by providing:

- Cash collateral
- Subordinate companion loans
- Guaranties
- Loan loss reserves

<http://www.vabankers.org/VSBFA>

Environmental Compliance Assistance Fund

This is a direct loan from the VSBFA to a business that seeks to finance equipment that will have less impact on the environment or the business is seeking to implement voluntary agricultural best management practices (BMPs). This is extremely useful for drone technologies focused in agricultural industries.

The Virginia Small Business Environmental Compliance Assistance Fund (ECAAF) provides Virginia businesses with financing for 1) equipment to comply with the federal Clean Air Act, 2) equipment to implement voluntary pollution prevention measures, or 3) equipment or structures to implement voluntary agricultural best management practices (BMPs)

<http://www.vabankers.org/environmental-compliance-assistance-fund>

Economic Development Access Program

Administered by the Virginia Department of Transportation, this program assists localities in providing adequate road access to new and expanding basic employers.

These funds may be used for financing the construction or improvement of secondary or local system roads within all counties and cities, and certain towns that are part of the Urban System, hereinafter referred to as eligible localities. Ancillary improvements, such as turn lanes or intersection modifications may also be warranted as part of the access project, but are not to be considered as the primary objective of the project

http://www.virginiadot.org/business/resources/local_assistance/access_programs/Economic_Development_Access_Program_Guide.pdf

Rail Industrial Access Program

Provides funds to construct railroad tracks to new or substantially expanded industrial and commercial projects.

The Rail Industrial Access Program promotes truck diversion by providing grant assistance to connect new or expanding businesses to the freight railroad network. The program supports localities, businesses, or industries seeking access to a common carrier railroad. Applications are accepted throughout the year

<http://www.drpt.virginia.gov/grantees/rail-grants/>

Transportation Partnership Opportunity Fund

TPOF is a discretionary grant available for transportation-related issues related to unique economic development projects.

The financial assistance may be used for transportation capacity development, on and off site; road, rail, mass transit or other transportation access costs beyond the funding capability of existing programs; studies of transportation projects including, but not limited to environment analysis, geotechnical assessment, survey, design and engineering, advance right-of-way acquisition, traffic analysis, toll sensitivity studies, financial analysis, or any other transportation development activity permitted by law. Transportation aspects of economic development projects that are also eligible for funding through the Revenue Sharing Program, the Industrial Road Access Program, the Industrial Rail Access Program, the Rail Preservation Program or the Rail Enhancement Program, may be eligible to receive financial assistance from the Fund. However, it must be demonstrated that such additional funding is necessary. Amounts received from these other funding sources, or used to leverage additional monies from the Fund, may not also be used for the required non-state match

<http://www.virginiaallies.org/assets/files/incentives/TPOFOverview.pdf>

ZONES

Enterprise Zones

The Virginia Enterprise Zone (VEZ) program is a partnership between state and local government that encourages job creation and private investment. VEZ accomplishes this by designating Enterprise Zones throughout the state and providing two grant-based incentives, the Job Creation Grant (JCG) and the Real Property Investment Grant (RPIG), to qualified investors and job creators within those zones, while the locality provides local incentives.

Provides state and local incentives to businesses that invest in and create jobs within Virginia's enterprise zones, which are located throughout the state.

<http://www.dhcd.virginia.gov/index.php/community-partnerships-dhcd/downtown-revitalization/enterprise-zone.html>

Technology Zones

Virginia authorizes its communities to establish technology zones to encourage growth in targeted industries. Presently, 30 cities and counties and 6 towns have created zones throughout the state. Qualified businesses locating or expanding operations in a zone may receive local permit and user fee waivers, local tax incentives, special zoning treatment, or exemption from ordinances. Once a local technology zone has been established, incentives may be provided for up to 10 years.

Localities that have established technology zones include the counties of Amherst, Arlington, Bedford, Caroline, Chesterfield, Culpeper, Fauquier, Frederick, Halifax, Henry, Page, Roanoke, Rockingham, Russell, Smyth, Spotsylvania, Stafford and Warren; the cities of Buena Vista, Charlottesville, Chesapeake, Falls Church, Franklin, Fredericksburg, Harrisonburg, Lynchburg, Manassas, Manassas Park, Newport News, Poquoson, Suffolk and Winchester; and the towns of Ashland in Hanover County, Bridgewater in Rockingham County; Cape Charles in Northampton County, Front Royal in Warren County, Kilmarnock in Lancaster County, Marion in Smyth County and Wytheville in Wythe County

<http://www.virginiaallies.org/assets/files/incentives/techzonewriteup.pdf>

Foreign Trade Zones

Foreign Trade Zones (FTZ) are areas which are geographically inside the United States, but are legally considered outside its Customs territory. Companies that locate in FTZs can benefit by using special procedures to encourage U.S. activity by reducing, eliminating, or delaying duties.

Virginia offers six foreign trade zones designed to encourage businesses to participate in international trade by effectively eliminating or reducing customs duties. Also, numerous subzones are provided and additional ones can be designated to enhance the trade capabilities of specific companies and technologies such as UMS.

<http://www.yesvirginia.org/ProBusiness/BusinessIncentives>

Defense Production Zones

Virginia's cities, counties, and towns have the ability to establish, by ordinance, one or more defense production zones to attract growth in targeted industries. Establishment of a defense production zone allows localities to create special incentives and certain regulatory flexibility for qualified businesses locating or expanding operations in a zone. These incentives may include: a reduction of user and permit fees, special zoning treatment, exemption from local ordinances or other incentives adopted by ordinance. Virginia authorizes its communities to establish local defense production zones to benefit businesses engaged in the design, development, or production of materials, components, or equipment required to meet the needs of national defense. Companies deemed ancillary to or in support of the aforementioned categories would also apply.

Once a defense production zone has been established, incentives may be provided for up to 20 years. Each locality designs and administers its own program. The establishment of a defense production zone shall not preclude the area from also being designated as an enterprise zone. Two localities currently have an established Defense Production Zone: Fauquier County and the City of Manassas Park. Henrico County will create individual defense production zones based around individual projects on a case by case basis.

Virginia authorizes its communities to establish local defense production zones to benefit businesses engaged in the design, development, or production of materials, components, or equipment required to meet the needs of national defense. Companies deemed ancillary to or in support of the categories would also apply.

http://www.vaallies.org/assets/files/incentives/defense_production_zoneswriteup.pdf



Enterprise Zone Job Creation Grant

Job Creation Grants are based on net new permanent full-time job creation exceeding a four-job threshold. Positions over the four-job threshold must meet wage and health benefits requirements to be eligible for the JCG. Firms can receive grants for up to 350 positions per year.

The Virginia Enterprise Zone (VEZ) program is a partnership between state and local government that encourages job creation and private investment. VEZ accomplishes this by designating Enterprise Zones throughout the state and providing two grant-based incentives, the Job Creation Grant (JCG) and the Real Property Investment Grant (RPIG), to qualified investors and job creators within those zones, while the locality provides local incentives.

The business firm must be located in a Virginia Enterprise Zone.

- The business firm must create at least four net new permanent full-time positions over the base calendar year
- The net new permanent full-time positions created over the four-job threshold must meet wage (at least 175% of the Federal Minimum Wage 150% in High Unemployment Areas) and health benefits requirement (at least 50% of employee's premium paid for by employer).
- Term Grants are available for a five-consecutive-year qualification period
- To be eligible for the JCG in years two through five of the grant cycle, a business firm must maintain or increase the number of eligible permanent full-time positions (above the four-job threshold) over base year employment. Base year employment levels are established during the first grant year and will remain consistent throughout the 5-year grant period
- Firms can continue to receive grants for any net new permanent full-time positions created over base year employment levels that meet wage and health benefits requirements
- Firms may apply for a subsequent five-year period given they meet the grant eligibility requirements. Grant Year 2011 was the first year firms were eligible to begin subsequent five-year periods

<http://www.dhcd.virginia.gov/images/VEZ/JCG-Instruction-Manual.pdf>

Enterprise Zone Real Property Investment Grant

Real Property Investment Grants are available for investments made to industrial, commercial, or mixed-use properties located within the boundaries of Enterprise Zones. Grants are available to qualified zone investors in amounts up to 20% of the qualified real property investment, not to exceed \$200,000 per building or facility within a five-year period.

The property (building or facility) must be located within the boundaries of a Virginia Enterprise Zone

- The building or facility must be commercial, industrial, or mixed-use. Mixed-use is defined as a building incorporating residential uses in which a minimum of 30% of the usable floor space is devoted to commercial, office, or industrial use
- For the rehabilitation or expansion of an existing structure, the zone investor must spend at least \$100,000 in qualified real property investments to be eligible
- For new construction projects, the zone investor must spend at least \$500,000 in qualified real property investments to be eligible
- Term Grants may not exceed \$200,000 per building or facility in a five-consecutive-year period. Five-year periods being with the qualification year in which a grant was first awarded
- After the conclusion of a five-consecutive-year period, the property begins another eligibility period and the grant cap of \$200,000 is restored

<http://www.dhcd.virginia.gov/images/VEZ/RPIG-Instruction-Manual.pdf>

The Virginia Economic Development Incentive Grant

The Virginia Economic Development Incentive Grant (VEDIG) is designed to assist and encourage companies to invest and create new employment opportunities by locating significant headquarters, administrative, or service sector operations in Virginia.

The VEDIG program has two separate eligibility requirements. Companies located in a Metropolitan Statistical Area with a population of 300,000 or more in the most recently preceding decennial census, must: (A) create or cause to be created and maintained (i) at least 400 jobs with average salaries at least 50% greater than the prevailing average wage, or (ii) at least 300 jobs with average salaries at least 100% greater than the prevailing average wage; and (B) make a capital investment of at least \$5 million or \$6,500 per job, whichever is greater. For all companies located elsewhere in Virginia, the company must create or cause to be created and maintained at least 200 jobs with average salaries at least 50% greater than the prevailing average wage, and make a capital investment of at least \$6,500 per job.

[http://www.virginiaallies.org/assets/files/incentives/VEDIG Guidelines.pdf](http://www.virginiaallies.org/assets/files/incentives/VEDIG%20Guidelines.pdf)

Commonwealth Development Opportunity Fund

The Commonwealth's Opportunity Fund (COF), formerly known as the Governor's Opportunity Fund (GOF), is a discretionary incentive available to the governor to secure a business location or expansion project for Virginia. Grants are awarded to localities on a local matching basis with the expectation that the grant will result in a favorable location decision for the Commonwealth.





FOR FURTHER INFORMATION PLEASE SEE **VUS.VIRGINIA.GOV**
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