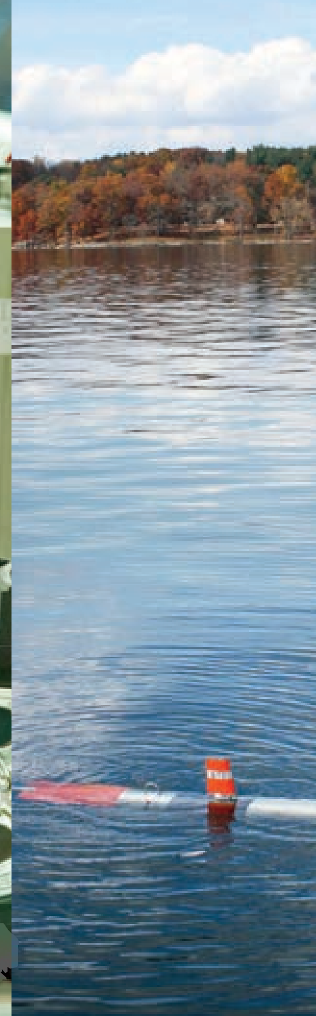
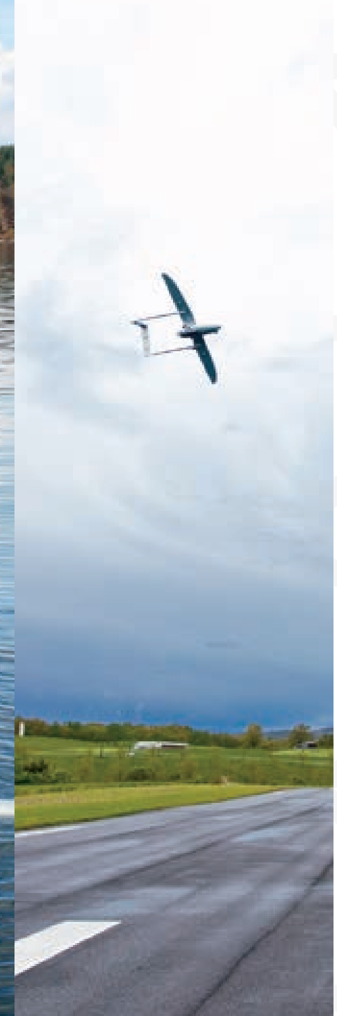


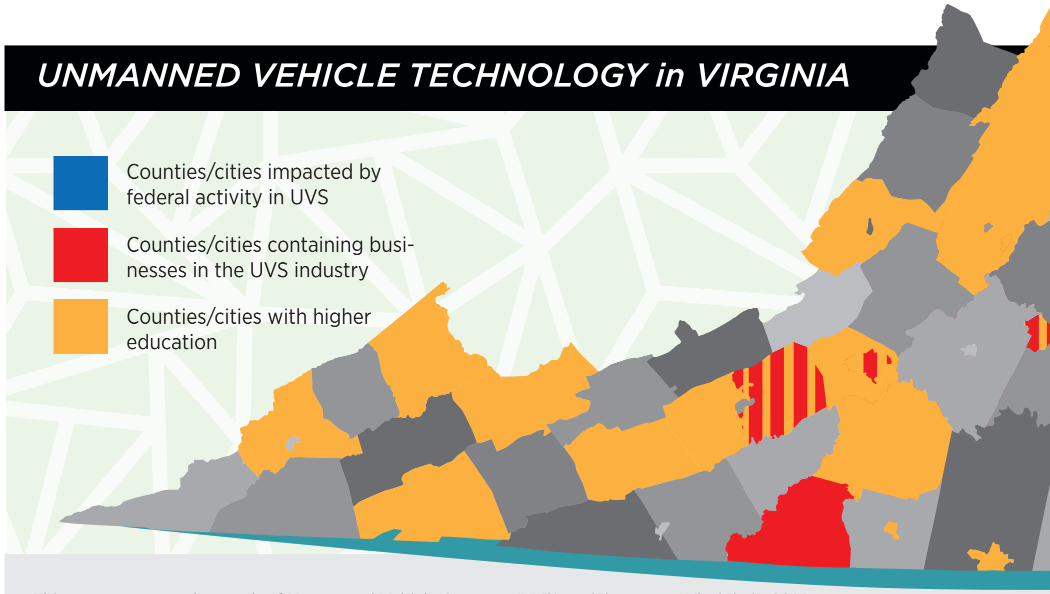


The future *of* UNMANNED VEHICLE SYSTEMS *in* Virginia

2014

EXECUTIVE SUMMARY

Virginia has the opportunity and the capability to be a national leader in the development, manufacture, and creative use of autonomous vehicles. Economic development in this area could yield thousands of high-paying, high-technology jobs in communities throughout the Commonwealth. Autonomous vehicles include intelligent cars, self-guiding tractors, water surface and underwater vehicles, and unmanned aircraft. Policies established by Virginia leaders will determine if and how the Commonwealth will leverage its substantial strength in this emerging technology. This study provides an overview of the issues and opportunities concerning autonomous vehicles in order to support informed decisions about the future of autonomous vehicles in the Commonwealth.



This map suggests the reach of Unmanned Vehicle Systems (UVS) activity across Virginia in 2013. As the technologies are commercialized, the impact will reach into every community of Virginia.

As a national leader in technology, Virginia is positioned to help define the blossoming unmanned vehicle systems (UVS) industry, generating high paying, high-tech jobs for the Commonwealth's communities in the process. The Commonwealth has been cited as one of the top 10 states that could see economic benefit from expanded use of autonomous vehicles.

FROM LEFT: NASA Langley AirSTAR testbed and Mobile Operations Station, a Virginia Tech autonomous underwater vehicle (AUV) being tested at Claytor Lake, the US Army's Rapid Equipping Force Investigates a Broad Range of Unmanned Systems

Economic Impact

The Federal Aviation Administration (FAA) is selecting six test sites to address public concerns about the civil and commercial use of Unmanned Aerial Systems (UAS). Virginia partnered with New Jersey to submit a proposal. According to a study by the state of Utah, the economic impact of selection is estimated to bring 23,000 new jobs, adding $12 billion in wages, $720 million in tax revenues, and an overall $23 billion in total economic impact over 10 years. The FAA will be examining the regulatory environment in making its selections.

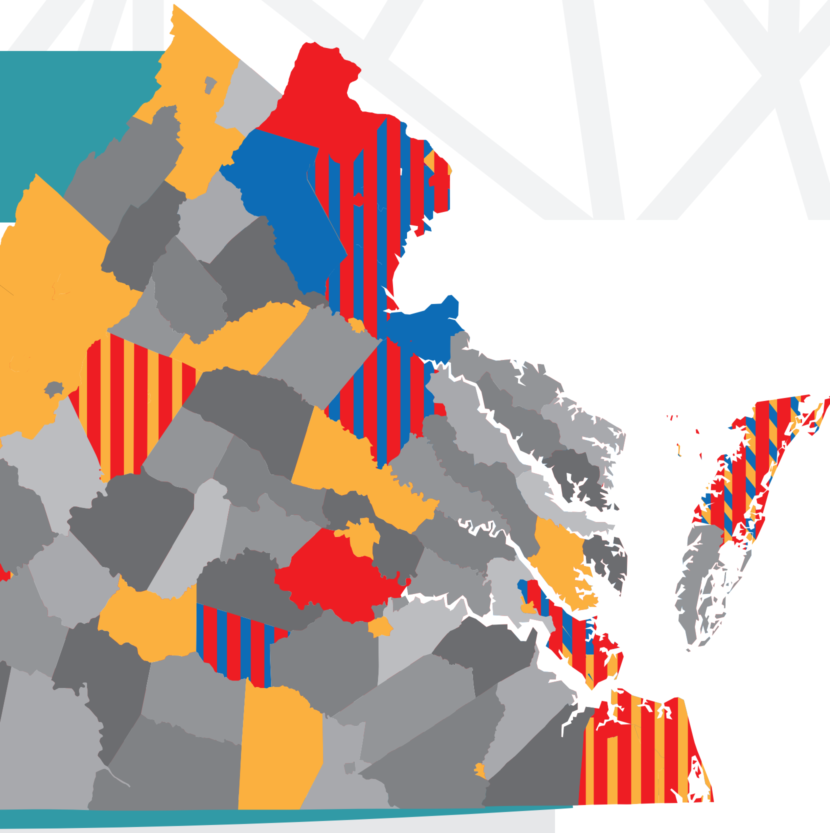
Even if not selected as a test site, Virginia still stands to benefit from the commercial and civil use of the technology. The Virginia/New Jersey partnership will continue regardless of selection, with an agreement to work with Maryland as well. The Association of Unmanned Vehicles Systems International (AUVSI) estimates that Virginia is poised to gain more than 3,500 new jobs and a total economic impact of more than $2.7 billion by 2025. Virginia's commercial stakeholders in unmanned systems include a wide range of commercial agents—from large-scale manufacturers to small research and development firms and service providers.

Benefits to Virginia

The immediate potential uses of unmanned aircraft include wildfire mapping (firefighters call them "lifesavers") and disaster response. Farmers can benefit by scanning fields for disease, recording growth and hydration rates, and developing more efficient spraying techniques that reduce both costs and pesticide use. Oil, gas, and electricity producers can monitor infrastructure with reduced costs and emissions.

Potential uses of unmanned ground and maritime vehicles are equally appealing. Self-driving cars can improve safety and capacity of our roads while saving hours each year for millions of commuters. Self-driving farm equipment is already being commercialized for row-crop harvesting and autonomous dump trucks are available for mining operations. Unmanned maritime vehicles (both underwater and surface vehicles) could transform cargo transport, water safety, and fishery management.

In addition to Virginia's commercial stakeholders, academic stakeholders include university researchers who are inventing new technology and university educators who are developing the workforce to sustain and lead the industry.



And a third stakeholder group, uniquely well-represented in Virginia, includes the variety of federal organizations such as NASA and the Department of Defense that have a direct interest in the development and deployment of unmanned systems.

The Importance of Balanced Policy

As we move into an era of unmanned aircraft and self-driving cars, Virginia policymakers must consider both the concerns and the economic potential of these new technologies. In response to a perceived policy vacuum concerning the use of UAS, Virginia became the first state in the nation to codify UAS legislation with a two-year moratorium limiting UAS access to the national airspace for certain law enforcement purposes. As the policy environment surrounding UAS matures, the Virginia General Assembly is tasked with balancing privacy, safety, and a considerable economic stake in this emerging industry.

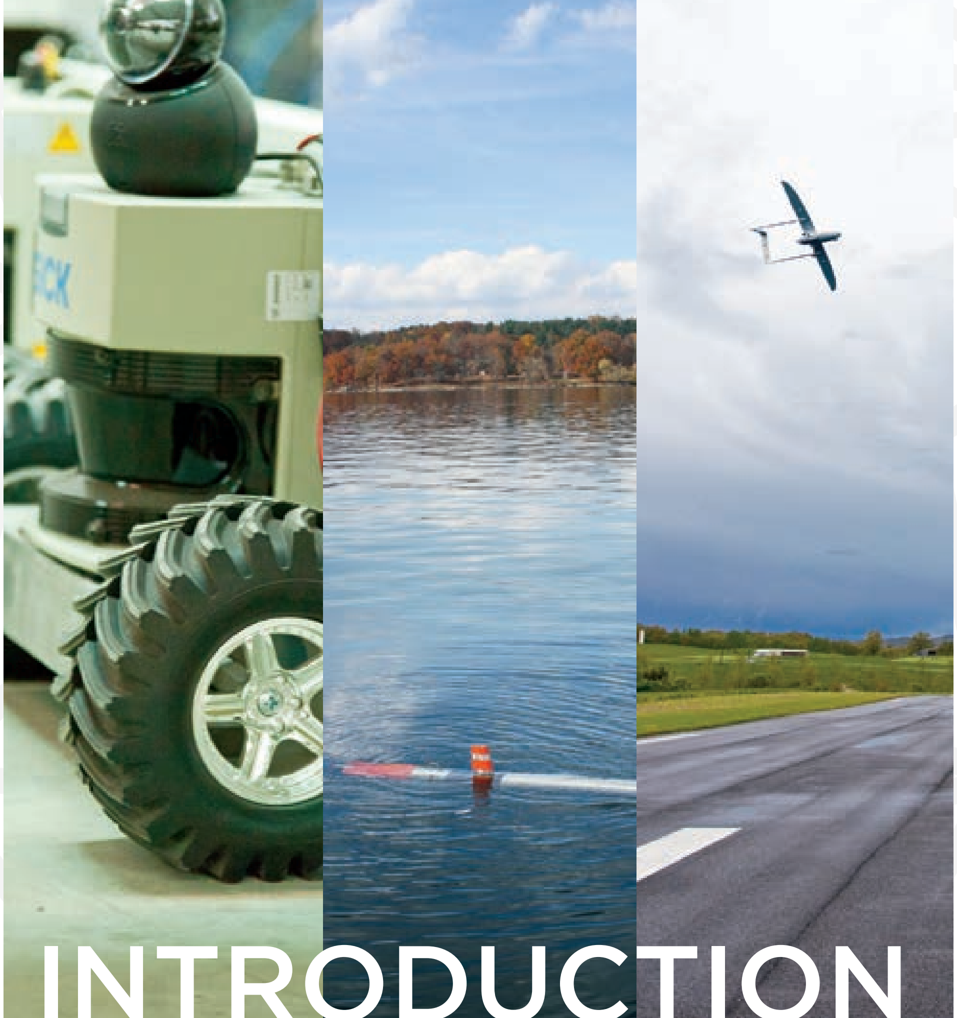
Due to the Commonwealth's existing resources and capabilities, Virginia is uniquely positioned to nurture this seedling industry, attracting companies and creating jobs more effectively than states choosing not to focus on this sector.

CONTENTS

Glossary

Autonomous - Self-controlled; requiring no human control
FAA - Federal Aviation Administration
NAS - National Airspace System
UAS - Unmanned Aerial Systems
Unmanned - Having no pilot or passengers aboard
UVS - Unmanned Vehicle Systems

December 2, 2013



INTRODUCTION

Autonomous (driverless) vehicle technology has matured to a point where civil and commercial applications are feasible and compelling. From aging seniors hoping to keep their independence thanks to self-driving cars, to farmers hoping to gain advance warning of crop problems, the technology holds the potential to benefit our citizens and industries in many ways. In addition to its applications, autonomous vehicle technology is poised to positively impact jobs and economic health throughout Virginia. As developers and prospective customers seek to deploy autonomous transportation in useful new ways, policymakers will increasingly face decisions that can either impede or accelerate the pace of innovation and, with it, Virginia's economic stake in the technology.

Benefits may be substantial, particularly to technology developers and potential customers. Current studies present a range of projections for job growth. One analysis places Virginia among the top 10 states to benefit from integration of Unmanned Aerial Systems (UAS) into the National Airspace System (NAS) in terms of economic impact, taxes, and employment; however "states that create favorable regulatory and business environments…will likely siphon jobs away from states that do not."[1] While the Federal Aviation Administration (FAA) currently allows UAS to fly in the national airspace only by exception, the administration plans to move from accommodation of UAS to integration, enabling a variety of new commercial and civil applications.

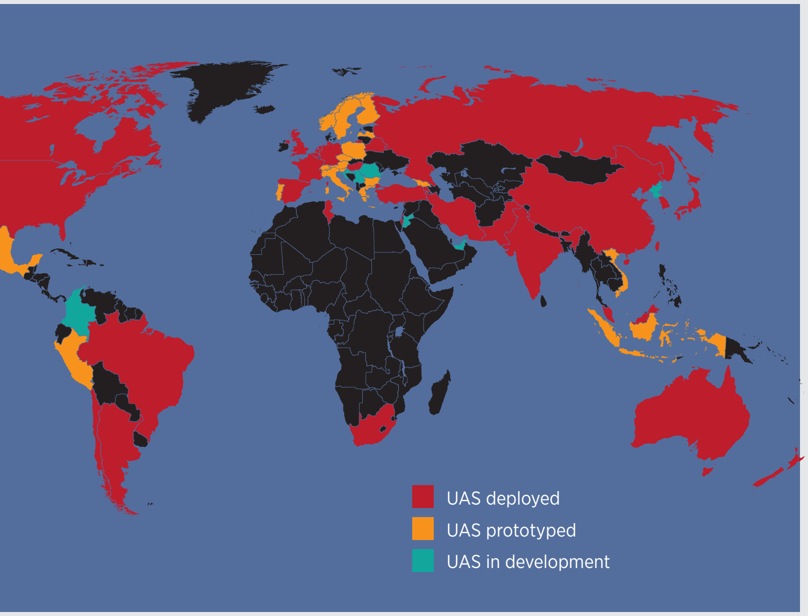
GROUND VEHICLES

Of the many autonomous vehicle technologies in development, self-driving cars will have the

[1]Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

GLOBAL COMPETITION IN UNMANNED AIRCRAFT

THE USE AND PRODUCTION OF UNMANNED AIRCRAFT are increasing every day throughout the world. While the United States and Israel were the sole producers of UAS only 15 years ago, today China, Russia, Iran, Australia, Brazil, Germany, Turkey, and Canada have stepped up their development programs and have begun exporting systems internationally. Commercially successful platforms such as Northrop Grumman's Global Hawk, General Atomics' Predator, AAI's Shadow, and Boeing/Insitu's ScanEagle and Firescout UAS have been joined by a host of foreign-developed platforms. These include Turkey's Anka, Europe's nEUROn, Australia's Campcopter-S, and South Africa's Seeker 400, which offer similar capabilities at lower costs regionally.[3]



Competition continues to grow as countries looking to develop high paying, high-tech manufacturing jobs see unmanned aircraft as a unique opportunity to enter into both commercial and military environments—offering products that can be used in multiple roles for domestic and international missions. A 2013 report by the Association for Unmanned Vehicle Systems International (AUVSI) recognizes, "the average price of the UAS is a fraction of the cost of a manned aircraft, such as a helicopter or crop duster, without any of the safety hazard. For public safety, the price of the product is approximately the price of a police squad car equipped with standard gear. It is also operated at a fraction of the cost of a manned aircraft, such as a helicopter, reducing the strain on agency budgets as well as the risk of bodily harm to the users in many difficult and dangerous situations. Therefore, the cost-benefit ratios of using UAS can be easily understood."[4] As one part-time safety officer puts it in an open letter, "I think there are many agencies who would like to use [unmanned aircraft] for public good, but they're stymied by the process."[5]

most visible effect on the daily lives of Virginia's citizens. In 2010, the average Washington, D.C. area driver lost 67 hours to traffic delays—the worst congestion in the United States. 2011 Census statistics show that residents of Prince William, Stafford, and Fauquier counties have average commute times "at or over 40 minutes."[2] Self-driving cars could address this problem, increasing both throughput and safety on our roads while increasing passenger comfort and productivity. Already, semi-autonomous functions in some newer car models are improving highway safety, for example, by automatically braking when approaching an obstacle. Self-driving cars will maintain more constant speeds and more predictable stops and starts, preventing many traffic jams.

Self-driving cars could help tackle other problems, from enabling senior citizens to retain their independence, to helping our smaller communities provide mass transit. Self-driving cars have already captured the public's attention with prototypes being developed by many of the major car companies. Perhaps the best-known prototype is the Google car, which has logged more than 300,000 autonomous driving hours.

Conventional road vehicles, such as passenger cars and freight trucks, are by far the most common type of ground vehicle. However, other ground vehicles include tractors, mining and construction vehicles, and a wide variety of "niche" vehicles such as those used by the military and law enforcement for explosive ordnance disposal.

Other applications for autonomous ground vehicles include self-driving farm equipment and mining vehicles, and fleets of transport vehicles that cooperate to quickly transfer cargo in congested ports.

MARITIME VEHICLES

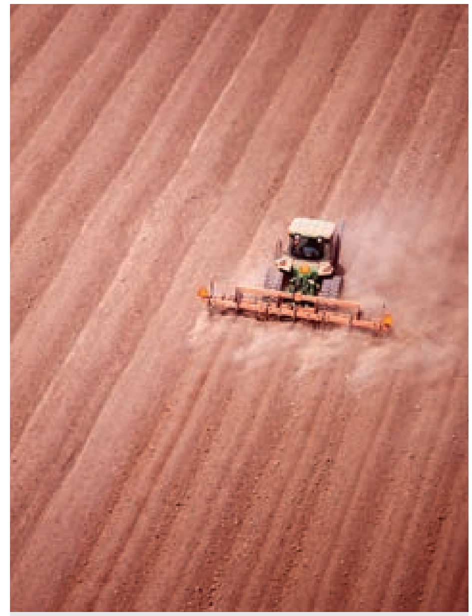
Unmanned maritime vehicles (surface and underwater vehicles) routinely perform environmental monitoring in the open ocean and they could easily be adapted for similar use in Chesapeake Bay and other inland waterways. Fleets of underwater vehicles could inexpensively monitor the water quality of Virginia's waterways, assisting the recreation and crabbing industries, among others. Chemical sensors on autonomous maritime vehicles could verify that potentially dangerous contaminants remain

[2]Traffic Congestion, Virginia Performs (Apr. 24, 2013), http://vaperforms.virginia.gov/indicators/transportation/trafficCongestion.php.

[3]HIS Jane's UAVs 2012

[4]Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

[5]Al Frazier. Preparing the Public Safety Community for UAS Operations, AUVSI Conference, Washington, D.C. (Aug. 12, 2013)



EXAMPLE:
POTENTIAL USES of UAS for AGRICULTURE[8]

- Terrain, rock, tree, and obstacle mapping
- Hybrid lifecycle charting
- Chlorophyll damage detection
- Ground covering profiling
- Wind profile and wind shear assessment
- Temperature and barometric pressure profiling

- Spore, dust, pollen counts
- Water quality assessment and survey
- Methane, ammonia, and CO2 sensing
- Trait assessment for breeding
- Wireless data collection from ground sensors
- Plat status tracking
- Crop status (growing stage, yield estimates, etc.)

- Precision agriculture prescription data
- Tiling/drainage evaluation and survey
- Time-saving pre-assessment for field tasks
- Oblique shots for de-tassel timing
- Drainage estimates and topography
- Planting evaluation and replanting requirements
- Pathogen introduction/tracking and weed levels

below acceptable thresholds and, if not, could locate the source of the contaminant. Patrolling autonomous maritime vehicles would operate regardless of wind and weather and would help the Commonwealth with port and waterway security.

AIR VEHICLES

While policymakers will face related challenges for all three autonomous vehicle technologies, the major focus of this report is unmanned aircraft. In its first annual Integration of Civil Unmanned Aircraft Systems in the NAS Roadmap[6], the FAA identified some potential applications for this technology, including disaster response, support for communications and broadcast, cargo transport, spectral and thermal analysis, critical infrastructure monitoring, commercial photography, mapping and charting, and advertising.

UAS offer an alternative to manned aviation that may be more attractive for some applications, particularly for tasks that carry a higher risk to pilots. Wildfire mapping is a representative mission for which unmanned aircraft have been lauded at all levels of government—firefighters call them "life-savers," "mission critical," and "their best friends in the air." They eliminate the need for pilots to risk their lives flying through smoke-laden updrafts to identify hot spots, shifts in direction, or dwindling areas that need less attention.[7]

If legal, farmers would benefit from using personally owned UAS to scan their fields for signs of disease or other health problems, to record growth and hydration rates, and to develop more effective and efficient spraying techniques that reduce pesticide, herbicide, and fungicide runoff.

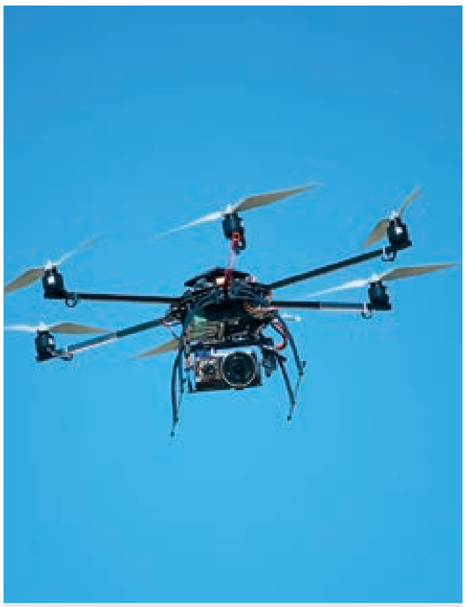
In addition to the benefits for firefighters and farmers, those responsible for disaster management, power line surveys, oil and gas exploration, aerial imaging/mapping, weather and environmental monitoring, telecommunications, television news coverage, sporting events, and cinematography can all incorporate UAS in ways that enhance their capabilities while reducing cost. Oil, gas, and electricity producers can monitor infrastructure with reduced cost and emissions. The potential benefits of UAS for commercial applications are extensive, but such uses remain unlawful until the FAA publishes regulations to enable them.

[6]Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap, U.S. Department of Transportation Federal Aviation Administration (Nov. 7, 2013), http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf.

[7]Matthew Durkee, Predators Improve Wildfire Mapping: Tests Underway to Use Unmanned Aircraft for Civilian Purpose, Tribune Business News (Aug. 26, 2007)

[8]Thomas Frey, Agriculture, the New Game of Drones, World Future Society (Aug. 30, 2013), http://www.wfs.org/blogs/thomas-frey/agriculture-new-game-drones

POLICY REVIEW



Civil applications of unmanned aircraft include aerial imagery for resource management and agricultural uses, in addition to search and rescue and disaster mapping.

WHILE UNMANNED VEHICLES of all types are under development, military use of unmanned aircraft has sparked domestic concerns about privacy and civil rights before the FAA has been able to establish clear policies for integrating these vehicles into the national airspace. The FAA Modernization and Reform Act of 2012 requires "the safe integration of civil unmanned aircraft systems into the national airspace system as soon as practicable, but not later than September 30, 2015,"[9] and many states have taken the initiative on this issue in the absence of federal action. Virginia was the first state to pass legislation limiting the use of unmanned aircraft. Many other states followed suit.

Recognizing that in the case of national airspace regulation, federal law preempts state law, many states have decided to act prior to the September 30, 2015 deadline. These groups may believe that by acting before the FAA does, they can argue that the 10th amendment gives them power to regulate because the FAA has deferred action. One should note, however, that the FAA was granted sole responsibility to oversee and regulate the airline industry and the national airspace for both military and commercial aircraft in the Federal Aviation Act of 1958.[10]

To accomplish its goal of integrating UAS into the national air space, the FAA was tasked with defining "acceptable standards for operation and certification of civil unmanned aircraft systems..." and to establish "standards and requirements for the operator and pilot of civil unmanned aircraft systems, including standards and requirements for registration and licensing."[11]

Current Virginia Law

Virginia's HB 2012 and SB 1331 (identical bills) were approved April 3, 2013, making Virginia the first state in the nation to address UAS and to define when, where, or why they could operate. The General Assembly of Virginia enacted a moratorium stating that *"No state or local government department, agency, or instrumentality having jurisdiction over criminal law enforcement regulatory violations… shall utilize an unmanned aircraft before July 1, 2015."*[12]

Still pertaining to law enforcement, the code goes on to identify when restrictions against UAS do not apply such as "Amber Alerts," "Blue Alerts," "for the purpose of a search or rescue operation where use of an unmanned aircraft system is determined to be necessary," or for "training exercises related to such uses."[13] This legislation directly limits any access to the national airspace rather than limiting the activities or outcomes of specific operations.

This emphasis on a specific group of people (law enforcement) rather than specific UAS activities differs from all legislation passed in other states. Privacy concerns stemming from inappropriate

[9]Appendix 1 provides a complete outline for all deadlines defined in HR 658.

[10]Federal Aviation Act of 1958. Print.

[11]Ibid.

[12]HB 2012: Drones: Moratorium on Use of Unmanned Aircraft Systems by State or Local Government Department, Virginia. (enacted) Apr. 2013. Print.

[13]Ibid.

or illegal use of pictures, videos, sound recordings, or other forms of surveillance are often identified as the main issue with UAS. However, Virginia's legislation prevents the use of UAS in the national airspace only by law enforcement users, without acknowledging why they are being banned and without addressing civilian (nonpublic) use of UAS.

The new law also makes exceptions for the Virginia National Guard, enabling the use of UAS during training for, and execution of, "federal missions… to include damage assessment, traffic assessment, flood stages, and wildfire assessment… [and] nothing herein shall prohibit use of unmanned aircraft systems solely for research and development purposes by institutions of higher education and other research organizations or institutions." The use of UAS for research and development remains unrestricted by the state through July 1, 2015.

> Virginia's HB 2012 and SB 1331 (identical bills) were approved April 3, 2013, making Virginia the first state in the nation to address UAS and to define when, where, or why they can operate.

The scope of the legislation goes beyond anything other states have attempted to do in limiting airspace access, and may be unconstitutional because it limits the access of public-use entities (state and federal law enforcement) rather than their activities. A different approach, embraced by many other state legislatures, has been to limit the types of activities (e.g. video surveillance recordings) that UAS are allowed to participate in. This approach is less vulnerable to the challenge that it infringes upon FAA authority because it does not limit access to airspace, a responsibility given solely to the FAA. This activity-limiting approach also reduces privacy concerns for citizens—a responsibility that has not been given to any regulatory body—while still supporting industry development and law enforcement functions. While determining Virginia's next step, other state legislation should be examined to see how future laws can be best adapted to the realities of unmanned aircraft in today's world.

Comparable Legislation in Other States

While Virginia was the first state to codify UAS legislation, others followed suit with legislation that generally falls into three categories:

1. Limiting the use of UAS,
2. Delimiting the role (but not access) of UAS, or
3. Supporting expansion of UAS research and usage within the state.

Idaho, Florida, and Montana offer the greatest insight with regard to limiting UAS use, having acted specifically to address the risk that UAS pose to individual privacy. While nine states have passed "UAS-limiting legislation" and 19 more defeated such attempts, these three serve as good templates for the "UAS-limiting" states.[14] These states have acted with more focused efforts to prevent the use of images, sounds, video footage, or other recordings made using UAS-mounted technologies such as infrared or hyper-spectral imaging systems. What makes these legislatures' approaches different than that of Virginia's is that they clearly identified the product of the flight (the pictures, video footage, etc.) as being unlawful as evidence unless attained through the execution of a search warrant, when in the protection of society from a terrorist event, or other very specific situations.

Idaho

Idaho limited UAS activities by first splitting the definition of unmanned aircraft. In SB 1067, Idaho excluded "model flying airplanes or rockets… that are radio controlled or otherwise remotely controlled and that are used purely for sport or recreation…" as well as "unmanned system(s) used in mapping or resource management."[15] By this definition, Idaho excludes two of three of the main uses of UAS from its legislation—hobby activity and agriculture/urban planning—opening the skies to all but law enforcement.

Florida

Florida's SB 92 was enacted to define precisely what an unmanned aircraft is and how law enforcement can and cannot use the technology. This law allows the use of UAS only after obtaining a warrant, in pursuit of a terrorist threat when that threat has been determined by U.S. Secretary of Homeland Security, when a law enforcement agency has determined that "swift action" is needed to prevent the loss of life or serious property damage, or in the search for a missing person or persons.[16]

Montana

Montana's SB 196 follows the same direction as the bills in Idaho and Florida; it does not limit airspace access but rather the manner in which information gained by UAS can be admitted as evidence in prosecution proceeding within the state. Again, the information can only be used if a search warrant has been granted and not as a way to gain a search warrant.[17]

Other states limit the role of UAS in their airspace, but have focused upon offering support to the industry with:

1. Explicit support of test center applications and funding for those test centers
2. Clear and concise limitations that describe operational boundaries

North Dakota

With this support, these states clearly plan to lead in the competitive marketplace for the UAS industry. At the most supportive, North Dakota's SB 2018 granted "$1,000,000 from the state general fund" to pursue designation as an FAA UAS Test Site, pledging an additional $4 million in funds upon receiving the approval of the test center bid. Hawaii's SB 1221 reflects the state's eagerness to pursue higher education funding for unmanned systems by funding two staff positions at the University of Hawaii. The positions would be used to create degree and technical programs relating to advanced aviation—one of which must be a professional UAS pilot program.[18]

[14] Mario Mairena & Brett Davis, Public Safety Use of UAS: A Legislative Update, 31 (10) Unmanned Systems. 21 (Oct. 2013)

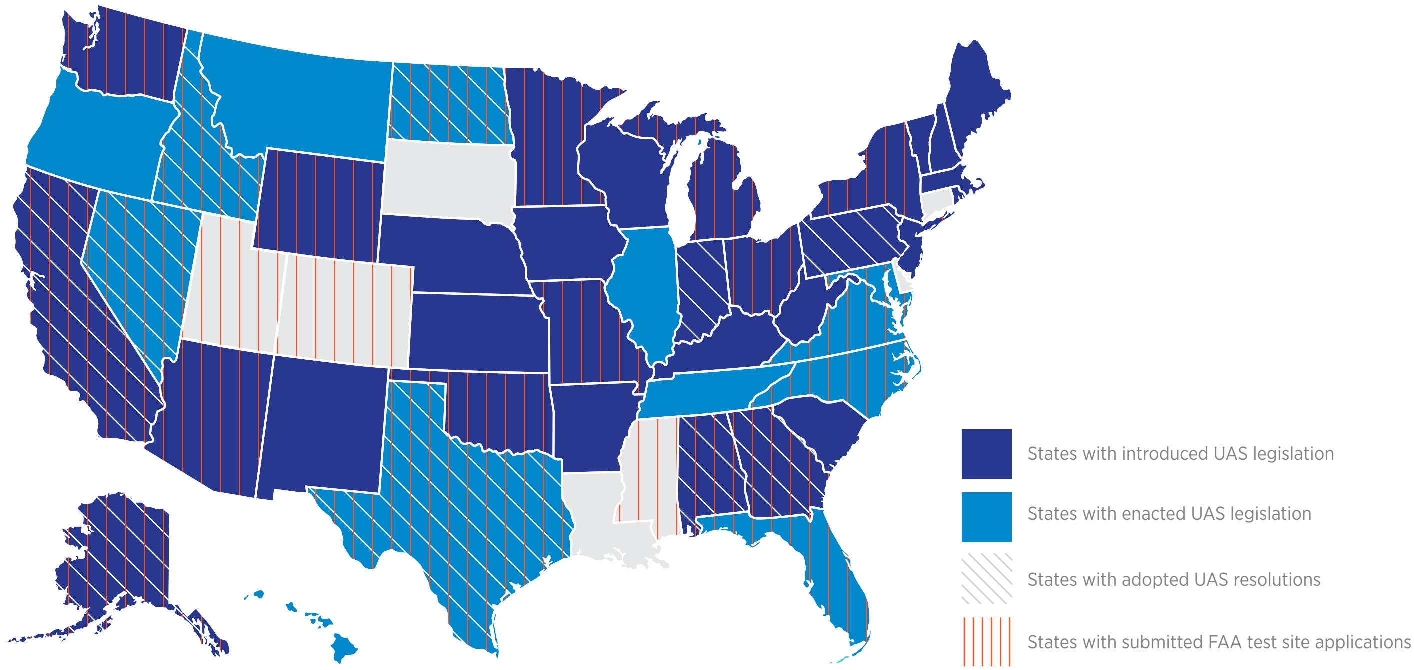
[15] SB 1134: Unmanned Aircraft/Restrictions, Idaho. (enacted) Apr. 2013. Print.

[16] 2013 Unmanned Aircraft Systems (UAS) Legislation, National Conference of State Legislations (Oct. 2013)

[17] SB 196: An Act Limiting the Use of Unmanned Aerial Vehicles by Law Enforcement; and Prohibiting the Use of Unlawfully Obtained Information as Evidence in Court, Montana. (enacted) 2013. Print.

[18] SB 1221: Relating to Hire Education, Hawaii. (enacted) July 1, 2013.

States with UAS Legislation and Actions



Source: National Conference of State Legislatures: 2013 Unmanned Aircraft Systems (UAS) Legislation page, accessed November 18, 2013. www.ncsl.org/research/civil-and-criminal-justice/unmanned-aerial-vehicles.aspx.

Texas

The Texas state legislature recently enacted HB 912, illustrating how a state legislature can limit inappropriate uses of UAS while supporting important law enforcement and commercial activities. In this legislation, Texas outlines 19 lawful uses of UAS including their use in "airspace designated as an FAA test site, their use in connection with a valid search warrant, and their use in oil pipeline safety and rig protection."[19] The act also creates two new Class-C misdemeanor crimes for the illegal use of an "image" attained from a UAS. The Texas Department of Public Safety is also expected to report to the legislature on the use of UAS by law enforcement. The Texas legislature's balanced approach to UAS both supports growth of the UAS industry and reduces privacy concerns with limitations to law enforcement.

Alaska

The state government that appears most welcoming of UAS activities is Alaska. It is probably no coincidence that Alaska is the first, and thus far only, active commercial authorization for UAS by the FAA. Alaska's HCR 6 is the nation's most supportive legislation through funding allocations, identifying of positive, unique qualities that define the UAS platform, and providing commercial access in deference to FAA decisions. This legislation clearly acknowledges the FAA's sole jurisdiction in determining airspace access, while outlining why privacy is the concern of the state. The bill states that "unmanned aircraft systems may present a substantial risk to privacy, but neither the Federal Aviation Administration nor any other state or federal agency currently has specific statutory authority to regulate privacy matters relating to unmanned aircraft systems."[20] While acknowledging the privacy concerns that UAS may represent, and deferring throughout the bill's text to the "Federal Aviation Administration…statutory authority," Alaska lauds the important positive uses of UAS "for gathering information necessary to protect human life in search and rescue operations, aiding in the management of resources, including marine mammal and fisheries research."[21]

Many states have imposed blanket limitations on UAS use, without acknowledging or supporting efforts to grow the industry to its safe, secure, and lawful potential. However, Alaska's HCR 6 establishes a well-balanced "Task Force on Unmanned Aircraft Systems" to review FAA regulations on UAS and to write recommendations and legislation that "protects privacy and allows the use of unmanned aircraft systems for public and private applications."[22]

It would be in Virginia's interest to follow Alaska's example, as it signals an appreciation for the potential value of UAS in civil society, acknowledges the statutory responsibilities and role of the FAA, and protects the interests of citizens concerned about privacy as well as those looking to work in this innovative field. Alaska has seen the first-of-its-kind commercial UAS certification for two different UAS models—the Boeing/Insitu ScanEagle and the AeroVironment Puma AE. These platforms may be used for continuous glacial movement tracking, "man-over-board" search missions, mammal migration research,

[19] 2013 Unmanned Aircraft Systems (UAS) Legislation, National Conference of State Legislations (Sept. 2013)

[20] HCR 6: Recognizing the Alaska Center for Unmanned Aircraft Systems Integration at the University of Alaska Fairbanks as a National Leader in Unmanned Aircraft Research and Development; and Relating to a Task Force on Unmanned Aircraft Systems, Alaska. (enacted) 2013.

[21] Ibid.

[22] Ibid.

and oil field perimeter management. Working closely with the FAA, Alaska is enabling important commercial activity, scientific research, and public safety uses in a way that can provide a model for similar efforts nationwide.

Public Safety and Privacy

While UAS have evolved into a technology that can serve a variety of industries, many stakeholders have operated without a clear understanding of regulatory policy—partially because the policy is underdeveloped. Now that the technology is moving into the public consciousness, many believe that law enforcement is the critical focal point, and requires the most attention because of privacy concerns. In reality, there are also many commercial interests that deserve attention. State legislatures have now begun to address two main concerns defining the debate over UAS—safety and privacy.

Fifteen different bills have been introduced by the U.S. Congress to redefine UAS activities by qualifying and delimiting their use, taking into account these systems' unique characteristics.[23] For example, the PATRIOT Act, Title I – Title X, significantly enhanced the authority of law enforcement and intelligence agencies and remained unchallenged until 2012 when H.R. 5925—Preserving Freedom from Unwarranted Surveillance Act of 2012—was introduced. The legislation was intended to reign in groups that Congress believed were violating the Constitution in their use of UAS. The House of Representatives included the following statement in this resolution:

"To protect individual privacy against unwarranted governmental intrusion through the use of unmanned aerial vehicles commonly called drones and for other purposes…"

"…shall not use a drone to gather evidence or other information pertaining to criminal conduct… except to the extent authorized in a warrant issued…"

Sheriffs, police, Customs and Border Protection, National Guard, Coast Guard and many other law enforcement organizations felt strongly that this legislation far exceeded regulatory restrictions on analogous technologies. H.R. 5925 died in committee.

H.R. 6199—Preserving American Privacy Act of 2012—was later introduced and was also defeated. This resolution stated that:

"No Federal agency may authorize the domestic use of an unmanned aircraft…for law enforcement purposes or for surveillance of a United States national or real property owned by that national, including by any State or local government, except pursuant to warrant and in the investigation of a felony."

This legislation would have put more restrictions into effect limiting law enforcement's ability to use surveillance and reconnaissance attained by UAS. The resolution ended for lack of support.

To date, the federal government has not come to a consensus on how far privacy concerns need to be protected with regard to UAS. The question being asked is whether or not there is a functional difference between manned and unmanned aircraft surveillance tools. The justice system seems to treat them equally. At present, law enforcement operates under the assumption that UAS can be used much like manned aircraft under the restrictions that have become precedent through case law. However, law enforcement has been hesitant to incorporate UAS into its everyday operations for fear of nullifying arrests. Across the nation, law enforcement is calling for clear and appropriate guidelines concerning when they can and cannot use this important, potentially life-saving technology, in the pursuit of suspects.

> Many states have imposed blanket limitations on UAS use, without acknowledging or supporting efforts to grow the industry to its safe, secure, and lawful potential.

Summary

Virginia legislators must answer a variety of questions moving forward. Does the state have the responsibility to regulate Virginia's airspace or does that responsibility reside within the federal government's power? For example, does the passage of House Bill 2012 and Senate Bill 1331—the first legislation of its kind limiting umanned aircraft use within a state—usurp the power of the FAA by redefining who can and cannot operate in the NAS above Virginia? Only when the whole picture of UAS regulation is understood can the state legislature guide Virginia's interests, balancing privacy concerns with economic gains in a safe, secure, and legal manner. Time is critical. Every day that full integration is pushed back, "the United States loses $10 billion in potential economic impact..." translating to a loss of "$27.6 million per day."[24] Competition in this market continues to grow between states and between countries. It is in the interest of the United States and of Virginia to develop clear and reliable legislation that will not change in two years.

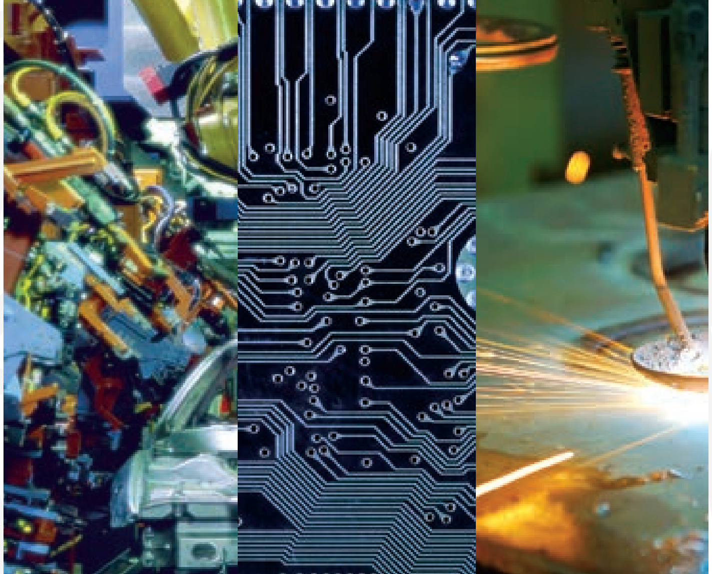
While Virginians examine the rules and regulations set forth in HB 2012 and SB 1331, the FAA is selecting six UAS Test Sites. Final Privacy Requirements[25] address public concerns about activities within these sites. Virginia partnered with New Jersey to submit one of the 25 UAS Test Site proposals that the FAA is currently considering. Maryland also has a test site proposal with, and understanding with Virginia that researchers from both states will work together regardless of who is selected. The economic impact of selection as a Test Site could be tremendous, bringing to the chosen states an estimated "23,000 new jobs adding up to $12 billion in wages, $720 million in new tax revenues, and an overall $23 billion in total economic impact over 10 years."[26] Winning a Test Site would raise Virginians' awareness of the tremendous potential (both positive and negative) of this burgeoning technology—making it all the more urgent that policymakers are well prepared to address concerns.

[23] Mario Mairena & Brett Davis, Public Safety Use of UAS: A Legislative Update, 31 (10) Unmanned Systems. 21 (Oct. 2013)

[24] Melanie Hinton, AUVSI Spokesperson, NDIA Business and Technology Magazine (Oct. 2013)

[25] Unmanned Aircraft System Test Site Program, Department of Transportation Federal Aviation Administration (Nov. 2013), http://www.faa.gov/about/initiatives/uas/media/UAS_privacy_requirements.pdf

[26] Melanie Hinton, AUVSI Spokesperson, NDIA Business and Technology Magazine (Oct. 2013)



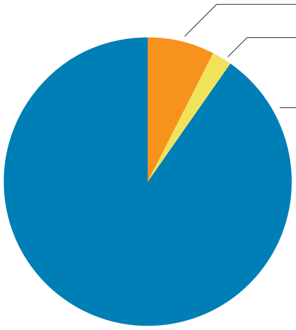
INDUSTRY STUDY

TODAY'S POLICY DECISIONS could have an enormous impact on Virginia's economy in the next few years and beyond. The impact is twofold: on jobs and economic activity, and on Virginia's reputation as a technology leader. Virginia currently supports the third highest concentration of technology jobs as a share of overall private-sector employment—behind Washington state and Massachusetts. Maryland, Colorado, and California are fourth, fifth and sixth, respectively.[27] Technology concentration tends to attract more high-paying technology jobs, which have been more resilient in the recent recession-and-recovery period. According to a December 2012 report by the Bay Area Council Economic Institute, "employment projections indicate that demand for workers in both high-tech industries and high-tech occupations will be stronger than the demand for workers outside of high-tech at least through 2020."

Because unmanned vehicles have captured the public's imagination, a leadership position in this industry will reflect well on a state's technological and economic prowess. Different studies present competing projections of job growth based on UVS technology. The highest projection predicts that the UAS industry alone will create 100,000 new jobs in the United States by 2025. That analysis places Virginia among the top 10 states to benefit.

Projections of the economic impact of autonomous vehicle industries are typically generated through the lens of current industry portfolios. However, similar to the Internet, autonomous vehicles are expected to create whole new industries. Current vehicle technologies are based on moving people and products, whereas UVS will not only move people and products (and more of them), but will perform new activities that were not feasible in the past. New activities could include persistent agricultural monitoring or even employing UAS to protect Virginia's grape harvest from birds. Uncertainty about new and expanding markets for autonomous vehicle technology makes it difficult to predict economic impact by extrapolating data from

*Virginia UVS-Related Industry Employment (2012)**



Vehicle Manufacturing — **27,202**

Systems and Componentry Manufacturing — **8,100**

Non-Manufacturing — **323,328**

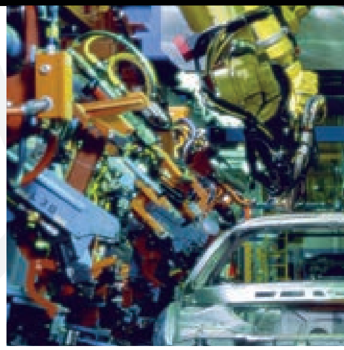
TOTAL UVS-RELATED INDUSTRY EMPLOYMENT — **358,630**

*Employment is privately-owned establishments only, that could serve the UVS industry.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (BLS QCEW); Economic Modeling Systems, EMSI Analyst; VEDP (2013)

[27] Ian Hathaway, Technology Works: High-Tech Employment and Wages in the United States, Bay Area Council Economic Institute (Dec. 2012)

UVS NAICS* Industry Descriptions

*NAICS: North American Industry Classification System Industry Codes



VEHICLE MANUFACTURING

Air (UAS)	Land (UGS)	Water (UMS)
336411 Aircraft manufacturing	**33611** Automobile and light truck manufacturing	**336612** Boat building
336412 Aircraft engine and engine parts manufacturing		**336611** Ship building and repairing
336413 Other aircraft parts and auxiliary equipment manufacturing		

COMPONENTRY MANUFACTURING

334511 Search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing

334220 Broadcast and wireless communications equipment

314990 All other textile product mills

335312 Motor and generator manufacturing

NON-MANUFACTURING SERVICES

517410 Satellite telecommunications

541300 Architectural, engineering, and related services

541511 Custom computer programming services

541512 Computer systems design services

541700 Scientific research and development services

541610 Management, scientific, and technical consulting services

541610 Environmental and other technical consulting services

541690 All other miscellaneous professional, scientific, and technical services

8112 Electronic and precision equipment repair and maintenance

National UVS-Related Industry Size

	GROSS OUTPUT		*EMPLOYMENT*	
Industry	**Average Annual Growth**	**Value Relative to Non-Manufacturing**	**Average Annual Growth**	**Total Relative to Non-Manufacturing**
Aircraft and Parts	0.9%	0.17	-2.3%	0.01
Automobile and Light Truck	2.3%	0.29	-2.8%	0.06
Ship and Boat	0.5%	0.03	-0.8%	0.04
Non-Manufacturing	3.8%	1	2.2%	1

This table suggests the relative sizes nationwide of the four major components of industry that relate to UVS. The non-manufacturing industries, which include engineering and services, are by far the largest component. Gross output value relative to non-manufacturing is the average of industry GDP, divided by non-manufacturing GDP from 1998-2011. Total employment relative to non-manufacturing is the average of industry private employment divided by non-manufacturing private employment for 1997-2012.

Source: U.S. Bureau of Economic Analysis GDP by Industry Gross Output, 1998-2011; U.S. BLS QCEW, 1997-2012, private sector employment

[28] Harrison (2013) notes that "lack of data on companies, combined with very limited market for public (i.e. governmental) and commercial uses of UAS, makes analysis difficult and speculative."

[29] M. Arel, Unmanned Systems Study, Virginia Economic Development Partnership (2011); B. Kroll, Economic Impact Assessment of the Mid-Atlantic Partnership Proposed UAS Test Sites, Virginia Economic Development Partnership (2013)

[30] National University System Institute for Policy Research (2012)

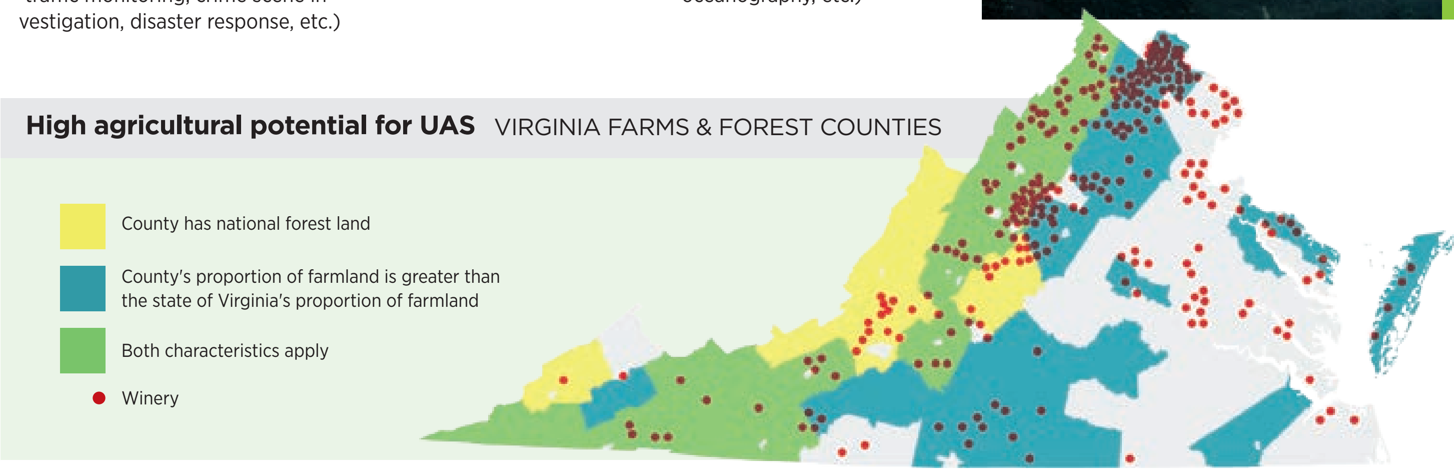
[31] North American Industry Classification System, United States Census Bureau (2012), http://www.census.gov/eos/www/naics/

[32] National University System Institute for Policy Research (2013); Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

Potential UVS Market Applications

Air	Ground	Maritime
Weather/environmental monitoring and other research	Border security	Port/harbor security
Aerial photography (geographic information systems, real estate, etc.)	Bomb disposal	Telecommunication (underwater infrastructure management)
Agriculture (land survey, crop health monitoring, etc.)	Surveillance	Oil and gas industry (underwater infrastructure management)
Homeland security (e.g. customs and border security)	Firefighting	Environmental monitoring (water quality, algal blooms, etc.)
Law enforcement (search and rescue, suspect tracking/surveillance, traffic monitoring, crime scene investigation, disaster response, etc.)	Disaster response	Ocean science (bathymetry, physical oceanography, etc.)

High agricultural potential for UAS VIRGINIA FARMS & FOREST COUNTIES



Sources: US Forest Service (http://www.fs.fed.us/land/staff/lar/2007/TABLE_6.htm), 2007; and USDA (http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Virginia/st51_2_008_008.pdf), 2007

existing related industries. The brief economic analysis presented here is preliminary and conservative, but provides some insight regarding growth potential.

Unmanned Vehicle Systems Industry

There is no standard industry definition for "unmanned vehicle systems,"[28] but the category generally includes both manufacturing and non-manufacturing activities.[29] The UVS manufacturing industries comprise firms that produce the finished vehicles and those that produce the components and instruments, which may be upstream from the vehicle manufacturers. The non-manufacturing industries consist of specialized technology, design, programming, and consulting services, which are inputs to the manufacturing industries. Another way to consider UVS is that the "unmanned" portion represents a new product line for existing vehicle and related technology industries.[30]

The table on page 12 provides the industry characterization of UVS used in this report, in terms of the North American Industry Classification System (NAICS).[31]

Currently, front-runners for UAS production in the United States include California, Florida, Washington, and Texas.[32] Virginia is expected to be among the top 10 states due to its "already thriving aerospace industry."[33] The speed of adoption and diffusion depends on several factors including regulation, costs to produce or obtain, savings generated, international policies, etc.[34] Additionally, the impact of commercialization on new production will be influenced by the extent to which users activate idle systems or obtain decommissioned, used parts.[35]

Unmanned Vehicle Markets

While there is no standard definition of the UVS industry, there is some consensus on the likely markets for these technologies.[36] UAS, with civil applications in surveillance and agriculture, have received the most attention recently (other than self-driving cars). In terms of industry growth, current estimates suggest similar global growth rates in both the ground and aerial unmanned vehicle markets. Military and first responder applications are expected to drive the

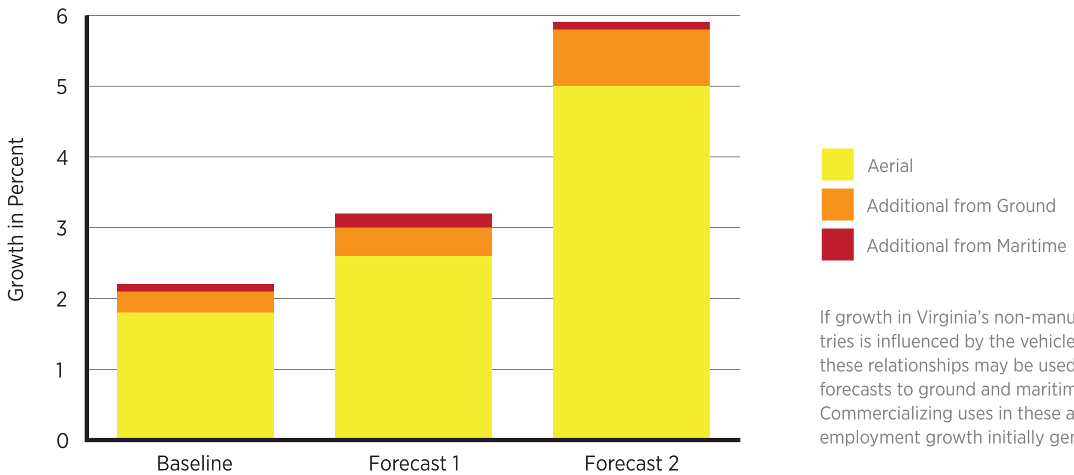
[33] Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

[34] M. Arel, Unmanned Systems Study, Virginia Economic Development Partnership (2011); Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

[35] W. Finn, UGVs & UAVs in Domestic Markets, AMREL (2012)

[36] It should be noted that currently the Teal Group and Association for Unmanned Vehicle Systems International (AUVSI) are the two dominant sources on market information for UAV technology. Wintergreen Research and Markets and Markets have published estimates on UGV technology.

Estimated Employment Growth



If growth in Virginia's non-manufacturing UVS-related industries is influenced by the vehicle manufacturing sectors, then these relationships may be used to extend the existing UAS forecasts to ground and maritime systems, illustrated here. Commercializing uses in these additional sectors will add to employment growth initially generated by UAS.[40]

*The Baseline forecast for UAS is based on IBISWorld, while Forecast 1 and 2 are from Teal Group and AUVSI respectively. The forecasts for unmanned ground and maritime are extrapolated from these forecasts.

growth of unmanned ground vehicles through 2019,[37] leaving UAS with the larger private markets initially. Note that the term "unmanned ground vehicle" as used in this report omits self-driving road vehicles. While we do not consider self-driving cars in this analysis, they will likely have an enormous economic impact in the next decade.

Industry Composition

Previous studies have estimated the potential impact of a commercial market for UAS in Virginia.[38] Estimates by the Association for Unmanned Vehicle Systems International (AUVSI) (2013) are based on calculating the size of the commercial UAS market that would accrue to Virginia. Estimates by the Virginia Economic Development Partnership (VEDP) (2013) are based on the size of the UAS-related manufacturing industry currently represented in Virginia.

The two studies also differ in how they define the UAS industry in Virginia. The AUVSI report focuses exclusively on manufacturing while the VEDP calculations include non-manufacturing industries. Unmanned vehicle manufacturers will likely depend on component distributors, testing and evaluation service providers, etc. This distinction is important and it raises questions about how to interpret estimates of the size of the UVS market.

As illustrated in the chart on page 9, non-manufacturing industries related to UAS are more heavily represented in Virginia.

The composition of Virginia's UVS industry has implications for the potential economic growth that would result from an expanding commercial market. Given the high fixed costs of setting up a production facility, for example, one might expect that manufacturing operations will be slowest to relocate or expand employment. In contrast, non-manufacturing industries, which include engineering and technology jobs, may be poised for faster near-term growth.

As new technologies and processes are more widely adopted, older ones will become obsolete, both on the production and user sides. The extent to which growing industries can absorb displaced workers from declining industries will influence overall employment growth. [39]

Potential Economic Impacts

As indicated earlier, Virginia's relative strength lies not in UVS or component manufacturing, but in the technical service industries that support all modes of autonomous vehicles. As these industries largely represent inputs to vehicle and component manufacturers, it is likely that growth in the final goods industries will govern overall market growth.

Nationally, employment and output have been growing faster in the non-manufacturing sector than in manufacturing. Manufacturing employment for aircraft and parts, automobiles and light trucks, and ships and boats declined between 1998 and 2011, while output grew during that interval. (Note that automobile and light truck production dominated in both the growth rate and value of output, underscoring the relative importance of ground vehicle manufacturing. While this report focuses primarily on UAS, it is likely that self-driving cars will have a far greater economic impact among UVS technologies.)

The convergence of UVS with new technologies such as 3-D printing could open even more job and economic growth frontiers for the Commonwealth.

[37]W. Finn, Explosive UGV Market Growth, Fact or Fiction (2013)

[38]Kroll, Economic Impact Assessment of the Mid-Atlantic Partnership Proposed UAS Test Sites, Virginia Economic Development Partnership (2013); Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

[39]Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013); Damon Lavrinc, People Would Rather Buy a Self-Driving Car from Google than GM, Wired (Oct. 10, 2013), http://www.wired.com/autopia/2013/10/autonomous-cars-study/

[40]Kroll, Economic Impact Assessment of the Mid-Atlantic Partnership Proposed UAS Test Sites, Virginia Economic Development Partnership (2013); Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

[41]Melanie Hinton, AUVSI Spokesperson, NDIA Business and Technology Magazine (Oct. 2013)

MID-ATLANTIC PARTNERSHIP *to* ADVANCE UNMANNED AIRCRAFT

THE FEDERAL AVIATION ADMINISTRATION (FAA) will be integrating UAS into commercial airspace by 2014. To make the transition easier, the FAA is selecting six test sites that will receive funding for UAS research and testing. Estimates from a study for the state of Utah suggest that selection as a test site will bring 23,000 new jobs, $12 billion in wages, $720 million in tax revenues, and an overall $23 billion in economic impact over 10 years[41].

Virginia and New Jersey have formed the Mid-Atlantic Aviation Partnership (MAAP), which has submitted an application for test site designation.

MAAP is a diverse team from academia, government, and industry with one mission: the safe integration of unmanned aircraft into the National Airspace System. Led by Virginia Tech, the team includes 38 members from Virginia and New Jersey.

Although MAAP is competing for the FAA's UAS Test Site designation (which is scheduled to be announced in December 2013), it will continue to build the UAS business in the mid-Atlantic with or without the test site designation. The team will also cooperate with the University of Maryland once the FAA announces the test site designation, and will move forward as a three-state partnership.

Team members have more than 70,000 hours of safe UAS flight experience, and their combined resources allow them to conduct up to 20 flight events simultaneously.

MAAP CORE TEAM

Organizations in italics are either based in Virginia or have a significant presence in Virginia

ACADEMIA
Virginia Tech
Rutgers
the State University of New Jersey
National Institute of Aerospace
Liberty University
New Jersey Institute of Technology
Rowan University
The Richard Stockton College of NJ
Virginia State University

GOVERNMENT
Commonwealth of Virginia
State of New Jersey
New Jersey Department of Transportation
New Jersey Economic Development Authority
South Jersey Transportation Authority
Virginia Small Aircraft Transportation System Lab (VSATS)
Virginia Department of Aviation

INDUSTRY
Aerosim Flight Academy; American Aerospace Advisors
Aurora Flight Sciences
B4Team
DDL Group
Engility
Enterprise Engineering Services
Hi-Tec Systems
KSI Video
NAVMAR Applied Science Corporation
Organizational Strategies Incorporated
Pentagon Performance
Sentinel Robotic Solutions
Sunhillo
UAV PRO

RESEARCH PARKS
Next Generation Aviation Research and Technology Park

ECONOMIC DEVELOPMENT ORGANIZATIONS
Choose New Jersey
Eastern Shore Defense Alliance
Fredericksburg Regional Military Affairs Council
Hampton Roads Military Federal Facilities Alliance
Virginia Economic Development Partnership

COMMERCIAL STAKEHOLDERS

VIRGINIA IS POSITIONED TO PROSPER from growth in the unmanned systems industry. The Commonwealth is estimated by a recent AUVSI study to be eighth among states to benefit from the expected boom in the UAS industry, with more than 3500 new jobs created and a total economic impact of more than $2.7 billion by 2025.[42]

The Commonwealth is also well positioned with regard to the larger spectrum of unmanned vehicle systems. Virginia is home to a number of large system integrators (companies that combine existing subsystems to create new technologies) with significant expertise in autonomy, and a number of small- and medium-sized companies that have established themselves as leaders in the emerging unmanned systems domain. The following examples are four companies that have been active in the growth of unmanned systems in Virginia.

EXAMPLE

Bosh Global Services

(Newport News)

BOSH has been an innovator in mission-critical unmanned systems since 2003, with expertise in command and control systems, operations and support, mission planning, hands-on technical and operational training, 24/7 communications and network support and solutions, intelligence, surveillance and reconnaissance data analysis, life cycle management, and flight operations innovation and support. BOSH is devoted to understanding unmanned system operations "tip to tail," and provides a degree of specialization to its clients that is so focused and advanced that it has its own trademark of first mover innovation known as "Para-Robotics™".

BOSH Super Swipe flies over farmland.

EXAMPLE

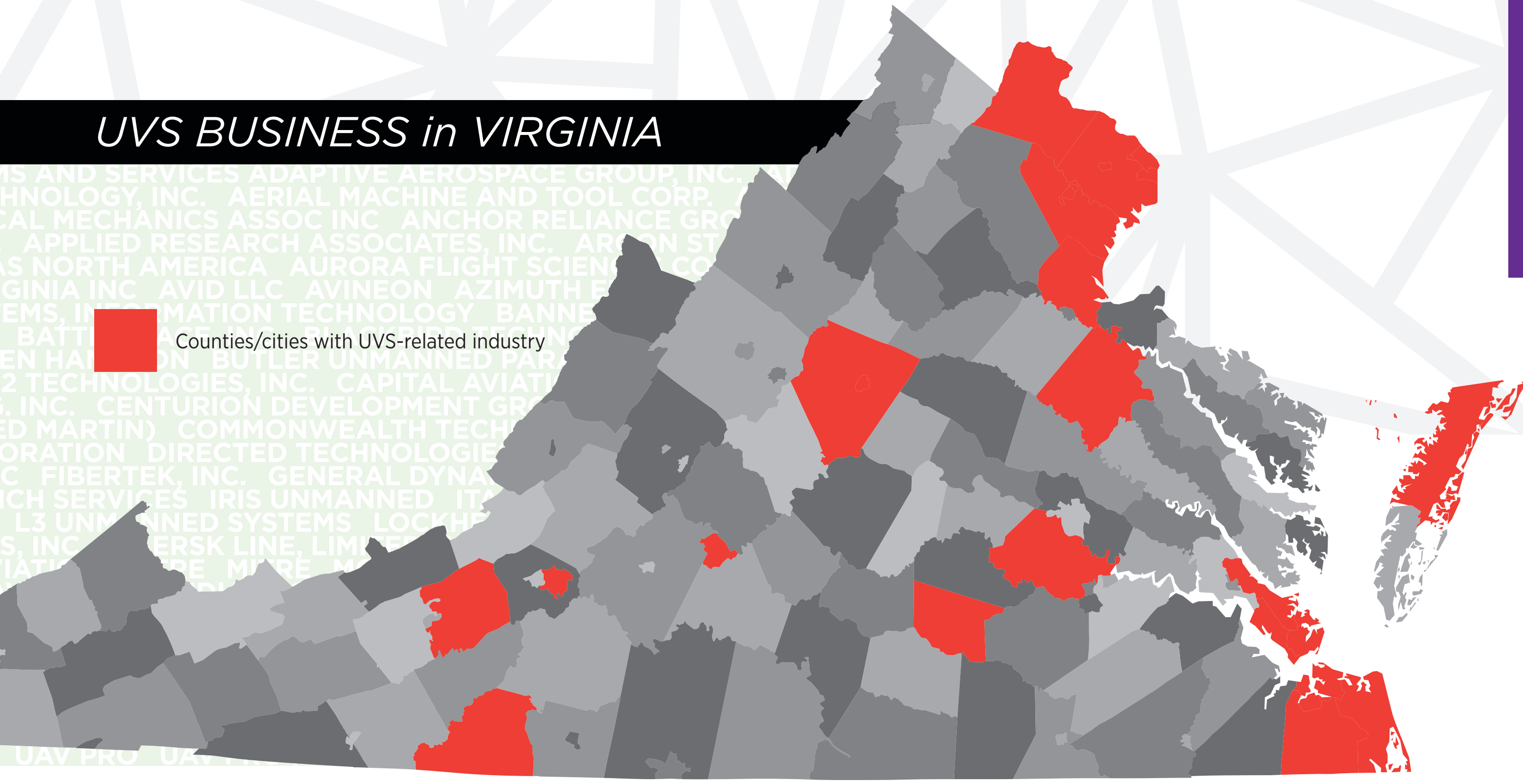
Organizational Strategies Inc.

(Arlington)

Since 2005, Organizational Strategies Inc. (OSI) has proven its breadth and depth of knowledge and experience with UAS operations both in the National Airspace System (NAS) and Department of Defense (DoD) Special Use Airspace (SUA). Through direct OSI support of U.S. Customs & Border Protection (CBP) MQ-9 Predator-B UAS operations at four national sites, CBP UAS operations have accumulated more than 20,000 flight hours to date. This equates to more flight time in the NAS over a large expanse of our nation's borders than any other governmental or private sector UAS entity. Through the efforts of OSI and CBP, the FAA's initial "total UAS airspace segregation" philosophy has slowly transitioned to a "limited access" philosophy, with full "integration" still to come. OSI and CBP remain at the forefront in successfully gaining access to the NAS with authorization in place for multiple CBP UAS simultaneously airborne across a large area of our nation's borders, over both land and water.

[42]Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)

UVS BUSINESS in VIRGINIA



EXAMPLE

TORC Robotics

(Blacksburg)

TORC Robotics LLC (TORC) is a leader in unmanned systems, vehicle automation, and robotics, providing advanced robotic solutions to many different industries. In 2007, lead engineers from TORC guided Team Victor Tango to be one of only three teams to successfully complete the DARPA Urban Challenge. According to TORC's website, the research and product development that followed the Challenge has brought forth a new era of driverless cars, unmanned farming, automated mining, and other rapid advancements in robotic application.

A TORC Robotics/Virginia Tech team participates in the Blind Driver Challenge.

EXAMPLE

UAV Pro

(Blackstone)

UAV Pro has a team of highly experienced personnel with a track record of exemplary performance operations, engineering, and training support for unmanned vehicles. The company specializes in providing year-round worldwide UAS training and support, UAS R&D and evaluation, UAS target services, surrogate operations, and demonstration and event assistance. UAV Pro has experience with the operation, maintenance, and training of a broad line of unmanned vehicle systems.

UAV Pro prepares a UAV for launch .

SURVEY *of* RESOURCES & CAPABILITIES

ACADEMIC STAKEHOLDERS

BEYOND ITS SUBSTANTIAL COMMERCIAL AND GOVERNMENT STAKE in unmanned systems, Virginia also has a strong, twofold academic stake: 1) workforce development and 2) research and development. Unmanned systems will remain a major priority for the U.S. military, and a variety of commercial applications are beginning to evolve as the regulatory climate adjusts to the new reality of highly automated vehicles.

To support a growing customer base, the unmanned systems industry will require a steady stream of highly trained, technically skilled employees. The following are examples of some universities with UVS activity. Other activities in Virginia academic institutions include Virginia State University's unmanned tractor program, William and Mary's maritime UVS efforts, and a variety of programs at other Virginia institutions.

EXAMPLE

Hampton University

Chutima Boonthum-Denecke, associate professor of computer science, is leading the ARTSI Alliance (Advancing Robotics Technology for Societal Impact), a consortium of Historically Black Colleges and Universities (HBCUs) and Major Research Universities (R1). The mission of the ARTSI Alliance is to provide education and research opportunities to engage undergraduate students from nontraditional backgrounds in the study of robotics in areas that are relevant to society. ARTSI has the following goals: 1) Increase the number of underrepresented (primarily African American) students who pursue advanced training in computer science or robotics; 2) Increase the institutional capacity of HBCUs to offer educational experiences in robotics; 3) Build an active community of HBCU faculty and students who collaborate with each other and with other institutions on robotics teaching and research, and 4) Conduct outreach activities for the broader public to increase awareness of and interest in African American achievement in robotics, and recruit new students to the pipeline.

Hampton University students Samantha Allen and Hasani Burns, participants in ARTSI.

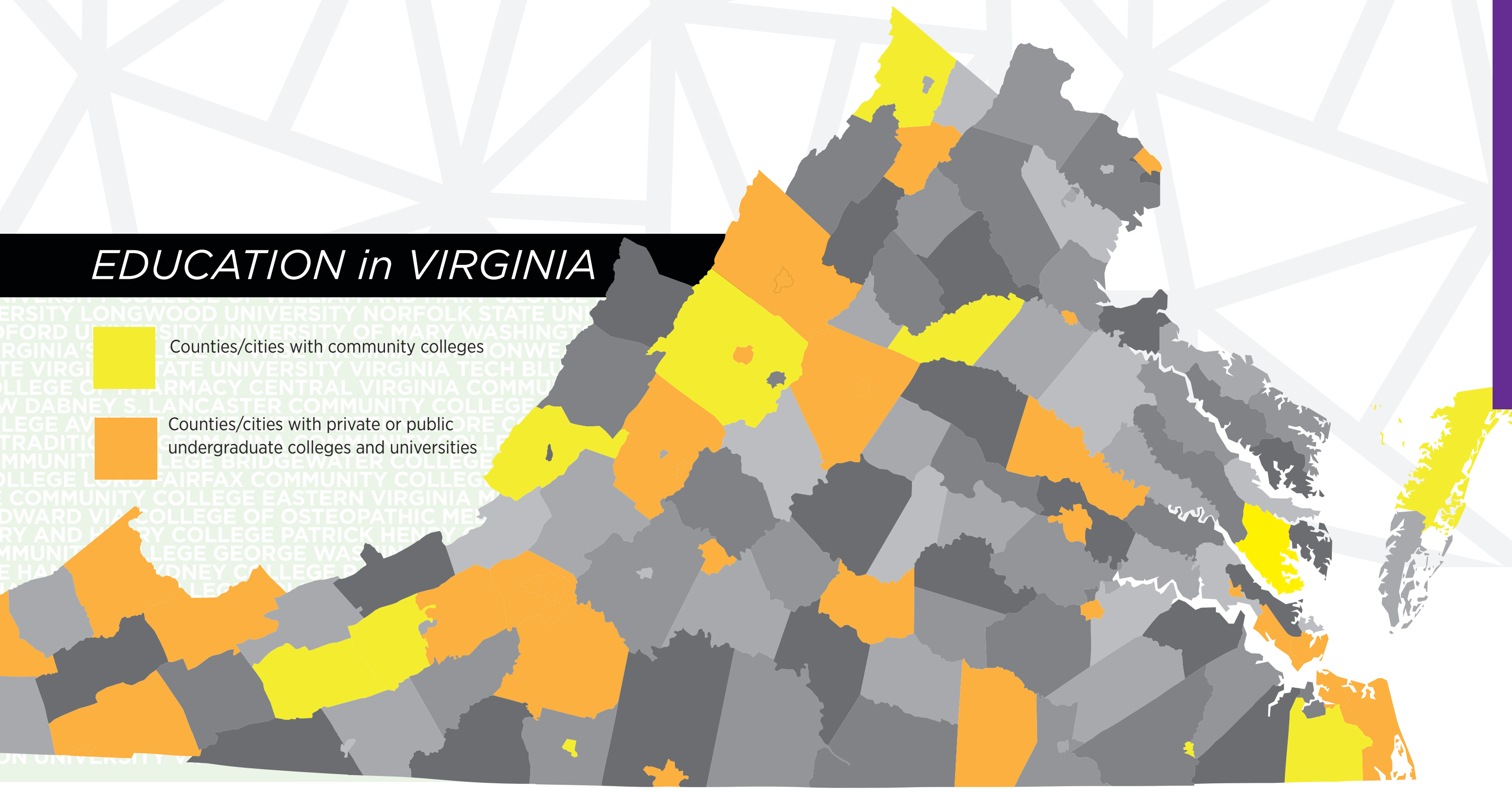
EXAMPLE

Liberty University

Liberty University School of Aeronautics (LUSOA) has experienced tremendous growth since its inception 10 years ago. Starting with four students, it now exceeds 400 students in residence and 200 online. The program has a fleet of more than 25 aircraft and four simulators, including a Canadair Regional Jet (CRJ) simulator. LUSOA offers several degrees and qualifications, including a B.S. in aeronautics with its newest concentration in Unmanned Aircraft Systems (UAS). According to John Marselus, associate dean of flight operations, the UAS concentration requires completion of a private pilot certification, an Instrument Rating, and academic classes including such topics as weather, safety, instruments, GPS, aerodynamics, etc. The UAS concentration requires six specific courses that include an elective in government, another in computer science, and four other courses specific to the concentration: Introduction to UAS, Command and Control of UAS, Small UAS Certification, and Medium UAS Certification.

Training is given in multiple UAS command and control systems including the Dragon Eye UAS and the Piccolo Command and Control system, along with Viewpoint. Agreements with industry have resulted in a program including a simulator lab with the latest in software and training manuals. LUSOA is also working with local law enforcement and industry to develop UAS that will support both special operations and law enforcement. The program has consulted with both military and private corporations, which has greatly aided in development of a program that provides industry with highly trained candidates for hire.

EDUCATION in VIRGINIA



EXAMPLE

Old Dominion University

Researchers in Old Dominion University's Vision Lab, directed by Khan Iftekharuddin, professor of electrical and computer engineering, are performing fundamental scientific and engineering research in the areas of computer vision and artificial intelligence, and developing and implementing advanced perception and planning algorithms for autonomous robotic platforms. For example, ODU researchers are developing bio-inspired "adaptive critic" neural networks for visual recognition, navigation, and decision-making. Perception systems of interest include arrays of visual and infrared cameras, microphones, sonar rangefinders, and inertial, tactile, and pressure sensors. Researchers are developing automatic face detection, recognition, and tracking algorithms, and are implementing them on autonomous ground and aerial robots.

ODU's MarcBot autonomous robot performing tracking and (inset) facial recognition.

EXAMPLE

Virginia Tech

Since its establishment, Virginia Tech's Virginia Center for Autonomous Systems (VaCAS) has advocated and supported a broad range of basic and applied interdisciplinary research activities focused on autonomous system technology. VaCAS now includes 14 core faculty members and nearly two dozen affiliate faculty members across the university. VaCAS hosts research activities spanning every application domain (marine, land, and air) and member research activities range from fundamental cognition and perception theory, to vehicle development, to applications for science, security, and commerce. Algorithm development efforts include verifiable implementations of robust vehicle planning and control algorithms, context-aware computer vision, environmental mapping, and minimum-risk motion planning. Separately, researchers with the Virginia Tech Transportation Institute (VTTI) generate methods and technologies to address transportation challenges involving road vehicles, drivers, infrastructure, and policy. VTTI research has also directly influenced public policy concerning driver, passenger, and pedestrian safety. As driver assistive technologies continue to advance, transportation research will increasingly focus on the challenges of integrating self-driving cars into public traffic, paralleling current efforts to integrate UAS into the national airspace.

The SPAARO Unmanned Aerial System, developed to carry a 10-pound payload for more than one hour. The VaCAS fleet sports more than a dozen types of fixed and rotary wing unmanned aircraft.

SURVEY *of* RESOURCES & CAPABILITIES

FEDERAL ORGANIZATIONS

AN EXCEPTIONAL VARIETY OF FEDERAL ORGANIZATIONS in Virginia have a direct interest in the development of unmanned systems. These organizations represent prospective customers, research and development partners, and test facility providers for the unmanned systems industry in Virginia.

By the simple virtue of proximity, Commonwealth companies and universities are well positioned to partner with these organizations. A brief summary of some key government players follows.

EXAMPLE

NASA

Wallops Flight Facility

For more than three decades, NASA's Wallops Flight Facility has been a national leader in UAS operations facilities. The Wallops Research Range's world-class airspace, facilities, instrumentation, and flight expertise have enabled federal agencies, industry, and academia to conduct hundreds of important R&D and training missions using dozens of different UAS systems. Wallops is also a leading NASA center in the management of earth science research conducted with UAS. These activities range from the use of small, low-cost systems carrying small sensors to the use of large, high-altitude Global Hawks to study the creation of hurricanes and other severe storms. Wallops engineers also develop advanced technologies that improve the utility of UAS platforms for research, such as the development of compact satellite data-relay systems and miniaturized laser terrain mapping instruments.

NASA Wallop's Global Hawk Team.

EXAMPLE

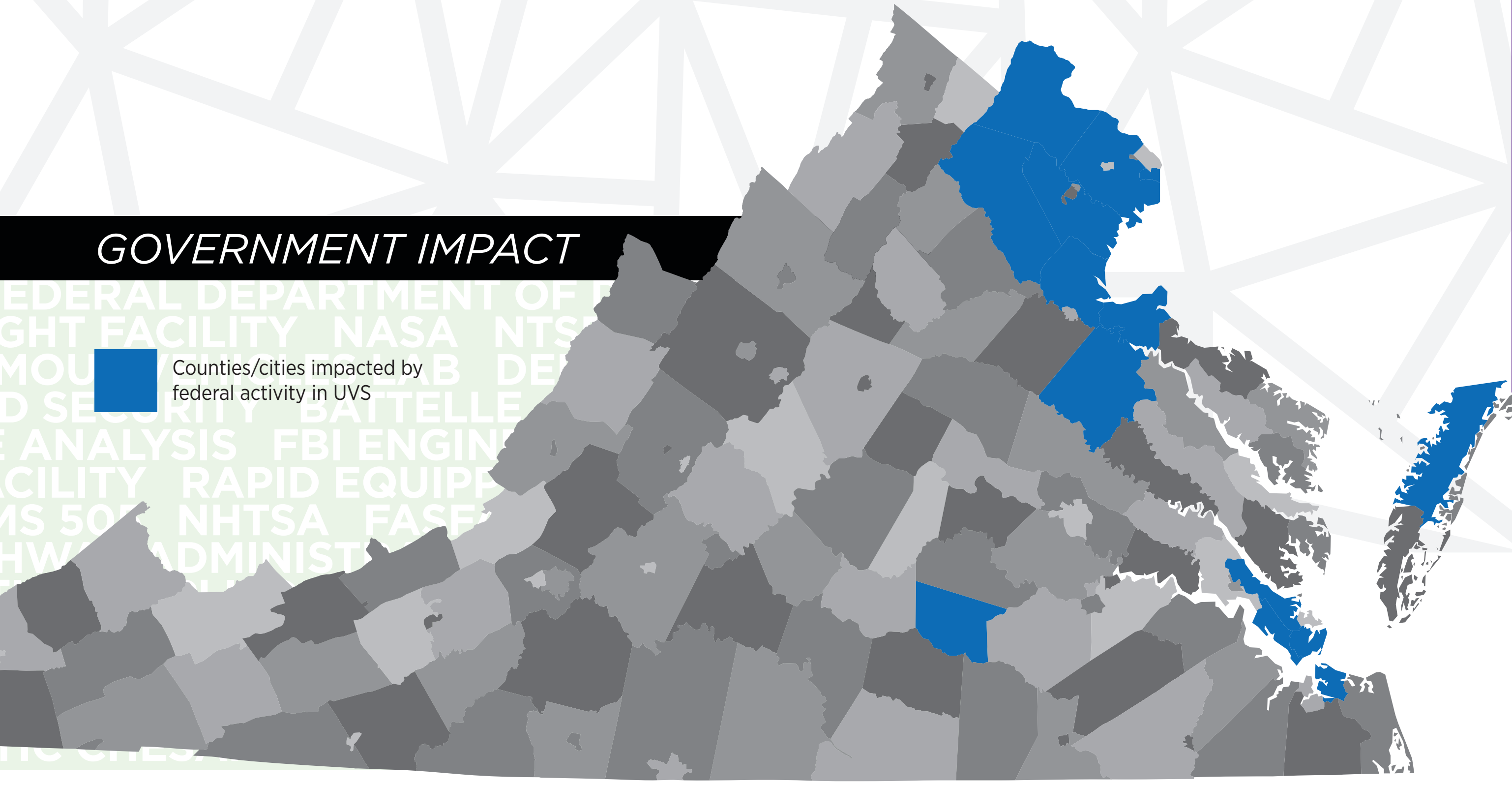
Naval Surface Warfare Center

Dahlgren

The Naval Surface Warfare Center, Dahlgren Division (NSWCDD) is the recognized leader in unmanned and autonomous weapons systems integration for the Navy's Surface Warfare missions. NSWCDD, with more than 3,000 scientists and engineers as well as controlled air, land, and sea ranges, is uniquely positioned to support autonomous systems research, development, testing, and evaluation. NSWCDD also provides technical support to the Marine Corps Warfighting Laboratory for robotic experimentation, and leads ship integration activities for Program Executive Office Unmanned Aviation and Strike Weapons for the FireScout Vertical Take-Off and Landing Unmanned Aerial System under the direction of NAVAIR. NSWCDD's Potomac River Test Range complex provides a controlled and instrumented surface range, restricted airspace, and controlled land ranges capable of non-lethal and live fire (weapons) testing.

Unmanned Surface Craft operations at Naval Surface Warfare Center Dahlgren.

GOVERNMENT IMPACT

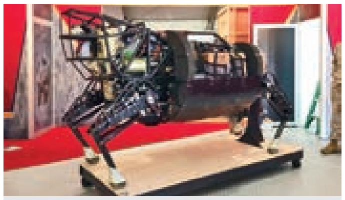


EXAMPLE

Marine Corps

Warfighting Laboratory

The Marine Corps Warfighting Laboratory (MCWL) rigorously explores and assesses Marine Corps service concepts using an integral combination of war-gaming, concept-based experimentation, technology assessments, and analysis to validate, modify, or reject the concept's viability, and identify capability gaps and opportunities, in order to inform and for future force development. MCWL has been the driving force for integration of UAS into Marine Corps units and has an active research and development program underway on unmanned ground vehicles.



The Marine Corps Warfighting Lab is experimenting with the legged squad support system, an autonomous robot intended to help reduce the loads that Marines carry.

EXAMPLE

United States Army

Rapid Equipping Force

The Rapid Equipping Force (REF), located in Fort Belvoir, harnesses current and emerging technologies to provide rapid solutions to the urgently required capabilities of US Army forces employed globally. The REF has led the effort to provide small unmanned aircraft systems for situational awareness to troops on the ground, explosive ordnance robots to permit ordnance technicians to more safely handle unexploded ordnance, and unmanned ground vehicles to help defeat the improvised explosive device threat.

The US Army's Rapid Equipping Force investigates a broad range of unmanned systems.

EXAMPLE

Fort Pickett

Fort Pickett is a maneuver training center operated by the Virginia National Guard. Restricted airspace is heavily used by Department of Defense UAVs and maneuver areas have been used extensively in the past for testing and experimentation of UGVs.

EXAMPLE

Fort A.P. Hill

Fort A.P. Hill, a Regional Training Center, supports national readiness through realistic and combined arms training support to America's Defense Forces and contingency capability for the Mid-Atlantic and National Capital Regions. The restricted airspace associated with the training center provides for safe experimentation and training with UAVs, and the maneuver areas are ideal locations for UGV operations.

EXAMPLE

Naval Surface Warfare Center

Carderock Combatant Craft Division

Located in Norfolk at the Joint Expeditionary Base Little Creek, the Combatant Craft Division provides superior quality total systems engineering support for all types of manned and unmanned combatant craft, boats, and advanced marine vehicles. This includes full spectrum and full life cycle engineering, research and development, concept feasibility, design, test and evaluation, and integrated logistic support. Combatant Craft Division led the Autonomous Maritime Navigation prototype system that demonstrated the capability of unmanned surface craft to perform a broad range of missions for the United States Navy and provides the technical support for all of the Department of Defense's boat and craft acquisition and life cycle support, including the suite of unmanned surface vehicles being developed for the U.S. Navy.

EXAMPLE

NASA

Langley Research Center

NASA Langley is a national leader in UAS research and development activities for NASA and other government agencies. NASA Langley operates numerous UAS as research platforms and is a leader in researching cooperative autonomous sense and avoid concepts. Activities include a wide range of UAS R&D needs for NASA as well as other agencies, including systems analysis, autonomy, electric propulsion, acoustics, aerodynamics, Certificate of Authorization (COA) approvals, range safety and data acquisition, and UAS fabrication.

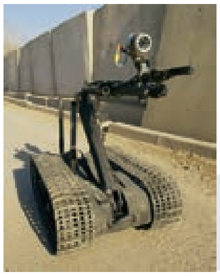
NASA Langley researchers with Quadrotor UAV.

EXAMPLE

Fort Eustis

Virginia Joint Unmanned Systems Experimentation Site

Fort Eustis and the James River Reserve Fleet offer a unique capability for joint, coalition, and homeland security experimentation. The site provides a confluence of air, land, and riverine areas, with commercial-type ships and critical infrastructure available to conduct unmanned and manned experimentation.



An experimental army robot operating at Fort Eustis Virginia Joint Unmanned Systems Experimentation Site.

GLOBAL COMPETITORS

THE RAPID PROGRESS of our international competitors amplifies the urgency of developing the market and R&D climate needed to sustain a robust unmanned systems industry.

EXAMPLE

China

China is uniquely positioned to debut autonomous vehicles, perhaps faster than the United States, because of looser regulations, a comparatively non-litigious judicial system, and a single-party government that can make things happen quickly.[43] More than 800 miniature micro-air vehicles (MAVs) and unmanned combat air vehicles (UCAVs) are made and sold commercially by the People's Republic of China.[44]

EXAMPLE

Germany

Germany is an autonomous vehicle leader in Europe. Companies such as BMW, Mercedes-Benz, Daimler-Chrysler, and Audi have active programs with goals to produce autonomous passenger cars for sale to the general public by 2020. A Mercedes-Benz, full-size S-class sedan recently drove 62 miles autonomously through open roads without incident.[45] A suite of roughly 30 UAVs are produced by German companies.[46]

EXAMPLE

Australia

In Australia, mining companies are embracing autonomous vehicles—particularly 50-foot robotic trucks the size of a house—for their ability to decouple mining from intensive human hands-on operations. Working in large strip mines, autonomous digging and hauling vehicles have the capacity to free the human operator for less monotonous projects than earth removal.[47] Industry and academic communities are also growing in Australia, e.g., the recent 2013 IFAC Intelligent Autonomous Vehicles Symposium was run in Gold Coast, Australia.[48] According to some experts, autonomous vehicles could be driving in Australian cities, as well as farming its fields with autonomous tractors, within just a few years.[49] More than 35 UAVs are produced by Australian companies for the commercial sector.[50]

[43] Richard Read, Autonomous Cars Will Probably Hit China First – And That's Okay, The Car Connection (May 13, 2013), http://www.thecarconnection.com/news/1084133_autonomous-cars-will-probably-hit-china-first---and-thats-okay

[44] List of Unmanned Aerial Vehicles of the People's Republic of China, Wikipedia (2013), http://en.wikipedia.org/wiki/List_of_unmanned_aerial_vehicles_of_the_People%27s_Republic_of_China

[45] David Undercoffler, Mercedes-Benz Reveals Recent Test of Self-Driving Car, Los Angeles Times (Sept. 10, 2013), http://www.latimes.com/business/autos/la-fi-hy-autos-mercedes-autonomous-car-20130909,0,5195752.story#axzz2lKZ5aRtu

[46] List of Unmanned Aerial Vehicles, Wikipedia (2013), http://en.wikipedia.org/wiki/List_of_unmanned_aerial_vehicles

[47] Kelsey Atherton, In Australian Mines, 50-Foot Robot Trucks Take Dangerous Work From Humans, Popular Science (Sept. 10, 2013), http://www.popsci.com/technology/article/2013-09/mining-company-uses-robotic-trucks?dom=PSC&loc=recent&lnk=1&con=in-australian-mines-50foot-robot-trucks-take-dangerous-work-from-humans

REFERENCES

1. M. Arel, Unmanned Systems Study, Virginia Economic Development Partnership (2011)
2. K. Dalamagkidis, K. Valavanis & L. Piegl, On Integrating Unmanned Aircraft Systems into the National Airspace System, International Series on Intelligent, Systems, Control, and Automation: Science and Engineering (2012)
3. D. Esler, Flying Among Robots, Aviation Week, Business and Commercial Aviation (2013)
4. Daniel Fagnant & Kara Kockelman, Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations, Eno Center for Transportation (2013)
5. W. Finn, Explosive UGV Market Growth, Fact or Fiction (2013)
6. W. Finn, UGVs & UAVs in Domestic Markets, AMREL (2012)
7. T. Harrison, Analysis of the FY 2013 Defense Budget and Sequestration, Center for Strategic and Budgetary Assessments (2012)
8. Ian Hathaway, Technology Works: High-Tech Employment and Wages in the United States, Bay Area Council Econoic Institute (Dec. 2012)
9. Melanie Hinton, AUVSI Spokesperson, NDIA Business and Technology Magazine (Oct. 2013)
10. R. Hogg, Autonomous Vehicle Study Predicts US$447bn Saving, Automotive World (2013)
11. Darryl Jenkins & Bijan Vasigh, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, Association for Unmanned Vehicle Systems (2013)
12. Kroll, Economic Impact Assessment of the Mid-Atlantic Partnership Proposed UAS Test Sites, Virginia Economic Development Partnership (2013)
13. P. Larsen, Issues Relating to Civilian and Military Dual Uses of GNSS, 17(2) Space Policy. 111 (2001)
14. Damon Lavrinc, People Would Rather Buy a Self-Driving Car from Google than GM, Wired (Oct. 10, 2013), http://www.wired.com/autopia/2013/10/autonomous-cars-study/
15. A. McGinn, Drones Flying High at Farm Science Review, Dayton Daily News, (2013)

[48] 2013 IFAC Intelligent Autonomous Vehicles Symposium, http://www.iav2013.org/

[49] Marton Pettendy, Cars That Drive Themselves Could be a Reality in a City Near You Within 10 Years, Go Auto (Sept. 27, 2011), http://www.goauto.com.au/mellor/mellor.nsf/story2/B37AF4CA64D0C422CA25791800101D48

[50] List of Unmanned Aerial Vehicles, Wikipedia (2013), http://en.wikipedia.org/wiki/List_of_unmanned_aerial_vehicles

Developed in collaboration with the *Virginia Tech Institute for Critical Technology and Applied Science*, and the *Virginia Tech Office of Economic Development*

Produced by *Uncork-It Communications*