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Assessing the Economic Impacts of a Small Satellites (SmallSat) Virginia Initiative

PREPARED BY: THE VIRGINIA TECH OFFICE OF ECONOMIC DEVELOPMENT

CONTRIBUTORS: SARAH LYON-HILL, SCOTT TATE, LUIS CAMACHO

EXECUTIVE SUMMARY

Since the beginning of the space race in the late 1950s, the satellite industry has been at the forefront of innovation. The industry continues to lower the cost of manufacturing satellites while reducing their size and increasing their performance. Global satellite industry revenue in 2014 totaled $203 billion, and the United States leads the global market, with a 43% market share between 2009 and 2014. The industry is undergoing rapid change and exponential growth – 208 satellites were launched in 2014, nearly doubling the number of launches in 2013.[1] Of those 208, 158 were small satellites (or smallsats) a categorization which includes nanosats, cubesats, microsats, and minisats. The smallsat market is projected to grow at a 17% rate over the next five years[2].

The Virginia Space Grant Consortium (VSGC) engaged the Virginia Tech Office of Economic Development (VTOED) to assess the potential economic impact and return on investment to Virginia from a proposed SmallSat Virginia Initiative. VSGC established a Virginia Small Satellite Working Group in 2011 and is leading efforts to maximize Virginia engagement in small satellite initiatives for economic development, technology development and demonstration, scientific advancement, workforce development, STEM education, and enhanced utilization of state aerospace resources and capabilities.

This report includes three sections: the projected economic impact of a proposed $4 million annual spending for the SmallSat Virginia Initiative; an overview of the satellite and small satellite industry; and a discussion of the potential for the SmallSat Virginia Initiative to strengthen Virginia's aerospace cluster and shape an emerging smallsat cluster.

VTOED used IMPLAN software and conservative estimates of in-state spending to project a total impact of the proposed $4 million annual state investment in the initiative. The direct, indirect, and induced effects of that amount totaled $13.5-$16.2 million dollars and 57-89 new jobs in Virginia over a three year period. The IMPLAN model does not account for leveraged time and money nor for anticipated cluster-strengthening impacts. A very minimal contribution estimate from confirmed partners would result in an additional $5.3 million over three years. Historically, the VSGC has generated an additional $6-$10 in additional investment for every $1 of NASA Space Grant funding. This aligns with findings from other states where funding for research in the aviation sector generated a 9:1 return on that investment[3]. If this pattern hold true, a 6:1 return on the 3-year $4 million annual state investment in research would total $72 million.

In addition, an industry overview and analysis of Virginia's existing aerospace cluster and emergent small satellites cluster suggest a critical need for the Initiative and the existence of a number of potential long-term benefits for the economic development of the Commonwealth.

[1] The Tauri group (2015)
[2] Euroconsult (2015). Prospects for the Small Satellite Market.
[3] Dieker, J. Kansas Aviation Industry Economic Outlook. Accessible at http://www.ncatkansas.org/docs/KS_Econ_outlook_John%20Dieker_v4.pdf

SECTION I: Projected Economic Impact of $4 Million Annual Spending For SmallSat Virginia Initiative

Investing $4 million in the SmallSat Virginia Initiative will enhance opportunities for synergies within the Commonwealth's Aerospace Sector, creating an effective engine for economic growth throughout the state. Virginia Tech Office of Economic Development (VT OED) used an IMPLAN input-output model to conduct a careful analysis of Initiative spending by industry sector to ascertain the three-year economic impact of this Initiative on Virginia.

IMPLAN is widely used software in academic and professional research, and relies on industry sales and/or employment data to provide estimates of the direct, indirect, and induced impacts of industry spending. Direct effects are all spending within a designated study area by the program being studied. This research captures all spending in Virginia by the SmallSat Virginia Initiative. An estimated budget helps to determine in what industry sectors the money would be dispersed, for instance, a certain amount may go into the "space satellites, communications, and manufacturing" industry. Indirect effects capture spending by the initially impacted industries and those spending impacts on the subsequent supply chain. For example, spending by the "space satellites, communications and manufacturing" industry and dollar impacts on their supply chain firms are indirect effects. Induced effects capture the spending by employees of these direct and indirect firms. Employees spend a portion of their earnings for goods and services in the local economy. At each stage of this spending cycle, additional money within the study area (e.g. Virginia) is generated, while some money is spent outside the study area. Total economic output is the sum of direct, indirect, and induced effects, which typically exceeds the initial industry spending. Total jobs created as a result of this dollar spending is also estimated and contributes to the overall economic impact of the study program, the SmallSat Virginia Initiative.

VSGC provided VT OED an estimated spending budget for the SmallSat Initiative based on expected annual activities. To estimate the potential economic impact, VT OED developed assumptions regarding out of state spending by the Initiative and distribution of spending into select industries. Different industries have varying spending profiles that may lead to greater indirect or induced effects, or conversely, may result in additional money leaving the state.

VT OED constructed an IMPLAN model and inserted data for industries that could directly benefit from the program. The model is inherently conservative in nature, and provides an annualized snapshot of reasonably anticipated effects, however it fails to project and account for changes in industry behavior over time. As a result, job creation numbers over multiple years remain relatively static, and cluster-strengthening effects of a program like the SmallSat Virginia Initiative are not incorporated into the model estimate. The report discusses cluster-strengthening in section 3.

To estimate the expected economic impact of the $4 million annually, VT OED developed three spending scenarios, ranging from estimates that include the most out-of-state spending and corresponding smallest indirect/induced effects to a scenario with the least amount of out-of-state spending and the greatest indirect/induced effects. The resulting numbers helped to create a range estimate of possible impacts as seen in Table 1.

In year one, the $4 million investment will generate a total output of $4.5-5.4 million and contribute to as many as 57-89 new jobs within the Commonwealth of Virginia. As Table 1 shows in the Total Output column, as much as $1-1.4 million will initially leave the state to pay for satellite deployers, other supplies and services not found in Virginia, and marginal costs for direct retail expenditures. This kind of leakage should be expected when making any type of investment, particularly in a nascent industry where the investment is focused on capacity building. The resulting direct effect, or $2.6-3 million of in-state direct spending on small satellite related industries, will generate an additional $1.9-2.4 million. Likewise, this initial direct spending will contribute to 41-75 jobs initially and 13-15 additional jobs via indirect/induced spending. Approximately $2.4 million of total output dollars will go to household incomes. From these impact dollars, as much as $172,000-215,000 will accrue to state and local taxes.

Table 1. Annual Impact of $4 Million Investment on SmallSat Initiative

	Jobs	Labor Income	Total Output
Direct	41-75	$1.6-1.7 million	$2.6-3 million
Indirect	3-5	$179,000-330,000	$551,000-1 million
Induced	10	452,000-475,000	$1.3-1.4 million
Total Impact	57-89	$2.3-2.4 million	$4.5-5.4 million

Initial years following year one will show similar impacts on an annual basis as $4 million a year is injected into the small satellite industry. Table 2 shows the projected economic impact of the SmallSat Virginia Initiative over three years. Of the total $12 million investment, $8-9 million will be spent in-state. The resulting total output is estimated to be between $13 and $16 million, $6.7-7.5 million of which will support households. Since the IMPLAN model is limited to a one-year snapshot, it can only project sustaining the 57-89 jobs initially created in year one. However, as this $12 million capacity-building investment spurs more development of small satellite related industries in the state, more job growth is distinctly possible.

Table 2. Three Year Impact of $4 Million Investment on Small Sat Initiative

	Jobs	Labor Income	Total Output
Direct	41-75	$4.8-5.1 million	$7.8-9 million
Indirect	3.0-5.5	$537,000-990,000	$1.7-3 million
Induced	10	~$1.4 million	$3.9-4.2 million
Total Impact	57-89	$6.9-7.2 million	$13.5-16.2 million

To increase total impact numbers and support Virginia's growing nano/microsatellites and related industries, it is recommended that universities and companies working with the

SmallSat Virginia Initiative be contractually obligated to spend at least 50% of their parts and materials budgets in the Commonwealth of Virginia. Assuming this contractual obligation is satisfied, total impact would veer to the higher end of the IMPLAN model's estimated impact range. As the small satellite industry and its supply chains develop in Virginia, more money could be spent in-state, increasing direct and indirect effects and consequently, the total economic impact of each annual investment.

This impact estimate also does not account for the in-kind work performed by the Initiative's partners. With the state's investment, the Initiative can also leverage time and in-kind cash from its partners. In-kind support first and foremost contributes to growing the capacity of the industry cluster, its research, technological strengths and workforce. However, if one were to monetize the time contributions of Initiative partners and combine it with the in-kind cash contributions, additional equivalent impact could be estimated. Already, the SmallSat Virginia Initiative has received letters of support from several partners including the Virginia Commercial Space Flight Authority, Cubic Aerospace, Intel General Corporation, Moog Inc., NASA Langley, NASA Wallops Flight Facility, Old Dominion University, OmniEarth, Schafer, Science and Technology Corp, Space Quest, University of Virginia, VPT Inc, Space@VT (Virginia Tech), Hume Center (Virginia Tech), GATS Inc., Nanoracks, Deep Space Industries, National Institute of Aerospace and Planetary Systems Corporation. These partners will contribute by being members of the Initiative Advisory Committee, providing advice and networking support, and helping grantees on projects such as identifying appropriate technologies. Assuming 20 partners contribute five hours a month at a rate of $150 per hour, total direct effects of this time would be $180,000 annually.

In the past, the Virginia Space Grant Consortium (VSGC) has also excelled at leveraging grant funds. Over a number of years, VSGC has demonstrated that for each dollar received from NASA's Virginia Space Grant Core award, an additional $6-$10 has been raised in both cash and in-kind support from federal, industry and state sources. There are a number of examples. In one instance, the Virginia Space Grant leveraged an initial $25,000 to attract an additional $75,000 from an industry partner in Virginia, followed by a subsequent DoD grant of $1.2 million.

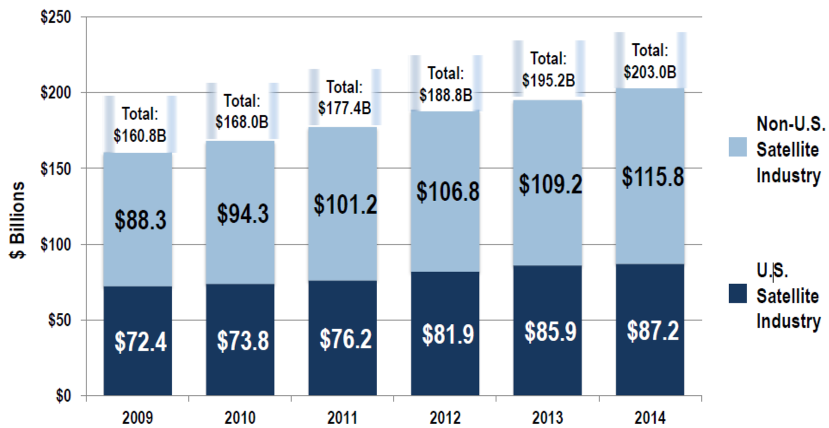
For the SmallSat Virginia Initiative, VSGC proposes to directly contribute a minimum match of more than $800,000 a year of in-state spending. Combining this spending with in-kind time and resource contributions, the equivalent direct effect of this match funding would be at least $980,000 annually. Combined with indirect and induced effects created after spending more than $980,000 in-state within small sat-related industries, the total estimated equivalent output would be $1,778,000-$1,816,000 a year, or more than $5.3 million over three years.

SECTION II: <u>State of the Satellite and Small Satellite Industry Nationally and Globally</u>

Today the global satellite industry is a significant technology-based economic activity with at least 57 countries operating at least one satellite.[4] More than 275 governments around the globe are projected to either contract, develop or launch earth observation (OE) satellites by 2022.[5] In 2014, approximately 208 satellites were launched, nearly doubling the number of launches in 2013.[6] Of the 208, 158 were small satellites (smallsats) a categorization which includes nanosats, cubesats, microsats, and minisats.

Global satellite industry revenue in 2014 totaled $203 billion, representing a percentage increase of approximately 144% between 2005 and 2014. The United States satellite industry leads the global market, with a 43% average annual market share between 2009 and 2014 (See figure 1).

Figure 1.Global Satellite Industry Revenues (2009-2014)



Source: The TAURI group (2015): State of the Satellite industry report

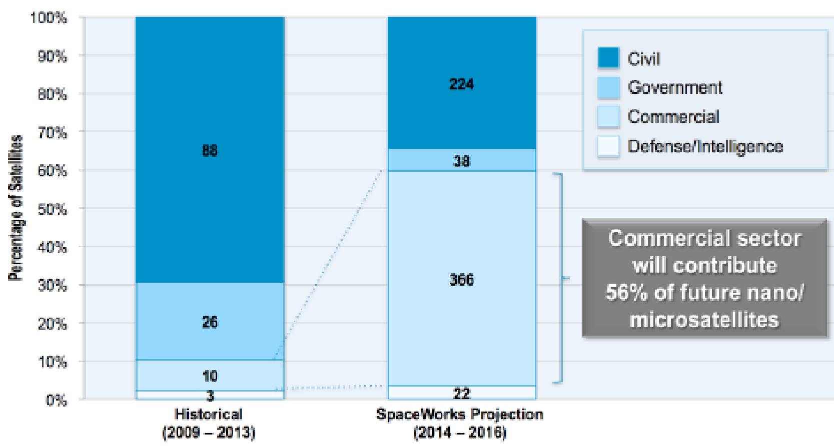
There are four segments comprising the satellites industry: satellite services, satellite manufacturing, launch industry, and ground equipment. Presently, satellite services constitute 61% of global satellite revenues, followed by ground equipment (29%), satellite manufacturing (8%) and the launch industry (3%).[7] In this global market, the United States captures 63% of global revenue from satellite manufacturing and 41% from each of the other segments. US companies completed 50% of global satellite launch orders, and built approximately 62% of the total satellites launched in 2014. The U.S. satellite industry also employed approximately 225,000 workers in all four segments in 2013.[8] An estimated 2,000 of these jobs are in Virginia's satellite manufacturing segment.[9]

[4] The Tauri group (2015) State of the satellite industry report. Satellite Industry Association. Retrieved Sept 2015 from: http://www.sia.org/wp-content/uploads/2015/06/Mktg15-SSIR-2015-FINAL-Compressed.pdf
[5] Meurer Robert & Peng Wee Seah (2014). Global commerce in Small Satellites: Trends and New Business Models. 28th Annual AUIAA/USU Conference on Small Satellites. http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3017&context=smallsat
[6] The Tauri group (2015)
[7] Ibid
[8] Satellite Industry Association (2014) State of the satellite industry report. Retrieved September 2015 from http://www.sia.org/wp-content/uploads/2014/05/SIA-Press-Release-2014-SSIR-2014-05-19-FINAL.pdf
[9] These data is an average calculated for years 2013-2015 from NAICS code 334220 from EMSI data base.

The growing satellite market is partly driven by the development of disruptive technological innovations fueled by government funding, university research and collaboration with private industry. These innovations have decreased the cost and time needed to design and manufacture satellites. It once took billions of dollars and as many as ten years to design, build and launch a single satellite. The development time and total costs have significantly decreased.[10] Including the launch, a nanosat of CubeSat dimensions might cost $150,000-$1 million, rather than the $200m-1 billion for a full-sized one. And the costs are continuing to decrease, as electronics technology advances and more affordable launch options emerge. Barriers to entry into the satellite market have significantly decreased.

As much as 20% of current global satellite industry revenue may come from nanosats (with masses between 1 – 10 kg).[11] The global nano/microsatellite (1-50 kg) market has over 1,100 identifiable satellites currently under development, and projections indicate 2,000-2,750 nano/microsats will require launches between 2014 and 2020.[12] Trends for 2014-2016 in the nano/microsat market forecast growth in all space industrial sectors – civil (including universities), government, commercial, and defense/intelligence (See Figure 2). Academic institutions which have been the predominant developers and builders of nanosatellites will continue contributing to this market even though the commercial sector is expected to grow significantly and compose as much as 56 percent of the total nano/microsat market.[13]

Figure 2. Historical (2009-2013) and future (2014-2016) Nano/Microsatellites trends by sector



Source: Buchen (2014): SpaceWorks´ 2014 Nano/Microsatellites Market Assessment

The numbers of small satellite companies and the amount of private investment in the industry has risen dramatically. The number of United States companies over the past five years has risen sixfold and now totals over 800 enterprises[14]. The smallsat industry reached a high in the

[10] Thomas, D. (2015). Operationally Responsive Space – The Way Forward. 29th Annual AIAA/USU Conference on Small Satellites, pg. 7.
[11] Deloitte (2015) Nanosats take off, but they don't take over. Report on Technology, Media & Telecommunications Predictions 2015.
[12] Ibid
[13] Ibid
[14] Dillow, C. (2015, August 4). Here's why small satellites are so big right now. Fortune. Accessible at http://fortune.com/2015/08/04/small-satellites-newspace/

number of deals completed and dollars invested during the first half of 2015 alone.[15] Approximately $2.5 billion has been invested in small satellites over the past ten years and almost half of that total has happened in the last 12 months. Investors perceive huge potential for a next-generation "space-based" internet anchored by thousands of small satellites as well as for rising demand for lower-cost, advanced, and near-real-time earth imaging. Google and other backers invested $1 billion in SpaceX's plans to develop a smallsat constellation for internet delivery and competitor OneWeb has plans for a $2 billion project to place 648 smallsats around the globe[16]. Meanwhile, smaller start-ups are now garnering tens of millions in venture capital to develop and launch smallsats for earth imagery, data services, and other functions.

Five categories often describe the purpose of small satellite missions: technology development/demonstration; communications; earth observation and remote sensing; science/space exploration; and reconnaissance. Historically smallsat missions focused on technology development and demonstration as seen in Figure 3. Led primarily by universities, this mission purpose is projected to decline, replaced by research on sister technologies such as low cost and disposable platforms to foster new disruptive satellite industry technology.[17]

Meanwhile, Figure 4 on the next page illustrates how other mission purposes, particularly earth observation and remote sensing missions run by primarily commercial groups are expected to increase and capture about half of the market by 2016.[18] As these trends suggest, the nano/microsatellite industry is expected to grow and has potential to contribute to numerous related industry sectors. Traditional customers of the satellite industry such as satellite TV, satellite radio, broadband, mobile satellite, and aviation are growing industries, demanding new products and services from the satellite industry.[19] Companies in these and other industries are also eager to develop space-based solutions to issues on Earth using low cost smallsat technologies.[20] Users range from the maritime industry, for tracking ships at sea to the widespread possible applications for drones or Unmanned Aerial Systems (UAS). Private and public sector entities, including the defense-related sectors are interested in communications and earth imaging. Indeed, many science and educational missions are currently developing research and building on the new opportunities that smallsats create.

Figure 3. Historical Nano/microsatellites (2009-2013) trends by purpose

[15] Ibid.
[16] Ibid.
[17] Deloitte (2015)
[18] Buchen Elizabeth (2014) SpaceWorks' 2014 Nano/Microsatellite Market assessment. 28th Annual AIAA/USU Conference on Small Satellites. Retrieved Sept 2015 from http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3018&context=smallsat
[19] The Tauri group (2015)
[20] Buchen Elizabeth (2015)

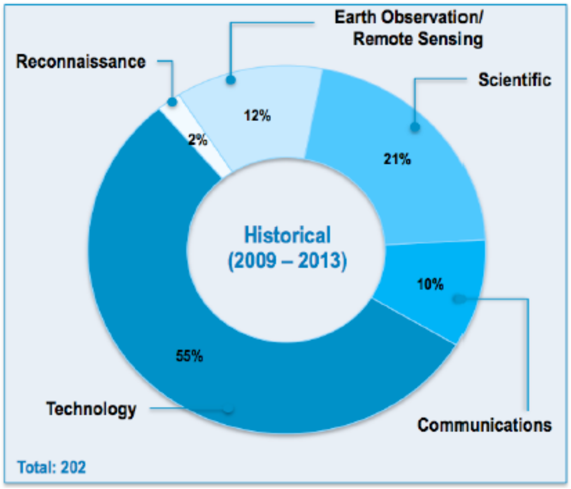
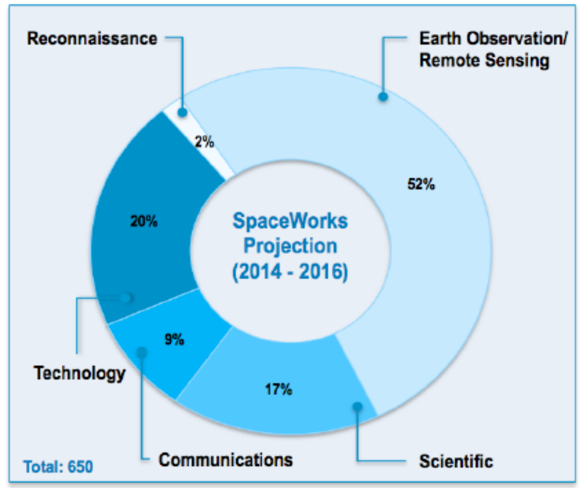


Figure 4. Future Nano/microsatellites (2014-2016) trends by purpose



Source: SpaceWorks´ 2014 Nano/Microsatellites Market Assessment

For example, smallsats and small sat-related research and development may help in more effectively commercializing UAS by supporting beyond-line-of-sight communications or augmenting fixed satellite service.[21] Satellites will become critical to the expansion of UAS networks and drone cloud infrastructure[22]. The potential is significant as UAS spending is expected to nearly double over the next ten years and total close to $91 billion as UAS applications grow. Current and emerging uses include search and rescue, weather forecasting, firefighting, disaster response, precision farming, commercial fisheries, scientific research and wildlife protection, aerial photography, delivery of goods in areas with poor infrastructure, communications relay, infrastructure monitoring and emergency management.

Even though the commercial sector is expected to grow in the Nano/Microsatellites Market, government space agencies continue to foster growth within the industry, especially for universities and non-profit organization groups in the civil sector. For instance, in the next five years, NASA's CubeSat Launch Initiative (CSLI) plans to select at least one CubeSat from each of the fifty states.[23] Market opportunities for small satellites continue to expand but require further research. In the past, most CubeSat and small satellite funding has come from federal funding agencies such as DARPA, NSF, and NASA's CubeSat Launch Initiative (CSLI). This funding has significantly contributed to the development of defense uses for small satellites such as the the Tactical Satellite (TacSat) microsatellite program intended to meet the needs of battlefield commanders.

A 2013 analysis of CubeSat launches found that most CubeSats launched up to that point were secondary (or tertiary) payloads capitalizing on the excess capacity of a rocket carrying a larger,

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[21] Aerospace Industry Asociation. (2015) Myth Vs Reality. Retrieved Sept 2015 from http://www.aia-aerospace.org/assets/UAS_Brochure__webready.pdf

[22] Bryan, C. (2015, April 20). Worldwide Drone Networks: Ready for Prime Time in Satellite. Accessible at http://interactive.satellitetoday.com/worldwide-drone-networks-ready-for-prime-time-in-satellite/

[23] Buchen Elizabeth (2015)

primary payload with only two "high-capacity" launches of ten or more CubeSats on the same rocket, though three more were scheduled for 2013. The author predicted the average number of missions per launch will rise, driven by launch capacity in the US and Russia and programs such as NASA's Educational Launch of Nanosatellites (ELaNa) program. The study also projected there will be many more deployments carrying ten or more missions.[24] In late 2013 and 2014, high-capacity launches from private companies such as Orbital Sciences and Kosmotras helped bear out these predictions.

Section III: The Potential for the Virginia Small Satellite Initiative to Strengthen Virginia's Aerospace Cluster

The Virginia Small Satellite Initiative holds potential to grow a small-satellite cluster and to strengthen Virginia's overall aerospace cluster. Clusters, as originally defined by Micheal Porter, are close groups of inter-connected companies and associated institutions in a particular industry sector. Clusters are important because proximity of location encourages collaboration and inter-industry cooperation which spurs economic development.

Technology-based economies such as Silicon Valley in California, Research Triangle in North Carolina and Route 128 in Massachusetts have shown us that successful regions specializing in technology-based industries like nano/microsatellites require:

- A research base that generates new knowledge;
- Mechanisms for transferring knowledge to the marketplace;
- An entrepreneurial culture;
- Sources of risk capital; and,
- A technically skilled workforce.[25]

Clusters also benefit from the support of an array of related industries and supportive infrastructure and other public and private entities including governments, universities, research labs, investors, and industry associations. Virginia has a number of such assets. Virginia's leadership role in the aerospace and aviation industry was cemented in 1917, with the establishment of America's first civil aeronautics laboratory in Hampton. The facility is now known as the NASA Langley Research Center.

NASA Langley Research Center is one of the oldest field centers for NASA. In 2014, NASA Langley's economic impact on the Commonwealth of Virginia was reported to include 7,394 jobs the generation of $870.2 million in economic impact[26]. In 2013 the FAA reported that

[24] Swartwout, M. (2013). The First One Hundred CubeSats: A Statistical Look. JoSS, Vol. 2, No. 2, pp. 213-233.
[25] State Science and Technology Institute (SSTI), "What is TBED?", Found on September 3, 2015 at http://www.ssti.org/TBED.
[26] NASA Langley Research Center. (2014). *Endless Possibilities.* Retrieved from http://www.nasa.gov/sites/default/files/files/LaRC_2014_EndlessPossibilities.pdf.

more than 736 million passengers traveled on airlines in the United States. Each of these airliners carried some technology developed by Langley. Recently, Langley has worked on projects dedicated to reducing aircraft noise around airports, improving fuel efficiency, diminishing air congestion, and evaluating new aircraft designs. In 2014, NASA's Environmentally Responsible Aviation program used an innovative manufacturing process to design an aircraft that will improve safety and fuel-efficiency. This structure will be tested at Langley. Also, during this year, Langley administrated more than 90 Small Business Innovation Research and Small Business Technology contracts worth approximately $30 million[27].

NASA Langley engages in substantial atmospheric science research that deploys research capability on satellites, including Small Sats and Cubesats. In relation to the SmallSats Virginia Initiative, Langley can provide design, development, and environmental test and qualification expertise for CubeSat payloads and CubeSat and Small Sat flight systems as well as participation in other NASA Launch Opportunities.

Virginia also features many other federal, nonprofit, and private research facilities devoted to aerospace and aviation such as the Wallops Flight Facility on the Eastern Shore. The Wallops Flight Facility was established in 1945 by the National Advisory Committee for Aeronautics as an aeronautic research center. Currently, this center is a prime location for implementation and management of NASA's suborbital research program.[28] This facility employs over 1,100 workers and generates $829.3 million in economic benefits. It covers 6,000 acres on Virginia's Eastern Shore and has two research airports. Since its establishment, Wallops has launched more than 16,000 rockets carrying, satellites, technology development payloads, space and earth science experiments, and aircraft models. It supports missions for suborbital and orbital rocket vehicles by providing, but not limited to range safety, surveillance, vehicle tracking and communications, and command systems.[29]

Virginia's post-secondary institutions constitute a solid aerospace-related education and research network. Four year universities such as Hampton, Liberty University, Old Dominion, Virginia Tech, the University of Virginia, the College of William and Mary and others offer four year aerospace-related degrees. Private institutions and the state community college system offers a number of associates degrees and certificate programs.

Virginia is home to over 265 aerospace-related firms.[30] Some of the state's top employers in the industry include BAE Systems, NASA, Lockheed Martin, General Dynamics, Raytheon, Orbital Sciences Corporation, Rolls-Royce, and Boeing. Virginia's aerospace and aviation industry employed 23,427 workers in 2014, with an average salary of $88,052. There were an

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[27] NASA Langley Research Center. (2014). *Endless Possibilities.* Retrieved from http://www.nasa.gov/sites/default/files/files/LaRC_2014_EndlessPossibilities.pdf.

[28] NASA. *About Wallops.* Retrieved from http://www.nasa.gov/centers/wallops/about/index.html#.VRrWGe7F-84.

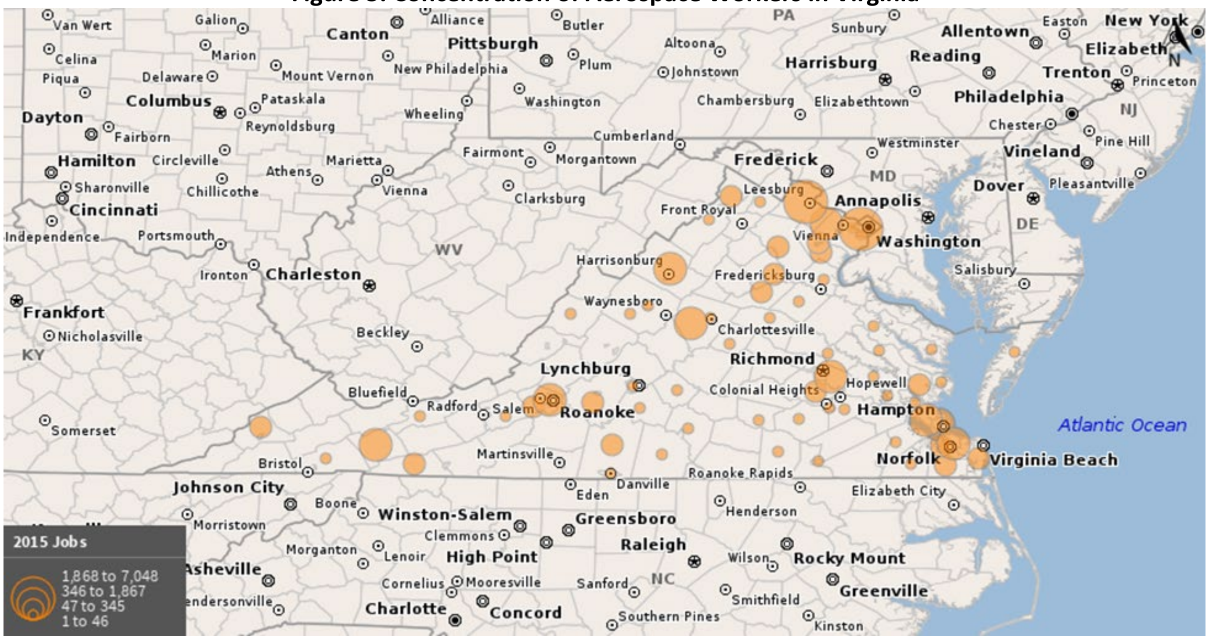
[29] NASA. *Wallops Flight Facility: NASA Facts.* Retrieved from http://www.nasa.gov/sites/default/files/files/WD13-065-001WallopsFactSheet2014.pdf.

[30] The Virginia Economic Development Partnership.

additional 2,132 public sector workers employed in the space research and technology industry in Virginia.[31]

There are significant aerospace-related employers scattered across the Commonwealth with employment most heavily concentrated in northern Virginia and the Hampton Roads region, as depicted in the image below.

Figure 5. Concentration of Aerospace Workers in Virginia



Source: EmsiAnalyst, QCEW+Non-QCEW Employees, 2015.1

A 2009 study commissioned by the Virginia Department of Aviation found that the civilian aviation and aerospace industry contributed $2.0 billion to the Virginia economy based on total wages and salaries.[32] The same study indicated that the space research and technology sector in Virginia had a higher location quotient (or a greater concentration of entities in this sector) than any other industry in the state in 2010 and possessed one of the highest annual average wages of all industry clusters examined.

The supply chain from aerospace and satellite-related industries in Virginia refers to the purchases this industry makes from all other industries and comprised more than 69 different NAICS code industry sectors in 2013.[33]

Virginia's competitiveness in aviation and aerospace may also be partially attributed to its proximity to the greater national capital region and its heavy concentration of government and military-related installations and contractors. Indeed, Virginia ranks first in the nation for U.S. Department of Defense Prime Contracts with $44.6 billion in fiscal year 2013.[34]

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[31] EMSI data and Bureau of Labor Statistics Quarterly Census of Employment and Wages, Seasonally Adjusted.
[32] 2011. *Virginia's Aviation and Aerospace State of the Workforce: 2011*. Chmura Economics.
[33] EMSI's model, incorporating data from the Bureau of Economic Analysis (BEA).
[34] Virginia Economic Development Partnership.

The Commonwealth Center for Advanced Manufacturing (CCAM) is another prominent driver for the aerospace industry in Virginia. CCAM member companies and its academic and government partners collaborate on research to lead to innovative manufacturing practices in aerospace, defense, and other related industries. Member aerospace industry companies include Airbus, Rolls-Royce, Aerojet Rocketdyne, and more. Rolls-Royce also opened its largest North American facility in Prince George County, Virginia to manufacture jet engine components and is partnering with the Commonwealth of Virginia, the University of Virginia and Virginia Tech in the Commonwealth Center for Aerospace Propulsion Systems (CCAPS), a virtual research and technology center of excellence.

Given the high industry wages in aerospace, the significant concentration of the industry in Virginia, and the wealth of cluster-related assets that are present in the Commonwealth, the aerospace industry is an important focus for economic development in Virginia. Section II details the growth of the small satellite market nationally and worldwide. Virginia, in some ways, has been at the vanguard of this growth. In November 2013, Orbital Sciences launched a rocket from Wallops with 29 nanosatellites, the most ever launched in one payload at that time, followed closely by a January 2014 launch of 33 satellites.

Virginia high school students at Thomas Jefferson High School for Science and Technology (TJHSST) made history in 2013 by building a TJ3Sat, pronounced TJ-cube-sat, which became the first-ever satellite built by high school students to be launched into orbit. Virginia also played an important role in the military's

multiple

Virginia businesses in the early development, start-up and expansion stage such as Arlington-based OmniEarth, an environmental analytics company with plans to place 18 satellites into orbit by 2018.[36] Dynetics, another Arlington-based entity, designs and builds satellites. Private industry in Virginia, with companies such as Orbital ATK and IntelSat General, possess a wealth of Small Sat capabilities including launch, payload and mission support services. STC is another Virginia enterprise, which also publishes an international, peer reviewed, Small Sat Journal.

In aerospace, the distinctions between private and public sectors are blurry. NASA and the defense agencies have boosted private space sector entrepreneurship through grants and contracts. However, with increasing spending constraints in the public sector, newer arrangements require private ventures to underwrite more of the financial burden and risk.[37] In

[35] Defense Industry Daily (2011) TAcSat -2 and beyond. Retrieved September 2015 from http://www.defenseindustrydaily.com/Small-Is-Beautiful-US-Military-Explores-Use-of-Microsatellites-06720/

[36] Kangarloo, K. (2015, April 28). "This Arlington startup." *Washington Business Journal*. Accessible at http://www.bizjournals.com/washington/blog/techflash/2015/04/this-arlington-startup-raised-1-3-million-aims-to.html?ana=e_wash_rdup&s=newsletter&ed=2015-04-28&u=Tsu/EauwCYNvRVAtRoGGyQ02a1c50a&t=1430232217

[37] See, for instance, Achenbach, J. (2013, November 23). Which way to space? *The Washington Post*. accessible at http://www.washingtonpost.com/sf/national/2013/11/23/which-way-to-space/

theory, the cost-savings pressures on the public and private sector should make cluster-related development even more relevant as the synergies and costs-benefits of proximity become more pressing.

Virginia's assets and positioning in the emerging small satellites sector are a solid foundation, but require nurturing. Other regions provide examples of what a flourishing niche-based aerospace cluster, such as small satellites, might produce. There are 17 space-related companies in Mojave, CA and up to 3,000 employees on a given day.[38] As another example, Silicon Valley is home to some of the largest industry players in the small satellites sector (such as Google and SpaceX) as well as a number of small-to-mid-size entrepreneurial satellite-related ventures such as Planet Labs and Nanosatisfi.

However, the industry is not limited to California and Texas. Kentucky and its higher education entities such as Morehead State and the University of Kentucky, has cultivated a burgeoning aerospace sector, including a small satellite focus. Aerospace products have become Kentucky's largest export totaling $5.6 billion in 2013, 22 percent of the value of all Kentucky exports.[39] A growing portion of Kentucky's focus is on small satellites and small technology for next generation spacecraft. Similar to the role that the Virginia Small Satellite Initiative would play, Kentucky Space LLC was created in 2010 as a non-profit corporation to coordinate university research with industry in the area of small satellites, with much of the work focusing on CubeSats. The state of Kentucky has invested $3 million annually in research funding and the early investment in the emerging small satellites sector has made Kentucky "clearly one of the global leaders in trying to work on and design this next generation of spacecraft. Our specialty is building small machines quickly."[40]

For Virginia to become an even more substantial player in the small satellite industry, state support at some level is vital, and as the impact numbers suggest, a small amount of support may reap many positive returns. In Kansas, a study of the aviation cluster revealed that state support for research investment in that sector generated a 9:1 return on that investment, from the leveraging of subsequent federal and industry dollars[41]. During the recession, Kansas continued to annually invest approximately $5 million in research expenditures related to the aviation industry, an identified economic cluster of importance in that state. The report advocated doubling that amount to $10 million per year and suggested the amount was because, "in the current aviation down-cycle, it is crucial our research and technology be expanded to protect our market share."[42]

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[38] Achenbach, J. (2013, November 23). Which way to space? The Washington Post. accessible at http://www.washingtonpost.com/sf/national/2013/11/23/which-way-to-space/

[39] Eblen, T. (2014, July 2016). Morehead space program shows Eastern Kentucky can aim high. *Lexington Herald-Leader*. Accessible at http://tomeblen.bloginky.com/tag/cubesats/

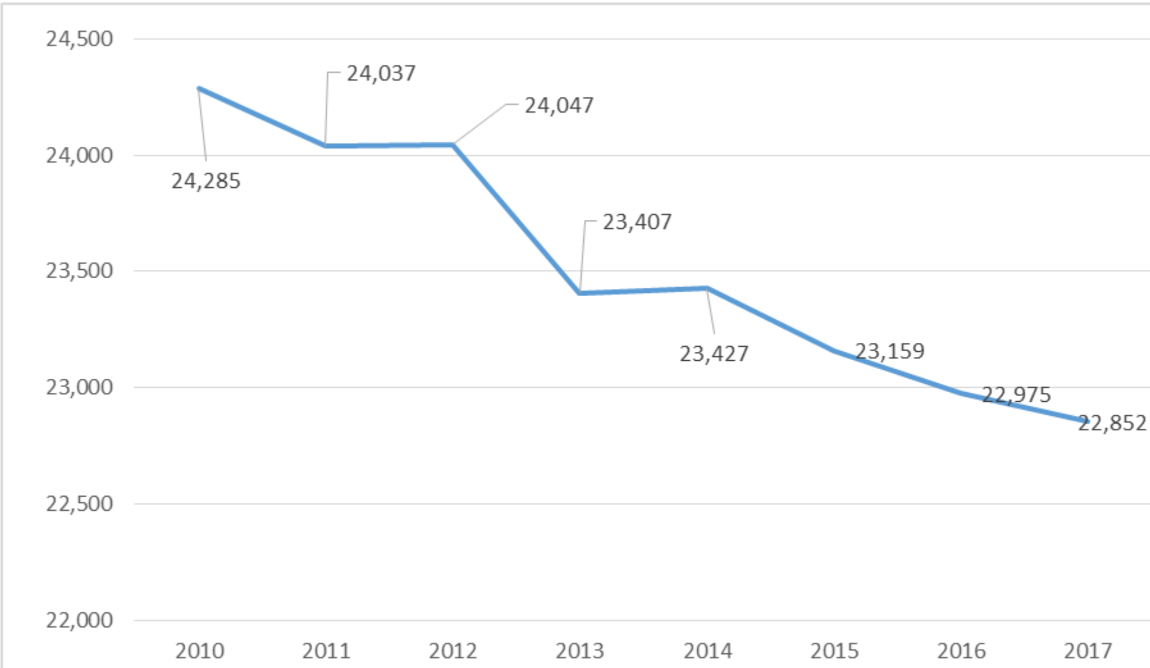
[40] Kimmel, K. qtd in Eblen, T. (2014, July 2016). Morehead space program shows Eastern Kentucky can aim high. *Lexington Herald-Leader*. Accessible at http://tomeblen.bloginky.com/tag/cubesats/

[41] Dieker, J. Kansas Aviation Industry Economic Outlook. Accessible at http://www.ncatkansas.org/docs/KS_Econ_outlook_John%20Dieker_v4.pdf

[42] Ibid.

Despite Virginia's many assets and strong positioning, there are some signs that this is a critical juncture for the aerospace industry in the Commonwealth. As illustrated in the table below, employment in the aerospace and aviation industry has declined slightly since 2010, mostly attributable to the after-effects of the recession and government sequestration.

Figure 6. Aerospace and Aviation Employment in Virginia 2010-2014[43]



Source: EmsiAnalyst, QCEW+Non-QCEW Employees, 2015.1

Deloitte's 2015 industry outlook for aerospace and defense predicts continued modest declines in defense-related spending. The report anticipates continuing defense sector challenges associated with how to increase profitability in a declining market and with how to best cut costs to maintain acceptable financial performance[44]. Given the significant presence of the defense industry in Virginia, this pressures may mount harder here than in some competitor states.

However, the Deloitte report highlights how successful defense companies are addressing these challenges by branching out into adjacent markets and investing in next generation product development in cyber security, defense electronics, precision strike, unmanned systems, and advanced analytics. Smallsat research and development is a prime opportunity area for this type of targeted diversification.

Moreover, the Deloitte report anticipates that revenue and earnings growth in the commercial aerospace sector is expected to be a bright spot and driving force behind the global aerospace

[43] Does not include NAICS 927110: Space Research and Technology

[44] Deloiite (2015). *2015 Global Aerospace & Defense Outlook*. Accessible at http://www2.deloitte.com/global/en/pages/manufacturing/articles/global-a-and-d-outlook.html

and defense (A&D) industry performance in the near future and may enjoy close to an 8 percent growth rate[45].

There are examples of clusters emerging quickly. In 2000, Morocco was home to only a handful of aerospace-related firms and had no discernible aerospace concentration. Over the next decade, the country experienced an unprecedented growth in the aerospace sector, partly due to industry cost-reduction imperatives. However, the rapid agglomeration of research assets and skilled workers also influenced the growth. The sector now consists of 50 companies, and provides 5000 jobs[46].

Ontario, Canada contains a thriving aerospace cluster with 350 aerospace and aviation companies, $6.4 billion in revenues, and over 22,000 skilled workers. Canada recognizes the significance of the sectors and they are overall Canada's largest recipient of research and development funding. The province of Ontario accounts for 30%, or $462 million, of all aerospace R&D in Canada. By focusing on research and other cluster-strengthening strategies such as those listed at the beginning of this report section, regional public and private sector leaders are focused on developing and nurturing their own version of a Silicon Valley-like 'innovation ecosystem'[47]

The French city of Toulouse and the surrounding regions of Midi-Pyrénées and Aquitaine are the base for one of the most competitive aerospace clusters internationally and the leading industry for French exports in terms of growth and of share.[48] The report describes the ways the French government helped catalyze the cluster's formation and growth through industry incentives, research funding, and anchor institution support. Similar to the manner through which the Virginia Space Grant Consortium expects to function in the proposed SmallSat Initiative, the French government sponsored an institution for collaboration (IFC) that worked to enhance the cluster by bolstering R&D collaboration[49]

The potential for SmallSats is enormous and attracting interest from industry heavy-hitters ranging from Samsung and Google to Elon Musk and Richard Branson. Both SpaceX and Virgin Atlantic are heavily investing in larger-scale development of small satellites in order to develop a lower cost, next generation worldwide communications infrastructure[50]. Not counting these ventures, a Euroconsult report projects the satellite industry to account for $255 billion in revenue over the next decade[51].

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[45] Ibid.

[46] India Science and Technology Ministry (2015.). Aerospace Report. Accessible at http://www.dsir.gov.in/reports/isr1/Aerospace/8_15.pdf

[47] Wallace, R. (2014). Ontario Aerospace Cluster Evolves 'Innovation Ecosystem' Approach. *Area Development Online*. Accessible at http://www.areadevelopment.com/Aerospace/Q2-2014/Ontario-aerospace-cluster-innovation-ecosystem-228155.shtml

[48] Harvard Business School (2013). *Aerospace Cluster in the Toulouse Region*. Accessible at http://www.aerospace-valley.com/sites/default/files/atoms/files/france_aerospace_2013.pdf

[49] Ibid.

[50] Peterson, M. (2015, January 16) Elon Musk and Richard Branson Invest in Satellite Internet Ventures. *Las Angeles Times.*

[51] EuroConsult. (2015). Satellites to be built and launched through 2024.

Beyond the IMPLAN numbers themselves, the cluster development literature and case examples from other regions such as those mentioned above, indicate that nurturing a cluster such as aerospace and small satellites in which significant assets and an already high concentration of industries exist makes sound economic sense. Public funding may help in developing markets, reducing risks for new and growing companies, and encouraging employment opportunities and future well-being for state residents. Moderate investment in developing the small satellite industry in Virginia can be expected to propel new startups, produce positive business spill over, and develop workforce competencies.