Virginia Commercial Space Flight Authority

Strategic Plan 2017-2022

December 1, 2016

VIRGINIA COMMERCIAL SPACE FLIGHT AUTHORITY

December 1, 2016

The Honorable Terry McAuliffe
Commonwealth of Virginia
Patrick Henry Building
1111 E. Broad Street
Richmond, VA 23219

Dear Governor McAuliffe:

As required by 2.2-2203.2. of the enabling legislation of the Virginia Commercial Space Flight Authority, please find enclosed the 2017-2022 Strategic Plan. This is the second installment and updates will follow every four years and as otherwise necessary.

Much has been accomplished and many challenges overcome by the Authority subsequent to the reconstitution of the VCSFA Board of Directors in 2012, which was required by Chapters 779 and 817 of the 2012 Acts of Assembly and Item 430 of the 2012-2014 Appropriations Act. Most notably, construction of the Mid-Atlantic Regional Spaceport Pad 0A was completed and Spaceport staff worked diligently to support a successful maiden voyage of the Orbital Antares rocket on April 21, 2013. Antares launched successfully four times from Pad 0A as part of CRS-1, the NASA Commercial Resupply Services contract to deliver cargo to the International Space Station (ISS). Concurrently, the NASA LADEE Mission to the Moon and ORS-3 launched from MARS Pad 0B. On October 28, 2013, the fifth Antares rocket suffered a catastrophic launch failure, causing approximately $15M in damage to the MARS Pad 0A infrastructure and assets.

Virginia Space entered a restructuring phase both physically and operationally in 2015. The MARS team worked diligently to rebuild Pad 0A and implement modifications to accommodate Orbital ATK's redesigned Antares rocket using new RD-181 engines. Virginia Space executive leadership worked with Orbital ATK, NASA, the US Congress and the Commonwealth to secure a solution for funding repairs and managing risk going forward. Pad 0A rebuild was complete on September 30, 2016. After all systems were certified a First Stage Engine Hot-Fire Test was conducted in May 2015, proving both the functionality of the new rocket and the rebuilt pad. On October 17, 2016, the Orbital ATK Antares rocket carrying the Cygnus spacecraft successfully returned to flight on the OA-5 mission to the ISS.

Looking to the future, MARS has a robust launch schedule with Antares launches on the CRS-1 contract which extends through 2018 followed by the recently awarded CRS-2 cargo resupply missions to the ISS that extends launches through 2024. Also, several potential DoD, science and commercial launches look promising for future launches off both MARS Launch Pads. Virginia's Spaceport has transitioned to the role of a sustainable facility and focus has shifted to attracting new business as launch providers mature and provide expanded services. Virginia sent a clear and strong message of support to the aerospace industry when Commonwealth legislators funded Spaceport operations through 2024, the current end-life of the ISS.

4111 Monarch Way, Suite 303 Norfolk, Virginia 23508
Phone: (757) 440-4020 FAX: (757) 440-4023

The MARS UAS Runway is nearing completion at the north end of Wallops Island with business development efforts strongly underway and flights to commence in early 2017. The Runway is attractive to government, DoD and their contractors due to its location on a secure federal facility and in a maritime environment. The ability to launch unmanned systems from off-shore vessels and land them on the runway is extremely beneficial to several potential customers. While the surrounding area is rural and testing can be completed in a discreet operating environment within restricted airspace, the MARS UAS Runway is only two hours away from Washington, DC. This close proximity reduces travel time and costs for businesses working with the Pentagon and other businesses in the DC metropolitan area.

Virginia Space is also excited about a revolutionary concept currently in development called PocketQube satellites. As part of our STEM legislative directive, we are working with Orbital ATK, NASA, and Twiggs Space Labs to provide elementary, middle school, high school and college students the opportunity to build and launch small satellites at an extremely affordable cost. This program will contribute to Virginia STEM initiatives by providing a project-based curriculum with real world experience as students build, test, launch, collect data and track their PocketQube through Extreme Low Earth Orbit (ELEO).

Finally, our organization has worked methodically to develop a strong management team and recruit a local work force through a highly successful internship program that targets future engineers and technicians from Virginia universities and the Eastern Shore Community College. Approximately 20% of the MARS workforce is now comprised of hires from the internship program. This recruitment method has reduced turnover and created stable, high-tech, 21st century jobs for the local economy.

The Virginia Commercial Space Flight Authority has changed the way we conduct business. Commonwealth assets are protected against damage and we are able to provide a state-of-the art launch facility at highly competitive prices. This is a direct result of the efforts by you personally, as well as, Secretary Aubrey Layne in renegotiating the service contract with customer Orbital ATK. I am extremely appreciative of your leadership in helping bring about these changes and accomplishments and I look forward to continuing our efforts to make the Mid-Atlantic Regional Spaceport at Wallops Island a premiere technology and economic driver for Virginia's New Economy.

Sincerely,

Dale K. Nash
Executive Director
Virginia Commercial Space Flight Authority

Table of Contents

1.0 EXECUTIVE SUMMARY 1
1.1 Purpose 1
1.2 Overview 1
1.3 Strategic Objectives 2
1.4 Strategic Direction 3
2.0 BACKGROUND 4
3.0 2012-2017 STRATEGIC PLAN REVIEW 7
3.1 Objective 1: Provide a framework for Orbital ATK's success as the "initial launch" customer 7
3.2 Objective 2: Develop MARS infrastructure to satisfy customer needs, manage the business, and enhance competition 8
3.3 Objective 3: Position Virginia Space as a leading launch service provider 8
3.4 Objective 4: Develop Virginia Space as a self-sustaining entity 9
3.5 Objective 5: Develop an efficient and competitive organization 9
3.6 Objective 6: Establish partnerships to promote research and commercial opportunities.. 9
3.7 Objective 7: Explore space tourism and other developing opportunities 11
3.8 Objective 8: Stimulate economic growth and provide a positive impact to the Commonwealth 11
4.0 MARKET DESCRIPTION 13
4.1 Launch Service Past Performance 15
4.2 2017-2022 US Launch Service Forecast 15
4.3 2017-2022 MARS Launch Forecast 16
5.0 COMPETITIVE POSITIONING 16
5.1 Current FAA-Licensed Spaceports 18
5.1.1 Florida Spaceports 19
5.1.2 California Spaceports 20
5.1.3 Alaska Spaceports 21
5.2 Market Differentiation 22
5.3 SWOT Analysis 23
5.3.1 Strengths 23
5.3.2 Weaknesses 23
5.3.3 Opportunities 23

5.3.4 Threats 24
5.4 Spaceport Customers 24
5.4.1 Existing Space Launch Customers 24
5.4.2 New Space Launch Customers 25
5.5 Virginia Space Diversification 30
5.5.1 Unmanned Systems (UMS) Customers 31
5.5.2 PocketQubes 34
6.0 STRATEGIC APPROACH 36
7.0 STRATEGIC PLAN 37
7.1 Objective 1: Provide a framework for Orbital ATK's continued success for Antares ISS Resupply Missions 37
7.2 Objective 2: Support Orbital ATK's efforts to secure additional Antares launches ... 37
7.3 Objective 3: Support Orbital ATK's efforts to secure additional Minotaur I and Minotaur IV launches 38
7.4 Objective 4: Secure a second (and possibly a third) space launch customer that utilizes the MARS facilities or the new NASA flat pad for Venture class launch vehicles 38
7.5 Objective 5: Diversify into adjacent aerospace markets and secure additional customers to better utilize existing assets and personnel 39
7.6 Objective 6: Expand current infrastructure to add additional economic benefit and growth opportunities for Virginia Space 40
7.7 Objective 7: Maintain Virginia Space as a sustainable entity to maximize the return on the state's existing investments 40
7.8 Objective 8: Provide and enhance education in aerospace technologies and processes in conjunction with universities, industry, and government 40
7.9 Objective 9: Establish Virginia as a leading space industry hub in the US to benefit both residents and businesses in the state 41
9.0 REFERENCES 44

List of Figures

Figure 1-1. Mid-Atlantic Regional Spaceport (MARS). 1
Figure 1-2. Virginia Space Facilities 2
Figure 1-3. Strategic Plan Approach 3
Figure 2-1. Pad 0A Medium Class Liquid Facility 4
Figure 2-2. Pad 0B Small Class Solid Facility 5
Figure 2-3. Launch Pad Repair 5
Figure 2-4. Facility Security Upgrades 6
Figure 3-1. 2012-2017 Strategic Plan Objectives 7
Figure 3-2. Historical Launches, 2011-2016. 8
Figure 3-3. Virginia Space Interns. 10
Figure 3-4. Space Tourism. 12
Figure 4-1. Operational US Orbital Launch Vehicles. 13
Figure 4-3. US Suborbital Launch Vehicles. 14
Figure 4-2. Planned US Orbital Launch Vehicles. 14
Figure 4-4. Total US Orbital Launches by Location, 2011-2016 15
Figure 4-5. Forecast for US Commercial Launches 2017-2022. 16
Figure 4-6. Forecast for MARS Launches 2017-2022 16
Figure 5-1. MARS Launch Trajectories 17
Figure 5-2. FAA Licensed Launch Sites 18
Figure 5-3. SpaceX's Brownsville Texas Site. 19
Figure 5-4. The California Spaceport® Site 21
Figure 5-5. Pacific Spaceport Complex Alaska 22
Figure 5-6. Orbital ATK Antares Orbital Launch Vehicle 24
Figure 5-7. Orbital ATK Minotaur I Orbital Launch Vehicle 25
Figure 5-8. Orbital ATK Minotaur V Orbital Launch Vehicle 25
Figure 5-9. Rocket Lab Electron. 27
Figure 5-10. Firefly Alpha 27
Figure 5-12. bSpace Volant. 28
Figure 5-11. Vector Space Wolverine 28
Figure 5-13. Super Strypi 29
Figure 5-14. Virgin Galactic LauncherOne. 29
Figure 5-15. Unmanned Aircraft System 31
Figure 5-16. Virginia Space Runway 32
Figure 5-17. US Navy Triton UAS. 34
Figure 5-18. Launching Small Satellites from Antares 35
Figure 6-1. Virginia's Space Workforce 36
Figure 7-1. Diversification into adjacent markets. 39

1.0 EXECUTIVE SUMMARY

Virginia Space's strategic plan offers a path to an exciting aerospace core that creates jobs, promotes scientific activity, and is a gateway to space for the Commonwealth of Virginia.

Virginia Space's strategic plan provides a path for continued growth over the next five years and beyond in diverse areas, enhancing the Commonwealth of Virginia's investment

- Anchor tenant Orbital ATK's Antares missions to ISS are firm through 2024, providing stability for Virginia Space.
- Additional Minotaur flights and nanosat launches from MARS add diversity and reduce overall costs.
- Expansion into the adjacent markets of unmanned systems provides dynamic growth.
- The introduction of CubeSats and PocketQubes design, manufacture, and launch based in Virginia help demonstrate that education and research are a priority.

1.1 Purpose

This Strategic Plan ("the Plan") is developed in response to Chapters 779 and 817 of the 2012 Acts of Assembly (HB 813/SB 284), which requires the Virginia Commercial Space Flight Authority to submit a strategic plan to the Governor and the General Assembly no later than December 1, 2016.

The Plan evaluates the current state of the Virginia Commercial Space Flight Authority (Virginia Space), the industry landscape, Virginia Space's competition, and available launch forecasts and trends. Building on these items, the Plan describes the strategic objectives and key actions for Virginia Space for the 2017 to 2022 period.

1.2 Overview

Virginia Space operates the Mid-Atlantic Regional Spaceport (MARS) located at the NASA Wallops Flight Facility (WFF) at Wallops Island, Virginia (Figures 1-1 and 1-2).

Virginia Space is permitted to use the land for MARS and does business with NASA through a regularly renewed Space Act Agreement. MARS is only one of four spaceports in the United States licensed by the FAA Commercial Space Transportation Office to launch to orbit allowing it to compete for the small-to-medium class launch vehicle market providing access to the Earth's orbit and interplanetary missions. It is also one of only two East Coast launch sites capable of launching to orbit and inclinations that are critical to NASA, government and other commercial customers.

Key drivers that will shape the future of Virginia Space are:

- NASA International Space Station (ISS) Resupply Missions
- Prospective Department of Defense (DoD) missions on the Minotaur launch family

Figure 1-1. Mid-Atlantic Regional Spaceport (MARS). *Virginia Space operates the Mid-Atlantic Regional Spaceport (MARS), a key gateway to space providing a bright and vibrant future for the Commonwealth of Virginia.*

Figure 1-2. Virginia Space Facilities. *Virginia Space's orbital launch facilities are modern and efficient, providing a base for years of future activity.*

- Prospective NASA science missions on Antares
- Additional space launch customers and missions
- Diversification into adjacent aerospace markets

By effectively focusing on these key drivers, the strategic objectives for Virginia Space will be met in the next five years.

1.3 Strategic Objectives

Virginia Space's ten strategic objectives for 2017-2022 are:

- **Objective 1:** Provide a framework for Orbital ATK's continued success for Antares/Cygnus ISS Resupply Missions
- **Objective 2:** Support Orbital ATK's efforts to secure additional Antares launches
- **Objective 3:** Support Orbital ATK's efforts to secure additional Minotaur family launches with plans to expand to Minotaur VI
- **Objective 4:** Secure a second (and possibly a third) space launch customer that utilizes the MARS facilities
- **Objective 5:** Diversify into adjacent aerospace markets (such as Unmanned Systems services) and secure additional customers use for better utilization of existing assets and personnel
- **Objective 6:** Expand current infrastructure to add economic benefit and growth opportunities for Virginia Space
- **Objective 7:** Maintain Virginia Space as a sustainable entity to maximize the positive economic impact from the state's existing investments
- **Objective 8:** Provide and enhance education in aerospace technologies and processes in conjunction with universities, industry, and government
- **Objective 9:** Establish Virginia as a leading space industry hub in the US to benefit both

residents and businesses in the state

1.4 Strategic Direction

Virginia Space has a unique heritage and a vibrant future because of the re-energizing efforts that have been completed by the Commonwealth during recent years. Recent actions taken by the Governor and the General Assembly have demonstrated that Virginia Space will be given the opportunity to grow and benefit from the future of space exploration. Based on the forecasted growth in demand from the US government, military agencies, international users, and commercial space customers for orbital access, Virginia Space is well positioned to meet the current and forecast launch demand through 2022 and beyond.

As such, Virginia Space will adhere to a policy of making appropriate investments to attract customers while carefully monitoring the space market development, civil, national security and commercial launch needs, and launch capacity supplied by other states. The Authority will balance longer-term Virginia Space investments with benefits those investments provide for the Commonwealth regarding jobs, education, and industry growth.

This strategy allows Virginia Space to grow rapidly, but strategically, with the space industry. It does not commit significant public funds to investment in areas that are speculative or still evolving. It also does not commit funds to areas that are not suitable for MARS. The plan positions Virginia Space to capitalize on its current strengths, proactively follow the market, quickly adapt to serve changing industry demands and attract new business to the Commonwealth of Virginia (Figure 1-3).

Strategic Approach	Strategic Objectives
Keep and grow the current core business	▪ **Objective 1:** Provide a framework for Orbital ATK's continued success for Antares/Cygnus ISS Resupply Missions ▪ **Objective 2:** Support Orbital ATK 's efforts to secure additional Antares launches ▪ **Objective 3:** Support Orbital ATK's efforts to secure additional Minotaur family launches with plans to expand to Minotaur VI
Attract additional launch customers	▪ **Objective 4:** Secure a second (and possibly a third) space launch customer that utilizes the MARS facilities
Diversify the customer base	▪ **Objective 5:** Diversify into adjacent aerospace markets (such as Unmanned Systems services) and secure additional customers use for better utilization of existing assets and personnel ▪ **Objective 6:** Expand current infrastructure to add economic benefit and growth opportunities for Virginia Space ▪ **Objective 7:** Maintain Virginia Space as a sustainable entity to maximize the positive economic impact from the state's existing investments
Enhance the region's aerospace footprint	▪ **Objective 8:** Provide and enhance education in aerospace technologies and processes in conjunction with universities, industry, and government ▪ **Objective 9:** Establish Virginia as a leading space industry hub in the US to benefit both residents and businesses in the state

Figure 1-3. Strategic Plan Approach. *The 2017-2022 Strategic Plan's goals map into nine distinct objectives to grow the space business in Virginia.*

2.0 BACKGROUND

Virginia Space was created by the General Assembly in 1995 to pursue the following four objectives:

- Develop and enhance infrastructure that facilitates timely, efficient, safe, and low-cost access to space
- Provide education and research in aerospace technologies and processes
- Preserve, as a national asset, the expertise and capability for launch operations resident at the NASA Wallops Flight Facility
- Stimulate aerospace-related economic activity in the region

Virginia Space is charged with operating the Mid-Atlantic Regional Spaceport (MARS), an FAA-licensed, full-service spaceport located on the southern portion of Wallops Island. Because of its geographic location, MARS is attractive for launch azimuths from 38 to 60 degrees making it an ideal location from which to reach the International Space Station (ISS).

MARS currently operates two space launch pads:

- Pad 0A, a Medium Class Launch Facility (MCLF) comprised of a state of the art cryogenic liquid fuel facility with a computer controlled commodities system, fortified launch mount, robust electrical and environmental control systems, and gravity fed fresh water deluge system (Figure 2-1). Pad 0A currently hosts the Orbital ATK Antares launch vehicle under contract through at least 2024 to deliver cargo to the International Space Station (ISS), with potential for significant other NASA, government, and commercial payload business.
- Pad 0B, a Small Class Launch Facility (SCLF) comprised of a launch stool, moveable service structure, and environmental control system (Figure 2-2). Pad 0B has hosted primarily

Figure 2-1. Pad 0A Medium Class Liquid Facility. *Pad 0A is a state of the art launch pad for medium class liquid oxygen/kerosene launch vehicles.*

Orbital ATK Minotaur class launch vehicles and is capable of significant reconfiguration to host nearly any existing small class launch vehicle on the market. Minotaur I to Minotaur V vehicles launched from Pad 0B includes the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission to the moon.

Besides the two launch facilities, MARS operates support infrastructure facilities including vehicle and payload processing integration facilities, support instrumentation and emergency facilities.

The recovery and rebuild of Pad 0A following the catastrophic launch failure of the ORB-3 Antares mission on October 28, 2014 was completed in September 2015. All Pad 0A systems were returned to operational status equivalent to or in better condition than what existed before the ORB-3 mishap. This rebuilding effort was accomplished in less than a year and within the budget of $15M (Figure 2-3). This rebuild was achieved by securing federal funding, as well as equitable contributions from Orbital ATK and Virginia Space.

Figure 2-2. Pad 0B Small Class Solid Facility. *Pad 0B is a state of the art launch pad for small solid fueled launch vehicles. The LADEE mission to the moon is shown.*

Virginia continues to play a vital role in

Figure 2-3. Launch Pad Repair. *Repair of Pad 0A was completed ahead of schedule to support future flight efforts.*

national security and assured access to space, as one of only four states in the United States licensed by the FAA to launch spacecraft into orbit or on interplanetary trajectories. MARS is only one of two launch sites capable of providing cargo resupply services to the ISS. MARS is also only one of three locations that currently provide Operationally Responsive Space (ORS) support for DoD. With the significance of these critical national missions, Virginia Space Executive Staff, Commonwealth of Virginia leaders, and the Congressional Delegation continue to pursue increases in funding from the both the Commonwealth and the Federal Government to adequately fund launch facility improvements at NASA Wallops, MARS, and maintain the newly developed launch capabilities as well as our nation's assured access to space.

Through these efforts, Virginia Space secured $2.65M in funding in the federal FY 2015 Appropriations Act to enhance spaceport capability to provide launches to mid-to-low inclination orbits in support of the national security space program. Three subtasks were performed throughout 2016 and contained specific projects with an overarching focus on enhancing rapid-response launch capability, ground system reliability, up-time for launch support, and increasing security protocols for Pad-0A. These projects were completed within the budget (Figure 2-4).

Although there are some states interested in developing spaceports and competing for federal and commercial customers, Virginia and Alaska are the only two non-federal spaceports that have ever successfully built, operated and launched rockets to orbital destinations and to have anchor customers providing a regular rate of launches for the spaceports. This distinction is likely to remain for some time, as the only other viable spaceport for launch to orbit under construction is SpaceX's private facility in Brownsville, TX. The current planned initial operating capability for the SpaceX pad is no earlier than 2018. Most of the other federally licensed state spaceports are inland and are capable of supporting only suborbital launches.

Figure 2-4. Facility Security Upgrades. *Facility security upgrades were made possible through Federal funding.*

3.0 2012-2017 STRATEGIC PLAN REVIEW

In reviewing the 2012-2017 Strategic Plan[i], it is clear that significant progress was made on all objectives. At the time the plan was released, Pad 0A construction had just been completed. Systems testing and check-out was ongoing and a launch had not yet occurred. Since the plan was developed the following has taken place:

- Antares successfully flew from Pad 0A four times
- Antares suffered a significant failure on its fifth flight
- Repairs and upgrades have been made to the facility
- Antares was redesigned to incorporate new engines
- Antares successfully returned to flight
- The Minotaur LADEE mission flew from Pad 0B to the moon
- The Minotaur ORS-3 mission successfully launched from Pad 0B

Despite the unforeseen events of the 2012-2017 timeframe, Virginia Space met almost all of the goals outlined in the strategic plan.

The objectives and status from the 2012-2017 Strategic Plan are listed below in Figure 3-1.

Objective	*2012-2017 Strategic Plan Objectives*	*Achieved?*
1	Provide a framework for Orbital ATK's success	Yes
2	Develop MARS infrastructure to satisfy customer needs	Yes
3	Position MARS as a leading launch service provider	Yes
4	Develop Virginia Space as a self-sustaining entity	Revised Goal
5	Develop an efficient and competitive organization	Yes
6	Establish partnerships to promote research and commerce	Yes
7	Explore space tourism and other developing opportunities	Yes
8	Stimulate economic growth and provide a positive impact to Virginia	Yes

Figure 3-1. 2012-2017 Strategic Plan Objectives. *Virginia Space met almost all of the strategic objectives from the Strategic Plan for 2012-2017 (Dec 1, 2012) through strong management and legislative support.*

3.1 Objective 1: Provide a framework for Orbital ATK's success as the "initial launch" customer

Without a doubt, this objective has been met. MARS is now a fully operational and dynamic spaceport. Since 2012, six missions have launched from MARS Pad 0A, and two missions have launched from MARS Pad 0B, all in support of Orbital (now Orbital ATK, due to a recent merger). Two additional Antares launches are planned for 2017.

Contracts are in place with Orbital ATK that provides launch services support for the current ISS contract and future missions through at least 2024. The catastrophic launch failure of the ORB-3 Antares mission restructured the relationship between Virginia Space and Orbital ATK, but both entities responded to rebuild the pad and return Antares to flight in a compressed timeframe and provide for a long-term strengthened partnership.

Beyond ISS contracts, Virginia Space understands Orbital ATK's future launch business objectives and is working hand in hand with them to help bring additional launches to MARS.

3.2 Objective 2: Develop MARS infrastructure to satisfy customer needs, manage the business, and enhance competition

Virginia Space has developed the infrastructure to meet current customer needs, and it continually reevaluates infrastructure needs based on prospective customer demands and the availability of federal and state funding.

MARS has the capability to be a multi-user facility as evidenced by both Antares launches and Minotaur launches. Had Lockheed Martin's Athena launch vehicle continued, it would have been a viable user for Pad 0B. Given the dynamic and fluid nature of prospective new entrants to the small launch market, MARS has been engaging in regular discussions but waiting to determine serious interest and whether they will come to market before expending significant funds to adapt facilities. Some high-profile new entrants have gone defunct before their first launch which provides a useful note of caution on making significant investments in infrastructure absent a firm launch commitment and demonstration of real payload customers.

MARS has updated its current infrastructure to reflect current needs and continues to seek opportunities to leverage federal resources, improve facilities to serve current customers, and appeal to prospective launch providers.

3.3 Objective 3: Position Virginia Space as a leading launch service provider

Focusing on small and medium-lift launches, Virginia Space is now a leading US launch site, with nine missions flown in the 2011-2016 timeframe. Only the two federal spaceports, Cape Canaveral Air Force Station (CCAFS) and Vandenberg Air Force Base (VAFB), have flown more launch vehicles from the US in the same timeframe (Figure 3-2).

Spaceport	*Ownership*	*Orbital Launches, 2011-2016*
Cape Canaveral Air Force Stations (FL)	Federal	77
Vandenberg Air Force Base (CA)	Federal	20
Mid-Atlantic Regional Spaceport (VA)	State	9
Pacific Spaceport Complex Alaska (Kodiak, AK)	State	1

Figure 3-2. Historical Launches, 2011-2016. *Mid Atlantic Regional Spaceport has hosted nine Minotaur and Antares Launches from Pad 0A and Pad 0B in the 2011 to the 2016 timeframe.*

Virginia Space's mission costs are competitive with other sites. MARS's lean manifest permits flexibility and responsiveness to change with customer needs. With some flights completed, costs are well understood. Efficiencies to reduce cost have been introduced, such as:

- Transitioning from a contractor-heavy workforce to in-house personnel
- Streamlined management team
- Process and system improvements to increase effectiveness and reliability

3.4 Objective 4: Develop Virginia Space as a self-sustaining entity

This objective depends more on the market and external influences than direct actions of Virginia Space. As the "tail of the dog," the launch site is at the end of the launch value chain. Many external factors drive the eventual selection of the launch site such as:

- Satellite/payload type
- Orbit requirements
- Launch vehicle type

These factors make marketing the spaceport to customers a long-term project, something that is not easily accomplished overnight. Marketing for a launch site is a continual process that requires the constant expenditure of resources to ensure a pipeline of future business. Virginia Space and NASA Wallops continue to engage and pursue launch opportunities with multiple launch customers. As a result, this goal has been revised to ensure that Virginia Space is a sustainable entity for the future.

Virginia Space has worked hard to maximize the benefits from state funding through the optimal use of resources. This is accomplished through a cost-effective mix of external contractors and internal management resources.

Virginia Space has also developed partnerships with other states and educational institutions to share costs and benefits of launch facilities, however not much has come of these agreements to date due to customer requirements that often do not overlap.

3.5 Objective 5: Develop an efficient and competitive organization

Virginia Space has been successful in aggressively developing a lean, competitive organization to compete with other spaceports for business. Through top-level leadership, proactive management at the operational level has kept existing customers satisfied and new customers interested. Management has clearly established core values that focus on efficiency and mission success and has demonstrated those values over various launch operations.

Virginia Space is highly respected in the space community due to its strong leadership and record of success. This has been recognized by the recent appointment of its Executive Director to the FAA's Commercial Space Transportations Federal Advisory Committee (COMSTAC) to represent the entire US spaceport community.

3.6 Objective 6: Establish partnerships to promote research and commercial opportunities

To accomplish its educational mission, Virginia Space participates in activities and organizations related to STEM education, including programs sponsored by professional aerospace organizations. Virginia Space executes its charter to support STEM education through multiple venues including a very productive summer internship at MARS.

Virginia Space has been an active contributor to Virginia STEM education across the commonwealth and on the Eastern Shore. The objective is to contribute to building regional talent within the aerospace community through a summer internship program. Efforts to support the growth and development of future employees in science, technology, engineering, and mathematics, have been incorporated into the Virginia Space/Mid-Atlantic Regional Spaceport internship program since 2010. During this time, eighteen students have participated and twelve

are now full-time Virginia Space employees. In 2016, the internship program had 65 applicants for the engineering program alone.

During the summer of 2016, as the Pad was prepared for Antares' return to flight mission, Virginia Space provided six internship opportunities; three engineering and three technical. Virginia Space also funded for the second consecutive year, an internship position for NASA at Wallops Flight Facility on the Eastern Shore. Staten Longo from the University of Virginia, Paige Pruce and Ryan McGuire from the University of Maryland, all rising seniors, filled the openings as Engineering Interns. Amanda Thomas, Charles Galloway, and Vincent Bailey, all three graduates of the Eastern Shore Community College, were selected as Technician Interns (Figure 3-3). Upon completion of this year's program, Vincent is now a full-time employee of the Pad Support team, Amanda is a full-time employee on the Quality team, and Charles is a full-time employee with the Systems Operations team.

In order to help establish partnerships with research institutions and industry, Virginia Space's Executive Director serves on the boards of the Space Transportation Association (STA), Commercial Spaceflight Federation (CSF), the SpaceTEC Advisory Committee, the Commercial Space Transportation Advisory Committee (COMSTAC), and National Association of Spaceports (NAS). These positions help provide high-level exposure to federal and commercial customers, launch providers and education partners at the national level.

Figure 3-3. Virginia Space Interns. *Virginia Space's intern program is a key educational outreach effort that develops local talent in aerospace career fields. Pictured from left to right: Staten Longo, Paige Pruce, Amanda Thomas, Ryan McGuire, Charles Galloway and Vincent Bailey.*

3.7 Objective 7: Explore space tourism and other developing opportunities

Virginia Space has continued to assess developments in the market for space tourism and explore the potential to leverage MARS facilities in order to benefit from this developing market. Due to recent setbacks in the development and viability of these systems, this opportunity has not developed at the pace that was originally envisioned. Currently, the space tourism sector remains a largely speculative market that is not backed up by long-term government or corporate contracts, and largely dependent on a limited pool of wealthy individuals who have the interest and resources to participate in short, suborbital flight experiences.

There have also been two notable setbacks that illustrate the challenges of this market. On 31 October 2014, the fourth rocket powered test flight of one of the Virgin Galactic's Spaceship Two craft, VSS Enterprise, ended in disaster as it broke apart in midair with the debris falling into the Mojave Desert in California shortly after being released from the mothership resulting in a fatality and serious injury. Virgin Galactic has only recently returned to captive carry flights with a replacement vehicle. There is no firm date for commercial suborbital tourist flights at this point. Virgin Galactic has committed to using Spaceport America (Truth or Consequences, NM) for its commercial tourist flights.

Additionally, it is anticipated that another space tourism vehicle, XCOR's Lynx Space Plane could take off in early 2017. However, funding for the project is in flux and a recent leadership turnover at the company may impact this project. XCOR's commercial suborbital flights are expected to originate and land at the Midland International Air and Space Port (Midland, TX).

MARS, along with NASA Wallops Flight Facility, is positioned to react quickly to take advantage of any opportunities in this market in the future should they be a viable proposition while carefully watching each company's progress to ensure that funds are expended only when the projects become viable (Figure 3-4).

3.8 Objective 8: Stimulate economic growth and provide a positive impact to the Commonwealth

Development of the commercial aerospace industry in Virginia has had a tremendous economic impact. According to a report by the Performance Management Group at Virginia Commonwealth University entitled, *"Competitive Analysis of Virginia's Space Industry"*[ii], the Virginia space industry contributes $7.6 billion in annual direct economic output and directly supports 29,638 jobs. Virginia holds a number of competitive advantages among those states excelling in the space industry. MARS is one of only four sites licensed by the FAA Office of Commercial Space Transportation to launch to orbit and one of only two sites capable of serving the International Space Station. Additionally, Virginia is home to the NASA Langley Research Center (LARC) and several other large Federal space related organizations, and as such is the recipient of a significant portion of the Federal budget for space. Finally, according to the Information Technology and Innovation Foundation[iii], Virginia ranks second in the number of scientists and engineers as a percentage of the workforce, second in the concentration of high-tech jobs as a percentage of the workforce, and sixth in non-industry investment in research and development.

Figure 3-4. Space Tourism. *Space tourism has yet to "take off", but bears close watching as the market develops. (NY Times photo).*

State economic development benefits, legislation, and zones established to encourage commercial space business in Virginia include the following:

- "Zero Gravity, Zero Tax" that provides state income tax incentives to locate and headquarter space flight launch and training business operations in Virginia
- Spaceflight Liability and Immunity Law, where the space flight entity is not liable for a participant injury, resulting from the risks of space flight activities in Virginia
- FOIA relief to the customer, when doing business with Virginia Space
- Enterprise Zone established on the Eastern Shore
- Foreign Trade Zone established on the Eastern Shore

4.0 MARKET DESCRIPTION

In 2015, there were a total of 86 orbital launches conducted by service providers in seven countries. Most of this launch activity is captive; that is, the majority of payload operators have existing agreements with launch service providers (often owned or subsidized by the government, in the case of international launches) or do not otherwise "shop around" for a launch.

Since about 2004, the annual number of orbital launches conducted worldwide has steadily increased. This has been due primarily to government activity, which tends to launch national payloads in a cyclical manner based on the age of satellite constellations. US government launches remain steady. For example, the retirement of the Space Shuttle in 2011 decreased the number of US launches per year relative to the previous three decades. However, commercial cargo missions to the International Space Station (ISS) have helped to fill the resulting gap.

The market for space launches primarily includes customers such as:

- Government agencies such as NASA, DoD, NRO and DARPA
- Private sector companies that use satellites to generate income, such as Intelsat General, O3B, Digital Globe, Terra Bella, etc.

These customers form the principle sources of demand for launch services

There are currently eight expendable launch vehicle types available for use by satellite customers in the United States (Figure 4-1).

Vehicle	*Operator*	*Year of First Launch*	*Total Launches 2015*	*Active Launch Sites*
Antares	Orbital ATK	2013	0	MARS
Atlas V	ULA/LMCLS	2002	9	CCAFS VAFB
Delta IV	ULA	2002	3	CCAFS VAFB
Falcon 9	SpaceX	2010	7	CCAFS VAFB
Taurus/ Minotaur-C	Orbital ATK	1989	0	CCAFS MARS VAFB
Pegasus XL	Orbital ATK	1994	0	CCAFS MARS VAFB
Minotaur I	Orbital ATK	2000	0	VAFB MARS
Minotaur IV/V	Orbital ATK	2010	0	VAFB MARS PSCA

Figure 4-1. Operational US Orbital Launch Vehicles. *These launch vehicles are currently available for use by US customers in 2016.*

The commercial launch market has not grown significantly during the past decade. There are some signs the commercial launch market may be expanding. However, several new launch vehicles are being developed specifically to address what some believe is a latent demand among small satellite operators. These vehicles are designed to launch payloads with masses of 500 kg (1,102 lb.) to low Earth orbit (LEO). Though the price per kilogram remains high relative to larger vehicles, their value is in scheduling. Small satellite operators, especially those with constellations of many satellites, can have greater control over their business plans. Previously, these small satellites would routinely "piggyback" as a secondary payload on a launch carrying a much larger payload. That primary payload dictated the schedule and the orbital destination.

Some of these new vehicles are in advanced stages of development are shown in Figure 4-2.

Vehicle	Operator	Planned First Launch	Possible US Launch Sites
Alpha	Fire Fly	2018	TBD
New Glenn	Blue Origin	2020	CCAFS
Cab-3A	CubeCab	2017	TBD
Electron	Rocket Lab	2016	PSCA MARS
Falcon Heavy	SpaceX	2017	KSC VAFB
GOLauncher-2	Generation Orbit	2017	Cecil Field Spaceport
LauncherOne	Virgin Galactic	2017	Mojave Spaceport Wallops
Lynx Mark III	XCOR Aerospace	2018	Midland
SOAR	Swiss Space Systems	2018	TBD
Stratolaunch	Stratolaunch Systems	TBD	Mojave KSC
Vulcan	ULA	2019	CCAFS VAFB
Wolverine	Vector Space Systems	2018	PASCA CCAFS MARS
Volant	bSpace	2018	TBD MARS
Space Launch System	NASA	2018	KSC

Figure 4-2. Planned US Orbital Launch Vehicles. *These US launch vehicles are currently in the design and development phase.*

Suborbital reusable vehicles (SRVs) are part of an emerging industry with the potential to support new markets shown in Figure 4-3. SRVs are commercially developed reusable space vehicles that travel just beyond the threshold of space, about 100 km (62 mi) above the Earth. While traveling through space, the vehicles experience several minutes of microgravity and provide relatively clear views of the Earth.

Many of these represent a capture opportunity for Virginia Space, should they complete development and come to market.

Operator	*Vehicle*
Blue Origin	New Shepard
Masten Space Systems	Xaero Xombie Xogdor
UP Aerospace	SpaceLoft XL
Virgin Galactic	Spaceship Two
XCOR Aerospace	Lynx

Figure 4-3. US Suborbital Launch Vehicles. *These suborbital launch vehicles are currently planned or available for use by US providers.*

4.1 Launch Service Past Performance

Within the United States, the majority of the launch activity in 2011-2016 took place out of KSC/Cape Canaveral (FL), with MARS (VA) and Vandenberg (CA) splitting the remainder of the manifest (Figure 4-4). Unlike MARS, which has had a series of orbital launches in 2013 and 2014, PSCA has not had an orbital launch since 2011.

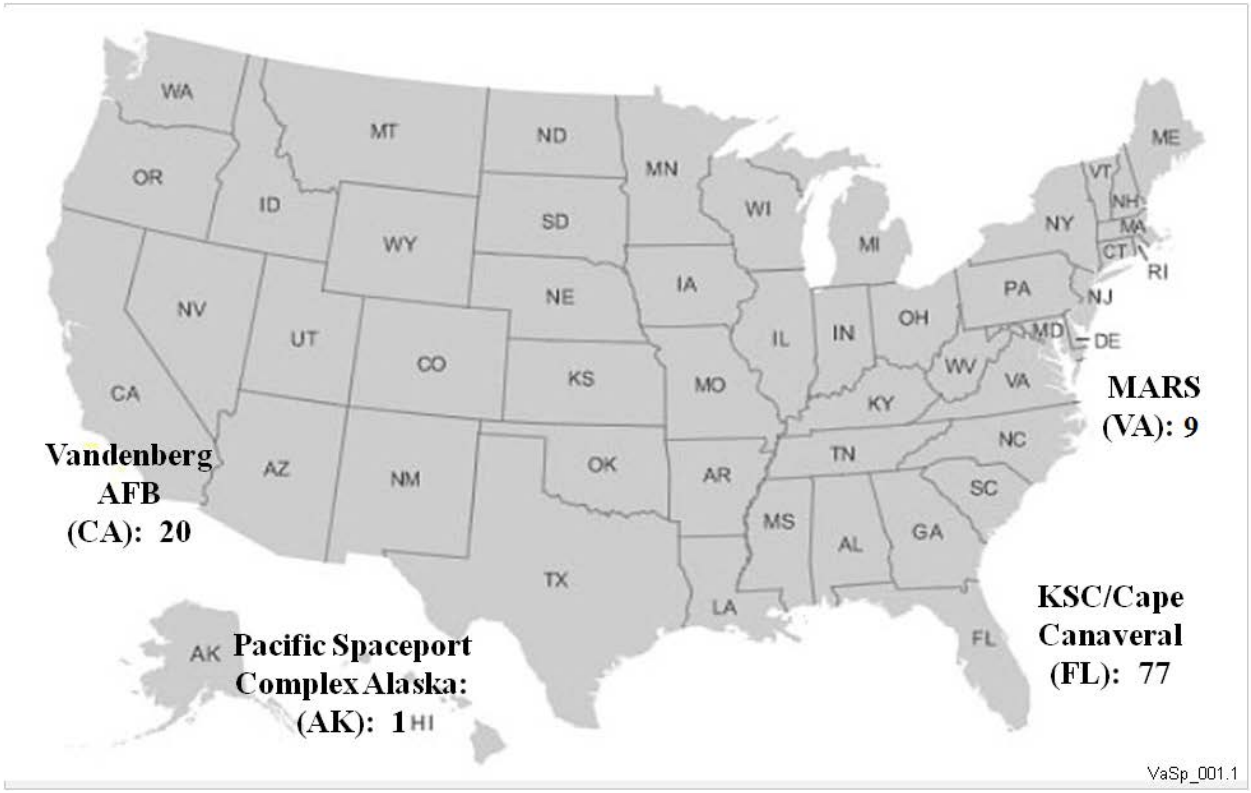

Figure 4-4. Total US Orbital Launches by Location, 2011-2016. *The majority of launches in the US are launched from Florida but Virginia has made significant progress since 2011.*

4.2 2017-2022 US Launch Service Forecast

The Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST) develops an annual forecast for commercial launch demand for all space systems deployed to non-geosynchronous orbits (NGSO), including low Earth orbit (LEO), medium Earth orbit (MEO), elliptical orbits (ELI), and external trajectories (EXT) to the Moon or other solar system destinations[iv],[v]. First compiled in 1994, the forecast assesses payloads most likely to seek commercial launch services during the next ten years. Commercial launches, as defined for this report, include those whose services are found on the international market. It also includes US domestic commercial launch services licensed by the FAA, such as commercial launches to the International Space Station (ISS). For this plan, commercial launches to geosynchronous orbit are ignored as MARS currently does not have the capability to support such launches.

Launch demand for non-geosynchronous orbits (NGSO) are divided into two vehicle capacity groups. The launches in the next ten years are predominantly commercial launches to the ISS that require medium-to-heavy vehicles.

Extracted from that report, Figure 4-5 shows the forecast for US Commercial launches 2018 through 2022 in the potential addressable market for MARS.

Category	2017	2018	2019	2020	2021	2022
NGSO Medium-to-Heavy	15	13	11	10	10	10
NGSO Small	4	2	1	0	1	0
Total	19	15	12	10	11	10

Figure 4-5. Forecast for US Commercial Launches 2017-2022. *The potential addressable market for MARS is a subset of these projections.*

4.3 2017-2022 MARS Launch Forecast

There are several important aspects to consider when evaluating a launch facility-specific forecast. Critical factors in determining an optimal launch location include existing launch pad infrastructure, supported payload size, and specific launch vehicles and launch azimuth for orbital access. Key selection criteria for spaceports include launch schedule, support and service, perceived capability and recognition, and mission cost.

Based on the FAA forecast, the MARS forecast was developed (shown in Figure 4-6). It assumes the following:

Category	2017	2018	2019	2020	2021	2022
NGSO Medium	2-3	2-4	2-4	3-4	3-4	3-4
NGSO Small	-	1-2	1-2	1-2	1-2	1-2
Total	2-3	3-6	3-6	4-6	4-6	4-6

Figure 4-6. Forecast for MARS Launches 2017-2022. *This forecast provides a conservative view of future MARS launches.*

- Orbital ATK Antares flights to ISS conducted at a nominal rate of 2 per year
- Orbital ATK secures additional Antares flights (ISS, NASA science or commercial customer) starting in 2018, at the rate of minimum one per year
- USAF-sponsored Minotaur Launch Vehicle flights are anticipated in 2018 through 2022
- An additional small launch flight provider begins service at MARS in 2019 and launches at a rate of two missions per year starting in 2020

Launch forecasts are impacted by the current political and economic landscape, social and educational aspects of space exploration, and technological advancements. Historically, projections for commercial space launch activity have exceeded actual launches. Because of the complex nature of launch activity, launches are susceptible to delays and cancellations. Accordingly, Virginia Space should take a balanced view of market forecasts.

5.0 COMPETITIVE POSITIONING

At the rate of 2-6 launches per year, Virginia Space can operate in a very cost effective manner. They key to capturing these future launches is to ensure that MARS is well positioned to compete for these projected launches as well as other opportunities.

Notably, MARS is one of only two US spaceports capable of launching to the ISS to support NASA's human spaceflight program. It currently provides 50 percent of US launch capacity to support the station through critical cargo deliveries. MARS also provides an important second launch site to the ISS in the event a launch failure, natural disaster, or national security event impacting launch facilities in Florida.

In addition to supporting NASA's human spaceflight program, MARS is capable of launching additional NASA science, NOAA and government payloads, either on the Antares rocket from Pad 0A or on the Minotaur rockets from Pad 0B. NASA and other commercial customers are likely to use the Antares rocket which launches exclusively from MARS in the years ahead.

A wide variety of launch trajectories is available from MARS. For most vehicles, orbital inclinations between 38 and 60 are achievable. With in-flight maneuvers, sun synchronous orbits are possible, adding to the value of the launch site. Figure 5.1 illustrates the launch trajectories flown from MARS.

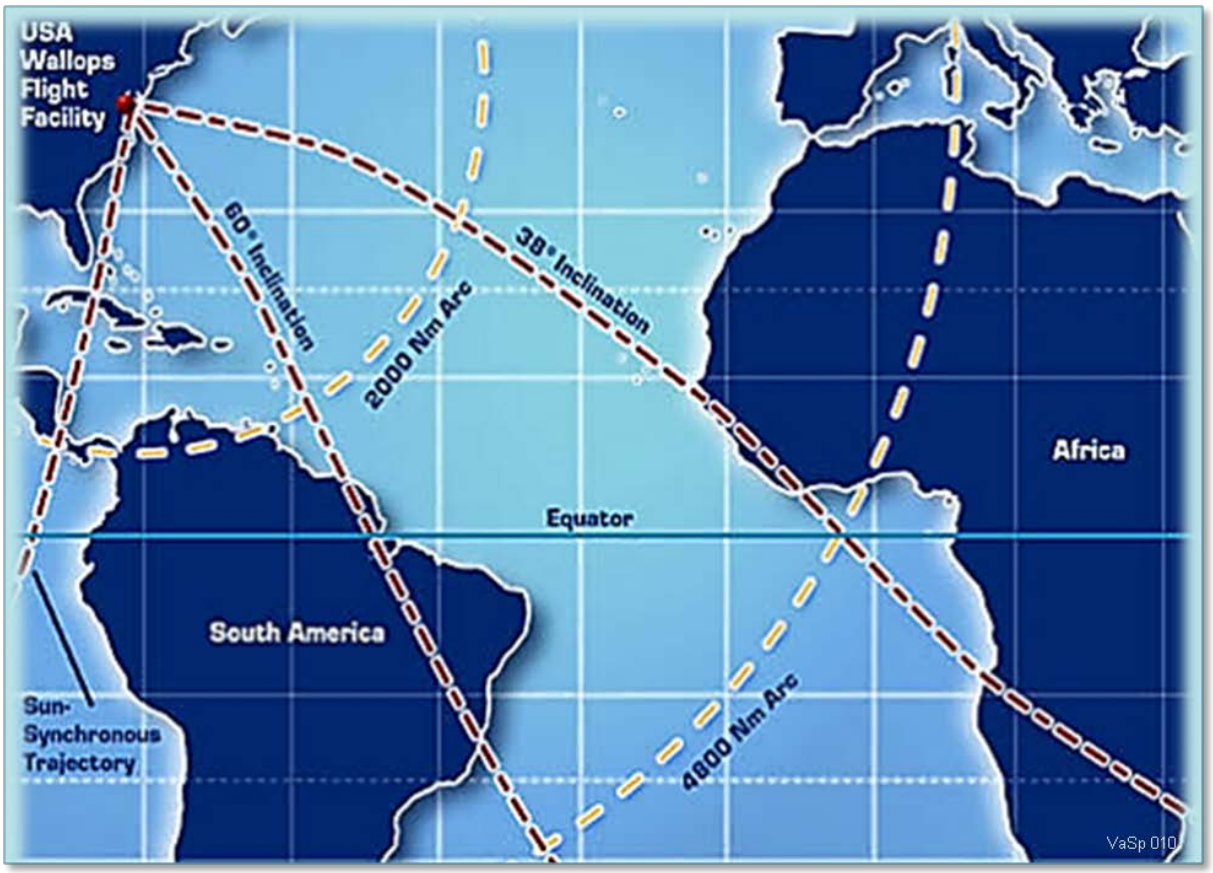

Figure 5-1. MARS Launch Trajectories. *Vehicles launched from MARS can fly to a wide variety of orbits, increasing the number of potential launches the site can attract.*

MARS benefits from several key factors:

1. Operating both liquid engine and solid motor pads, which provides a diversity of launch options using and/or leveraging existing infrastructure and experience

2. An experienced in-house workforce capable of supporting launches from both types of rockets.
3. A non-congested range environment compared to Cape Canaveral, where a delay in one company's launch can have significant cascading impacts and delays on other launches
4. Strong support from Virginia's Governor and Administration, the General Assembly as well as Virginia and Maryland Congressional Delegations

5.1 Current FAA-Licensed Spaceports

FAA AST licenses commercial launch and reentry sites in the United States. As of the end of 2015, FAA AST had issued ten launch site operator licenses, as listed in Figure 5.2.

Launch Site and State	Operator	License First Issued	Launch Type	2016 Flights
California Spaceport, CA	Spaceport Systems International	1996	Orbital or suborbital	0
Mid-Atlantic Regional Spaceport, VA	Virginia Commercial Space Flight Authority	1997	Orbital or suborbital	1
Pacific Spaceport Complex - Alaska, AK	Alaska Aerospace Corporation	1998	Orbital or suborbital	0
Cape Canaveral Spaceport, FL	Space Florida	1999	Orbital or suborbital	TBD
Mojave Air and Space Port, CA	East Kern Airport District	2004	Suborbital only	0
Oklahoma Spaceport, OK	Oklahoma Space Industry Development Authority	2006	Suborbital only	0
Spaceport America, NM	New Mexico Spaceport Authority	2008	Suborbital only	TBD
Cecil Field Spaceport, FL	Jacksonville Aviation Authority	2010	Suborbital only	0
Midland International Airport, TX	Midland International Airport	2014	Suborbital only	0
Ellington Airport, TX	Houston Airport System	2015	Suborbital only	0

Figure 5-2. FAA Licensed Launch Sites. *MARS is one of only ten licensed launch sites in the United States.*

VAFB and CCAFS, because they are owned and fully funded by the DoD, are not considered commercial sites and not licensed by the FAA, though they may host FAA-certified commercial flights.

Each of these states, except California, have state-owned space authorities responsible for facilitating commercial space activity. Of the ten licensed operators, only Virginia, California, Florida, and Alaska have spaceports that are licensed and currently equipped with infrastructure to launch payloads into orbit. These are "vertical launch to orbit" spaceports.

The remaining spaceports are "runway-based". Most are airports that have been expanded to accommodate horizontal launch and landing of the suborbital vehicle. These spaceports are better suited for space tourism and suborbital research.

Four additional private spaceports are in use or under construction at this time:

- Blue Origin's Van Horn, TX site, used for suborbital launch and landing tests
- Blue Origin's Cape Canaveral, FL site, planned for launches to orbit
- SpaceX's McGregor, TX site, used for suborbital launch and landing tests
- SpaceX's Brownsville, TX site, planned for launches to orbit **(**Figure 5-3)

Figure 5-3. SpaceX's Brownsville Texas Site. *When complete, SpaceX's Brownsville TX site may compete for launches with Virginia Space. (Photo: SpaceFlightNow.com).*

The private companies' suborbital test sites do not compete with Virginia Space's future operations but the two sites that permit launches to orbit will have an impact.

Blue Origin is building the "New Glenn" launch vehicle, paying tribute to John Glenn, the first American to orbit Earth. Only NASA's Space Launch System launch vehicle will be taller. These are large rockets with planned versions standing 270 feet and 313 feet tall. The basic two-stage New Glenn generates 3.9 million pounds of thrust from seven BE-4 engines when it blasts off from Cape Canaveral Air Force Station's Launch Complex 36, possibly before the end of the decade. Though taller, the New Glenn is not as powerful as SpaceX's Falcon Heavy which will generate more than 5 million pounds of thrust. While the land for the site is CCAFS, Blue Origin is leasing the site from Space Florida and is making a significant private investment to build out the launch infrastructure.

When SpaceX's Brownsville site becomes operational (reportedly in 2018), it will compete for certain launches with MARS due to the eastern trajectories flown from the site. It is expected that most of the missions flown from the Brownsville site will be used to put geosynchronous satellites into orbit. The SpaceX Brownsville site is used exclusively by SpaceX and is not planned to support other launch vehicles at this time.

Each of the four US orbital launch sites have unique advantages and disadvantages depending on the mission requirements. Generally speaking, mid-inclination to equatorial orbits are best accessed from Virginia or Florida's launch sites and used for NASA's human spaceflight program, government, science, and communications. High-inclination and polar orbits accessed from California or Alaska's launch sites are used for government, earth-mapping, science, reconnaissance, some communications and weather satellites.

5.1.1 Florida Spaceports

Florida has long been the epicenter of civil space activity. There are three organizations located at Cape Canaveral: Cape Canaveral Air Force Station, NASA Kennedy Space Center, and state-owned Space Florida. All organizations share land, assets, and resources for launching space vehicles and have the capacity to launch small, medium and heavy lift vehicles. All commercial launches operate out of Cape Canaveral, while the Kennedy Space Center has served only NASA-related missions to date. Space Florida was created to "be the world leader in developing tomorrow's aerospace enterprise." These entities benefit from 60+ years of

significant federal investment in infrastructure, and have "excess" facilities, including payload processing, assembly and launch pads, that they make available to commercial customers at very low or no cost.

Cape Canaveral Air Force Station (CCAFS) is an installation of Air Force Space Command's 45th Space Wing and is the primary launch head of America's Eastern Range, with three active launch pads, Space Launch Complexes 37, 40, and 41. It is located on Merritt Island, south of NASA's Kennedy Space Center, and has a 10,000-foot-long runway. The US government has used CCAFS since 1949. SpaceX launches its Dragon spacecraft to resupply the International Space Station from SLC-40 at CCAFS.

Kennedy Space Center (KSC) is NASA's Launch Operations Center supporting Launch Complex 39 (LC-39) originally built for the Saturn V, the largest and most powerful operational launch vehicle in history, for the Apollo program. Since the Apollo program, LC-39 has been used to launch every NASA human spaceflight including Skylab, the Apollo-Soyuz Test Project, and the Space Shuttle Program. Most recently, SpaceX signed an agreement with NASA to lease Launch Complex 39A for the Falcon Heavy,and the company began modifying the facility in 2014. Starting in 2014, KSC's OPF-1 and OPF-2 began the modification process to accommodate the Air Force's X-37B space plane, and Boeing signed a lease agreement with NASA in 2014 to use OPF-3 for the CST-100 Starliner crewed capsule currently in development for use in transporting crew to the ISS.

Cecil Field Spaceport (CFS) is the only licensed horizontal launch commercial spaceport on the East Coast and it is owned and operated by the Jacksonville Aviation Authority (JAA). CFS is positioned on 150 acres of dedicated spaceport development property adjacent to the runway and taxiway system at Cecil Airport near Jacksonville, Florida. It is specially designed with a 12,500-foot-long runway, 18L-36R, to launch and recover space vehicles that take off and land horizontally. Prompted by a Space Florida resolution, legislation to amend the Florida statutes to designate Cecil a "Space Territory" passed, allowing Space Florida to include it in master planning efforts and space-related infrastructure upgrades. Cecil Field Spaceport may be a future competitor to MARS in the suborbital reusable vehicle market.

Florida, with its historical ties to NASA and US manned space program, is one of the strongest space states in the country and it appears it will continue to serve as one of the nation's premier launch facilities for space launches.

5.1.2 California Spaceports

Spaceport Systems International (SSI) operates The California Spaceport®, a 100% commercially run Satellite Processing Facility and Space Launch Facility located on Vandenberg Air Force Base, California (Figure 5-4). SSI offers full service access to space from the California central coast. The site has the capability to launch small and medium payloads to high inclination (150 – 270 degrees) launch azimuths. Due to the orbits flown from the California Spaceport, it only competes with MARS for very few suborbital missions.

Figure 5-4. The California Spaceport® Site. *The picture above depicts the Spaceport site as viewed from the south looking toward Space Launch Complex 6 (SLC-6). (Photo: California Spaceport).*

Vandenberg Air Force Base (VAFB) is under the jurisdiction of the 30th Space Wing, Air Force Space Command (AFSPC). It is the only location in the United States where both commercial and government polar orbiting satellites are launched. Launches from VAFB are unique in that an entire mission, from launch to orbital insertion, takes place over open water. VAFB also conducts ballistic missile defense missions, conducting space and missile launches since 1959. VAFB also manages the West Coast Off-shore Operating Area which controls air space for aircraft testing.

5.1.3 Alaska Spaceports

The Alaska Aerospace Corporation (AAC) operates out of the Pacific Spaceport Complex – Alaska (PSCA). Used for US military and defense missions, PSCA currently can launch small and medium lift launch vehicles to polar orbit, and PSCA is the only US spaceport that can launch high inclination missions without land over-flight and the requirement to resort to energy consuming dogleg flight segments. AAC is a state-owned corporation that permits it to operate in a commercial manner with state employees. (Figure 5-5).

Alaska is also home to the Poker Flat Rocket Range (PFRR), a suborbital sounding rocket range near Fairbanks, Alaska. PFRR's mission is similar to NASA Wallops Flight Facility (WFF), and in fact, operates under contract to NASA WFF. It is owned and managed by the University of Alaska, Fairbanks (UAF). PFRR is home to five launch pads, two of which optimized are for extreme weather conditions. The 5,000-acre facility has performed more than 1,700 launches to study the Earth's atmosphere and its interaction with the space environment.

5.2 Market Differentiation

MARS competes most directly with the Florida launch sites because of the orbital inclinations available from both sites are similar. Here are the factors that differentiate MARS from the Florida sites:

Figure 5-5. Pacific Spaceport Complex Alaska. *PSCA can also launch Minotaur's, but to vastly different orbits, making their capabilities complimentary to Virginia Space's. (Photo: Alaska Aerospace).*

MARS

- Best latitude for access to ISS, given fuel efficiencies, realized from orbital dynamics
- Proximity to Orbital ATK's Dulles Campus, MARS's primary customer
- Commercial launches are not interrupted by higher priority DoD and NASA missions due to the client's mix and launch rate
- Use of a NASA range, rather than a US Air Force range, resulting in increased flexibility and responsiveness for customers
- Proximity to the nation's leadership and various government agency headquarters
- Proximity to numerous research organizations and universities

Kennedy Space Center / Cape Canaveral Air Force Station (Florida)

- Latitude allows for economic launch to Geo-synchronous Earth Orbit (GEO), but need more powerful launch vehicles (or, as a trade, less payload) to reach ISS than required for a launch from Wallops
- Historical capability to launch 12-18 missions per year, but pads are shared by DoD, NASA, and commercial users so private users typically have lower priority which often results in costly delays
- Space Florida uses significant state funds to provide grants and loans to incentivize potential customers to launch from Florida
- Significant existing and surplus infrastructure built by the Federal government over 60+ years of launch activity that is available to Space Florida and commercial customers at low- or no cost

Because California and Alaska launch to highly incline polar orbits, they do not directly compete with Virginia. MARS does have some capability to launch to highly inclined orbits depending on the orbit parameters and payload size.

5.3 SWOT Analysis

Based on the above assessments, a SWOT (strengths, weaknesses, opportunities, and threats) analysis is updated for Virginia Space from the previous strategic plan (2012-2017). The findings of this report are summarized below.

5.3.1 Strengths

- MARS' geographic location is ideal for launch to orbit and the International Space Station (ISS)
- The facility is FAA licensed for orbital launches
- The Virginia Space's primary customer, Orbital ATK, is one of three large commercial companies that have a contract with NASA for ISS resupply missions through the mid-2020s
- NASA owns WFF and has a large stake in its success, so the agency has an interest in seeing successful launches take place at the facility
- Wallops Research Park provides an excellent location and resources for commercial space companies
- Strong support from the Virginia Governor and Administration, the General Assembly as well as Virginia and Maryland Congressional Delegations
- Virginia is a leader in passing state legislation to offer tax and financial incentives to commercial space companies that settle and conduct operations within its borders
- Virginia has several well-known and reputable research and technical universities that work with MARS for educational and research opportunities to benefit MARS customers
- Space companies are exempt from import duties when importing equipment for launching out of Wallops as the facility is designated as foreign trade zone by the Commonwealth

5.3.2 Weaknesses

- Reliance on NASA contracts may provide for periods of inactivity should NASA prefer a different launch site for certain missions or a flight failure grounds Antares
- Current levels of state funding may make it difficult to expand Wallops infrastructure and operations in the short term
- Aged Wallops infrastructure surrounding the facility reduces ease of access
- Florida offers a broader range of financial incentives to secure launch customers than Virginia

5.3.3 Opportunities

- Virginia Space management structure and funding allow the Authority to improve the infrastructure and technical capabilities to support current customers and attract new customers
- Development of a payload processing facility and secured operations facility may bring additional launches
- Expansion of Wallops Research Park, positioned close to the launch facility, provides an attractive environment for commercial space companies to conduct operations at MARS
- Expansion of NASA's existing 8,750 feet horizontal runway to 10,000 feet has potential for

attracting other types of commercial space flight, specifically space tourism and suborbital vehicles

- An attractive legal framework provides incentives for new commercial space companies to locate their business in Virginia and launch from MARS
- An emerging market for smaller and less expensive missions for research, experiments and quick reaction capabilities presents a potential opportunity for MARS
- Virginia Space/MARS can become another scientific and technical hub in the Commonwealth where industry, federal government agencies, the Virginia educational system, and the Department of Transportation (VA) provide the impetus to move to the next level in the commercialization of space

5.3.4 Threats

- Florida and Texas are making moves to secure a larger portion of the launch business
- NASA may choose to award more cargo launches to SpaceX or use a Cygnus on ULA's Atlas out of Florida, constraining the number of Antares missions
- Finite land area for expansion may limit Virginia Space's ability to build new launch pads to service other customers
- Some of the potential new launch providers may not come to market due to technical or financial reasons, limiting the number of real growth opportunities
- Premature shut down or loss of the ISS would remove the anchor customer for MARS launch services

5.4 Spaceport Customers

5.4.1 Existing Space Launch Customers

Virginia Space anchor tenant Orbital ATK is a launch service provider and manufacturer of small to medium lift launch vehicles, satellites, and space systems for commercial, government, and military customers. Orbital ATK manufactures satellites and spacecraft for travel to geosynchronous orbit, low earth orbit, and deep space.

5.4.1.1 Orbital ATK's Antares Orbital Launch Vehicle

Orbital ATK announced on January 14, 2016 that it has been selected by NASA for a second contract to provide commercial cargo delivery and disposal services to and from the ISS. Under the Commercial Resupply Services-2 (CRS-2) contract, the company was awarded six initial cargo missions valued at about $1.2-$1.5 billion to be carried out beginning in 2019. Depending on

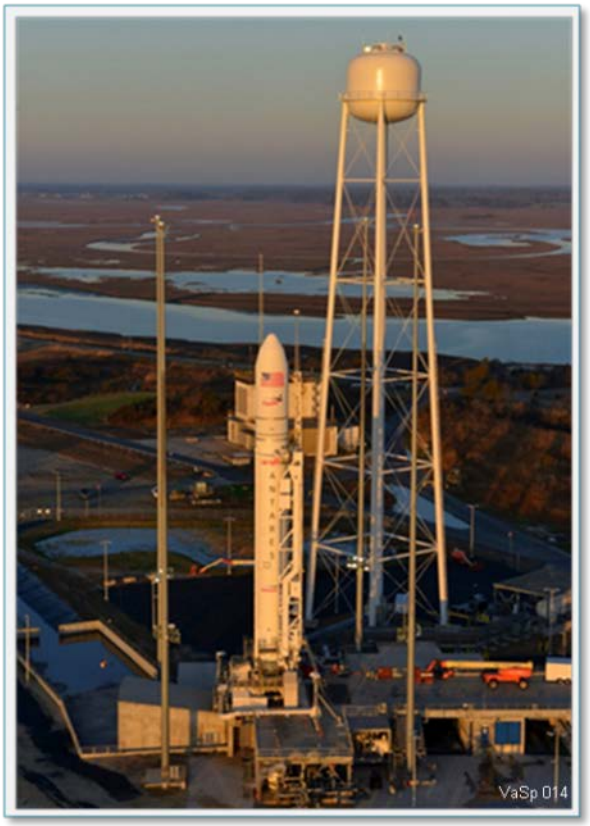

Figure 5-6. Orbital ATK Antares Orbital Launch Vehicle.

the spacecraft/launch vehicle configurations used, these initial missions will deliver approximately 22,500-26,500 kilograms (or 49,000-58,000 pounds) of supplies and equipment to the orbiting laboratory. Later in the contract, NASA may award additional missions for the 2021-2024 period based on operational requirements of the ISS.

The company has stated that any missions flown on Antares (Figure 5-6) would likely be launched from MARS. These vehicles fly from Pad 0A.

Figure 5-7. Orbital ATK Minotaur I Orbital Launch Vehicle.

5.4.1.2 Orbital ATK's Minotaur I Orbital Launch Vehicle

The Minotaur I is a solid fuel rocket derived from converted Minuteman intercontinental ballistic missiles (ICBMs). They are built by Orbital ATK via contract with the Air Force Space and Missile Systems Center (SMC) as part of the Air Force's Rocket Systems Launch Program which converts retired ICBMs into space and test launch systems for US Government agencies. These vehicles fly from Pad 0B.

A Minotaur I (Figure 5-7) launch is expected to be manifested for a 2018 timeframe.

5.4.1.3 Orbital ATK's Minotaur IV/V Orbital Launch Vehicle

The Minotaur IV and Minotaur V are solid fuel rockets derived from converted Peacekeeper ICBMs. Orbital ATK builds them via contract with the Air Force Space and Missile Systems Center (SMC) as part of the Air Force's Rocket Systems Launch Program which converts retired ICBMs into space and test launch systems for US Government agencies. These vehicles fly from Pad 0B.

No Minotaur IV or Minotaur V (Figure 5-8) launches are currently manifested but there are indications that additional launches may be announced soon.

Figure 5-8. Orbital ATK Minotaur V Orbital Launch Vehicle.

5.4.2 New Space Launch Customers

Several prospective space launch companies will need to have an East Coast launch site. The

focus of each company varies and includes satellites and space systems, resupply missions, reusable suborbital vehicles, orbiting laboratories, crew transportation, and more for civil, military, and commercial clients.

In the Small to Medium Class Launcher categories, the following are candidates to launch from MARS:

- Arianespace Vega/Vega C Orbital Launch Vehicle
- DARPA XS-1 Program

Virginia Space and NASA submitted a combined response to the DARPA XS-1 Spaceplane RFP. Formal results of the competition are pending, but early indications are that Wallops is one of two sites remaining after the potential customer down select. Virginia Space proposed using MARS Pad 0B for XS-1 test flights, expanding Pad 0B use beyond Orbital ATK's Minotaur Class (Minotaur I, Minotaur IV, and Minotaur V) launch vehicles. Bidders for the first phase of the XS-1 program were:

- Boeing
- Masten
- Virgin Galactic

NASA opened a new avenue for exploration and technology development with awards to three companies to launch missions dedicated to Cubesats. The price tag for each mission is one-tenth the cost of the least-expensive traditional launcher. Proposals were accepted from Firefly Space Systems, Rocket Labs USA, and Virgin Galactic to conduct demonstration Cubesats launches in the 2017-2018 timeframe. NASA officials anticipate more Venture Class launches to serve SmallSats in the future.

In the Nanosat Class Launcher categories[vi], the following are candidates to launch from MARS:

- Electron, manufactured by Rocket Lab, is a company headquartered in the US but with most of its operations in New Zealand. The Electron is capable of placing 150 kilograms into orbit, and its first flight planned for 2017. Rocket Lab plans to use its launch site in New Zealand for polar orbit flights possibly backed up by PSCA for US payloads. For low inclination US launches, Rocket Lab is considering both MARS and a pad offered by Space Florida (Figure 5-9).
- Firefly Space Systems is working on its Alpha vehicle with an initial payload capacity of 200 kilograms to orbit. Firefly plans to start flying the Alpha in 2018 and its manifest of flights that year are sold out as is most of 2019. The proposed launch site for Firefly has not been announced. (Figure 5-10).

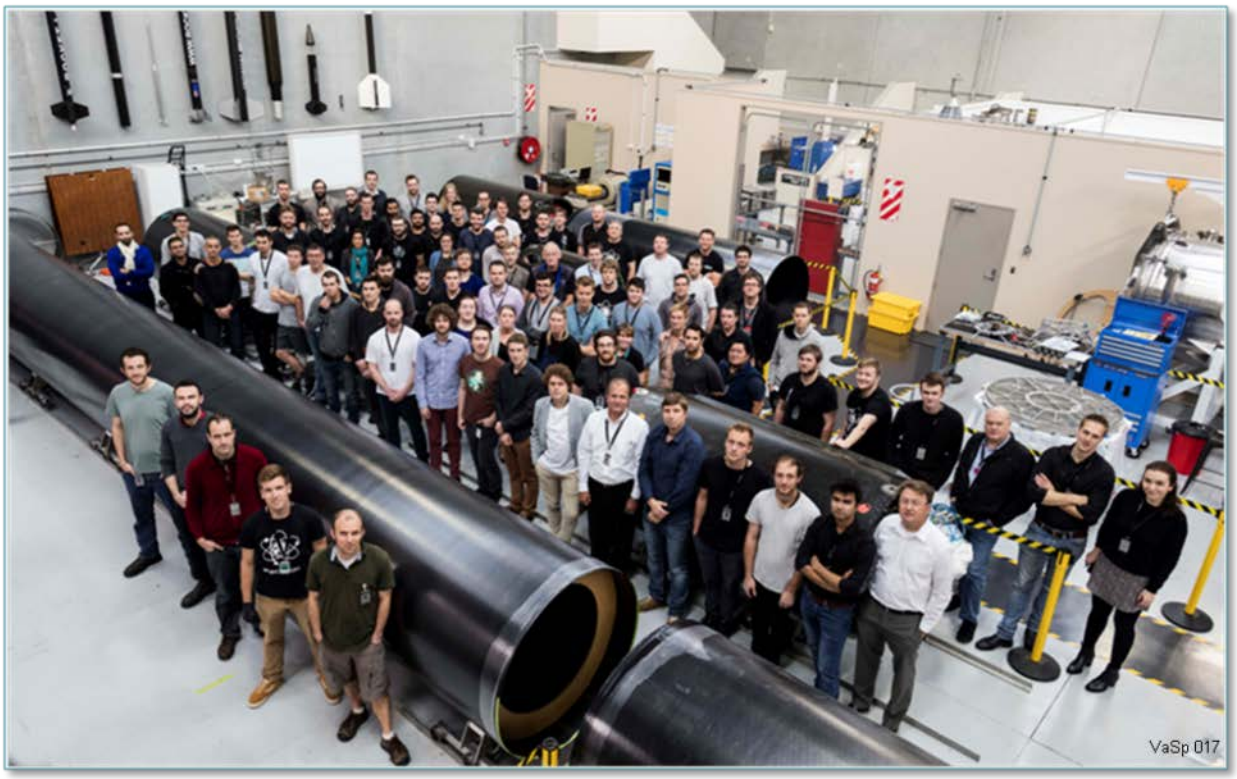

Figure 5-9. Rocket Lab Electron. *The Electron looks to be the first of the nanosat launch vehicles to fly, with flights to orbit planned for 2017. (Photo: Rocket Lab).*

Figure 5-10. Firefly Alpha. *The Firefly Alpha awarded a NASA contract to launch nanosats. (Image: Firefly Space Systems).*

- Vector Space Systems is developing the Vector One rocket based in part on a nanosatellite launch vehicle concept focused on the smaller end of the market, with a payload capacity of about 50 kilograms to orbit. Vector Space expects to start launches in 2018 and has announced an anchor customer. Initial flights are planned from PSCA. (Figure 5-11).
- bSpace has announced its Volant space launch vehicle. Funding for this venture appears to be in the early stages. (Figure 5-12).
- Super Strypi, developed by the USAF ORS Office, the University of Hawaii, Aerojet Rocketdyne, and Sandia National Lab, failed in its inaugural flight in 2015 but is actively searching for funding for a follow-on flight. First flights are from the Pacific Missile Test Range (Kauai, HI). (Figure 5-13).
- Virgin Galactic's LauncherOne is launched from a Boeing 747 and can fly from various launch sites, constrained only by runway length and range safety assets. LauncherOne's payload capacity is approximately 300 kilograms to orbit. Launches are scheduled to begin in 2017 with initial flights out of the Mojave Air and Space Port. The company is also looking for sites to launch lower inclinations. Both KSC and Virginia's Wallops Flight Facility are options. (Figure 5-14).

Figure 5-11. Vector Space Wolverine. *The Wolverine is Vector Space's planed SmallSat launcher. (Image: Vector Space).*

Figure 5-12. bSpace Volant. *The Volant is a conceptual nanosat planned by bSpace. (Image: bSpace).*

Figure 5-13. Super Strypi. *Super Strypi has made one unsuccessful flight to date. A second flight is planned for 2018, depending on funding. (Photo: US Air Force).*

Figure 5-14. Virgin Galactic LauncherOne. *LauncherOne ignites after being released from Cosmic Girl, a 747 that could take off from Virginia Space's runway. (Image: Virgin Galactic).*

Other nanosat vehicles are in various stages of development, including:

- Rocket Crafters
- Zero2infinity Bloostar
- CubeCab
- Generation Orbit GO Launcher 2
- Scorpius Space Launch Company Demi-Sprite

Suborbital/Orbital Vehicles require runway landings

- Virgin Galactic SpaceShip 1 and/or Launcher One
- Stratolaunch Orbital Launch Vehicle
- XCOR Lynx
- Sierra Nevada Corporation Dream Chaser
- Swiss Space Systems SOAR

Suborbital Testing

- MDA Targets and Interceptors
- DARPA Test Vehicles
- SMDC Test Vehicles
- Contractor Test Vehicles
  - Previously limited to White Sands, this provides an expanded opportunity for Virginia Space to fly vehicles from East Coast contractors.

5.5 Virginia Space Diversification

While the focus of the strategic plan is in space launch operations and customers, other customers can use Virginia Space's unique facilities. Diversification of the client base adds both revenue and stability to the cyclical nature of the launch business. It is imperative that, from an overall perspective, additional customers be included in the launch services base. The additional clients can take advantage of the unique facilities while the additional income from outside sources reduces overall overhead costs and keeps the facility cost competitive for all activities. Diversifying Virginia Space's portfolio helps ensure future sustainability.

Virginia Space is embracing the idea of developing a space industrial research base to maximize the economic benefit to the Commonwealth of Virginia and the surrounding region.

To maintain and grow the core business, Virginia Space plans to expand and diversify into two growth areas:

- Unmanned Systems
- PocketQube Satellites

These two opportunities have been identified as best options for diversification based on existing infrastructure, capital requirements, and potential benefits to Virginia.

5.5.1 Unmanned Systems (UMS) Customers

Unmanned Systems (UMS), including air, (Figure 5-15) marine, and land systems are the largest and most diverse set of potential customers to use Virginia Space's facilities located at the Wallops Island Facility.

Figure 5-15. Unmanned Aircraft System. *UAS such as Virginia's own Vanilla Aircraft represent growth potential for Virginia Space's services.*

The Vanilla Aircraft team with the aircraft following the successful first flight
Left to right: Daniel Hatfield, Peter Bale, Daryl Perkins, Jeremy Novara, Neil Boertlein and Phil Barnes (Photo; ©2009-2016 Vanilla Aircraft, LLC).

The recent Virginia legislative session added support of UAS to the Virginia Space mission set. The Virginia FY2015 budget provided $5.8M in funds for Virginia Space to build a runway for UASs and initial runway operational support and business development. Virginia Space, in close coordination with NASA Wallops and the Mid-Atlantic Aviation Partnership (MAAP – one of six FAA selected UAS Test Ranges in the United States), will offer unique capabilities and services for UAS operators from industry, NASA, and DoD. Additional FY 2017 Virginia Space funds are allocated for runway hangar infrastructure, ongoing operational support and business development.

Construction activities for Virginia Space's new, purpose-built UAS runway located on the north end of Wallops Island began in early 2016. The Virginia Department of Transportation (VDOT) was selected as the Construction Management group for the project, bringing extensive engineering, regulatory and project management experience. As charged by the Virginia Secretary of Transportation, partnering with VDOT provided an efficiency of operations and expertise which resulted in a fiscally responsible use of resources within the Secretariat. The project is progressing within budget and on schedule, for operations to begin in early 2017.

The runway site is located on the north end of NASA Wallops. Virginia Space will lease the land, build the runway, and conduct flight operations through cooperative agreements with NASA (Figure 5-16). The runway is planned to be 3,000 feet long by 75 feet wide and is designed per FAA standards for light civil aircraft. The runway site is located within restricted airspace controlled by NASA Wallops that is ideal for UAS developers conducting test flights in preparation for regular operations in the National Airspace System (NAS). To facilitate economic development and encourage business, runway use fees will be competitively low and Virginia Space will provide "concierge" services to ensure UAS operators swift and unencumbered access to the runway.

Figure 5-16. Virginia Space Runway. *The Virginia Space runway site is ideal for UAS developers conducting test flights.*

Potential UAS customers include:

- NASA Wallops
- NASA Langley Research Center
- US Navy NAVAIR (with Vanilla Aircraft Company, a Virginia company)
- United States Coast Guard/ Department of Home Land Security
- SOCOM, the US Special Operations Command
- DARPA (with Aurora Flight Sciences, a Virginia company)
- Vanilla Aircraft (A Virginia Company)

- Virginia Cyber Security Commission
- Marine Corps War Fighting Laboratory
- AAI Textron
- Martin UAV
- Insitu (Boeing)
- L-3 Com

MARS offers significant advantages for these agencies as a possible base. Proximity to the Pentagon and discreet operating environment that includes restricted air space and waters for testing make MARS attractive to potential users. MARS is in coordination with the leadership of Department of Homeland Security (DHS) and NASA to use the assets on the Eastern Shore to attract potential users to the new UAS runway. The opportunity is appealing to several potential customers including the DHS (with the port of Chincoteague being very close) to allow for UAS and integrated unmanned maritime systems operations.

The Association for Unmanned Vehicle Systems International recently put the total economic impact of drones during the first three years they were integrated into the national airspace in the United States at more than $13.6 billion with more than 70,000 jobs created. The impact on Virginia could be $342 million by 2025, according to the organization.

The Commonwealth was one of six test sites designated by the Federal Aviation Administration in 2013 for the development of unmanned aerial systems. The Virginia Tech-led partnership includes locations in Virginia, Maryland, and New Jersey.

Additionally, as drones become more commonplace, the FAA needs to designate a center for testing and approval. Because of its location and facilities, MARS could become one of the FAA's primary test and certification site for UAS's over the 55lb threshold and with Beyond Line of Site (BLOS) activities.

Virginia has pursued, along with Maryland and Delaware, the US Navy's decision to base a portion of its new Triton drone fleet at Wallops Flight Facility (Figure 5-17). The Navy confirmed in April 2016 that it is considering Wallops and two bases in Florida as possible sites for the program that is expected to bring at least 400 jobs. Virginia was instrumental in the process for the application of the increased Restricted Airspace around the Wallops Flight Facility. The approval of the airspace was published in the FAA Federal Register on November 7, 2016 with full implementation during February 2017.

Figure 5-17. US Navy Triton UAS. *The US Navy is gearing up for the first test-flight of its MQ-4C Triton aircraft, a wide-spanning 47-foot long surveillance drone. (Photo; US Navy).*

5.5.2 PocketQubes

Through partnerships with Orbital ATK, NASA Wallops and Twiggs Space Labs, Virginia Space is planning to provide access for small satellite developers to utilize the excess weight capacity on the second stage of Antares flights. Starting as early as October 2017, up to 96 tiny "PocketQube" satellites will be deployed from the second stage of the Antares before it deorbits at an altitude of 200-250 km providing an orbit life of 5 days to 2 weeks. The size and quantity of satellites to be deployed on each ISS mission makes this program impactful for meaningful educational opportunities and aerospace research.

The PocketQube satellites (Figure 5-18) provide elementary, middle school, high school and college students the opportunity to build and launch their satellites at an affordable cost. The various scheduled supply missions to the ISS provide predictable launch opportunities at least every six months. PocketQube materials are estimated to cost less than $5,000 per satellite, and the target cost for using the educational PocketQube in the classroom is $10,000 per year. The short mission timeline of the PocketQube ensures student engagement from program start to mission end.

As the PocketQube and UAS programs develop, opportunities should arise for cross utilization of MARS resources. One option for program integration is to test PocketQube payloads on UAS flights prior to suborbital or orbital flights to space.

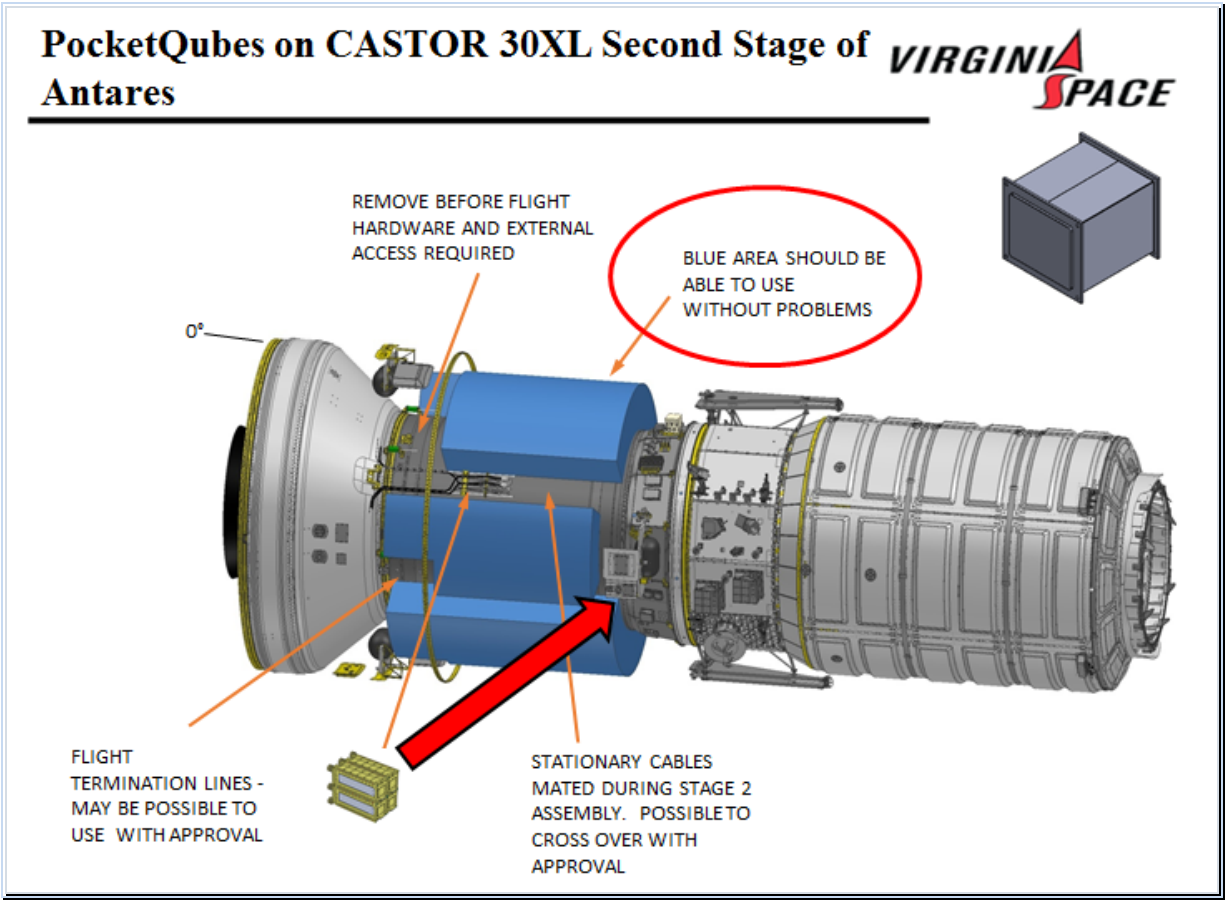

Figure 5-18. Launching Small Satellites from Antares. *PocketQubes and CubeSats flown on the second stage of Antares represent a great diversification opportunity for Virginia Space.*

Benefits from the program include:

- Training future small satellite designers and technicians as well numerous related fields, such as consumer electronics
- Development of manufacturing and test facilities and increased use of existing facilities in the region
- Engagement of not just students, but teachers, educational institution administrators, and local community business supporters

Because of the potential cost, schedule and scope of impact benefits provided by PocketQubes, they will be Virginia Space's primary focus for the Antares second stage manifest. However, as the PocketQube program matures, traditional CubeSat developers, including those at NASA Wallops and Virginia universities will be considered for the Antares missions.

6.0 STRATEGIC APPROACH

The overall strategy for Virginia Space for the 2017-2022 timeframe consists of four overall approaches:

- Keep and grow the current core business (Orbital ATK Antares and Minotaur launch vehicles). This provides stability to the enterprise going forward
- Attract additional launch customers who recognize the value offered by flying from Virginia. With the potential addition of new players into the launch market over the next five years, Virginia Space needs to position itself to take advantage of the market expansion
- Using the primary assets under Virginia Space's control, diversify the customer base to expand job creation, educational opportunities, and research
- Raise, train, and sustain high-end technical positions to expand and enhance the region's aerospace footprint (Figure 6-1)

The previous sections have outlined potential opportunities and customers. To execute and capture those opportunities, a plan is required.

Figure 6-1. Virginia's Space Workforce. *Continued investment in Virginia's space workforce provides significant benefits to the local area, the Commonwealth of Virginia, and to the nation.*

7.0 STRATEGIC PLAN

Strategic planning is an organizational management activity that is used to set priorities, focus energy and resources, strengthen operations, ensure that employees and other stakeholders are working toward common goals, establish agreement around intended outcomes/results, and assess and adjust the organization's direction in response to a changing environment. It is a disciplined effort that produces fundamental decisions and actions that shape and guide what an organization is, who it serves, what it does, and why it does it, with a focus on the future. Effective strategic planning articulates not only where an organization is going and the actions needed to make progress, but also how it will know if it is successful.

A strategic plan is a document used to communicate with the organization the organization's goals, the actions needed to achieve those goals and all of the other critical elements developed during the planning exercise.

The basic premise of the Virginia Space 2017-2022 Strategic Plan is to create a diverse, sustainable business model for the Authority. Use of Virginia Space's unique location, experience and facilities help to sustain the current business and gain additional business. The strategic plan is an extension of the work accomplished in the report "Virginia Commercial Space Flight Authority Strategic Plan 2012 – 2017 (dated December 1, 2012), and serves as a foundation for achieving the Commonwealth's priorities and Virginia Space's objectives.

7.1 Objective 1: Provide a framework for Orbital ATK's continued success for Antares ISS Resupply Missions

Virginia Space should work to ensure that the Orbital ATK CRS-2 ISS flights keep flying on Antares from MARS for as many missions as possible.

By keeping costs low and providing quality service, Virginia Space can continue to grow the relationship alongside its anchor tenant with the Antares flights to the ISS in place through 2024. Recognizing that there is always the possibility of Orbital ATK using an Atlas V to launch the Cygnus vehicle to ISS from Cape Canaveral, Virginia Space must keep Orbital ATK committed to MARS through:

- Continued exceptional customer support and service
- Cost competitive pricing for services
- Streamlined operations and approvals
- Continued infrastructure investment for facility maintenance, modifications, and upgrades
- Digitalization and enhanced interconnectivity where possible to reduce paperwork and increase efficiencies

Success Metric: Measure number of Antares ISS missions flown from MARS

7.2 Objective 2: Support Orbital ATK's efforts to secure additional Antares launches

Provide a cost competitive, high service environment that permits Orbital ATK to win additional Antares non-CRS missions including science and commercial missions. Ensure that all necessary facilities are in place to support Orbital's prospective satellite customers.

To make Antares as attractive as possible for prospective customers, Virginia Space can do the following to enhance the chances of winning additional missions:

- Low mission costs
- Payload processing support as needed
- Co-marketing support at launch-related trade shows and conferences
- Upgrade operations center and payload processing facilities to accommodate classified operations and equipment
- Timely support of proposal requests

Success Metric: Measure number of non-CRS Antares missions flown from MARS

7.3 Objective 3: Support Orbital ATK's efforts to secure additional Minotaur I and Minotaur IV launches

Provide a cost competitive environment that permits Orbital ATK to win additional missions. Ensure that all necessary facilities are in place to support Orbital ATK's prospective satellite customers, especially those with national security requirements.

To make Minotaur I/Minotaur IV as attractive as possible for prospective customers, Virginia Space can do the following to enhance the chances of winning additional missions:

- Low mission costs
- Payload processing support as needed
- Co-marketing support at government customer meetings as required
- Upgrade operations center and payload processing facilities to accommodate classified operations and equipment
- Timely support of proposal requests
- Support for commercial use of ICBMs for additional mission opportunities

Success Metric: Measure number of Minotaur missions flown from MARS

7.4 Objective 4: Secure a second (and possibly a third) space launch customer that utilizes the MARS facilities or the new NASA flat pad for Venture class launch vehicles

Continue business development strategies, tactics, and techniques, to attract one or more emerging launch providers to use MARS for their low inclination launches.

To make the Wallops area as attractive as possible for prospective customers, Virginia Space can do the following to enhance the chances of winning additional missions:

- Develop a package of potential incentives (with Commonwealth support) that can be made available to new customers
- Engage with possible launch providers to ensure they are aware of the opportunities to launch from Virginia
- Attend the primary, industry-wide launch-related trade shows and industry events to promote Virginia as a spaceport
- Leverage Executive Director's role on boards of the COMSTAC, STA, CSF and NAS to build relationships with launch providers and highlight opportunities with Virginia
- Tailor infrastructure to attract new customers; this may require construction of a new "nanosat" pad, or additional upgrades to MARS Pad 0A, Pad 0B or the NASA Venture class

flat pad

- Upgrade the facilities to be capable of processing classified payloads

Success Metrics:

- Measure number of new customer agreements to fly missions from MARS
- Measure number of new customer missions flown from MARS

7.5 Objective 5: Diversify into adjacent aerospace markets and secure additional customers to better utilize existing assets and personnel

Using the Virginia Space runway as an anchor (Figure 7-1), grow the UAS business to compliment the launch services business.

Work to secure UAS customers by:

- Engage with potential UAS users promoting Virginia Space's facilities
- Engage with potential UAS manufacturers promoting Virginia Space's facilities
- Attend pertinent UAS trade shows and industry events promoting Virginia Space's facilities
- Tailor infrastructure to attract new customers

Figure 7-1. Diversification into adjacent markets. *Virginia Space's runway provides an excellent facility for additional aerospace business diversifying the user base.*

Success Metrics:

- Measure number of new customer agreements to use MARS infrastructure
- Measure number of new customer UAS missions flown from MARS
- Measure new economic benefit generated

7.6 Objective 6: Expand current infrastructure to add additional economic benefit and growth opportunities for Virginia Space

Add a secure payload processing facility, deep-water dock, UAS support buildings, and other enhancements to enhance the customer experience at MARS and permit additional customers to use the facility.

Plan and work to secure funding for infrastructure necessary to expand and enhance Virginia Space's existing infrastructure including:

- US Flight Operations and Maintenance Center
- Deep water dock
- Lengthened UAV Airstrip
- Nanosat LV Operations Location

Success Metrics:

- Measure infrastructure growth
- Measure new economic benefit generated as a result of new infrastructure

7.7 Objective 7: Maintain Virginia Space as a sustainable entity to maximize the return on the state's existing investments

Develop additional sources of funding, such as new customers, federal funding, and private investment to grow the funding base for Virginia Space and give it additional flexibility.

Ensure that multiple funding streams flow into Virginia Space including:

- New customers
- Federal funding
- Customer and private funding where appropriate

Success Metrics:

- Measure economic benefit generated from all sources vs. Virginia Space costs

7.8 Objective 8: Provide and enhance education in aerospace technologies and processes in conjunction with universities, industry, and government

Develop and support educational outreach programs to enhance the aerospace industry in Virginia.

Make Virginia Space a visible part of the K-12 and collegiate level educational activities by:

- Support educational outreach programs tied directly to MARS
- Use existing Antares resupply missions to the ISS to diversify operations into PocketQube satellites. This program significantly enhances Virginia Space's outreach into STEM and

aerospace research.

Success Metrics:

- Measure number of projects initiated and sustained
- Measure number of students impacted
- Measure number of internships provided in aerospace as a result of Virginia Space's efforts

7.9 Objective 9: Establish Virginia as a leading space industry hub in the US to benefit both residents and businesses in the state

Aggressively establish Virginia as a "space state" and meet the challenges presented by Florida, Texas, California and other states.

Promote "tourism for space" – in other words, use the exciting events of space launches to draw spectators to witness launches. This benefits the local businesses in the MARS area, and, with the Philadelphia/Baltimore/Washington DC/Richmond corridor a relatively short drive away, many people who would otherwise never see a launch can experience one in person. This also builds support for additional funding for launch initiatives at the grass roots level.

Virginia Space should target partnerships with aerospace and space companies to provide infrastructure where needed. Virginia Space should foster economic development activities by supporting, assisting, facilitating and/or consulting on space industry-related needs for attracting, retaining, and expanding aerospace or related supply chain businesses that create economic opportunities for Virginia.

Virginia Space in conjunction with the launch customers should continue to promote launches through the media:

- Work with local schools to promote field trip tours; invite local classes or science fair winners to attend launches
- Work with aerospace providers to promote their activities to local organizations, schools, and the community on a regular basis

Success Metrics:

- Number of launches from Virginia
- Measure the number of companies that use or associates with MARS
- Measure the number of press releases issued
- Number of people who have visited from outside the local area to witness operations

8.0 CONCLUSION

The US space program, after nearly a century of space exploration and investment by the Federal Government, is currently undergoing radical change, evolving from an industry led by government objectives to one that is supplemented by the private sector. Against this backdrop, the next five years represent a once in a generation opportunity for Virginia Space to consolidate its position at MARS and attract customers.

Virginia Space is well positioned to take advantage of these opportunities. MARS has a unique heritage and a vibrant future because of the re-energizing efforts that have been completed by the Commonwealth and Virginia Space during recent years, such as:

- The Governor and the General Assembly of the Commonwealth have committed that Virginia Space will be given the opportunity to grow and benefit from the future of space exploration
- The Governor and the General Assembly have allocated funds to support Virginia Space's success
- NASA assistance has been constructive in supporting Virginia Space to provide launch vehicle suppliers and mission payload builders a new access to space
- The Authority management is evolving and shifting focus from starting a new business to building a stronger base for winning new business and providing skilled technical expertise
- The Authority has a business arrangement with Orbital ATK that will benefit both parties for at least the next five years. This arrangement allows Orbital ATK to fulfill its obligations to NASA and provide a base for the Authority to attract new customers that may take advantage of the Virginia Space assets and economies of scale

All of these re-energizing activities for Virginia Space are coming at the right time given the increased requirement for access to space from the US government, military agencies, international and commercial space users.

Accordingly, it is important for Virginia Space to continue to improve their offerings to the industry, as follows:

- Demonstrating a mission success and safety template to the industry through a successful launch record
- Continuing to offer a "red-tape" free launch availability and scheduling process
- Providing a cost competitive package regarding launch costs and continued upgrades to the current advantageous tax and liability provisions

The results of this strategy should provide benefits to the Commonwealth through improvements in the following areas:

- Job creation – utilization of current resources, such as the launch facilities at Wallops and Wallops Research Park, and new launch companies attracted to the area will help induce job creation
- STEM benefits – when launch facilities are in your backyard, teachers, professors, and students will all want to learn more about something they can see every day
- Utilization and synergy with all Commonwealth resources – using all educational and industry resources of the Commonwealth, Maryland, and federal agencies within the MARS boundaries should further scientific goals and assist the nation's access to space.

Given the above, it is expected that Virginia Space will continue to offer the space industry an exciting aerospace core in the Commonwealth. This nexus will create a job magnet for the area, a new hub of scientific activity, and a potential tourist destination for the Commonwealth of Virginia.

9.0 REFERENCES

[i]Virginia Commercial Space Flight Authority Strategic Plan 2012 – 2017, December 1, 2012.

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

[iii] The 2014 State New Economy Index, Information Technology, and Innovation Foundation.

[iv] The Annual Compendium of Commercial Space Transportation: 2016, FAA Commercial Space Transportation (AST).

[v] 2015 Commercial Space Transportation Forecasts, FAA Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee (COMSTAC), April 2015.

[vi] 2016 Nano/Microsatellite Market Forecast, Bill Doncaster, SpaceWorks Enterprises, Inc. (SEI)