

Building A Thriving Space Enterprise At Vandenberg Air Force Base



Vandenberg AFB Commercialization Master Plan
Phase 0 Public Report

August 5, 2020

Preface

Leaders from the State of California, REACH, the 30th Space Wing, Cal Poly State University and Deloitte have announced a commitment to develop a thriving spaceport at Vandenberg Air Force Base and the surrounding area. According to the memorandum of understanding, the parties will develop a master plan that identifies the required infrastructure, human capital development, governance and financing necessary to support the United States Space Force mission and position California as a global leader in the future of the commercial space industry.

The memorandum is a key part of a larger strategy for economic development in the Central Coast region, built in collaboration with the governor’s Regions Rise Together initiative, REACH and Deloitte.

The U.S. government, in its first National Space Strategy, identifies the space industry as a top priority and highlights dynamic partnerships between government and commercial partners as essential to our economic prosperity, national security and scientific knowledge.

The region boasts several attributes that make it an ideal location for commercial space operations, a sector that is likely to lead high-quality job growth over the coming decades. Vandenberg already maintains active launch capabilities and favorable geography, and Cal Poly produces world-class engineering and science talent.

The commercial space activities centered on the base could support a larger industry, and parties envision a robust cluster of space-related activities taking root in the region, with sustained presence of companies across the ecosystem from manufacturing and launch to maintenance and support and enabling human spaceflight for the first time in California.

This document reflects the first part in a larger effort to reimagine and transform space within the State of California. We collectively invite you to learn more, reach out, and join us on this journey towards tomorrow.



About REACH

REACH is an economic impact organization created to ensure the Central Coast of California is a place where current and future generations have the opportunity to thrive. With a mission to increase economic prosperity through big thinking, bold action and regional collaboration, REACH serves the Central Coast Region, that includes San Luis Obispo and Santa Barbara Counties. For more information visit www.reachcentralcoast.org.

About GO-Biz

The Governor’s Office of Business and Economic Development (GO-Biz) serves as the State of California’s leader for job growth and economic development efforts. GO-Biz offers a range of services to business owners including: attraction, retention and expansion services, site selection, permit streamlining, clearing of regulatory hurdles, small business assistance, international trade development, assistance with state government, and much more. For more information visit, www.business.ca.gov.

About Vandenberg Air Force Base

The 30th Space Wing, Vandenberg’s host unit, supports West Coast launch activities for the Air Force, Department of Defense, National Aeronautics and Space Administration, national programs and various private industry contractors. The Wing supports the processing and launch of a variety of expendable vehicles including Atlas V, Delta IV, Delta II, Pegasus, Minotaur, Taurus and Falcon. The Wing also supports Force Development and Evaluation of all intercontinental ballistic missiles, as well as Missile Defense Agency test and operations.

About Cal Poly

Founded in 1901 and part of the renowned California State University system since 1960, Cal Poly is a nationally ranked, four-year, comprehensive polytechnic public university located in San Luis Obispo, California. Known for its “Learn by Doing” approach, small class sizes and open access to expert faculty, Cal Poly is a distinctive learning community whose 22,000 academically motivated students enjoy an unrivaled hands-on educational experience that prepares them to lead successful personal and professional lives. For more information, visit www.calpoly.edu.

About Deloitte

Deloitte provides industry-leading audit, consulting, tax and advisory services to many of the world’s most admired brands, including nearly 90% of the Fortune 500® and more than 7,000 private companies. Our people work across the industry sectors that drive and shape today’s marketplace — delivering measurable and lasting results that help reinforce public trust in our capital markets, inspire clients to see challenges as opportunities to transform and thrive, and help lead the way toward a stronger economy and a healthy society. Deloitte is proud to be part of the largest global professional services network serving our clients in the markets that are most important to them. Now celebrating 175 years of service, our network of member firms spans more than 150 countries and territories. Learn how Deloitte’s more than 312,000 people worldwide make an impact that matters at www.deloitte.com.

Acknowledgements

This report was commissioned by the REACH board in support of the MOU agreement. Any opinions, findings, and conclusions or recommendations expressed within this document are those of the author(s) and do not necessarily reflect the views of the United States Space Force or United States Air Force.

This document is approved for public release does not contain any confidential or technical data subject to restrictions.

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Looking towards the Future

We firmly believe that the next decade will be transformative for U.S. commercial and defense space capabilities. It is through this lens that our team has come together to develop a master plan for Vandenberg AFB that supports the United States Space Force mission and positions California as a global leader in the future of the commercial space industry.

Preamble

The Central Coast region of California is comprised of several key assets – a robust university presence, the Vandenberg Air Force Base (VAFB), an engaged community of leaders, consistent tourism, an agreeable climate, and a geography stationed between the metropolitan hubs of San Francisco and Los Angeles.

Recently, the region has faced economic challenges and is now at a critical juncture in its growth trajectory. REACH, an economic development action-tank focused on creating high quality jobs throughout the Central Coast, is taking the lead to foster a prosperous economy, and is calling on regional leaders to embrace big thinking, bold action, and regional collaboration in order to shape a vibrant economic future for the nearly half a million people within the region.

To catalyze such change, REACH is helping align Federal, State, Local, commercial, and academic entities on a future vision for VAFB's commercial space activities to drive new economic growth, partnership opportunities, and social value for the Central Coast and state of California.

VAFB plays a central role in attracting commercial space opportunities to the

region. The base falls under the jurisdiction of the 30th Space Wing of the United States Space Force (USSF) and is primarily used for both space and missile testing and for launching satellites into polar orbit. VAFB has a long history of space industry involvement. The first ever satellite to be launched into polar orbit was launched out of VAFB in the late 1950s. Throughout the following decades, the base continued to develop strong space infrastructure, but ultimately ended several space initiatives following technical challenges and the Space Shuttle *Challenger* disaster in the 1980s.

The space domain is returning to its prominence as a national priority across multiple commercial sectors, as well as the military and civil domains. In contrast to prior decades where engineering and government requirements eclipsed cost and agility, today's industry transformation is characterized by a focus on the business case, market conditions, and fundamental economics. In the last two years, the United States has seen the reestablishment of the National Space Council, a renewed push for public-private partnerships, and a spike in commercial space interest.

The Central Coast is in a unique position to capitalize on these trends and has an extraordinary opportunity to achieve new space industry milestones and promote inclusive economic development in the process. As we define and implement innovative economic development solutions through commercial space partnerships in the VAFB Master Plan, the region has the potential to create significant economic impact for its citizens.

We are pleased to deliver the first step towards the completion of the VAFB Master Plan, which is this preliminary Phase 0 foundational overview report. The purpose of this Phase 0 report is to establish the *Art of the Possible* vision for the future and rally stakeholders around this vision, which will set the stage for our detailed planning in Phases 1 and 2 of the Master Plan development. We welcome all questions, feedback, and contributions to our report, as we seek to collaborate with the state, military, and local stakeholders throughout this process.

Project Overview

The project has been scoped into three distinct phases as follows:

Phase 0: *Art of the Possible* (This Document)

Intent: Socialize the art of the possible vision to catalyze funding opportunities and arm stakeholders with public talking points for the March 16th MOU signing across the following entities: Deloitte, U.S. Space Force, REACH, GoBiz, CalPoly San Luis Obispo University Content Included:

- Clear vision of a commercialized region and base in both the near and long term (e.g. 2030)
- Stakeholder identification and potential partners with an approach to engage them
- Required base capabilities to recognize near term growth opportunities
- Prioritized infrastructure projects, cost estimates, and funding options

This document was commissioned by the REACH board in December 2019 to provide a foundation and stakeholder education in support of the development of the full master plan in phases 1 and 2

Phase 1: Interim Master Plan

Intent: Provide the draft Master Plan recommendations and infrastructure assessment to provide opportunities for stakeholder input and collaboration

Phase 2: Final Master Plan

Intent: Provide final report to inform regional decision-making and budget allocation and assist in formal investor pitches and government funding requests

A note on the project's current scope

The MOU holders are currently exploring increasing the scope to include an additional focus on the regional economic impacts and regional requirements to enable the vision for the future. These discussions are currently on going and we

expect the revised scope to be finalized in early August 2020.

A note on the impact of COVID-19

This report was primarily produced between January 2020 and March 2020 with a planned delivery date that coincided with the California Shelter-in-Place orders to prevent the spread of COVID-19. Efforts have been made to update information within this document as the industry dynamics and markets changed between March 2020 and July 2020. Good faith attempts to keep this document current have been made but due to the fluidity of the current situation, some information may no longer be applicable. Regardless, we believe the impact of COVID-19 on our vision for the future will be more limited to schedule impacts and should not affect the ability of the region to attract and grow space industry activities. Simply put, despite the uncertainty, we remain optimistic for the future.



Members of our team from the State of California Go Biz, the 30th Space Wing, REACH, Deloitte Consulting LLP, and the Central Coast Communities in front of SLC-6 at Vandenberg during the September 2019 Commercialization Greenhouse Lab.

The Art of the Possible for Vandenberg AFB

Examining the intersection of industry and market dimensions helps clarify the “where” and “how” to play for a desired future state of space within the Central Coast Region

Setting the Stage

The state of the space industry is strong, but, as with any emerging growth industry, there are some underlying factors which need to be addressed in order to create a sustainable and economically viable vision for the future. Simply put, the old adage of “if you build it, they will come” or the “Field of Dreams” model does not, and will not, work for spaceport development. As such, we have created a foundational vision for the future based on a portfolio approach that spreads focus and risk across multiple segments of the value chain to drive the greatest chance of growing space within the region. Our initial draft of this vision is presented in this Phase 0 report and will be further refined in subsequent phases of this project through additional industry engagement and collaboration with the key stakeholder groups.

To formulate our vision for the future, we performed in-depth analysis of the current state of the space economy and market segments; the launch services industry; and the various types of economic, industrial base, and capability development within the United States as of early 2020. Through an alignment of

these three primary dimensions and subsequent discussions with launch services operators, industry specialists, and former range officers, we have developed a series of insights to determine “where” and “how” to play in order to develop a more robust and sustainable space industry presence within the Central Coast Region.

While it should be no surprise that California, as a long-standing critical component of the aerospace and defense industrial base, has competitive advantages across almost the entire space industry value chain, our findings have highlighted challenge areas and opportunities in which the State may be able to significantly transform the space industry.

To get to this initial future vision, we started with the core mission of assured access to space from VAFB for national security and U.S. Government priorities (e.g. civil space exploration and earth observation) and then mapped a future state that couples the requirements of the launch services industry with complimentary or linked activities across the value chain which add resilience. With concern over the volatility and a potential decrease in the commercial addressable

market for commercial launch services providers in the near-term, we envisioned a future state of the base with a workforce, activities, and regional infrastructure that were less prone to commercial market supply or demand shocks. This is no small task and we know that this Phase 0, interim report, is simply a start towards designing a sustainable and implementable vision.

At the end of our Phase 0 analysis, we remain optimistic about the future of space within the Central Coast Region and we eagerly look towards a potential vibrant future state of commercial activities built around, and in conjunction with, VAFB.

“If Vandenberg can successfully develop the required, and sharable, infrastructure that we need to succeed, we could perform all our government launches out of Vandenberg.”

-New Entrant Launch Company



Market Research

Market research suggests an opportunity to capitalize on the growing commercial space industry activities and attract additional commercial activity to VAFB

Our Approach

Our approach is to examine the intersection of industry dimensions to determine the “where” and “how” to play for a desired future end-state of space within the Central Coast region.

The framework on this page provides a simplified visual representation for our approach and includes the following components:

Dimension 1: The Value Chain

We commonly use a value chain to evaluate growth opportunities in emerging and growth markets. Our view

of the space value chain encapsulates the space ecosystem across three primary segments centered around launch as the enabling factor. Each segment requires a tailored approach to navigate factors such as regulatory environments, capital expenditures, barriers to entry, and potential ROI

Dimension 2: Launch Systems Types

We have categorized launch vehicles into four categories based upon our value chain and spaceport development research in conjunction with our industry and specialist interviews conducted to-date.

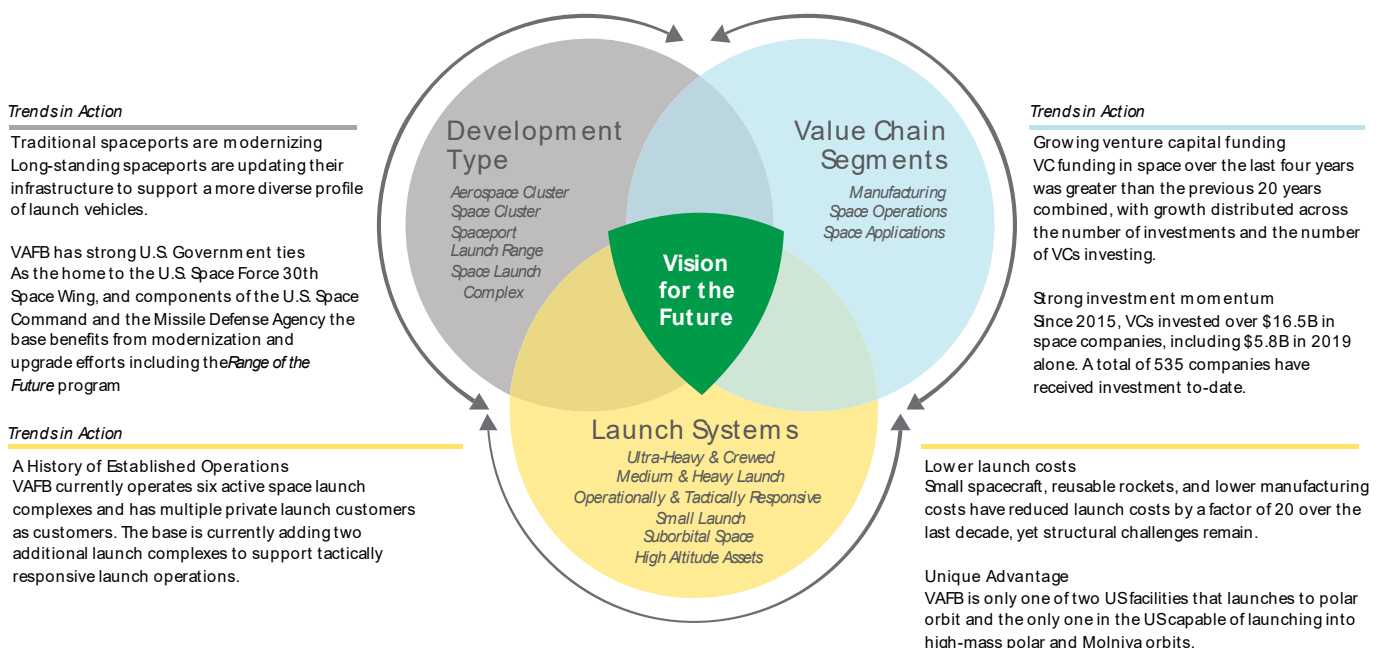
Dimension 3: Development Type

To benchmark future end states and scenarios for VAFB, we have formulated economic, industrial base, and capability growth into five categories ranging from the creation of a simple concrete pad through a concerted development effort to create a true aerospace cluster.

The following sections and associated appendices provide details on each dimension and the recommendations derived from the analysis.

FIGURE 1

The Intersectionality of Dimensions and Industry Trends in Determining the Future End-State



Dimension 1: The Value Chain

The breadth of today's space economy makes it difficult to assign prescriptive definitions. Space technologies – both goods and services – are increasingly important to a range of consumers and, as such, the benefits derived by users are no longer exclusive to core space participants. For example, the activities associated with sending satellites into low earth orbit (LEO) generate significant economic returns, as both organizations and individuals on Earth use the data these satellites generate or supply (i.e. GPS data provided from space). In developing a definition for the space economy and associated industry and value chain segments, we have drawn upon Deloitte's global work to-date, our Deloitte Access Economics group, and a number of reputable international and authoritative sources.

More specifically, this report uses the Organization of Economic Cooperation and Development (OECD) definition of the space economy as a grounding basis and draws on the detailed definitions in studies of other space economies to guide sub-sector classification. The international studies drawn on include London Economics (for the United Kingdom Space Agency) and Australian studies conducted by Deloitte Access Economics and ACIL ALLEN.

This report has adopted the OECD definition of the space economy to capture broader space-related activity. This definition reflects the traditional activities of the space industry, but also broader uses of space-derived technologies and applications.

OECD Definition of the Space Economy

"The full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilizing space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the space economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society.¹

Industry Size & Context as of Today

The space economy boasts \$414.75 billion (USD) in annual global spend², which encompasses a complex ecosystem of governments, commercial companies, venture capital firms, accelerators, incubators, research organizations, and academic institutions.

The Future of the Global Space Economy

Goldman Sachs, Morgan Stanley, and Bank of America have estimated that the global space economy is headed towards a \$1 Trillion market size between 2030 and 2045³. The path towards a 3x growth in industry size is underpinned by advances in manufacturing technologies, a better understanding of market and mission gaps, and a massive influx of venture capital that has seen over \$25.6 Billion of external capital invested into the industry since 2000⁴.

Venture capital investment in the space industry over the last four years was greater than the previous 20 years combined, with growth distributed across both the number of investments and the

number of venture capital firms investing. Since 2015, venture capital firms have invested over \$16.5B in space companies, including \$4.8B in 2019 alone⁵. 55% of new space ventures, or 91 start-ups, are based out of the United States⁶. While the investment trends are promising, there are growing concerns over the exit strategies for venture-backed launch companies, as the often missed technical and programmatic milestones create a ripple effect on the launch sites and satellite industry. Venture capitalists have not been afraid to back out of several promising ventures in the launch and enabling space operations segments.

There is an increased focus on public-private partnerships to support the warfighting mission. To increase space superiority for the warfighter, procurement times must decrease, initial operating capacity must occur faster, and the development of space technologies for the warfighter must be closer aligned to the agile and iterative practices of other technology-heavy industries. Leading the way is the USSF Space and Missile Systems Center (SMC) and the

newly created Space Development Agency.

Currently, the value chain segments continue to mature at an uneven pace due to funding, business, or market conditions – factors that may result in new structural barriers to commercial providers or consumers. A renewed push for agile development and rapid acquisition of commercial services from the military space segment, coupled with increased budgetary pressures and the lunar mandate on the civil side, should result in more opportunities for commercial space providers.

Introduction to the Space Value Chain

Given the breadth and depth of the global space economy and the disparate nature of its activities from antenna manufacturing to ensuring the survivability of astronauts on-board the International Space Station (ISS), there is no singular view of the space value chain or a unified view of the space economy market sectors and industry segments. From a top-down view, we can derive the value of specific types of activities or services (e.g. commercial space services that provide satellite television) from the aggregate global space economy figures. From a bottom-up view, we can derive the value of commercial space and entrepreneurial activities from private and public investments into early-stage through public-facing companies. Unfortunately, while these views provide valuable insight into the state of the market, this does not help us assess commercialization activities within the Central Coast Region and necessitates the development of a more granular approach to examining value creation.

To properly examine where to play within the global space economy and space industry, we have compiled a highly coupled value chain centered around the launch services industry and the primary commercial driver of the launch services industry: satellite deployment. By creating a value chain specific to the activities related to the primary mission of VAFB, we can perform a top-down alignment to the global space economy and a reasonable bottom-up alignment of the investment themes. Our value chain is meant to be a guiding construct for the development of the future state and is expected to evolve over subsequent phases of this project.

Our value chain is aligned around three main activity segments (manufacturing, space operations, and space applications) that are further decomposed to capture the operational nature of the activity (e.g. space-based, data-driven, or end-user service driven). Each segment and its subsegments require a tailored approach to navigate factors such as regulatory environments, capital expenditures, barriers to entry, and potential ROI.

Observations within the Value Chain Segments

The alignment of the value chain segments and components allow us to derive ongoing industry trends relevant to the health of the global space economy, the space industrial base, and the customers for each segment (e.g. demand-side). Not all the value chain segments are directly applicable to VAFB and the vision for the future as outlined in this report. This report identifies a broad range of value chain activities for satellite manufacturing, satellite space launch, space applications, and other

downstream activities so as to provide a holistic view of the market and industry activities. Ultimately, our vision for the future and recommendations are centered around launch concepts and orbits that are serviceable or accessible from VAFB. Where value chain segments are not applicable, fewer insights are provided during this phase in order to focus on more actionable and addressable segments.

To identify the most immediately viable options for commercial development at the base, we have performed a current state assessment to gauge VAFB's current capabilities across the Space Value Chain. This assessment was based on both industry knowledge and industry specialist interviews with former U.S. Air Force personnel with direct VAFB experience. In summary, VAFB has a strong history and legacy of experience in the space industry, a moderate amount of infrastructure suitable for today's market, and a core group of commercial partners/customers. These factors will help demonstrate to the market the base's capabilities to handle demand for both launch and other space services. The current state assessment presented in our value chain analysis represent high-level findings to-date, and we will work with the 30th Space Wing and other project stakeholders to further refine the analysis in the subsequent phases of the project.

“The future of space at Vandenberg should better reflect the modern operating environment and the current state of the space market.”

-- Space Industry Executive

FIGURE 2

The Space Value Chain for Satellite Operations and Applications

Global Space Economy Segmentation	Commercial Infrastructure & Support Industries						Commercial Space Products & Services			
Value Chain Segment	Manufacturing	Space Operations					Space Applications			
		Space-Based Assets & Transportation			Non-Space Based Assets		Data Exploitation, Analysis, & Dissemination Activities		End User Services	
		Launch Services	Operations	Logistics	Ground Infrastructure	Fixed Sensing Collectors	Data Collection & Aggregation	Analytics & AI-Fueled Analysis	Direct-to-Consumer Services	Telecom & Connectivity
Investment Market Segmentation	Multiple Segments	Launch	Multiple Segments	Logistics	Satellites					
Global VC Investment*	\$873M	\$12.3B	\$2.2B	\$199M	\$222M	\$220M	\$1.1B		\$2.8B	
Description	Manufacturing of space vehicles, satellites, ground station equipment inclusive of all subcomponents	Space launch providers, rideshare & launch brokerage, and spaceport operators	Mission operations of satellites and space vehicles	Space Domain Awareness, Space Debris Mitigation, On-orbit Servicing	Ground stations and the necessary systems to transfer data, and communicate	Sensors attached to satellite, probe, or spacecraft carrying cargo as well as ground-based sensors	The collection and aggregation of data from space-based platforms (e.g. remote sensing)	Data science, analytics, or machine-assisted solutions for the analysis of space-derived data	Direct-to-consumer services, such as satellite TV, radio.	Telecom and connectivity services provided to end-users via satellite

*Investment time period includes VC investment from 2015-2019. Source: Deloitte Space VC Tracking Report based on Crunchbase and PitchBook

Dimension 2: Launch Systems

Launch systems are an integral component to any spaceport, and the market currently presents unique trends and challenges that VAFB can use to the base's advantage.

Trends in the Launch Domain

The last decade has seen \$25.7B in investment, of which \$12.0B was invested into 95 launch companies, making launch the recipient of the most venture capital of any space industry segment including satellites and satellite applications¹². To investors, the message is clear that launch is not only the key enabling factor for the future of space, but that the industry has been traditionally underserved. As the industry is technically transforming, economic and market structural barriers are increasingly being addressed through new concepts of operations for launch including commercial ride-shares and multi-manifested payloads, as well as launch vehicle reusability.

Yet, despite the over 100 known in-development or active launch companies, concerns still linger over the ability of the market to satisfy demand, even if it remains constrained due to other factors. While there are multiple launch vehicles under development between now and 2025, significant performance gaps exist due to a focus on larger, cargo/payload-oriented rockets, exploration-class human-rated missions (beyond-LEO, Lunar, and Mars), and small launchers focused on the exploding cubesat/smallsat market. Additional risks include schedule risk, cost uncertainty, demand uncertainty, launch site capacity and availability (i.e. what happens in the event of hurricanes, fires, or launch pad failures close launch sites and ranges),

and launch services supply risk (i.e. what happens when another "established" launch company exists in the market).

Challenges in the Launch Services Market

Despite the strong investment and enthusiasm around launch services, market research indicates there are several significant challenges that must be addressed. While it is not the role of VAFB and the Central Coast communities to solve all of these problems, the structural conditions of the market do present opportunities that can be exploited.

- **Structural barriers:** The industry suffers from structural inefficiencies that limit the market's ability to satisfy demand for launch to many orbits and inclinations. Despite required decreases in heavy launch vehicle costs due to new program development and the introduction of reusability, the cost of launch remains high enough to block the conversion of latent demand into addressable and serviceable demand¹³.
- **Prohibitive Costs:** Launch costs still represent the highest barrier to increased utilization of current and planned US spaceports. The small satellite revolution has driven down costs, yet the total cost of direct financial expenditures and opportunity costs remain high, as access to orbit for specific use cases is not timely and does not provide enough agility¹⁴.
- **Uneven Growth:** Value Chain segments are not maturing in a complementary way. Value chain segments have matured along with

priorities set by both Foreign and American government agencies. Segments developed by purely commercial inputs have not experienced the same level of maturity and growth¹⁵.

- **Restrictive Conditions:** Venture and private capital have reshaped the industry, but the investment dollars come with potentially restrictive conditions. There are growing concerns over the exit strategies for venture-backed launch companies, as the often missed technical and programmatic milestones create a ripple effect on the launch sites and satellite industry. Venture capitalists have not been afraid to prematurely back out of several promising ventures in the launch and enabling space operations segments¹³.

Types of Launch Systems and Concepts of Operations

Traditionally when the industry examines launch systems and the associated concepts of operations, launch gets bucketed into the type of launch (i.e. vertical vs. horizontal), the class of launch vehicle (i.e. small, medium, heavy, or ultra-heavy), and the mission type (i.e. cargo transportation, satellite deployment, human spaceflight, or deep space exploration). The only additional categorization that often occurs is for which type of customer did the launch occur: defense (National Security Space), civil (NASA or NOAA), or commercial.

As our challenge is to formulate a view of the future, we have aligned our research into the types of launch systems and concepts of operations in a differentiated manner that allows us to more holistically assess the current technical, operational, and competitive landscape. We have defined the macro-categories of launch systems and in the following sections¹⁷:

Suborbital and High-Altitude Assets

Suborbital and high-altitude capabilities provided by sounding rockets, balloons (i.e. World View Enterprises), drones, specialized high-altitude aircraft (i.e. NASA WB-57 or USAF U-2) or suborbital space vehicles (i.e. Virgin Galactic’s *SpaceShipTwo*).



U-2 Dragon Lady High-Altitude Crewed Aircraft. *Credit: USAF*

Strategic Space Launch (SSL)

Unmanned National Security Space Launch (NSSL) capabilities currently acquired by the defense and intelligence communities and supplied and operated by vendors such as United Launch Alliance and SpaceX in support of USSF, USAF, and NRO needs. Unmanned space launch capabilities for commercial or government satellite deployment in support of earth-focused and deep space exploration missions. Human-rated and crewed capabilities currently acquired by NASA in support of the International Space Station operations and eventually the Artemis program as well as future commercial space tourism customers.



A United Launch Alliance Delta-IV Heavy Rocket Lifts off from SLC-6. *Credit: USAF*

Within this concept, we see demand primarily as Security-Driven (NSSL and USG Earth Observation Missions), Exploration-Driven (NASA Commercial Crew and Deep Space Exploration Missions), and Market-Driven (commercial satellite deployment and commercial human spaceflight).

Responsive Space

Any capabilities that are responsive to market, operational, or tactical needs as applicable for each demand category.



A USAF X-37B Spaceplane post-landing on the VAFB runway. *Credit: Boeing/USAF*

Within this concept, we identify demand primarily as Market-driven (commercial satellite deployment or flexible human spaceflight options), Operationally-Driven (ORS), and Tactically-Driven (TRS). We have defined ORS and TRS as follows:

Operationally Responsive Space (ORS)

Unmanned responsive space launch capabilities currently acquired by the USG and supplied and operated by vendors such as Boeing (X-37B) or future launch

services entrants such as Relativity Space, and Rocket Lab.

Tactically Responsive Space (TRS)

Unmanned or manned systems acquired by the USG, owned and operated by the USSF, commanded by combatant commanders, and supported through depot maintenance (or equivalent) by US industrial base members. Tactically Responsive Space (TRS) is any launch system or capability that enables the warfighter to achieve and maintain space superiority through unfettered and assured access to space through systems that are high-cadence, low-cost, and owned and operated by the US Department of Defense in support of the national security mission.

Collectively, these current and emerging launch concepts of operations (ConOps) will have the ability to push the limits of how the US utilizes the national launch ranges. New launch entrants and their associated launch systems are trying to reach space at cadences never seen before, with operational characteristics unheard of a decade ago. New launcher concepts increasingly have reusable stages that require return flights through temporarily restricted airspace to barges or launch complexes, are launched into air on former commercial or specialty-built aircrafts, or are built to fly ten times in ten days from multiple sites. The capabilities are evolving but the spaceport operating models are not. Therefore, in imagining a future construct for access to space, whether it be a national spaceport construct or positioning VAFB as a spaceport and range of the future, the challenge becomes which types of launch vehicles and concepts are inherently attractive and supportable.

FIGURE 3

Current and Emerging Launch Systems Concepts of Operations

User Groups	Suborbital Spaceflight	Orbital Spaceflight				
		Strategic Space			Responsive Space	
		Security-Driven	Exploration-Driven	Market-Driven	Operationally-Driven	Tactically-Driven
National Security & Defense	Not a primary focus area	Assured access to space for strategic space missions for the DoD and Intelligence Community (IC)	Not a primary focus area	Not a primary focus area	Responsive to unexpected loss or degradation of selected capabilities, and to provide timely availability of tailored or new capabilities	Responsive to the tactical needs of a warfighter across the Combatant Commands and combat theaters
Civil	Test Flights & Demonstration Missions	Assured access to space for non-DoD/IC missions such as weather monitoring or earth science	Assured access to space for human and space science exploration missions	Not a primary focus area	Responsive to provide timely availability of tailored or new capabilities	Not a primary focus area
Commercial	Test Flights, Demonstration Missions, and Space Tourism	Not a primary focus area	Access to space for commercial exploration missions including commercially procured human spaceflight missions for exploration	Access to space for new telecom, sensing, or other payloads responding to market needs as well as commercial human spaceflight	Reconstitution or replenishment of commercial constellations at planned intervals	Not a primary focus area

Dimension 3: Development Types

To benchmark future end states and scenarios for VAFB, we have formulated economic, industrial base, and capability growth into five categories ranging from the creation of a simple concrete pad through a concerted development effort to create a true aerospace cluster.

To service suppliers, multiple spaceports are available across the U.S. from Alaska to Florida; however, few of these are currently launching rockets into orbit. Varying utilization between these facilities can lead to suboptimal outcomes for businesses and government alike. Other spaceports, supported by significant public funding, are also facing financial and development issues which could result in their closure over the next five to 10 years¹⁸.

Modernization efforts at some of these facilities — such as migration to Automated Flight Safety System and range scheduling system upgrades — should help increase launch cadence at a few key spaceports in the future. These limitations in early infrastructure capacity, coordination, and uncoordinated operating models have created a backlog in new space launches disproportionately spread across the active launch sites. At the same time, the annual number of launches by the three primary providers in the U.S. market (United Launch Alliance, SpaceX, and Northrup Grumman Innovation Systems) and new entrants (Blue Origin, Rocket Lab, and Virgin Galactic) will continue to increase.

The Development Debate

For any group looking to advance the presence of commercial, civil, or military

space companies, operations, or activities within their region, there should be substantial debate over the “how to play” component. Each region will have to assess their competitive advantage such as access to a talented workforce, underutilized or unrestricted airspace, locational advantages for orbital insertion into various inclinations, and existing infrastructure. As such, the options for each region to develop space may include all development options ranging from a space launch complex through an aerospace cluster. More likely, each region will center their development efforts around a type of development and the type of launch most easily addressed within that region.

Surprisingly then, the number of “spaceports” currently in development within the United States is staggeringly high. Besides the challenge that there are more spaceports in development than potential supply or demand to adequately utilize them, there is a large disparity between spaceport development plans, which suggests that some of these efforts may be using the spaceport terminology more from a marketing and explanatory approach than as an actual representation of what is truly being developed. Conversely, some sites and development efforts may be underrepresenting what they are trying to build and accomplish.

Trends in the Current View of Spaceport Development

Currently most of the domestic spaceports, operational and planned, operate in a loosely coupled manner and most closely align themselves to a diversified operating model. While some activities, departments, sources of funds,

and areas of responsibilities are coupled, most of the loose coupling comes from historical precedent or from shared authorities and similar missions. When looking holistically across the current and planned spaceports in the United States, it becomes clear that both standardization and coordination remain low. The most closely coupled spaceports, from an operating model perspective are Cape Canaveral AFS and the Kennedy Space Center, given their geographical proximity and the domain authority of the Eastern Range and the 45th Space Wing.

We have also observed, a strong amount of state or county level efforts to build smaller spaceports generally supported by the “if you build it, they will come” mindset – which has yet to pay off in a sustainable way at any new build (i.e. greenfield) or adaptive reuse (i.e. brownfield) spaceport as of 2019. While 2020 holds promise for a few spaceports, most notably Spaceport America, the last decade of spaceport development has highlighted a variety of challenges from market supply shocks through delays in the market entry of multiple launch providers that continue to stifle the development of spaceports across the United States¹⁹.

While this is exciting and transformative time for the industry, an increase in operational tempo at existing sites, such as Cape Canaveral and VAFB, as well as in-development sites in states such as Colorado, Georgia, Virginia, and Washington, has the potential to fragment both government and commercial efforts. The overdevelopment of spaceports could possibly hinder a nationally coordinated space launch construct that ensures continued access to space in support of the national

security mission and increases commercially available launch slots.

A Construct for Development Efforts

To assess the development types applicable to VAFB, the Central Coast Region, and other initiatives we are seeing within the region, we have segmented the development types into five categories that are defined in the following sections. These categories are meant to frame our analysis and recommendations and may differ from other economic development terms currently being employed at the local or state levels.

Types of Development

An **aerospace cluster** is a geographic concentration of competing and collaborating firms within the aerospace industry. An aerospace cluster spurs innovation within the industry and tends to result in higher than average wages. Clusters develop specialized competencies that allow it to produce goods and services, such as aviation equipment, rocket components, aerospace hardware/software, etc.

A **space subcluster** is a portion of the Missiles and Space Vehicles subcluster within an aerospace and defense cluster. It is same concept from a development perspective yet differs from an aerospace cluster in that the talent, manufacturing, investment, etc. are focused exclusively on space flight, rather than aviation and space flight.

A **spaceport** is a dedicated site for sending and/or receiving spacecraft into space and orbit.

A **launch range** is a facility with multiple launch pads and a surrounding safety area. A launch range has the telemetry, tracking, and assets that support launch.

A **space launch complex** or launch site refers to the launch pad and supporting launch infrastructure that is used to conduct launch operations and launch vehicle recovery efforts.

While a fully developed aerospace cluster would create the most economic impact for the Central Coast region, it also requires the most investment and coordination. Using the development definitions from above, VAFB currently operates as part of the Western Launch range with multiple space launch complexes. As the region coordinates infrastructure projects and commercial projects, there is potential to develop into an aerospace or space cluster.

Inherent Market Attractiveness in Development

To understand where various spaceports and associated development efforts are occurring, we looked at 21 spaceports or space launch complexes, as defined in this section, within the United States to see what part of the value chain or activity areas each development was currently engaged in or targeting for development.

Development of a Space Cluster

The prime example of where economic development has led to the creation of a space cluster is Florida's Space Coast, whereby their development approach connected infrastructure, operations, and the management of civil, commercial, and national security space launch operations. There is a strong argument to be made that much of that success was owed to

the decades-long sustainment of the Space Shuttle program in concert with the ultimate workforce drawdown following the Shuttle's last flight in 2011 and the observed economic impacts that spurred action. Regardless, the success of the Florida Space Coast does prove that a more unified approach and space cluster construct is possible and is an encouraging sign that a properly formulated construct around VAFB can be enabled.

Benchmarking VAFB's Capabilities

In the summer of 2019, key stakeholders from across the Central Coast region convened at a REACH/Deloitte workshop, where industry insights and competitor benchmarking were presented. *Figure 4* leverages the insights from this workshop to present the key characteristics that exist at Cape Canaveral and Wallops, two of the more advanced commercial spaceports. These characteristics span across a range of financial incentives, governance models, infrastructure, and site capabilities. This matrix highlights areas that VAFB could focus on to enhance its attractiveness to commercial companies.

VAFB's ability to launch to high mass polar and Molniya orbits is a unique differentiator from other launch sites. Although VAFB is not as far along it its stakeholder engagement and establishment of clear working groups to address these challenges as other competitive spaceports, VAFB and the region are actively working to catch up take advantage of the lessons learned from other spaceport developments.

FIGURE 4

Market Attractiveness Matrix for Major U.S. Government-Operated Spaceports

Program Does Not Exist
 Program in Progress
 Program Exists

	Vandenberg AFB	Cape Canaveral AFS & Kennedy Space Center	Wallops Flight Facility
Funding/financing from State Government			
Funding/financing from Federal Government			
Funding/Financing from private sector			
Relationships with government offices at a spaceport			
Commercial enterprise zones or equivalent			
Formal space industry commission			
Developed master plan			
Presence of commercial space companies			
Ability to launch to GEO			
Ability to launch to polar orbit			
Statewide entity for space industry development			
Site champions at the Federal level			
Tax programs/incentives			



A Future Vision for Vandenberg

As we build out the Master Plan, we have identified an overarching future vision for VAFB supported by specific opportunities to drive growth.

A Vision for the Future & A Bold Challenge

As the commercial space market continues to grow and put pressure on the national space launch infrastructure, the DoD, NASA, and the U.S. Intelligence Community are all reimagining the future of domestic space launch and the ability of the U.S. industrial base to serve current and future demands in space. Historically, limiting factors for space launch were primarily supply-side driven in the form of cost, launch cadence, or life capabilities offered. The current focus of new launch services providers is to push towards previously unserviceable demand by offering higher launch cadences, lower costs, new concepts of operations, and new capabilities.

Demand for launch services remains primarily for payloads, projected at over 40,000 satellites over the next decade²², driven in part by the “CubeSat revolution”, which has made affordable access to space available to a much broader user community, and the resurgence of the satellite constellation use case. The early 2020s may be the start of the long-promised tipping point for space launch – a year of potential commercial firsts, specifically the creation of the Commercial Crew Development program to support human spaceflight missions through NASA and privately operated crew vehicles, the first

commercial passenger flight for Virgin Galactic, the first commercial launch for Virgin Orbit, and the first human flight for SpaceX – all launching from different spaceports.

Our Vision of the Future in the Context of Aerospace and Defense in California

Examining the market and industry dimensions and in consultation with government and industry leaders, we have identified four emerging areas for growth that may impact the future of space in the State of California. It is no coincidence that three of the four areas are well represented as defined segments within the value chain – the State has a long history of success in aerospace manufacturing, launching rockets, and the pursuit of digital through application and technology development. Additionally, our initial findings at the state level present key questions for the role of the State in growing not just activities at VAFB but other components of aerospace within the state.

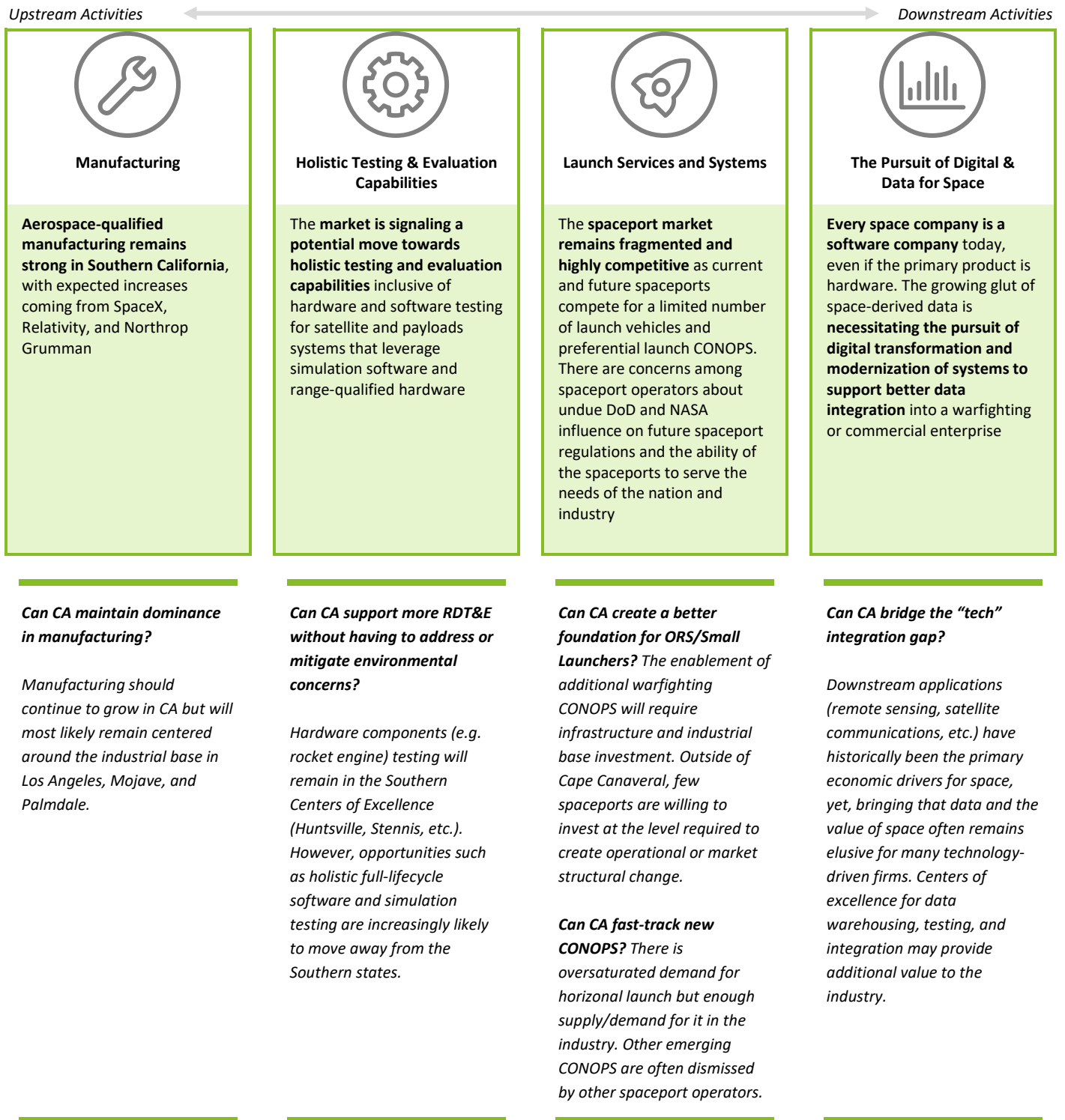
The State of California is committed to cultivating innovation and growing the space industry by making a long-term bold play to create growth across the state. To support this vision in the Central Coast region, we have created a vision for the future and are proposing a bold challenge of where to go with that vision.

Our vision for the future of space in the Central Coast region is a developed space cluster, centered around VAFB, with elements of the 1) launch, 2) downstream applications, and 3) testing and evaluation services segments that support national security, civil, and commercial space missions and operations. These three pillars build off the existing launch infrastructure at VAFB and the competitive advantage of having a fully established launch range, while providing more stability due to a highly coupled but also diversified industry, market, and operational cycles.

We have the unique opportunity to develop a space subcluster that would create meaningful and sustainable economic growth for the region. The challenge we have proposed is for the subcluster to establish itself as a global space industry leader through the following elements: 1) ability to host regular orbital launch from multiple launch service providers; 2) establishment as an ecosystem for logistics, downstream applications, and testing and evaluation capabilities; 3) destination as a research hub for SDA. In addition to those core elements, we also challenge this coalition to look towards a future state that potentially enables sustained human spaceflight operations to orbit and orbital destinations for the first time from the State of California.

FIGURE 5

Industry Context and Trends



A Vision for the Future for Vandenberg AFB

Where to Play

Dimension 1: The Market Play

We recommend a focus on leading in the 1) launch services, 2) logistics, and 3) downstream applications segments of the value chain.

Dimension 2: The Operations Play

We recommend a focus on 1) continuing to support strategic (heavy) launch for all users while enabling operationally responsive space.

Dimension 3: The Development Play

We recommend a focus on developing a space cluster centered around launch, logistics (SSA/SDA), and downstream applications.

How to Play

Grow Launch Services Activities

Focus area: Increase capabilities at Vandenberg AFB and the Western Range to support additional launch types and concepts of operations inclusive of most launch architecture types

Outcomes: Diversifies launch activities beyond heavy launch to include horizontal (air launch), small vertical launch, and potential other emerging concepts

Build an Ecosystem for Downstream Applications

Focus area: Build the regional ecosystem to support downstream applications (space data and services) companies and the associated workforce

Outcomes: Diversifies the space companies and associated value chain components within the region by providing a more continuous workforce presence

Create Capabilities for Testing & Evaluation

Focus area: Create capabilities for testing and evaluation in support of launch and downstream applications

Outcomes: Diversifies the aerospace and defense presence within the region and provides sustainable operations and a more continuous workforce presence within the region

Requirements to Enable the Vision

- Targeted investment in supporting and enabling on-base infrastructure
- Creation of the Commercial Space Zone
- Targeted investment or improvements in regional infrastructure including those that support workforce transportation to/from other major hubs
- Utilization of incentivization “levers” to support the growth of the commercial space user base across the launch services and downstream segments of the value chain
- Support from key stakeholder groups at the federal, state, regional, and local levels
- Development of a skilled workforce by building a talent pipeline and/or relocating talent

Preliminary End State Goals

Increased number of LSPs that provide most of the CONOPS and vehicle classes: 5-7 LSPs focused on Small/ORS, Medium/TRS, Heavy/Ultra Heavy, and Horizontal

Creation and development of the Commercial Space Zone (CSZ)

Developed and attracted a sustained presence of technology companies to the CSZ focused on Space Domain Awareness, Downstream Applications, and Ground Systems

A Bold Challenge for California

Together, we can imagine a bold future where there is a developed space subcluster in the Central Coast that contains a sustained presence from companies across the value chain and....



Supports regular orbital space launch from multiple launch service providers



Enables and supports the military and commercial use of responsive access to space



Is home to multiple vertical launch providers and at least one horizontal launch provider



Operationally responsive space is enabled and supported through horizontal and vertical launch providers



Is home to an ecosystem for logistics, downstream applications, and testing and evaluation capabilities



Integrates the commercial and government ecosystem for Space Domain Awareness



Provides the conditions to attract and sustain downstream applications providers



Expands the roles of universities in Space Domain Awareness, technology transfer, and innovation

...enables sustained human spaceflight to orbit and orbital destinations for the first time in California

Enabling the Vision

To make the future vision a reality as we move towards bold long-term goals, it will be imperative to continuously scan the value chain, assess competition, and engage VAFB stakeholders. In the near-term, we have identified specific growth opportunities for VAFB to explore on its journey to become a space cluster development. In the longer term, as the State of California and the region boldly commit to a global space industry leader status, we will need to continuously re-assess the market opportunities based on the value chain assessment, the infrastructure projects required to make these opportunities a reality, and the willingness of stakeholders to continue building this vision.

The vision and challenge outcomes are not achievable overnight, and we understand that we may wish to temper our expectations as factors across the various dimensions play out accordingly. As such, the roadmap produced in later phases of this project will provide additional fidelity in the pathways to achieving this vision and responding to the challenge. For now, we ask that we all think boldly about the future of space in California and the Central Coast Region.

Identification of Growth Opportunities with the Space Cluster Development – Where to Play

Based on the intersection of industry reach, the value chain assessment, launch types, and development goals, we have identified specific growth opportunities that couple potential market positions for VAFB and the Central Coast Region with

tangible capabilities to create a portfolio-driven outlook.

Recommended Market Play (Dimension 1) – Launch Services, Logistics, and Downstream Applications

Our vision for the future of VAFB and space within the Central Coast Region is one that expands beyond the core operational profile of launching heavy rockets in support of the NSSL mission and commercial customers. However, due to the volatility of the heavy launch market and potential near-term contracting demand, we looked across the value chain to examine where the region could have a competitive play in coupled or adjacent areas of the market. This ensures that the overall space activity in the region, and the corresponding workforce and the presence of commercial space companies, remains stable and diversified even if launch operational tempos fluctuate.

Market Segment 1: Launch Services (See Recommended Operations Play)

Market Segment 2: Logistics

The physical presence of the Combined Space Operations Center (CSpOC) at VAFB in conjunction with the current guidance for Space Policy Directive 3 provides an opportunity to expand engagement around SDA, space traffic management, and debris mitigation. Despite SDA falling in the Space Operations segment of the value chain, the requirements for SDA more closely resemble downstream applications, and we expect synergies to come from the pairing of this portion of

the logistics segment and activities in the downstream applications.

Market Segment 3: Downstream Applications

The market for space-derived data (i.e. remote sensing) is only growing, yet the ability to ingest and exploit that information into a business environment in a timely and relevant manner remains constrained. On the horizon, we see a powerful role for artificial intelligence, machine learning, and analytics in advancing the commercial value of space data. Additionally, the State of California has a leading position in next-generation technology and application development. A linking of the State's core competencies and competitive advantages in technology with the space domain is already occurring in the San Francisco Bay Area. However, there are advantages to collocating closer to the mission and the operations, especially when paired with the operations and logistics subsegments within the Space Operations segment. There is precedent for this model already in Colorado with the TAP Lab in Boulder that provides unclassified testing environments for infrared remote sensing data.

Recommended Operations Play (Dimension 2) – Enable the Entire Launch Spectrum

Our vision for the future of VAFB is one that supports and enables mixed-modes of launch architectures that support national security, civil, and commercial space transportation, and access to orbit needs. This vision recommends addressing the entire launch CONOPS spectrum but doing so in a targeted

manner over multiple time horizons to better mitigate volatility in the launch vehicle supply and commercial demand.

We have assessed VAFB’s current state launch capabilities across multiple user groups (National Security & Defense, Civil, and Commercial), as well as suborbital and orbital launch capabilities using market research and industry specialist interviews. This benchmarking assessment was used to inform recommendations to enable the full spectrum of launch CONOPS at VAFB.

The launch capabilities outlined in *Figure 6* are for launch CONOPS to orbits that are achievable from VAFB. While Phases 1 and 2 of this project will further refine the roadmap for potentially enabling the entire launch CONOPS spectrum at VAFB, our initial recommendations are as follows:

1. Continue to support and sustain heavy launch to NGSO for the NSSL mission and commercial providers;
2. Position to be the primary basing location for one horizontal orbital satellite launch services provider;
3. Focus on the renovations/restoration of SLC-8 to support small launch vehicles; and
4. Determine the applicability of hosting TRS capabilities at VAFB and supporting their needs within the region.

coupled, complimentary, and adjacent but addressable components of the three dimensions.

By focusing on the development of a space cluster versus a more traditional spaceport construct, we believe that VAFB and the Central Coast Region will have a stronger business case to attract and maintain space industry activity across the identified segments of the value chain. Furthermore, a developed space subcluster is less likely to see volatility as it is not solely dependent upon the activities of the launch services providers.

Recommended Development (Dimension 3) Approach – Space Subcluster

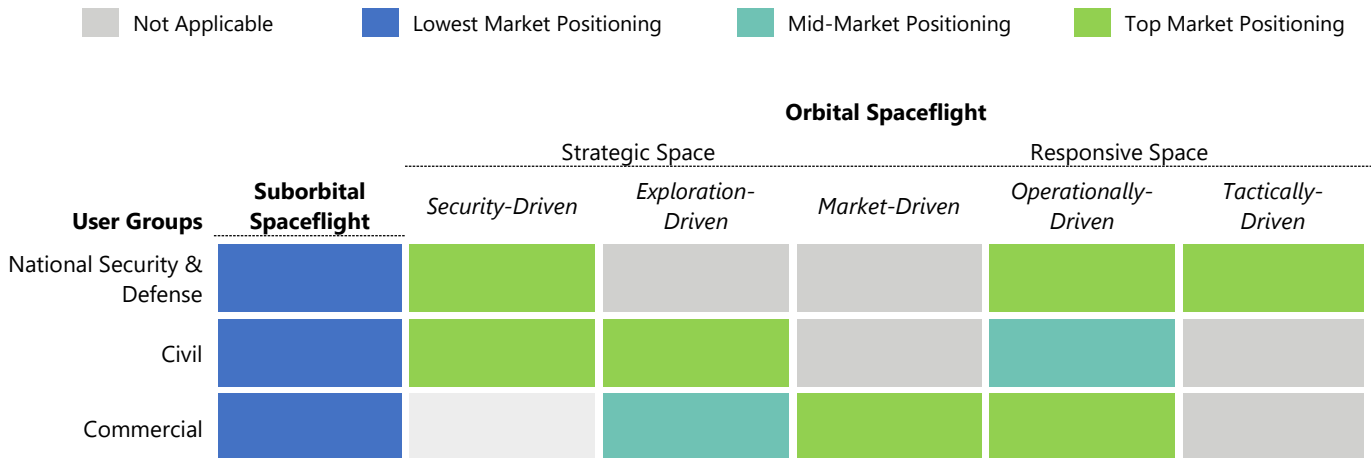
Following our initial research and analysis, we recommend that collective stakeholder groups adopt a space cluster development approach and focus on

Enabling a space subcluster is not without its own unique challenges, and our recommendations for areas to address are as follows:

1. Transportation and logistics challenges will continue to stifle growth opportunities within the

FIGURE 6

Launch Services Capabilities Attractiveness Mapping for Vandenberg AFB Operations



region: VAFB is challenging to get to from Los Angeles, San Francisco, or Colorado Springs.

2. The earlier stage companies that are most likely to be partners and participants within the subcluster may lack the infrastructure development capital required to move their workforce or capabilities, thereby making incentivization mechanisms critical to enablement of the subcluster.
3. U.S. Government contracts act as a driver for collocation, and the USSF's presence in the subcluster may create barriers to growing company presence if historical contracting precedent remains. Simply put, if there is a perception that USSF contracts related to SDA will continue to go small business for prime contract award, the desire for medium and large companies to relocate may be low.

Growing Identified Opportunities within the Region – How to Play

With the recommended development approach defined, the “how to play” across the development areas becomes more evident. At the conclusion of Phase 0, we have synthesized three pathways that help frame the steps required to implement the vision. These pathways come with their own infrastructure and operational requirements, as well as considerations for how to incentivize growth and which industry players to target. While they are inherently coupled from a market perspective, there are enough nuances such that they each require their own structured approach as they will be implemented and operated across different time horizons.

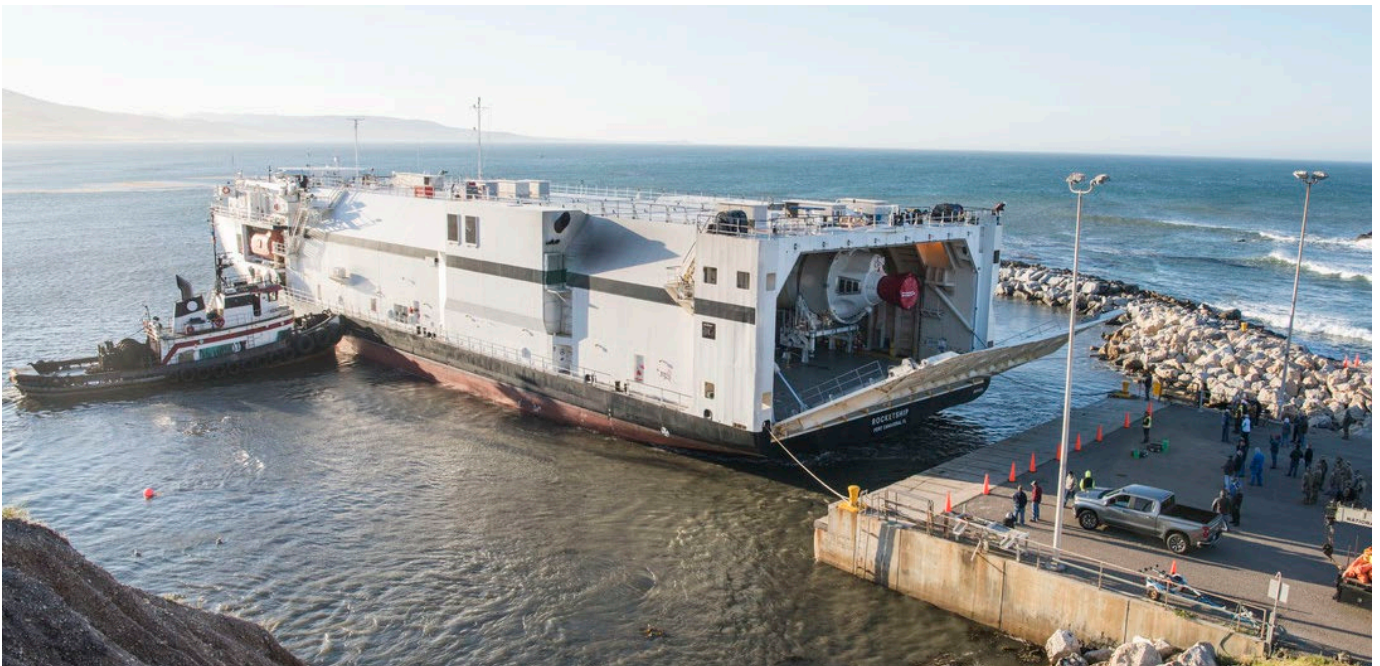
What Comes Next

At the end of Phase 0, we believe that VAFB and the Central Coast communities have a great potential to build a commercial space presence in the region

that promote economic development and job creation, position California as a global leader in the future of the commercial space industry, and advance the national security of the United States.

We still have a ways to go towards delivering the full master plan across Phases 1 and 2 of this project but we approach this challenge, collectively, with excitement of what we can build together and with a goal of enabling our vision and rising to meet our bold challenge.

In Phases 1 and 2, we will expand our analysis across all the dimensions along with working closely with the Central Coast communities, the ever-expanding commercial space industry, academia, and everybody in between. We welcome engagement and participation from all potential stakeholders – academia, national labs, venture capitalists, students, states, commercial space companies, and more – as we strive to reach these goals.



The hatch opens on a United Launch Alliance barge, known as the *RocketShip*, revealing a Delta IV Heavy booster May 4, 2020, at Vandenberg Air Force Base

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Images

- Page 4. *Vandenberg AFB LCDM Launch Site.* NASA Landsat Data Continuity Mission (LCDM). Credit: NASA
- Page 8. *A United Launch Alliance Delta IV-Heavy rocket launched by team Vandenberg from Space Launch Complex-6.* Credit: U.S. Air Force photo by Joe Davila/Released
- Page 14. *A United Launch Alliance Delta IV-Heavy rocket launched by team Vandenberg from Space Launch Complex-6.* Credit: U.S. Air Force photo by Joe Davila/Released
- Page 14. *A U-2 Dragon Lady approaches an altitude near 70,000 ft. above California, Mar. 23, 2016.* Credit: U.S. Air Force photo/Staff Sgt. Robert M. Trujillo
- Page. 14. *The third mission (OTV-3) of the Boeing-built X-37B Orbital Test Vehicle on Oct. 17, 2014, when it landed and was recovered at Vandenberg Air Force Base, Calif, following a successful 674-day space mission.* Credit: Boeing/USAF
- Page 26. *The hatch opens on a United Launch Alliance barge, known as the RocketShip, revealing a Delta IV Heavy booster May 4, 2020, at Vandenberg Air Force Base, CA.* Credit: U.S. Air Force photo Senior Airman Aubree Owens

Appendix

The following section contains the full text of the Memorandum of Understanding (MOU) as signed by all parties on July 15, 2020.



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