Washington State Space Economy

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PREPARED BY: **BERK**

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Executive Summary

Washington state and the central Puget Sound region are positioned to lead commercial space exploration and development. Over the past 50 years, space activities in the region have evolved from early research, development, and manufacturing for the US national space program into a diverse pool of local and international companies providing a range of space-related services. Today, the region's mix of high-tech manufacturing resources and information technology assets creates significant opportunities to compete in this growing sector.

The modern space economy involves a broad spectrum of goods and services that support the access and use of space:

- **Lower-tier suppliers** that provide parts, components, and other services to space-related manufacturers and other customers
- **Upper-tier suppliers and original equipment manufacturers (OEMs)** that manufacture spacecraft, satellites, launch vehicles, or major assemblies or systems for these products
- **Space launch service providers** that maintain and operate facilities for launch vehicles and coordinate mission management and ongoing operations
- **Providers of space-related goods and services** that manage the products that are directly derived from spacecraft, satellites, and launch vehicles
- **Businesses supported by space activities**, including firms that rely on space-related goods and services in their operations

The ongoing commercialization of space has changed this economic landscape dramatically since the Space Race of the 1960s. Spacecraft and satellites cost less to build and put into space. Lower costs have spurred new applications for space and allowed a broad range of companies, organizations, and governments to access space-related services such as positioning, telecommunications, and Earth observation. This expansion of "NewSpace" or "Space 2.0" has also broadened competition in areas traditionally reserved for governments and multinational corporations. For example, Blue Origin, SpaceX, and other companies have developed space launch services over the past several years that are rivalling what larger traditional aerospace companies such as United Launch Alliance and Arianespace can provide.

In the central Puget Sound region, aerospace has been a traditional focus of the economy, and suppliers and manufacturers are located across the region and state. New companies have entered the market, however, and are expanding. Blue Origin in particular has grown substantially, with over 1,100 employees at its headquarters in Kent, and plans to expand its manufacturing and launch service operations further. SpaceX has developed satellite manufacturing capabilities in Redmond and Seattle to support its Starlink satellite constellation for providing broadband internet. Other space companies and startups are also in the area and have added further diversity to the larger aerospace cluster in the region.

Calculating the economic effects of the space economy can be challenging. Products and services that use space are ubiquitous in our economy today, and suppliers to space companies are integrated into the

broader aerospace supply chain. Focusing on the core elements of the space economy, including original equipment manufacturers (OEMs), launch service providers, and satellite support services, these businesses are currently responsible for about $1.8 billion in economic activity, with about 6,221 jobs supported across the entire economy. These companies also contribute about $65 million in state and local taxes. These are notable impacts, and likely to increase in the future as startup businesses become more established and sustainable through generated revenue.

Competition between other regions in the US and abroad will be challenging in the years to come. Many other space-related economic clusters have developed around existing launch and manufacturing facilities for space and defense, which has encouraged new growth in commercial space companies through access to supporting infrastructure and talent. Although other areas in the US have fewer traditional ties to the space industry, access to sufficient venture capital has been another competitive advantage, especially versus space-related startups in other countries. The central Puget Sound region is well-suited to compete in many areas, however, with a strong pool of talent, interest in the region from single-investor venture capital, and the network of existing aerospace suppliers.

Maintaining and enhancing the quality and availability of local talent will be a major consideration in promoting space-related businesses into the future. In this region, competition for talent will be significant, and not only between other space firms. Multiple large aerospace and technology firms headquartered in the region employ a significant amount of skilled labor, and will compete for talent across multiple science, technology, engineering, and math occupations. Although some space companies can work to attract talent from across the country, startups and suppliers may need or prefer to draw from local talent. Educational institutions in the state that support this local talent pipeline may need to expand their programs further, which may also be required to meet the needs of aerospace in general.

Efforts that can support future competitiveness and growth in the regional space economy include the following:

- **Providing state tax credits through SB 6411.** State tax credits to support spacecraft and satellite manufacturing have been proposed in the Legislature since 2015 and have failed to move out of committee. The most recent attempt, SB 6411, is still under review and should be approved to support state and local businesses involved in space.
- **Supporting space-related startups with incubator/accelerator services.** Access to sufficient venture capital and supporting services can be essential for new companies. Although this is typical of all new companies, space-related companies often have different requirements for facilities and capital and supporting services than other high-tech startups, such as support for navigating federal regulations about space technology.
- **Developing and expanding supplier relationships.** Building the relationships between space companies and suppliers in the region can be essential in capturing more of the economic benefits of Opportunities should be explored both to link upper-tier manufacturers and original equipment manufacturers with existing lower-tier suppliers, and to attract, grow, and retain new suppliers that can support growing demands for a space-related supply chain.

Contents

Introduction

Washington state and the central Puget Sound region are positioned to play a significant role in the future of commercial space exploration and development. Over the past 50 years, space activities in the region have evolved from early research, development, and manufacturing for the US national space program into a diverse pool of local and international companies providing a range of space-related services. Today, the region's mix of high-tech manufacturing resources and information technology assets creates significant opportunities to compete in this growing sector.

These opportunities are coming at a time of significant growth for the space economy in the US and around the world. Projections by leading investment banks have suggested that the space economy could increase from around $350 billion today to about $1.1 trillion by 2040 (Morgan Stanley, 2017) or as much as $2.7 trillion by 2045 (Sheetz, 2017). Much of this growth is expected in products and services accessible to smaller firms such as satellite manufacturing and services, an area which has outpaced overall growth in the sector and forms 77% of the overall space economy.

To understand the extent of these future opportunities, this report is intended as a guide to the commercial space economy in the central Puget Sound region and Washington state. As part of this study, we outline activities such as satellite and space vehicle manufacturing, parts suppliers, space-related research, and space-related products and services. We also identify emerging opportunities at the regional and state level to better compete in the space economy, with the objective to promote awareness of our local potential.

This study includes the following:

- An **overview and definition of the "space economy,"** including major industries in the central Puget Sound region and Washington state and major users of space-related services
- **Economic impacts of the regional space economy**, with estimates of type and number of jobs created, associated increases in state and local GDP, and the breakdown of impacts by sector, developed using the IMPLAN II software package
- A **competitive analysis of domestic and international regions**, with a focus on their comparative strengths and weaknesses versus the central Puget Sound region and Washington state
- **Workforce and education requirements** for space-related firms in the region and state, including any potential pipeline concerns identified in the current system
- An **evaluation of the competitiveness of the central Puget Sound region and Washington state** based on the results of these analyses and stakeholder interviews

  Although this study is intended to be descriptive, we note potential areas of interest for state and regional economic development agencies throughout the report. We also highlight possible areas of economic growth that could be explored in future work.

An Overview of the Space Economy

Producing spacecraft, satellites, and other space-related products involves a complex web of activities that rely on goods and services across the entire economy. One list produced by the US Department of Commerce consists of 16 general market segments in space-related products and services (2014a):

- Spacecraft & Launch Vehicles
- Propulsion Systems & Fuels
- Navigation & Control
- Communications Systems
- Space Survivability, Environmental Control/Monitoring, and Life Support
- Payload Instruments & Measurement Tools
- Ground Systems
- Non-Earth Based Surface Systems
- Power Sources & Energy Storage
- Electronic Equipment
- Computer Hardware & Robotics
- Software
- Materials, Structures, and Mechanical Systems
- Manufacturing Tools & Specialty Equipment
- Services
- Research & Development

These products and services relate to accessing space, but commercial applications of space-related services from satellites and spacecraft also drive the space economy. Today, products and services such as telecommunications, satellite TV and radio, and GPS navigation are supported with satellites, spacecraft, launch vehicles, and related infrastructure. In the future, commercial space businesses are expected to be involved in other space-related activities such as asteroid mining, space tourism, and colonization as well.

When reviewing production and supply chains, and the downstream products and services that rely on access to space, we divide the activities in the space economy into five major categories (Exhibit 1):

- **Lower-tier suppliers** that provide parts, components, and other services to space-related manufacturers and other customers
- **Upper-tier suppliers and original equipment manufacturers (OEMs)** that manufacture spacecraft, satellites, launch vehicles, or major assemblies or systems for these products
- **Space launch service providers** that maintain and operate facilities for launch vehicles, and coordinate mission management and ongoing operations
- **Providers of space-related goods and services** that manage the products that are directly derived from spacecraft, satellites, and launch vehicles
- **Businesses supported by space activities**, including firms that rely on space-related goods and services in their operations

  Businesses in the space economy can be in more than one role. For example, SpaceX, currently an OEM and launch service provider, is planning to provide space-related services through its Starlink satellite broadband internet service.

Exhibit 1. Major elements of the space economy supply chain.

LOWER-TIER SUPPLIERS

UPPER-TIER SUPPLIERS AND OEMS

SPACE LAUNCH SERVICE PROVIDERS

SPACE-RELATED GOODS AND SERVICES

SPACE-SUPPORTED BUSINESSES

DESCRIPTION

Lower-tier suppliers provide key raw materials, parts, and services that are used for space-related applications. These suppliers may not be exclusive to the space and defense industries.

Upper-tier suppliers create the major assemblies, components, and systems for spacecraft, launch vehicles, and satellites, and **Original Equipment Manufacturers (OEMs)** provide the final manufacturing and assembly of these products.

Space launch services (public and private) provide for the launch of spacecraft and satellites, and their ongoing management and operation.

Space-related goods and services are provided directly by firms via operating space-craft, satellites, and other space-based equipment.

Space-supported businesses incorporate the output of satellites and spacecrafts into a range of goods and services.

ACTIVITIES

- Power systems
- Communications systems
- Structural components
- Machined parts
- Support services

- Launch vehicle engine manufacturing
- Structural assemblies
- Spacecraft manufacturing
- Satellite manufacturing

- Launch facilities
- Private launch services
- Spacecraft / satellite mission management

- Global Positioning Systems (GPS)
- Satellite telecommunications
- Earth observation
- Space exploration
- Asteroid mining
- Space colonization

- Satellite TV
- Weather forecasting
- Vehicle fleet tracking and management
- Space-supported research
- Defense applications

LOCAL EXAMPLES

Electroimpact, Inc. in Mukilteo manufactures composite materials and machined parts for satellite fixtures, containers, and trailers, as well as other aerospace and related products.

Blue Origin in Kent is currently developing the BE-4 rocket engine for the United Launch Alliance and the *New Glenn* orbital launch vehicle for future spaceflight services.

Spaceflight Industries in Seattle provides satellite launch and mission-related services, including transportation and "ridesharing" of payloads on commercial launch vehicles.

Planetary Resources in Redmond is planning to survey asteroids and coordinate long-term robotic asteroid mining operations.

Zonar Systems in Seattle provides fleet tracking and management services, in part relying on GPS and satellite services.

Source: BERK, 2018.

LOWER-TIER SUPPLIERS

At the initial stages of the supply chain, lower-tier suppliers produce the constituent materials and parts for spacecraft, satellites, and launch vehicles. These suppliers include businesses like metal and plastics manufacturers, machine shops, instrument manufacturers, and electronics producers. The activities involved are wide-ranging, and businesses often are not limited to space applications. While some companies do specialize, others produce materials also used in aircraft, maritime, or automotive manufacturing.

This category also includes support services related to production. Professional services such as business management, operational support, transportation and warehousing, and legal services are a significant portion of the total inputs to manufacturers. These services are critical for businesses in the space economy, but many of these businesses also do not specialize in providing these services to the space economy.

The history of commercial aircraft manufacturing in the central Puget Sound region has built a broad base of specialized aerospace manufacturers and service providers. These businesses benefit new spacecraft, launch vehicle, and satellite manufacturers desiring to locate in the region.

Local Examples

Businesses in this category in the central Puget Sound region include the following:

- **Electroimpact, Inc.** Electroimpact is an aerospace tooling and component manufacturer in Mukilteo. Its operations include the design and production of space and satellite components such as fixtures, containers, trailers, and other forms of satellite tooling. It has the capacity for providing satellite and panel assembly, satellite transporters, specialized lifting equipment, and mass simulators.
- **Crane Aerospace & Electronics.** Crane AE in Lynnwood is a manufacturer of major aerospace components and systems, including sensing systems, fluid management, landing gear, and cabin systems. It offers product development, production, and aftermarket support for components.
- **Tethers Unlimited, Inc.** Tethers Unlimited designs and manufactures power, propulsion, actuation, and communications systems for small satellites; robotic technologies for on-orbit fabrication and assembly; software defined radio communications; and 3-D printed radiation shielding. Its products have numerous applications across the space economy, ranging from small-satellite industry, to in-space manufacturing and construction, and defense applications.

UPPER-TIER SUPPLIERS AND OEMS

Developing and manufacturing spacecraft, satellites, and launch vehicles to access space is core to the space economy. Upper-tier suppliers include businesses that develop major assemblies and systems for these products, including communications, power, engine, and structural systems. Original equipment manufacturers (OEMs) provide the final development and assembly of spacecraft, satellites, and launch vehicles. Altogether, the final output of these businesses are products ready to launch into space.

There is significant crossover between this category and defense-related activities. Guided and unguided missile manufacturing facilities can be repurposed for building rockets for launch vehicles. In other areas, this has allowed businesses involved in defense applications to manufacture space-related products as well.

Puget Sound has a history of supporting upper-tier suppliers and OEMs. The Boeing Kent Space Center developed and manufactured lunar rovers for the Apollo missions, and continues to support Boeing activities related to space-based equipment. Recently, however, new space-related OEMs have been founded here, such as Blue Origin, or have relocated here, such as SpaceX.

Local Examples

Examples of upper-tier suppliers and OEMs in the central Puget Sound region include:

- **Blue Origin.** Blue Origin is a private spaceflight services, orbital spacecraft and launch vehicle manufacturing company headquartered in Kent. Founded in 2000, this firm has positioned itself at the forefront of the NewSpace field, developing the BE-3 engine and New Shepard suborbital rocket, the BE-4 engine for United Launch Alliance's Vulcan rocket while investing in the creation of the New Glenn orbital launch vehicle for spaceflight services. Lunar exploration activities have also been proposed. The Kent campus is also supplemented by launch and testing facilities in Texas, the New Glenn manufacturing and launch complex in Florida, as well as a proposed manufacturing facility in Huntsville, AL.
- **Boeing Defense, Space & Security.** The Boeing Company operates facilities for Boeing Defense, Space & Security in the central Puget Sound region. Previously, these activities have been hosted at the Boeing Kent Space Center in Kent, which opened in 1964, and have included the development and construction of the lunar rovers and upper-stage rockets for space exploration. This facility has been downsized, and the company has shifted employees to facilities in Tukwila.
- **SpaceX.** Space Exploration Technologies Corporation (SpaceX) is a private spaceflight services and launch vehicle and orbital spacecraft manufacturing company. Headquartered in Hawthorne, CA, the company has development and testing facilities in Seattle and Redmond for satellite development and production. They are related to the Starlink project, which will launch and maintain a constellation of 4,425 satellites to provide global broadband internet services, projected to begin by 2021.
- **Aerojet Rocketdyne, Inc.** Aerojet Rocketdyne is a space systems manufacturer headquartered in El Segundo, CA, with a branch located in Redmond. The Washington-based facility produces 200-500 rocket thrusters a year, ranging from tiny rockets to keep satellites properly positioned to ones rated at 600 pounds of thrust or more.

SPACE LAUNCH SERVICE PROVIDERS

Businesses and organizations that manage the launches of spacecraft and satellites into space are critical to the space economy. This includes not only the launch facilities themselves, but also the coordination of spaceflights, mission management, ground support of spacecraft, and ongoing operations of satellites.

These services were provided by the US federal government in the past, but since the 1980s businesses have worked with foreign governments and increasingly commercial launch service providers to access space. The dynamics of commercial launch providers are also changing. Larger private enterprises such as the ULA and Arianespace are now competing with smaller, privately owned launch providers such as SpaceX, Blue Origin, and RocketLab for both government and commercial launch contracts.

The central Puget Sound region has no government or commercial launch facilities available. There are smaller businesses in this category that also broker and manage launch services for clients, and companies such as Blue Origin and Stratolaunch rely on launch facilities elsewhere.

Local Examples

- **Spaceflight Industries.** Spaceflight Industries is headquartered in Seattle and provides end-to-end mission management, launch services, and connectivity for small satellite missions. They coordinate launches through "ridesharing," using payload capacity available in larger launches for the secondary deployment of smaller satellites into orbit. The company has served 32 countries through 10 launch vehicles, with about 4,900 kg of satellites on contract to launch.
- **Stratolaunch Systems Corporation.** Stratolaunch is a Seattle-based company developing a horizontal launch vehicle to take off from standard airfields and deploy payloads into orbit from the air. Co-founded by Paul Allen and Burt Rutan, and managed under Vulcan, Inc., this company works with Scaled Composites at the Mojave Air and Space Port, CA, in these development activities.

SPACE-RELATED GOODS AND SERVICES PROVIDERS

The goods and services provided by satellites and spacecraft are another focus of the space economy. Today, these include:

- **Telecommunications**, including TV and radio, telephony, broadband internet, satellite telemetry, fleet management communications, and other communications services using satellites
- **Earth observation (EO) and mapping**, including multi-spectral imagery acquisition and processing, global positioning system (GPS) services, weather observation, and other services that collect data about the Earth from space
- **Research**, including experimental work in physics, life sciences, metallurgy, chemistry, and other fields in zero-g and extreme environments in space
- **Defense**, which may include telecommunications and earth observation as well as other space-based military applications

Future applications are expected to provide a greater range of goods and services, including:

- **Space mining and resource extraction**, including asteroid mining and solar power generation
- **Space industrial operations**, such as zero-g refinement and manufacturing processes
- **Space tourism**, including civilian tourism
- **Exploration and colonization**, such as future lunar and Martian exploration missions

Many of these speculative activities are not practical today. However, numerous businesses and research organizations are actively conducting research today to make them cost-effective in the future and are currently courting venture capital funding.

In the central Puget Sound region, these businesses tend to be small-scale and focused on specific applications. SpaceX is expected to be a major service provider within the next few years, with the Starlink satellite constellation network anticipated to provide low-cost, satellite-based broadband internet access by 2021.

Local Examples

- **Planetary Resources.** Planetary Resources is exploring profitable asteroid and comet mining through advancements in the necessary space technologies. The company has created an earth observation platform with infrared and hyperspectral sensors, and is researching how to produce propellant in space from water and methods to manufacture high-end electronics, laboratory equipment, and spacecraft components in zero-g.
- **RBC Signals.** RBC Signals from Redmond provides "infrastructure-as-a-service" offerings for satellite operations, providing real-time communications with satellites through ground stations. They broker unused capacity from participating stations to customers without dedicated ground stations available, reducing costs to users.
- **BlackSky.** BlackSky is the digital-imaging subsidiary of Spaceflight Industries and is located in Seattle. They provide customers with combinations of high-resolution satellite imagery and real-time sensor data such as news feeds, social media, and radio communications. These can be used for a range of applications, such as tracking economic assets, monitoring illegal activity, providing humanitarian relief, and managing borders.

BUSINESSES SUPPORTED BY SPACE ACTIVITIES

As the commercialization of space continues, space-related technologies are improving the quality and functionality of a wide range of goods and services, and reducing production and service delivery costs. Examples include:

- Satellite TV and radio service providers
- Telephone and internet providers
- Weather forecasting services
- Fleet and asset tracking systems
- Navigational systems, including maritime, aircraft, and personal systems
- Disaster management and search & rescue coordination
- Research activities in agriculture, oceanography, climatology, and other areas that rely on detailed data collected from satellites and spacecraft

Although these activities have all existed prior to commercial access to space, satellite telecommunications, earth observation, and GPS are being used in production processes, service delivery, and uses of these goods and services to enhance their usefulness and make them more affordable.

Identifying businesses in the central Puget Sound region that use satellite and space-related services is challenging, as they are commonplace in the current market. Space-related services are often interrelated with the services provided by the information and communication technology services cluster found in the central Puget Sound region, especially with respect to computer programming and "big data" management. Likewise, navigational systems for aircraft and maritime vessels provide crossovers between space-related services and the maritime and aerospace manufacturing sectors in the region.

Local Examples

- **Zonar Systems, Inc.** Zonar Systems is a Seattle-based firm that manages a technology platform for fleet management, route optimization, and asset tracking using telematics, including satellite

communication. They provide real-time management for mass transit, school bus transportation, commercial trucking, delivery, construction, waste management, and other fields.

- **Meteorcomm LLC.** Meterocomm is a Renton-based firm that coordinates wireless communications, including satellite communications, for the rail industry. This includes its Interoperable Train Control Network (ITCnet), which provides interoperable communications across major railroads, commuter, and short-line railroads for asset management and train safety.

A SHIFTING LANDSCAPE: THE RISE OF "NEWSPACE" / "SPACE 2.0"

Space exploration has been the domain of governments for decades, with economic applications a distinct part of this effort. However, the ongoing commercialization of space has changed the focus of activities in space. This started in the in the mid-1980s with the *Commercial Space Launch Act* of 1984 (Canlis 2016). Commercial space launches grew in importance after the Challenger disaster in 1986, after which the US Space Shuttle program no longer carried commercial satellite payloads.

This increased commercialization and decline in government involvement with space-based activities has led to the emergence of "NewSpace," or "Space 2.0." The Space Frontier Foundation defines NewSpace as:

> *"People, businesses and organizations working to open the space frontier to human settlement through economic development."* (2018)

Overall, this broad trend has included:

Cost Reductions

- **Reduced costs for satellites and spacecraft.** New production processes and materials have reduced the costs to build and launch satellites and spacecraft. Modern satellites are scaled to purpose with limited lifetimes (such as smaller satellites developed under the 10-cm CubeSat standard), and can be constructed with off-the-shelf parts at lower cost.
- **Reduced costs for access to space.** The private sector has also reduced the price of space launches to customers. Blue Origin, SpaceX, RocketLab and over 90 other private companies have led this effort, and firms such as Spaceflight Industries "rideshare" smaller satellite payloads into orbit more efficiently. The use of less expensive launch facilities overseas and more efficient uses of payload spaces are also reducing prices. Overall, the cost of a launch has been reduced to the tens of millions of dollars. Launching a satellite that is the weight of Sputnik I into low Earth orbit can even be achieved today for less than $4 million as part of a combined payload (Spaceflight Industries, 2018).

Increasing Diversity in Participation

- **Lower barriers to entry for startup companies.** With lower production costs, lower requirements for initial capital investments, lower costs to access space, and a greater availability of space-related services across the economy, space-related startups no longer have the barriers to entry from decades ago. Smaller companies can build and launch satellites and offer space-related products and services for a fraction of the cost than before.

- **Democratizing access to space.** As barriers to entry decrease, a range of countries, businesses, and other organizations can now launch and operate satellites independently. This means that more groups can be part of this market than ever before and take advantage of access to space apart from traditional government space programs.
- **Increased role of private capital in space development.** As the commercialization of space has continued and startup companies are playing a greater role in the market, private capital in the sector has increased to support this new market activity. For smaller startups, venture capital funding and crowdfunding have been important, and even larger private companies such as Blue Origin are funded through regular capital contributed by Amazon CEO Jeff Bezos (estimated at about $1 billion per year).

More Ambitious and Diverse Applications

- **Broader applications of space.** With greater commercialization, more participants in the market, and lower costs to build and deploy satellites and spacecraft, a greater range of applications for space are available over such disparate fields as agriculture, surveying, disaster relief, weather and earthquake prediction, environmental monitoring, and others. This not only promotes more commercial activity in the space economy, it also continues to improve the capabilities and efficiency of goods and services across the economy as a whole.
- **Private initiatives for space exploration and colonization.** As the costs to access space have declined and the private sector has taken a greater role, businesses are also exploring more speculative, long-term activities. This includes exploration and future colonization: Blue Origin and SpaceX have publicly announced initiatives for lunar and Martian exploration and colonization, respectively, and are currently pursuing the technology necessary for this work.

THE SPACE ECONOMY IN THE PUGET SOUND AND WASHINGTON STATE

While the central Puget Sound region has had some involvement in the space program in the past through the Kent Space Center, the local aerospace sector is specialized in commercial aircraft production. However, the central Puget Sound region has become more competitive because of several trends related to the commercialization of space:

- **Increases in local space-related employment have been supported by private capital investment.** Private capital in the space economy has supported the rise of several firms, including Blue Origin, which is now the largest regional employer in the space sector. The founding of the Blue Origin headquarters in Kent has helped to boost the central Puget Sound region as a major location for space-related activities in the nation and across the world.
- **Attracting talent is an important factor in business success.** New space-related businesses can choose to locate in high-amenity areas to attract and retain talent. The quality of life in the central Puget Sound region can be a major draw for these firms, as they can access a strong talent pool.
- **Access to existing aerospace supply chains and talent can support space-related businesses.** Space economy startups can access the existing aircraft manufacturing supply chains in the central Puget Sound region for required parts and assemblies, including off-the-shelf components that can

be produced at lower cost, as well as the existing regional labor pool of engineers, technicians, and other workers.

- **There is less overall dependence on traditional space centers.** Reduced barriers to entry, increased investment from private capital sources, and broader applications of space means that businesses in the space economy are not limited to where larger firms or government installations are located. Smaller startup businesses can choose to operate outside traditional regions for the space industry because they are not restricted as before. For the central Puget Sound region this is a strong advantage, as the lack of space-related infrastructure has limited participation in the economy in the past.

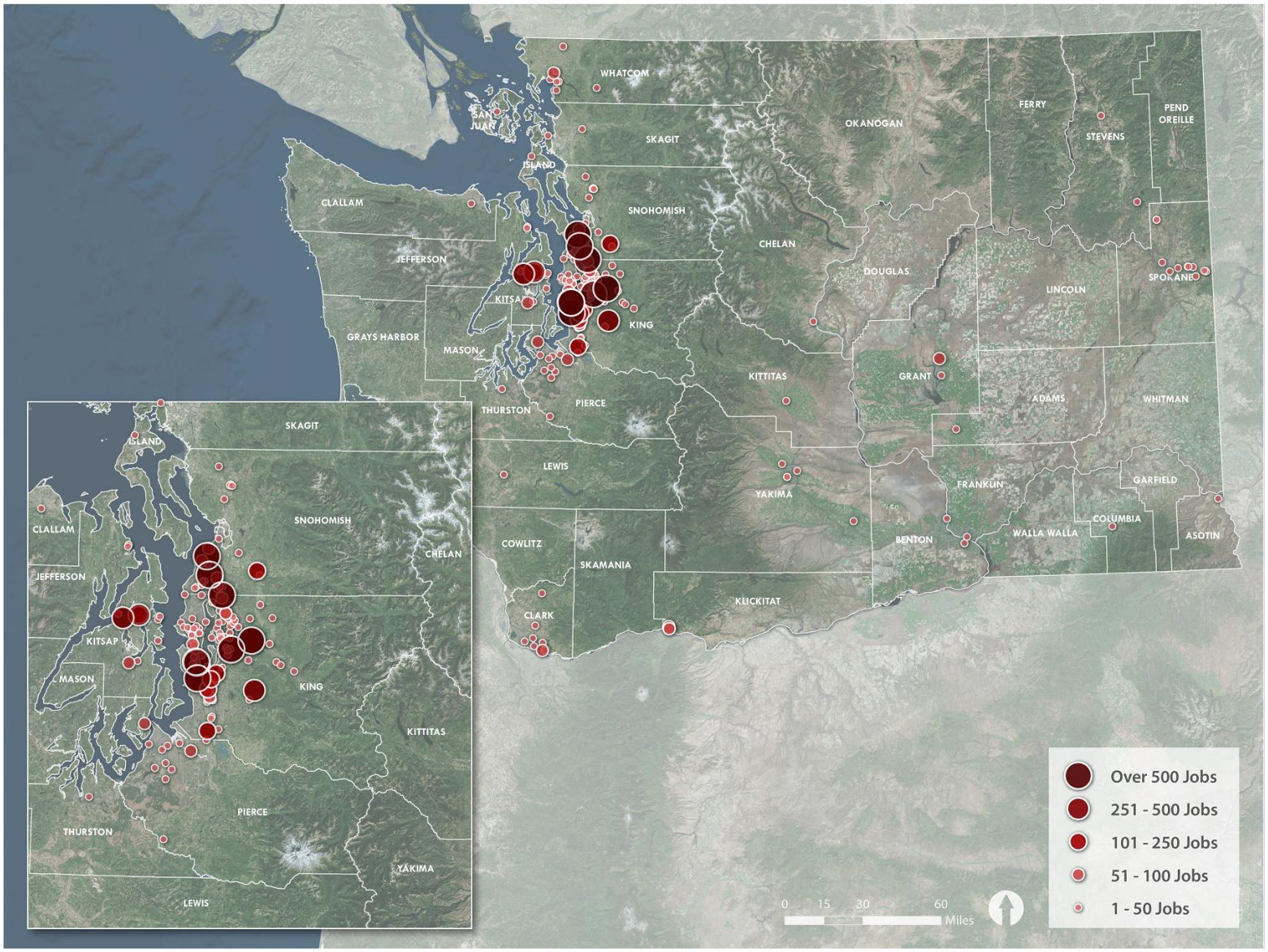
The locations of space-related companies in the central Puget Sound region and Washington state are shown in Exhibit 2. They are generally distributed as follows:

- **King County** has the largest concentration of space-related businesses, including major OEMs and upper-tier space manufacturers such as Blue Origin, SpaceX, and Aerojet Rocketdyne. The primary focus of this activity is in Kent, Redmond, and Seattle. Other suppliers are also located in other communities in the county.
- **Snohomish County** has many of the traditional aerospace suppliers that support Boeing operations in Everett and the region. Although these businesses focus on parts and assemblies for aircraft, they are positioned to support the activities of the space economy as well.
- **Pierce County** has firms that provide support for aerospace manufacturing, primarily through the manufacturing of composites, instrumentation, electronic parts, and navigational systems.
- **Kitsap County** includes operations by major defense contractors such as Northrup Grumman, Raytheon, and Lockheed Martin related to guided and unguided missile manufacturing and maintenance at Naval Base Kitsap facilities, which may draw on a common regional labor pool.

Although Puget Sound is the focus of the space economy in Washington state, space-related businesses are found in other regions as well:

- **Skagit County** has several maritime manufacturers that supply the regional aerospace market. Janicki Industries in Sedro-Wooley is a major supplier that provides composites manufacturing, production tooling, and fly-away parts manufacturing for spacecraft.
- **Grant County** includes businesses located close to the Grant County International Airport (MWH), which was previously an alternate landing location for the US Space Shuttle program. The aerospace sector in this region is focused on aircraft maintenance and defense applications, with divisions of Precision Systems (a subsidiary of General Dynamics OTS) and Aerotec in the county.
- The **Spokane region** has the second-largest aerospace cluster in the state. This includes part and assembly manufacturers that support local aircraft maintenance and supply parts to state, national, and international customers. Hi-Rel Laboratories in Spokane provides failure and materials analysis services for parts and components, including space-related testing for NASA and the Department of Defense.
- **Clark** and **Whatcom counties** include companies in the statewide supply chain that provide components for aerospace and satellite applications.

Exhibit 2. Washington state space vehicle, guided missile, and satellite business locations.



Sources: Hoovers, 2018; BERK, 2018.

SUMMARY OF KEY FINDINGS

The central Puget Sound region is well-positioned to compete in the modern space economy. Current and historical activities in aerospace have developed a broad and supportive network of suppliers and an available and highly skilled talent pool in engineering and manufacturing. Commercialization in the space industry has also led to the rise of smaller startup companies outside the dominant aerospace firms. The central Puget Sound region has been the location of new businesses in the space economy over the past several years, and these recent trends favor the business environment and competitive advantages that the region provides.

The benefits of the space economy have been centralized in the region. Seattle, Kent, and Redmond have significant employment in upper-tier manufacturing, launch services, and space-related products and services, and have been the primary locations for new businesses. Snohomish and Pierce counties have traditional aerospace suppliers, and retaining many of the economic benefits of local activities in the space economy may depend on supporting these businesses in maintaining and expanding their markets in space-related applications.

Growth in other parts of the state may be possible, given the lower costs of entry. With the rise of smaller, more flexible manufacturers and service providers in the space economy, new space-related businesses are less dependent on location. Attracting and retaining these businesses will depend on other local community characteristics, including quality of life, production costs, and available talent.

Impacts of the Space Economy

From a national and international perspective, the central Puget Sound region and Washington state are emerging as a new location for major space-related industries. Building from the traditional foundations of the aerospace sector built by Boeing and other firms, private space companies such as Blue Origin and SpaceX have increased their activities in the region related to space, and local employment in the space economy has grown.

In this section, we outline the current impacts of the space economy in the central Puget Sound region and Washington state, and highlight future growth prospects. This focuses on the core of the space economy as highlighted in Exhibit 1, specifically on upper-tier suppliers, OEMs, launch providers, and direct suppliers of space-related goods and services.

APPROACH

For this analysis, we evaluate the impacts of the space economy using the IMPLAN economic modeling package. This package relies on the US Bureau of Economic Analysis Benchmark Input-Output Accounts as a basis for models of impacts, with proprietary adjustments made to account for additional sectors and shifts in the economy over time.

For the purposes of this analysis, we assumed the "core" space economy includes upper-tier suppliers, OEMs, launch providers, and direct suppliers of space-related goods and services. Lower-tier parts suppliers may also support businesses outside of the space economy, and downstream companies that use space-related services in their business may have other inputs as well, making it difficult to allocate their activities specifically to the space economy.

We have defined the industries included in the core space economy according to the following NAICS codes:

- **Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing** (NAICS 334220), which includes satellite manufacturing
- **Propulsion Units and Parts for Space Vehicles and Guided Missiles** (NAICS 33641A), including the development and manufacture of rocket engines and major spacecraft components
- **Nonscheduled Chartered Freight Air Transportation** (NAICS 481212), which includes private space launch services
- **Satellite Telecommunications** (NAICS 517410), focusing on businesses that provide telecommunication services to other industries, including resellers of these services

Government-related space research and technology (NAICS 927) could also be considered part of the local space sector, but this industry is not strongly represented in the central Puget Sound region or the state overall.

Exhibit 3 provides a list of the firms in the region identified as part of the "core" sector, with estimates of current employment drawn from publicly available sources and direct communication with the companies where possible.

Exhibit 3. Estimated direct local employment in core space economy activities.

NAICS	INDUSTRY	DIRECT EMPLOYMENT (EST.)
334220	**Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing (305)**	
	SpaceX	800
	TOTAL	**800**
33641A	**Propulsion Units and Parts for Space Vehicles and Guided Missiles (361)**	
	Blue Origin	1,100
	Boeing Defense, Space & Security	500
	Aerojet Rocketdyne	330
	Stratolaunch Systems Corporation	25
	TOTAL	**1,955**
481212	**Nonscheduled Chartered Freight Air Transportation (408)**	
	Spaceflight Industries	150
	TOTAL	**150**
517410	**Satellite Telecommunications (429)**	
	RBC Signals, Inc.	10
	TOTAL	**10**
	Overall direct employment, core activities in the space economy	**~2,915**

Sources: Hoovers, 2018; Washington State Space Consortium, 2018; BERK, 2018.

We identified the businesses in Exhibit 3 from a review of available Dun & Bradstreet data for businesses in the listed NAICS industries listed, and an evaluation of membership in the Washington State Space Consortium regional trade group. We also used other available news sources on the regional space economy as needed. Companies with fewer than 5–10 local employees were not included on this list.

As necessary, NAICS codes identified for firms were adjusted to reflect local activities. For instance, although SpaceX is broadly defined as manufacturing space launch vehicles and providing space launch services, its operations in the central Puget Sound region are related to satellite manufacturing.

Suppliers to these businesses were not included on this list to prevent double-counting of impacts, since the outputs from these businesses may already be captured in the IMPLAN modeling results. Separating the portion of business activity for these suppliers destined for out-of-state markets would require more detailed business-level information that is not currently available. This should not discount the role of these suppliers as part of the regional space economy, however, and can provide economic benefits in supporting space-related activities nationally and internationally.

According to 2016 US BEA data, national employment in space vehicle and guided missile manufacturing industries (NAICS 336414–9) was approximately 54,953. Note that while the businesses in Exhibit 3 represent about 4% of this figure, this statistic also includes guided missile manufacturing, which can understate the role of the central Puget Sound region in the national space economy, especially against other regions that specialize in military and defense-related applications.

REGIONAL ECONOMIC EFFECTS

The estimated economic impacts of the core space economy in the central Puget Sound region are summarized in Exhibit 4. Over the entire regional economy, core space-related businesses increase economic output by about $1.76 billion, supporting a total of 6,221 jobs and $614 million in labor income across the region altogether. These impacts are divided between:

- **Direct impacts** from the businesses themselves
- **Indirect impacts** from across the supply chain
- **Induced impacts** from the associated increases in household expenditures

Altogether, a total of 2.13 jobs are created across the entire economy for every job created in businesses in the regional space economy, and every dollar spent on output represents 1.51 dollars of regional economic activity, and 0.53 dollars of regional labor income.

Exhibit 4. Estimated 2018 economic impacts from the core space economy.

	OUTPUT (IN $ MILLIONS)	EMPLOYMENT	LABOR INCOME (IN $ MILLIONS)
Direct Impacts	$ 1,163 M	2,915	$ 400 M
Indirect Impacts	$ 232 M	1,060	$ 88 M
Induced Impacts	$ 368 M	2,247	$ 127 M
TOTAL	**$ 1,763 M**	**6,221**	**$ 614 M**

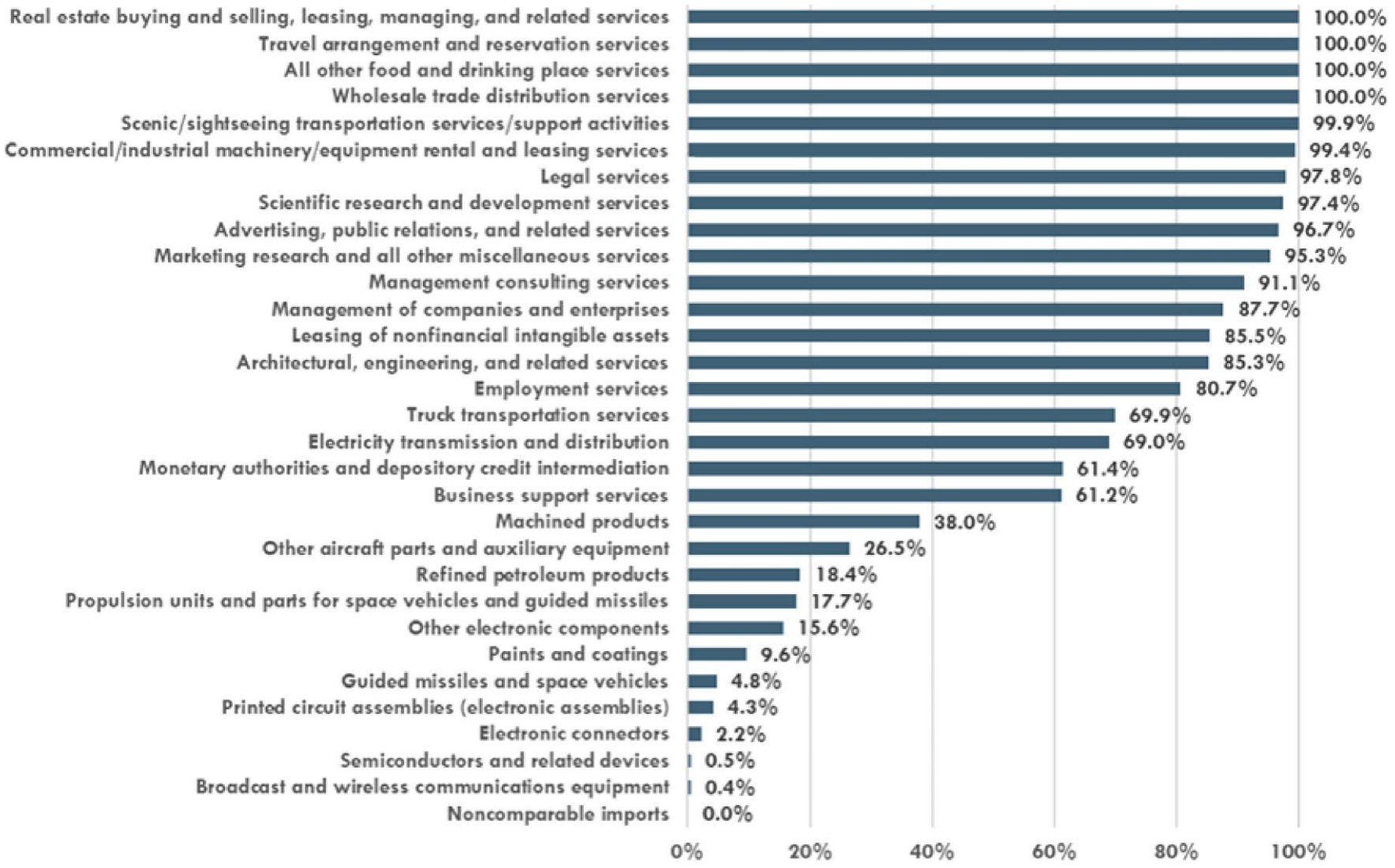
Sources: IMPLAN, 2018; BERK, 2018.

The results of the economic modeling have also been assessed to provide an understanding of how local supply chains contribute to retaining economic benefits within the region. The chart in Exhibit 5 shows how core space industries regionally source the different inputs needed for production according to available economic data. The "regional purchase coefficient" (RPC) reflects the proportions of different products and services that are purchased locally to support economic production. Exhibit 5 includes the top 10 commodities by gross input amounts for all selected core space industries, sorted by RPC.

This chart demonstrates that the greatest capture of indirect impacts by suppliers is with management and administrative services purchased locally. This includes services such as real estate management, management, and legal services that are locally specific. Conversely, lower-tier suppliers in the product supply chain are found to a greater extent outside the region; components such as "machined products" (38%), "paints and coatings" (9.6%), and "printed circuit assembles" (4.3%), are less likely to be produced regionally.

These lower RPCs indicate an opportunity for capturing additional benefits from these activities in the region. Supporting efforts by lower-tier suppliers in the region to link with upper-tier suppliers and OEMs can be one approach to retain economic benefits and ensure that other businesses can benefit from regional growth in the space economy.

Exhibit 5. Regional Purchase Coefficients for commodities demanded by 2 or more core space industries.



Sources: IMPLAN, 2018; BERK, 2018.

TAX EFFECTS

We include the estimated impacts of activity in the core space economy on federal, state, and local tax receipts in Exhibit 6. The tax impacts in this table are divided according to the jurisdictions receiving benefits and the type of taxes included. These include:

- Taxes on the income received by business proprietors and self-employed individuals
- Taxes on the total payroll cost of the employee paid by the employer
- Taxes on production and imports (TOPI) that are chargeable as a business expense in the calculation of profit-type incomes
- Taxes paid directly by households, including sales and income taxes
- Taxes paid directly by corporations, including taxes on profits

Exhibit 6. Estimated 2018 impacts of the core space economy on tax receipts (in millions).

	FEDERAL	STATE	COUNTY	CITIES	SPECIAL DISTRICTS	TOTAL
Proprietor Income	$ 1.45	-	-	-	-	**$ 1.45**
Employee Compensation	$ 71.41	$5.09	-	-	-	**$ 76.50**
Tax on Production and Imports	$ 6.11	$36.09	$ 4.80	$ 6.48	$ 9.35	**$ 62.83**
Households	$ 53.71	$1.83	$ 0.30	$ 0.53	$ 0.12	**$ 56.49**
Corporations	$ 18.51	$0.06	$ 0.01	$ 0.02	$ 0.03	**$ 18.63**
TOTAL	**$ 151.19**	**$ 43.08**	**$ 5.11**	**$ 7.03**	**$ 9.51**	**$ 215.92**

Sources: IMPLAN, 2018; BERK, 2018.

Generally, the space economy contributes about $43 million to the state in taxes, with about $22 million provided to county and local governments (including special districts). The greatest taxes from the sector are received by the federal government, in part due to the high employee compensation received in this sector. For state and local governments, the greatest proportion of taxes received is from the tax on production and imports, related largely to sales taxes.

ECONOMIC SUSTAINABILITY AND GROWTH

Commercial aircraft manufacturing will continue to dominate the regional aerospace economy, but the impacts of the space economy in the region and state are important to consider given their potential for future growth. Regional firms are positioned to grow as the global market expands, and should be a factor in economic development policy and programming.

Future actions in this area should consider the following:

- **The regional space economy includes larger private companies backed with significant venture capital investment.** Recent growth in the space economy in the region has been supported by private investment. The larger private commercial space firms that have emerged in the Puget Sound area (e.g., Blue Origin and SpaceX) are backed with substantial venture capital from individual investors/owners, and smaller startups have also been funded through seed capital.
- **New entrants in the regional space economy are moving towards business sustainability.** Although commercial space companies in the region are working on business offerings to bring in stable sources of revenue, they are still dependent on private funding. Their long-term success will depend on developing successful business lines, which are expected within the next few years. Blue Origin, for example, has recruited customers for launch services using the *New Glenn* launch vehicle, and the BE-4 engine under development is slated to be used in the ULA *Vulcan Centaur* rocket. For SpaceX, the Starlink satellite broadband system under development in Redmond and Seattle is planned for deployment by 2021.
- **New space-related startups in the regional economy may benefit from business support.** As barriers to entry have been lowered, more startups in the space economy are emerging in the region as a result. Access to venture capital and new markets for products will be essential for these businesses to succeed. Providing support for startups in these areas may be an effective strategy for encouraging the growth and development of new regional businesses in the space economy.

The economic characteristics of space-related startups today are comparable to high-tech startups in other fields. Smaller startup firms have the potential to take advantage of a growing commercial market that is just beginning to adjust to lower costs of space access, research, and development. Long-term success will be dependent on providing the support that these new firms will need to succeed in the marketplace.

SUMMARY OF KEY FINDINGS

Space-related products and services are playing a greater role in the economy of the central Puget Sound region and Washington state. From this economic analysis of the space economy in the region, we can highlight the following conclusions:

- **Employment in the local space industry has shifted to newer, privately financed firms.** There has been a marked increase in regional employment in the space economy from newer firms. The rise of these firms, ranging from larger operations such as Blue Origin and SpaceX to smaller startups, has highlighted the region as a major center for space businesses.
- **The impact of the space economy in the central Puget Sound region is significant.** The total economic impacts of regional businesses in the core space economy are estimated to be $1.7 billion across the entire economy, supporting a total of 6,221 jobs with $614 million in total labor income. A total of 2.13 jobs are created in the economy for each job in a space-related business, and every dollar spent leads to a total of 1.51 dollars of regional economic activity.
- **The regional space economy focuses on high value-added activities with high wages.** High-skill activities in high-tech manufacturing, services, and research found in the space economy in the region means that significant value is added from labor. This is linked to higher-wage jobs in the regional economy, and greater positive impacts to household income and spending.
- **Supplier relationships are important to overall economic impacts.** Based on available data, some inputs to the space economy in the region are supplied locally, while others are drawn more from outside the region and state. This suggests that supply chains extend beyond the region to other suppliers, both nationally and internationally. Increasing the local contributions in these supply chains would be an important target in future economic development efforts, which would allow more of the economic benefits of space-related activities to be retained in the region.
- **Long-term growth prospects are promising as the market matures.** The rise of larger privately funded space companies and smaller commercial startups have highlighted opportunities in the space economy. As the markets for space-related products and services begin to mature, these businesses will take a more sustainable role in both the growing commercialization of space and the economy of the central Puget Sound region.

Competition in the Space Economy

Although the central Puget Sound region contains one of the largest aerospace clusters in the world and has made historic contributions to the space industry, other locations provide competition in space-related products and services. Several regions across the United States have a history of aerospace and defense manufacturing comparable to the central Puget Sound region, and many have adapted this to a role in the commercial space industry. In other regions across the country, new opportunities related to existing high-tech manufacturing and service offerings have promoted a strong position in the commercial space economy.

Around the world, there is also active competition in the commercial space economy. This can range from the operations of large commercial launch service providers such as Arianespace in Évry, France; to smaller space-related startups in Singapore and Luxembourg; to national space programs in China, India, and other countries.

This section provides details about how competition from other regions may impact efforts to promote the central Puget Sound region as a hub for national and international space-related activities. This assessment is provided at two levels:

- For the **domestic market**, spaceport and launch facilities in the country are described, as well as key competitor regions in the space industry and implications for policy.
- Competition from **international markets** is described at a high level, with a review of major considerations for the central Puget Sound region.

DOMESTIC COMPETITION

Overview

In this section, we identify and assess major domestic competitors for the region and state, including key components of each local ecosystem. This includes an examination of:

- Spaceport locations in the US
- Employment and major activities in key space-related sectors
- Supporting government policies and programs in other jurisdictions

This is intended to provide a perspective on the competitive position of the state and region against these other jurisdictions, and how economic development efforts can leverage the strengths and opportunities in the state and regional space economy to build and enhance space-related businesses.

Spaceports

One of the most visible facilities in the commercial space industry is the *spaceport*, which includes launch (and potentially receiving) facilities for space vehicles. Although spaceports were originally developed as government facilities, the Federal Aviation Administration has licensed several public and private facilities owned and operated by states, authorities, and private companies.

There are three general types of spaceports, mainly based on the types of launches conducted:

- **Traditional range** spaceports provide vertical launches of space vehicles from a launch pad, such as Cape Canaveral in Florida.
- **Aero-spaceports** support reusable launch vehicles that take off horizontally like an airplane and launch off-site from the air. Cecil Spaceport in Jacksonville, FL is an example, with horizontal launch facilities located on a civil-military airport facility.
- **Hybrid facilities**, such as Spaceport America in New Mexico, include both vertical and horizontal launch facilities.

Siting new spaceport facilities can have several operational requirements, including FAA regulatory requirements for permitting that are included in applicable federal regulations (Ball 2014):

- **Launch facilities closer to the equator are preferred for flight efficiency.** The Earth's rotation provides additional speed that supports a launch vehicle in reaching escape velocity, and satellites intended for geostationary orbits do not need to perform large course corrections if they are launched closer to the equator.
- As launch vehicles are often assembled and prepared for launch at the spaceport, the spaceport must have **sufficient access to cargo via highway, rail, and/or seaport facilities** to allow for transporting components or assembled rockets.
- The launch facility must have **boundaries that can protect the public** from debris or other hazards from possible accidents during launches and landings.
- **Overflight exclusion zones must be provided downrange** to keep the public clear of high-risk areas for the duration of flight. This includes air and maritime traffic, as well as people on the ground.

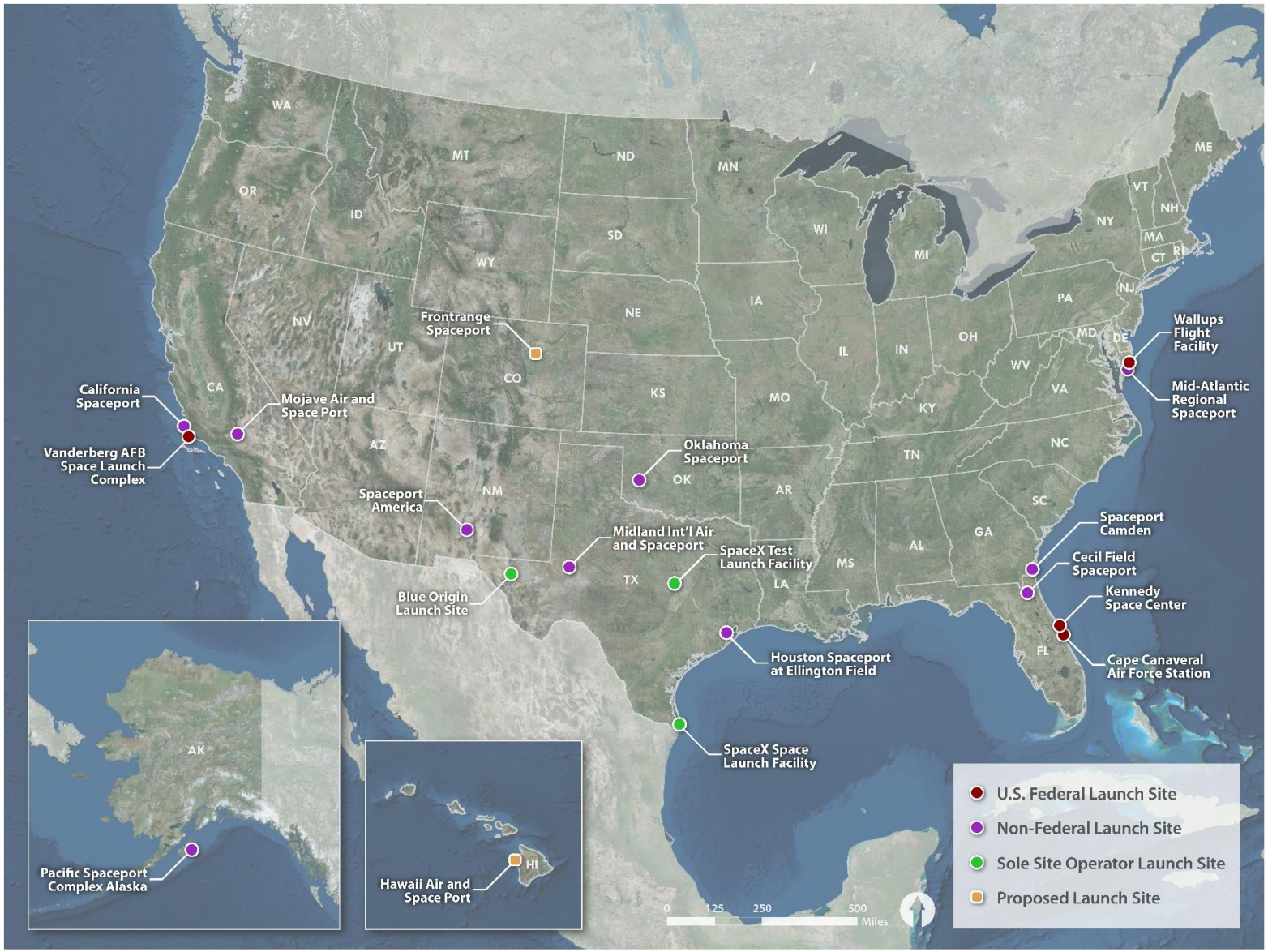
Exhibit 7 shows the spaceports currently operating or planned in the United States. An additional North American spaceport has been proposed for Canso, Nova Scotia, which is not included on the map.

Currently, there are no spaceports in Washington state. The Grant County International Airport (formerly Larson Air Force Base) is a general aviation airport which has been speculated as a potential site for an aero-spaceport. Blue Origin is a commercial space services provider headquartered in the region, although its launch facilities are in Texas and Florida. There are also smaller businesses that are involved with brokering and managing launch services for clients.

Other types of launch facilities are also available for commercial access to space:

- **Ocean-based launch pads** allow launches to occur on mobile platforms on ocean vessels. These launch pads can be brought closer to the equator, while avoiding impacts to populated areas and lanes of traffic. Sea Launch (a consortium of companies from the US, Norway, Ukraine, and Russia) provided mobile maritime launch services based in Long Beach, CA, until 2014.
- **International spaceports and launch services** in other counties have also supported commercial launches for decades, and expansions of both government and private launch services have been seen around the world. Commercial startups such as Equatorial Space Industries in Singapore and Rocket Lab in New Zealand have been working to provide commercial launch services over the next few years.

Exhibit 7. Spaceport locations in the United States.



Sources: FAA, 2018; BERK, 2018.

Major Competitor Regions in the Space Economy

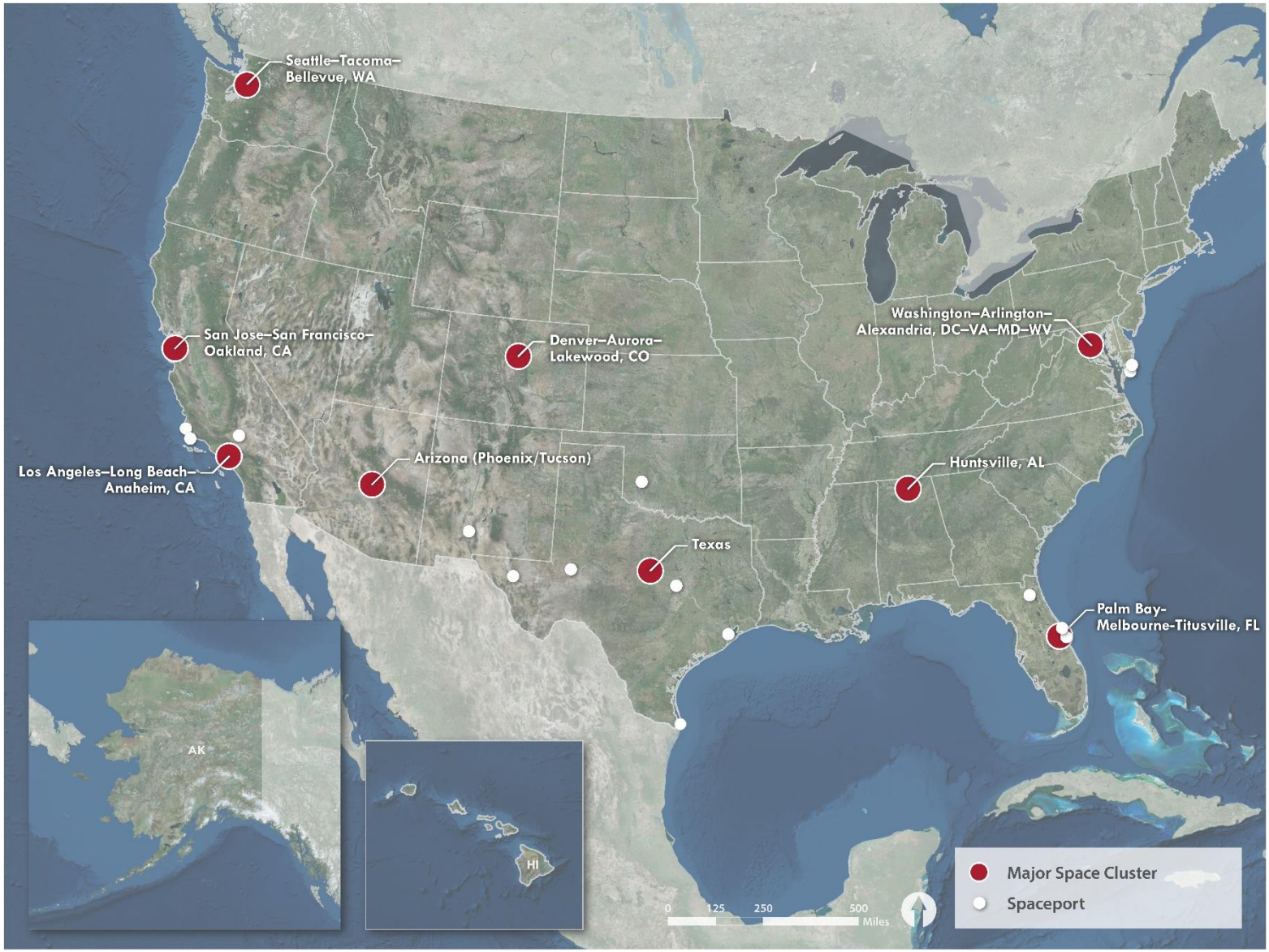
The distribution of activity in the US space economy has shifted substantially because of national and international trends, including the rise of space commercialization since the 1980s. Major factors have shaped how different regions responded to these trends:

- **Shifts in government support of space-related activities have impacted traditional centers.** There has been a general decline in funding for the US space program, especially after the end of the US space shuttle program. Because of this, many traditional centers for space-related activity have declined or worked to attract commercial space activities as a replacement.
- **There is increasing national and local competition for talent.** Access to talent in engineering, sciences, and other relevant fields is essential for both new space-related startups and larger, more traditional firms in the space economy. Regions with institutions and training programs that support a highly skilled local workforce, as well as high-amenity regions that are more competitive in attracting talent from elsewhere, are more likely to be competitive for future growth in the space economy.
- **New space companies are less dependent on traditional locations for success.** Given that space-related companies are less dependent on capital-intensive infrastructure such as spaceports or specialized manufacturing facilities, new space-related businesses can have greater freedom than before in their location. In certain cases, clusters of new activity have emerged in areas which may not have had major space-related businesses in the past.

Exhibit 8 highlights major competitor regions in the US commercial space economy. We have identified these regions based on economic and employment statistics for Metropolitan Statistical Areas (MSAs), as well as information on the distribution of space-related firms in the US, drawn from available Dun & Bradstreet data for relevant NAICS industries.

In the following section, we outline a short summary of major regions and characteristics related to their competitiveness in national and international markets.

Exhibit 8. Major competitor regions in the US space economy.



Source: BERK, 2018.

Los Angeles–Long Beach–Anaheim, California

Historically a focus of military and defense activity, the space economy in the Los Angeles–Long Beach–Anaheim MSA is one of the largest in the US, and it has been experiencing significant growth recently. Raytheon, Northrup Grumman and Boeing are major firms in the space economy that have had long-term space-related operations in the Los Angeles-Long Beach-Anaheim MSA, and Aerojet Rocketdyne Holdings, Virgin Orbit and SpaceX are headquartered here. Local research facilities and universities with top-ranked aerospace engineering programs, including the Jet Propulsion Laboratory and the California Institute of Technology, also bolster the strength of the local cluster and support a highly trained workforce.

The nearby Mojave Air and Space Port in Mojave, CA, is also a center of activity in the space economy, with several space-related firms with operations located there, such as Virgin Galactic, Masten Space Systems, and Interorbital Systems.

Key characteristics of the Los Angeles region include the following:

- **Large existing aerospace sector.** Next to the Seattle–Tacoma–Bellevue MSA, the Los Angeles area has the second-highest amount of employment in aerospace and defense manufacturing in the country, with over 10% of national employment in aerospace. This includes one of the greatest concentrations of space- and defense-related employment in the country.
- **Substantial growth in private commercial space businesses.** Virgin Orbit and SpaceX are examples of large private firms supported by individual venture capital that have located in the Los Angeles area. Smaller private firms supported by venture capital have also located in the region, such as Phase Four, a satellite propulsion system startup, and Relativity Space, a rocket manufacturing startup relying on 3D metals printing. Overall, there has been substantial growth in the private commercial space companies in the region, especially with startup companies.
- **Access to significant venture capital funding and support.** California and the Los Angeles area have been the focus of significant venture capital funding for startups in space-related fields, with the greatest amount of venture capital available by state and region. Space-related accelerators such as Starburst are also located in the Los Angeles area.
- **Access to launch facilities.** Vandenburg AFB includes both government and commercial launch facilities (as the California Spaceport), and there are additional facilities located at the Mojave Air and Space Port in Mojave, CA. Ocean-based launches have previously been based out of Long Beach, with Sea Launch conducting operations there until 2014. This access has been useful for regional space-related firms, especially those working on launch systems.

San Jose–San Francisco–Oakland, CA

The San Jose–San Francisco–Oakland CSA includes the areas around Silicon Valley and San Francisco. New space-related firms in this region have been created not only because of ongoing activities in the aerospace sector, but also because of the support available for high-tech startups and local access to highly skilled talent. Major space economy companies such as Lockheed Martin Space Systems and SSL (satellite manufacturing) operate out of the region, and startups such as Deep Space Industries (asteroid mining), Spire (satellite tracking/Earth observation), and Planet (satellite imagery) have a presence in the local market as well.

Key characteristics of the San Jose–San Francisco–Oakland region include the following:

- **Access to venture capital funding and support.** As with the Los Angeles area, there is significant availability of venture capital for high-tech startups in the Silicon Valley and San Francisco, which has been a benefit to new firms in the space economy. Business accelerators such as the Silicon Valley Space Center (SVSC) are located here, which provide technology development, business structuring, and angel funding assistance to local commercial space startups.
- **Local research and education facilities.** The region includes aerospace research and education institutions such as Stanford University, which support a well-trained workforce and ongoing space-related research activities. Moffett Field, a NASA research, testing, and airfield facility, is located in the area, and supports ongoing research activities and provides leased space to space-related companies.
- **Connections with other high-tech activities.** Many of the space-related startups located in the region are concerned with activities such as satellite imagery and tracking that involve crossover applications in information and communications technologies. This builds upon the strengths of the region as a major high-tech hub, and extends this expertise to space-related applications.

Denver–Aurora–Lakewood, Colorado

The Denver-Aurora-Lakewood MSA has been a hub for government and private space activities, including major production facilities for Boeing and Lockheed Martin, and headquarters for the ULA joint venture between these two firms. The area includes other space-related firms, such as Ball Aerospace & Technologies Corp, SNC Space Systems, DigitalGlobe, Inc. and Maxar Technologies, as well as research and operations facilities for the Department of Defense and NASA. Dish Network and its former parent company Echostar are headquartered in the region, and maintain a satellite fleet and associated infrastructure for satellite TV services.

Key characteristics of the Denver–Aurora–Lakewood region include the following:

- **Large existing space and defense sector.** The Denver-Aurora-Lakewood area includes one of the greatest concentrations of space and defense employment in the country and includes considerable infrastructure to support its role in space- and defense-related research and manufacturing activities.
- **Ongoing investment as a major space-related manufacturing and development center.** Lockheed Martin operates seven separate facilities for space vehicles and rockets in the Denver-Aurora-Lakewood MSA, including the base for the Orion deep space exploration vehicle, and employs 8,600. A $350 million satellite production facility is under construction, planned for completion in 2020. Boeing also operates substantial satellite and launch vehicle manufacturing facilities in communities in the region.
- **Strong connections with the US military and other government agencies.** ULA has been at the forefront of manufacturing launch vehicles for the US Space program. Peterson Air Force Base is located in Colorado Springs, which is the home of the US Air Force Space Command and US Army Space and Missile Defense Command / US Army Forces Strategic Command.

Huntsville, Alabama

The Huntsville MSA has been a major hub for the US space program with several facilities related to this role, including Cummings Research Park (CRP), the second-largest research park in the US; the Redstone Arsenal, a research, engineering, and test center for missile defense and aviation systems for the US Army Aviation and Missile Command; and the Marshall Space Flight Center, a NASA propulsion research facility.

In addition to defense industries, commercial space companies have major operations in the region. The ULA maintains a rocket manufacturing facility for Atlas and Delta launch vehicles in Decatur, and Aerojet Rocketdyne and Blue Origin have announced plans to develop manufacturing facilities for rocket engines in Huntsville. Smaller firms are located in the cluster to provide supporting manufacturing, design, testing, simulation, software, and management services.

Key characteristics of the Huntsville region include the following:

- **Long-term cluster of space and defense activity.** The Huntsville area has been the focus of space- and defense-related research and manufacturing activities since the 1950s, and has provided significant support for the US space program since the Apollo program. This has been supported by long-term investment in infrastructure in the area, including transportation routes for launch vehicles to launch sites.
- **Specialization in launch vehicle manufacturing.** The Huntsville region has a strong focus in missile and launch vehicle manufacturing, and ongoing activities in this area are being supported by the ULA, Blue Origin, Aerojet Rocketdyne, and other firms. This is also the focus of many of the supporting firms within the local supply chain.
- **Strong linkages with future government space requirements.** Current manufacturing of the Delta and Atlas launch vehicles by the ULA in the Huntsville area, as well as the development of the future *Vulcan Centaur* launch vehicle, is focused on providing launch services for the US Department of Defense and NASA.

Washington–Arlington–Alexandria, DC–Virginia–Maryland–West Virginia

The space economy in the Washington–Arlington–Alexandria MSA has strong linkages to the federal government, with the Goddard Space Flight Center, the Pentagon, NASA headquarters, and other government agencies located in this area. Northrop Grumman and Lockheed Martin are headquartered in the Washington–Arlington–Alexandria region, and Aerojet Rocketdyne and Boeing have operations in the area as well. Intelsat SA, one of the world's largest satellite operators, is located in Fairfax County.

This area is close to the Wallops Flight Facility, which is managed by the Goddard Space Flight Center and provides launch services for government agencies. The Mid-Atlantic Regional Spaceport (MARS) is a commercial launch facility located on at the southern end of the Wallops Facility, and includes two pads for launches by private companies.

Key characteristics of the Washington, DC region include the following:

- **Major commercial aerospace and defense headquarters.** There are several national and international firms with major headquarters in the Washington area, which has led to a concentration of aerospace- and defense-related jobs in the region. This provides a considerable basis for talent in the region.
- **Strong connections with the US military and government agencies.** Given the proximity of major government agencies, as well as the Pentagon and military installations, space-related activities in the region are well-connected with the public sector. Additionally, the US space program has major operations here, including the NASA Goddard Space Flight Center.
- **Access to spaceport launch facilities.** The Wallops Flight Facility, which includes the Mid-Atlantic Regional Spaceport, includes spaceport capacity to accommodate both public and private launches, which can be useful for supporting local activities in space.

Palm Bay-Melbourne-Titusville, Florida MSA

The "Space Coast," which includes Cape Canaveral, FL, was the long-term site for space launches by the US government during the Space Race. Even after the US Space Shuttle program ended, the launch facilities have been in use for both government and commercial space missions. This area has been the hub for major activity by a range of different commercial launch providers, with the ULA and SpaceX both leasing launch pads from the facility. Blue Origin has leased Launch Complex 36 for future launches, and has built a manufacturing plant at Exploration Park at the Kennedy Space Center.

Key characteristics of the Space Coast region include the following:

- **Access to extensive spaceport launch facilities.** Cape Canaveral has the most extensive spaceport facilities and the greatest number of space launches in the US, and has been a center for launch services for decades. These launch facilities are currently in use for both government and private sector activities, and will continue in this role into the future.
- **Focus for government launch activities.** The Kennedy Space Center and Cape Canaveral will be maintained as the focus of launch services for the US government space program, and will be the location for planned launches of future manned spaceflight coordinated by NASA.
- **Significant private-sector space activities related to proximity to launch services.** The ULA, Blue Origin, and SpaceX have operations related to the manufacturing and assembly of launch vehicles in the Space Coast area, and OneWeb has planned to develop a satellite manufacturing plant in this area. Other industries, including startups, are located here to take advantage of the existing infrastructure and talent in the region.

Arizona

Space-related activities in Arizona extend to both the Phoenix–Mesa–Scottsdale and Tucson MSAs. A significant amount of aerospace and defense activity in the state is related to guided missile manufacturing by Raytheon Missile Systems. However, several firms are involved with space activities in the state. Northrop Grumman Innovation Systems (formerly Orbital ATK) manages a Launch Vehicle Division in Chandler, AZ, and companies such as Vector (launch vehicle manufacturing), Paragon Space Development (environmental controls), and World View Enterprises (near-space tourism) operate in the

Tucson area. Pima County opened the Tucson Spaceport in 2016, which is currently focused on near-space tourism and scientific research based on balloon flights.

Key characteristics of Arizona clusters in the space market include the following:

- **Historic focus in aerospace and defense.** The aerospace and defense market in Arizona has been strongly oriented to defense-related manufacturing, and Pima County near Tucson is one of the largest manufacturing centers for guided missiles in the US. The talent and infrastructure present to support these activities also supports newer startups and space-related businesses.
- **Early efforts in space tourism.** World View Enterprises is working to provide opportunities for near-space tourism with balloon travel out of the Tucson Spaceport. Although this is not directly related to launch services, it provides a means to build the market for space tourism with lower-cost options.

Texas

The state of Texas includes a number of hubs for space-related activities, including:

- Dallas–Fort Worth–Arlington MSA
- Houston–Sugar Land–Baytown MSA
- Austin-Round Rock MSA
- SpaceX Test Launch Facility, Cameron County
- Blue Origin Launch Site, Van Horn
- Midland International Air and Space Port
- Houston Spaceport (Ellington Airport)

The Johnson Space Center in Houston has been a major field center for the US space program since in the 1960s, and still includes significant space-related scientific research facilities. Major companies with crossover capabilities located in the state include Raytheon, Boeing, General Dynamics, and UTC Aerospace. Newer space-related businesses are strongly represented in Texas, such as Firefly Aerospace, a launch vehicle manufacturing company based in the Austin area.

- **Multiple commercial launch facilities.** Texas includes two spaceports and dedicated launch sites used by SpaceX and Blue Origin. These facilities provide a significant amount of potential launch capacity in the state.
- **Long-term connections with the US space program.** The Johnson Space Center in Houston continues to be a major facility for the US space program, and has strong connections with the commercial space industry.
- **New space-related investment from launch facilities.** As with the Space Coast, Texas has seen a significant number of newer space-related firms locate to the state. This is in part due to the development of new test facilities, as well as connections with the state aerospace and defense market.

Other Regions

There is a wide distribution of aerospace and defense firms across the US, with significant centers of research, development, manufacturing and testing in New England, New Mexico, Missouri, Kansas, Oklahoma, Arkansas, and elsewhere. As the costs to access space are lowered further, and the market

for space-related solutions in linked businesses expands, there is significant potential for new startups to emerge across the country.

State-Level Support of the Space Economy

Certain state governments have provided incentives for businesses in space-related industries to relocate, operate, and expand within their jurisdiction. Given the size of the industry even at this stage, these types of incentive packages are often integrated with broader economic development efforts, including those targeted at high-tech industries across multiple sectors.

One popular type of initiative that has been supported by several state governments has been the development and operation of spaceports. Given the capital-intensive nature of these developments, some states have authorized the formation of authorities which manage a spaceport within the state, and work to attract space launch activities and space-related businesses to these facilities.

Brief summaries of relevant programs and incentive packages intended to support the space economy in other US states is provided below. A listing of relevant programs from other states is provided in the Appendix.

Washington

Recognizing the intense growth of the space industry in the state, the Washington State Department of Commerce formed the Washington State Space Coalition (WSSC) in 2014. The organization both supports the industry and provides a forum for companies to interface with the state Office of Aerospace and with each other.

In order to keep pace with the growth of local space cluster, WSSC recently transitioned into a fully-fledged industry association led by the Aerospace Futures Alliance (AFA). As the premier industry association for the state's aerospace sector, AFA has been successful in helping the aerospace companies thrive through its efforts in advocacy and policy development, workforce development, economic impact studies, regulatory analysis, marketing, and hosting industry events.

Given the evolution of Washington's space sector, the state's government and legislative body are working in concert with local companies to explore new and innovative methods to support the industry's growth. One of the primary objectives is to extend the state's existing tax credits for commercial aircraft manufacturing to include space-related activities such as the manufacturing of launch vehicles, manned spacecraft, and satellites.

California

From 1996 to 2011 California relied on the California Space Authority (CSA), formerly the California Space and Technology Alliance, to promote California as an international center of space technology by administering a competitive grant program, linking state and local resources to space and technology enterprises, and serving in a coordinating capacity for the sector overall. However, due to depletion of federal funding, the CSA dissolved in 2011 (Lompoc Record, 2011).

At present, California maintains no other space-specific incentive programs, but regularly provides incentives to aerospace and defense contractors in the state on a case-by-case basis. Additionally, there are business incentives applicable to California businesses more broadly that would apply to space-related firms (California Business Portal, 2018).

New Mexico

New Mexico offers the Space Gross Receipts Tax deduction for a broad range of activities supporting a spaceport, and research and development, testing, and evaluation for the US Air Force Operationally Responsive Space Program. Other incentive programs for aerospace and aviation may apply to space businesses, but predominantly highlight military applications, including the US Air Force and Department of Defense. Other incentives may be offered on a case-by-case basis.

Texas

Texas includes the Spaceport Trust Fund in its suite of incentive program offerings, with the others providing benefits not tied to specific industries or sectors. The Spaceport Trust Fund provides grant funding on a cost-reimbursement basis for expenditures related to building a spaceport.

Florida

Florida has long administered space incentive programs at the state and local levels, including tax exemptions, deductions, and refunds for a broad range of space-related activities. Space Florida, an authority authorized by the state to provide financial, development, and workforce support, operates to "attract and expand the next generation of space industry businesses," and has conducted more than $500 million in financing transactions since 2000.

Virginia

The Virginia Commercial Space Flight Authority (VCSFA) is a politically authorized operator of the Mid-Atlantic Regional Spaceport (MARS), and is a designated Enterprise and Foreign Trade Zone, in addition to offering partners relief from Freedom of Information Act (FOIA) regulations and liability for space flight participants. Separately, the state of Virginia adopted "ZeroGravity, ZeroTax," a tax exemption for income from space trainings and flights.

Oklahoma

The Oklahoma Space Industry Development Authority manages its spaceport and related facilities, and develops and promotes opportunities for space businesses in Oklahoma. In addition, sales of property to Oklahoma's spaceport users, and purchases of launch vehicles, satellites, and related attached or used property are exempt from sales tax. Oklahoma offers other incentives for the aerospace industry, which may include eligible space-related firms.

INTERNATIONAL COMPETITION

Although the US is home to about 76% of space-related startups worldwide (Bryce, 2018), the role of international companies in the commercial space sector is growing. Costs to access space are declining and more governments and companies around the world are launching satellites and even space vehicles into orbit and beyond. These trends associated with space commercialization are also impacting national space agencies in other jurisdictions, and new space-related startups are emerging around the world to take advantage of this growth in demand.

Major elements of international activities in space that could potentially impact the central Puget Sound region now and into the future include competition in the following areas.

National Space Programs

Worldwide, government space programs amount to about one quarter of total space-related economic activity, with about 50 countries with dedicated space budgets. Nine national space programs have budgets exceeding $1 billion: the US, China, Europe, Russia, India, Japan, France, Germany, and Italy. Although the US has the largest combined space budget in the world, China ($11 billion) and the European Space Agency ($7 billion) have considerable capacity and the technical capabilities for space launches and spaceflight programs.

Although the US has been a leader in providing space launch services, it is not responsible for a majority of the world's orbital launch activity. In 2017, the US had 29 launches of orbital flights, or about 32% of 90 launches worldwide. Russia (21%), China (20%), Europe (12%), Japan (8%), and India (6%) all provided additional orbital launches for military, government, and commercial applications, and New Zealand had its first commercial space launch (FAA, 2018).

Smaller Countries and Niche Programs

Although countries with major space programs are seen as the key players in the space industry, smaller companies are also striving for key roles in the future of commercial space. Several countries around the world have leveraged their unique positions to provide niche support for companies interested in space exploration.

One strong example of this is **Luxembourg**. The country has been positioned as a center for finance in Europe due to its small size and light regulatory environment, and this has served as a base for new involvement in space applications. While a member of the European Space Agency, the country has also actively invested in additional regulatory policies and incentives to attract activities of certain space-related businesses. This has extended back to 1985, when a license was granted to Société Européenne des Satellites (SES) for the launch and operation of a telecommunications satellite for television, and today this has led to the country being the headquarters for SES and Intelsat, two of the largest satellite companies in the world.

The country's recent Space Law, passed in August 2017, provides a licensing and regulatory system for ownership of space resources from the Moon, asteroids and other near-Earth objects, which has been an attractive incentive for asteroid and comet mining companies interested in legal certainty of ownership. The country has also provided significant financing to support space research through LuxIMPULSE, its national space program, to a maximum of €400,000 per contract, and has supported other businesses through a €200 million fund to help finance new space-related applications.

A more recent example has been in **Australia** with the development of the new Australian Space Agency. Formed in July 2018, this agency is associated with the Industry Department of the national government and is dedicated in part to supporting the growth of Australia's space industry and sharing the country's expanding role in space and importance to the national economy. This has been done in part to address flat growth with existing satellite operations, and to capitalize on opportunities to leverage a skilled workforce involved with space-related applications for international corporations.

In addition to receiving authority to regulate aircraft-based satellite launches, the new agency has received a budget of A$41 million for ongoing cooperation with international space agencies and efforts to promote Australian space businesses. Additionally, the Australian government is looking to invest A$260 million in satellite infrastructure and technologies for new satellite positioning and Earth observation systems to support business and community applications of this information.

Private Launch Services

As many government programs are looking to support more commercial activity, private launch services are also important to consider from an international perspective. The dominant private launch provider in the world has been Arianespace, which was responsible for 56% of the world's commercial launch market in 2016. Although the decline in launch activity by Russian providers has increased Arianespace's market share, the company has recently expressed concerns about competition from SpaceX and other new commercial launch providers that can achieve launches for lower cost.

Smaller launch service companies are also emerging onto the international scene. RocketLab, a joint US–New Zealand orbital launch provider, has facilities for space launches in Mahia, New Zealand, as well as in Cape Canaveral, FL, and has entered into contracts with Spaceflight Industries and BlackSky for future small satellite launches with its Electron launch vehicle. Equatorial Space Industries, a space startup in Singapore, is exploring the feasibility of launches from sea platforms close to the equator in the Pacific. As worldwide demand continues to increase, emerging firms across the world will look to compete for this business.

Space-Related Startups

The US has been the location of significant startup activity, as over two-thirds of investors in space are found in the US. However, the ability for new space startups to be located anywhere with talent and resources has allowed these businesses to emerge throughout the world.

A primary focus for international startups has been the market for small satellites, often launched on rocket flights from other countries, but a diverse range of new companies have emerged for different space-related applications in hubs as varied as Scotland, Finland, and Spain. A sample of these startup companies include:

- **Zero2Infinity (Spain).** Zero2Infinity, based in Barcelona, Spain, is researching approaches to access near space and low Earth orbit with high-altitude balloon systems, either alone or as a rockoon that carries a rocket with a small satellite payload into the upper atmosphere for launch. These launch vehicles have also been suggested as a platform for space tourism.
- **PLD Space (Spain).** PLD Space is a launch vehicle manufacturer that is developing reusable launch vehicles for suborbital and orbital flights, which would carry research payloads or small satellites into orbit. Its first launch of a suborbital rocket is expected in 2019.

- **Axelspace (Japan).** Axelspace is a microsatellite design and manufacturing firm founded in Tokyo in 2008 that is dedicated to building small, inexpensive, custom-built satellites for customers. These are largely Earth observation satellites and are typically built with inexpensive parts to keep costs to customers low.
- **Iceye (Finland).** Iceye, located in Espoo, Finland, is a microsatellite manufacturing company that has specialized in developing the ICEYE synthetic aperture radar satellite constellation, which allows for imaging and radar mapping of any location on Earth every three hours. The company also maintains a library of previous imagery and radar data for clients.
- **Leaf Space (Italy).** Leaf Space, based in Como, Italy, is a company that provides subscription services to support small satellite operators with a technology platform for ground station communications. This service relies on a network of 20 ground stations throughout the world, which are suitable for supporting larger satellite constellations.

Altogether, these companies are a small, representative sample of startups around the world that are working to get involved in new space-related applications. As the costs to access space and build satellites continue to fall, and this range of international companies work to fulfill needs from around the world, new space startups in the region will face more competition from companies abroad.

SUMMARY OF KEY FINDINGS

In addition to the central Puget Sound region, the space economy is expanding across the US and the world. From the assessment of competitor regions and the state of the market, we can draw the following conclusions:

- **The lack of a spaceport in the state may limit some opportunities for growth, but it is not a constraint to the regional space economy overall.** Some discussions have arisen about the use of the Grant County Airport as an aero-spaceport for launch vehicles carried by airplanes, but the lack of these facilities in the state is not a major constraint on activity in the space sector. The rise of payload sharing and the presence of launch facilities in other more southerly parts of the US means that satellite and launch vehicle manufacturers can use launch services elsewhere more efficiently. Other states have relied on their spaceports as a means to promote growth in commercial business, such as with the Mojave Spaceport or the launch facilities on the Space Coast, but the central Puget Sound region can choose to specialize in other aspects of the space economy.
- **Several other competitor areas have had long-term involvement in the space and defense sectors.** Other regions in the US have had space-related facilities since the early days of the US Space Program. With the decline of elements of this program, especially after the Space Shuttle program ended, regions such as Florida's Space Coast have been working to attract new space-related activities that can use the existing infrastructure and draw on the workforce in the area. These areas have advantages with respect to the availability of local infrastructure that can be of use for space-related applications.
- **States such as California have been successful with drawing upon sources of venture capital for space-related businesses.** Startup space-related businesses in California have been very successful in attracting sources of venture capital to support new activities in space. Although the most visible examples of this are with single investors such as Elon Musk (SpaceX) and Richard Branson (Virgin Orbit), other startup businesses have tapped into venture capital available more broadly to tech firms in the state.
- **Support at the state level for space-related businesses has been uneven.** Over the US, there is a patchwork of incentives at the state level targeted specifically to space-related businesses and startups. While states like Florida have been actively involved in providing financing and support for space firms, California has not maintained significant incentive programs specifically for the field. In Washington state, bills that have attempted to extend tax credits to launch vehicle, spacecraft, and satellite manufacturing have not left committee, and no other program is specifically targeted to businesses in the space economy.
- **International activity in the space economy will provide opportunities for competition and collaboration.** The lowering of costs for access to space worldwide, as well as the rise of startups in the space economy, will lead to increased competition for business not just from other regions in the US but also from firms overseas. Although US commercial launch providers such as SpaceX have taken a larger share of the market, companies around the world are working to deploy launch vehicles for a range of different applications. The lower costs of small satellite manufacturing is also attracting significant international attention, especially for tailored applications.

Workforce and Training

For ongoing growth with the state and regional space economy, Washington and the central Puget Sound region benefit from access to the labor from the existing aerospace cluster to support new businesses in the space economy. With the greatest concentration of aerospace workers in the US and as one of the largest tech-based economies in the country, there is considerable expertise available in the labor pool in the Puget Sound region to take advantage of new opportunities in the field.

The region and state also have educational institutions that provide an ongoing talent pipeline to support aerospace and aerospace-related employment needs into the future. Although the space economy often relies on national and even international talent, providing "homegrown" workers through local training can be essential both in ensuring that there is an adequate local talent pool available, and encouraging those workers to stay within the region.

In this section, we outline available information on national and regional employment and training to highlight major areas of consideration for the space economy in the region and state. This includes the following:

- A high-level overview of the labor pools in aerospace between the Puget Sound region and other competitor regions in the US
- A review of major regional elements of the labor pool that are relevant to businesses in the space economy
- An assessment of the contributions that educational institutions are continuing to make to the regional labor pool

As with other assessments, space-related activities in the economy can be wide-reaching, impacting a range of different occupations. Businesses that are participating in the space economy can require specialized knowledge in fields such as meteorology, transportation logistics, agriculture, and others. Although these are important to consider, we have targeted this assessment to the core space economy, and specifically the manufacture, use, and management of spacecraft, launch vehicles, satellites, and other space-related products. Constraints on the labor pool in these areas would severely limit the growth of startups in the local space economy, especially if demands are high.

Additionally, available statistics about the workforce in the space economy are limited, and typically aggregated with aerospace manufacturing and other applications. Where possible, we outline the specific needs for space-related applications, but information for the broader aerospace cluster can be used to provide context about the larger labor pool.

NATIONAL COMPETITION FOR LABOR IN AEROSPACE

Understanding the position of the central Puget Sound region with labor in aerospace requires an understanding of the nature of the labor market here in comparison to other markets. Exhibit 9 provides 2017 data from the US Bureau of Labor Statistics (BLS) that highlights the relative amount and growth of aerospace employment in the Puget Sound (Seattle-Tacoma-Bellevue, WA MSA) region, as compared to several competitor regions in the US defined in the previous section.

This employment is identified from BLS data on the industry defined as NAICS 3364 (*Aerospace Product and Parts Manufacturing*). Although other industries have been defined as part of the core space economy, local representation of employment in launch services and satellite telecommunications is relatively low compared to other jurisdictions. Satellite manufacturing is also aggregated with a wider range of communications-related manufacturing and may be hard to distinguish from other activities that are not related to space in an analysis.

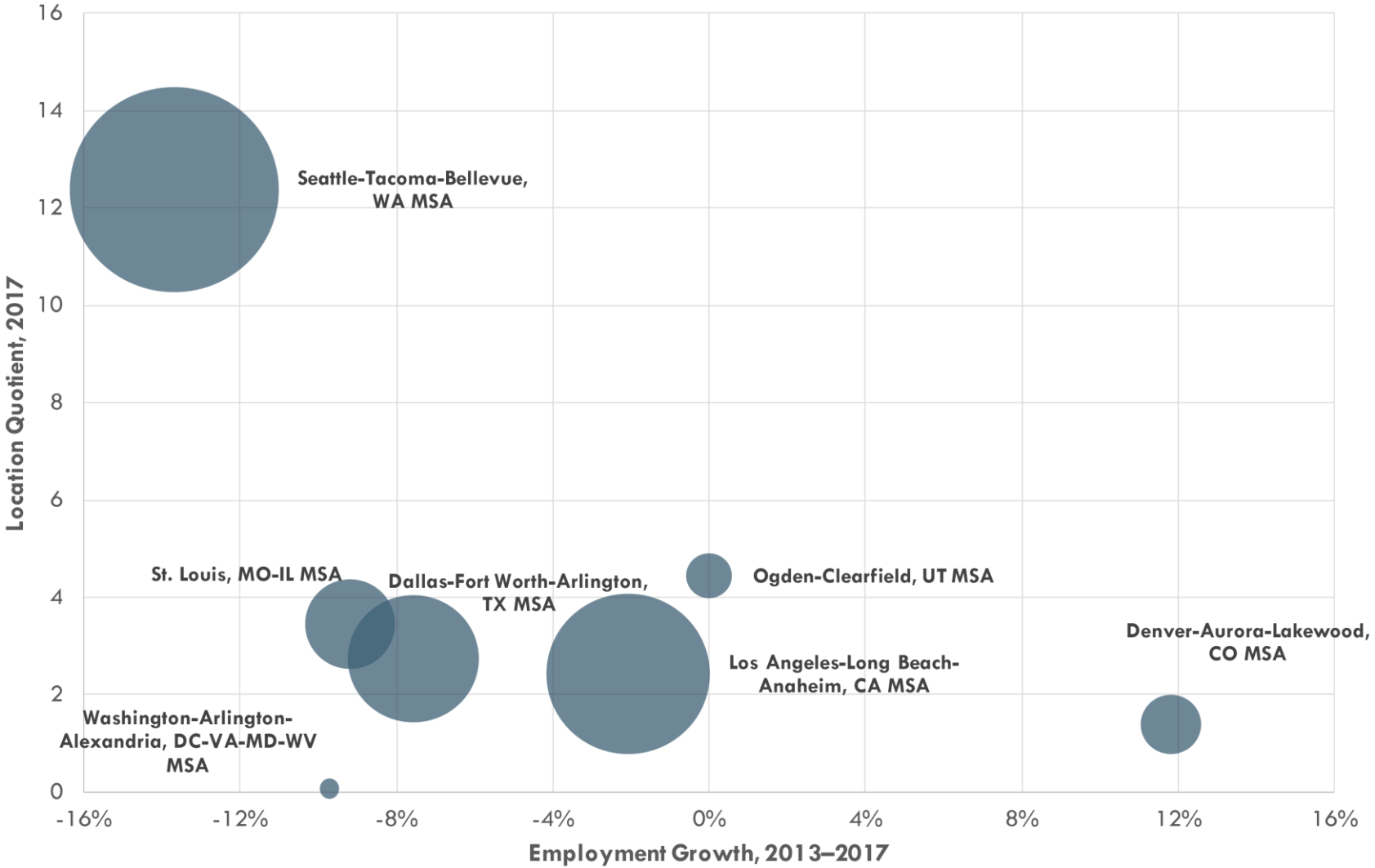
This chart demonstrates that the Seattle-Tacoma-Bellevue, WA MSA has the largest concentration of aerospace manufacturing employment of any identified competitor region. This is true in absolute terms, with employment in the aerospace industry estimated at 88,000 jobs in the region and 90,900 in the state in 2016, significantly outpacing other jurisdictions. The concentration of jobs is also higher than any other region in the US, and in terms of the proportion of the regional economy. Note that the significant change in employment is likely due to year-to-year shifts in the needs for the sector based on demand for commercial aircraft.

Although other regions noted in this graphic are general competitors in aerospace, their markets are aligned with different specializations. While the central Puget Sound region has a workforce specialized in commercial aircraft manufacturing, other regions have been focused on other activities, such as:

- Corporate management (Washington DC)
- Guided missile manufacturing (Denver, CO)
- Military aircraft (St. Louis, MO)
- Smaller passenger aircraft (Dallas-Fort Worth, TX)
- Composites and parts manufacturing (Ogden, UT)

This reflects a different available pool of talent and potential differences in the ability for local talent to meet the needs for space-related applications.

Exhibit 9. Competitor MSAs by employment growth and location quotient.



Sources: Bureau of Labor Statistics, 2017; BERK Consulting, 2018.

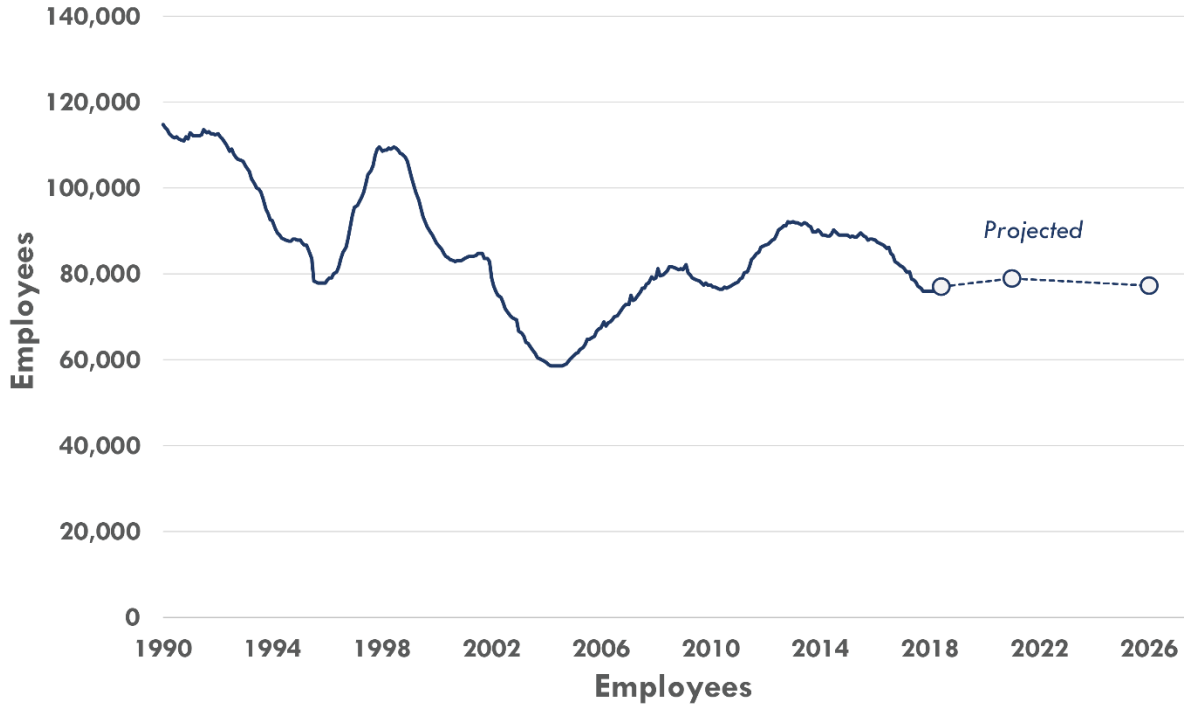
CHARACTERISTICS OF THE REGIONAL LABOR MARKET

Exhibit 10 provides employment statistics and estimates for long-term employment in the regional aerospace sector under NAICS 3364 (WA ESD, 2018). These estimates show that the aerospace sector experienced highs in the 1990s, with a major decline around 2004. Long-term projections by the WA Employment Security Department suggest that the broader market will remain stable with employment estimated at 77,300 employees in 2026.

While the stability of employment suggests the sector will be experiencing relatively little change, there are major trends that will impact labor in the sector in the coming years:

- **Aging of the workforce.** As the "Baby Boomer" generation is moving towards retirement, this "silver tsunami" is expected to have major impacts on the economy. Aerospace and defense industries are projected to experience significant gaps in labor supply due to attrition from retirement, which may be challenging to replace. It was estimated in 2016 that nearly 23% of aerospace workers were eligible for retirement, and that nationwide over the next decade up to 190,000 workers will need to be replaced (AIA, 2016).
- **Automation and efficiency in manufacturing.** One ongoing trend that is also evident with aerospace is with increased efficiency with manufacturing. As Boeing continues to plan for its new mid-sized airplane (NMA) over the next decade, there are increasing pressures to cut costs, especially to target sale prices of $65–75 million per plane for the NMA. This will likely involve greater use of automation and more efficient use of labor, especially if labor supply is expected to be constrained.

Exhibit 10. Regional aerospace sector employment (NAICS 3364), historic and projected, 2009–2026.



Sources: WA ESD, 2018; BERK Consulting, 2018

Exhibit 11 shows the current gaps and projected employment in the top occupations found in the aerospace sector overall in the central Puget Sound region. This table includes the following statistics:

- The proportion of employment in this occupation in aerospace nationwide
- The average gap between employment supply and demand calculated by the Washington State Employment Security Department for 2017
- Projected employment for 2016, 2021, and 2026
- Projected change in employment between 2016 and 2026

These statistics highlight some key points. First, there are very significant gaps between current supply and demand for certain occupations in aerospace, most notably with software development and industrial engineering. Although these occupations are not directly involved with aerospace and support other sectors of the economy as well, a tight labor market for these occupations could constrain certain space-related applications.

This is also related to a broader issue faced by some suppliers and space-related startups. For very large high-tech employers in the region, including Boeing, Amazon, Microsoft, and others, scaling up operations and hiring new staff from the local workforce will often be done by drawing in employees from smaller companies that cannot be as competitive with salaries and benefits. This can be a challenge across the market, as smaller businesses may face labor shortages when these larger companies are looking to expand quickly.

Although there is a gap between supply and demand for aerospace engineers today, these statistics suggest that total employment in the region will decrease by over 9% by 2026. This net decline is not as significant as aircraft assembly workers, but it does mask the trend of massive retirements expected in the field. If about 30–40% of the nationwide workforce is expected to retire and be replaced within the next decade, these numbers suggest that a significant amount of new recruitment to required occupations will be necessary.

Exhibit 11. Current employment gaps and projected employment by occupation, central Puget Sound region.

SOC	OCCUPATION	% OF EMPL.	GAP (2017)	PROJ. EMPLOYMENT			2016–26 CHANGE
				2016	2021	2026	
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	7.8%	-122	11,306	10,086	9,873	-12.7%
17-2011	Aerospace Engineers	5.3%	101	6,652	6,101	6,025	-9.4%
17-2112	Industrial Engineers	4.7%	2,118	6,138	6,273	6,602	7.6%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	4.4%	-21	8,338	8,029	8,007	-4.0%
49-3011	Aircraft Mechanics and Service Technicians	4.2%	-146	4,974	4,719	4,704	-5.4%
51-4041	Machinists	3.4%	-27	6,792	6,763	6,843	0.8%
15-1133	Software Developers, Systems Software	3.2%	1,057	13,938	16,781	19,091	37.0%
17-2141	Mechanical Engineers	2.6%	611	4,883	5,042	5,202	6.5%
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic	2.2%	40	1,369	1,260	1,225	-10.5%
43-5061	Production, Planning, and Expediting Clerks	2.1%	92	7,800	8,052	8,401	7.7%
51-1011	First-Line Supervisors of Production and Operating Workers	2.1%	1,736	7,990	8,150	8,273	3.5%
13-1199	Business Operations Specialists, All Other	2.0%	699	25,203	27,707	29,943	18.8%
13-1081	Logisticians	1.9%	201	5,647	5,499	5,636	-0.2%
15-1132	Software Developers, Applications	1.8%	22,899	56,275	76,570	93,259	65.7%
17-2071	Electrical Engineers	1.6%	753	4,668	4,832	5,111	9.5%
11-9041	Architectural and Engineering Managers	1.6%	539	3,191	3,239	3,323	4.1%
49-2091	Avionics Technicians	1.3%	-23	2,259	2,163	2,175	-3.7%
17-2199	Engineers, All Other	1.2%	-166	2,098	2,119	2,207	5.2%
15-1121	Computer Systems Analysts	1.2%	4,659	13,966	16,631	19,007	36.1%
13-1111	Management Analysts	1.0%	3,477	21,870	26,483	30,323	38.7%
17-2072	Electronics Engineers, Except Computer	1.0%	412	2,840	2,833	2,898	2.0%

Sources: WA ESD, 2018; BERK Consulting, 2018

WORKFORCE TRAINING

Workforce training in the region and state is focused on the needs for commercial aircraft manufacturing, and the University of Washington, Washington State University, and the network of state colleges support these efforts.

Post-Secondary Education

Exhibit 12 provides a list of key engineering programs in the state relevant to the manufacturing and production of space-related goods and services, with the number of graduates from each program for 2016.

Within the state of Washington, only one university provides academic programs directly related to aerospace engineering, with the Department of Aeronautics and Astronautics at the University of Washington Seattle. This program provides bachelor's, master's, and doctoral degrees as well as certificate and continuing education courses, and has been at the forefront of research in aerospace for decades. The UW Aerospace Research Consortium (UW-ARC) also supports close coordination with industry to provide for collaborative research and education opportunities, and support the commercialization of space technology developed at the university.

While Washington State University (WSU) does not have a dedicated aerospace program, the Mechanical Engineering program located on the campus has provided opportunities for students to receive training in space-related applications. Centers at WSU have also coordinated several research projects with NASA in multiple departments, ranging from engineering and chemistry to astrobiology.

Other universities in the state also offer programs in different engineering disciplines that can support a skilled workforce in space-related applications, including Eastern Washington University, Gonzaga University, and Seattle University. Although these programs are not directed specifically at aerospace education, they do provide training in broader areas of engineering that may be applicable for space-related applications, such as power and communications systems.

Exhibit 12. Engineering degrees awarded from Washington state universities, 2016.

CIP	PROGRAM	DEGREES PROVIDED				
		ASSOCIATE	BACHELORS	MASTERS	DOCTORATE	TOTAL
14.0201	Aerospace, Aeronautical and Astronautical/Space Engineering	-	72	78	5	**155**
14.1001	Electrical and Electronics Engineering	45	528	112	36	**721**
14.1801	Materials Engineering	-	83	46	12	**141**
14.1901	Mechanical Engineering	121	638	105	27	**891**
14.3201	Polymer/Plastics Engineering	-	13	-	-	**13**

Sources: NCES, 2018; BERK Consulting, 2018

Center of Excellence

The Washington State Centers of Excellence (CoE) are industry-directed educational centers located at state colleges throughout Washington. These institutions are dedicated to building connections between industry and education to provide for workforce training and the distribution of leading-edge research to businesses, and build the state's competitive advantage in key business areas. There are currently 11 Centers of Excellence, each devoted to different industries of regional importance in its service area.

The Center of Excellence in Aerospace and Advanced Manufacturing is located at Everett Community College in Snohomish County, and has coordinated grants for regional and statewide workforce development in areas related to manufacturing and aerospace. The CoE has also worked to develop ongoing partnerships with the aerospace industry to identify major workforce needs and support a strong pipeline of skilled labor.

Apprenticeships

Apprenticeships in the region are promoted in the region as major pathways for industries to access talent. In the central Puget Sound region, the Aerospace Joint Apprenticeship Committee (AJAC) was created in 2008 to provide apprenticeship opportunities in aerospace and advanced manufacturing production. This program matches businesses and mentors with students that work through a combination of on-the-job training and classroom education requirements to receive specialized training. This apprenticeship training currently includes machining, metal fabricator, tool and die making, and industrial maintenance.

Although space-related businesses may be challenged to employ apprentices on highly technical design and manufacturing operations, lower-tier suppliers to the industry are active participants in AJAC programs. Tailoring future apprenticeships and coursework to address the needs of space-related suppliers may be an important approach to building stronger supplier connections to the space economy in the region.

RESTRICTIONS ON FOREIGN EMPLOYMENT

The US and other countries have significant restrictions on the export of sensitive technologies, including advanced military technologies, under the International Traffic in Arms Regulations (ITAR). Many spacecraft, launch vehicles, satellites, and their parts have been deemed as "dual use", which means that they are applicable to both commercial and military uses and treated as "munitions" under the United States Munitions List (US Department of State, 2018). In 2014, reforms to the law allowed for the export of communications and some types of satellites, but restrictions on launch vehicles and other technologies remain (US Department of Commerce, 2017).

Although this regulation controls the export of certain components and products, this also impacts the workforce that can be involved with these technologies. The export control system restricts access of foreign nationals to technical data and components related to these technologies without a specific waiver from the US Department of State. This is a major constraint in employing non-US citizens in space-related businesses, as these waivers may be challenging to obtain depending on the circumstances.

SUMMARY OF KEY FINDINGS

From the analysis of the regional workforce, we can provide conclusions related to future efforts with the space sector:

- **The presence of a large aerospace workforce supports the development of the regional space economy.** As with the presence of a mature supply chain, the ability for space-related startups to tap into an extensive talent pool in aerospace can be a significant advantage. Although other areas in the US and world may have a longer history of satellite and spacecraft manufacturing, this workforce provides a substantial advantage over other areas without a large aerospace cluster.
- **High current demand and gaps in the workforce can make it difficult for space-related companies to retain staff, however.** The ability for regional businesses in the space economy to succeed will depend on the availability of this workforce. High demand for skilled labor from large firms in the region, including not only Boeing but larger businesses in the local space economy and even businesses in related fields, may restrict the ability for newer firms to access the workers they need. These gaps may be seen in aerospace engineering and related fields, such as computer programming and industrial engineering.
- **Future gaps from the "silver tsunami" will have a greater impact on the ability to access skilled labor.** In the longer term, the retirement of the Baby Boomer generation will have a significant effect on the supply of labor in the market. General improvements in efficiency and automation in aerospace manufacturing may address some of these shortfalls, but there are significant concerns that constraints in labor supply will restrict the ability for businesses across the aerospace cluster to grow.
- **Supporting training and education programs will have the greatest impact on startups and suppliers that are more likely to recruit locally.** Although larger companies such as SpaceX and Blue Origin may have the ability to draw on a national labor pool, many startups and suppliers often rely on local labor to meet their needs. Providing for a greater availability of skilled labor locally can be an effective strategy in supporting startups and suppliers to encourage growth and capture additional economic benefits from space-related activities.
- **Restrictions on foreign nationals in space-related employment are a significant limitation to recruiting available talent.** The ITAR restrictions on foreign nationals accessing dual-use technologies with local firms is a notable constraint on the ability to recruit skilled talent, both for non-citizens currently working in the US and international talent interested in working in the US. Although the federal government is responsible for the oversight of this program, assisting with applications for ITAR waivers with the US Department of State can be one way for economic development agencies to support space-related startups in workforce recruitment.

Overall Competitive Position

From a preliminary assessment of interviews and economic data, the space economy in the central Puget Sound region can be framed with the following strengths, weaknesses, opportunities, and challenges:

STRENGTHS

- **There has been significant long-term investment in the region from major OEMs in aerospace.** As the birthplace of Boeing, the central Puget Sound region has been the site of significant investment in aerospace manufacturing, which has included activities in the space economy. This has encouraged the growth of regional infrastructure and relationships to support the sector as the industry has evolved over time.
- **Historic local supply chains provide support for the space industry.** With the long history of aerospace manufacturing in the region, there are a considerable number of local aerospace suppliers at all tiers present throughout the region. This provides support for traditional OEMs involved with space, as well as new firms in the space economy.
- **There is strong representation of private firms in the local sector.** The representation of new private firms such as Blue Origin, SpaceX, Tethers Unlimited, Planetary Resources, and other companies in the local economy is noteworthy, and reflects a transition towards a more competitive business model oriented to commercial applications of space technology.
- **Local educational institutions provide support for research and workforce development.** The University of Washington and Washington State University are strong resources in both the training of talent for the sector, and the development of innovative technologies related to the space economy through research and collaboration with industry.
- **A significant labor pool is available for space and space-related applications.** The presence of significant firms and training programs in aerospace and related fields in engineering and technology provide for a comprehensive pool of skilled labor available for firms in the regional space economy.

WEAKNESSES

- **Workforce pipelines for the education and training of more skilled workers may not be sufficient for demands.** Currently, the graduates from engineering programs are limited within the state, which can restrict the expansion of the local labor pool. As the demands for skilled labor with large aerospace and technology firms are expected to continue, this can be a challenge for finding and retaining talent, especially for suppliers and startups that may not be able to attract employees at a national level.
- **State tax incentives have not been as significant as in other jurisdictions.** Although the state does not have a corporate income tax, other states interested in cultivating their own space-related economic clusters have provided tax incentives to attract and retain companies and encourage local growth of new firms. Washington has not to date extended business and occupation (B&O) tax credits for manufacturing and product development to include spacecraft development and

manufacturing to provide comparable benefits, with unsuccessful attempts through House Bills 2226 (2016) and 1894 (2017).

- **There is strong local competition from other sectors for talent.** Technology firms in other sectors of the local labor market have provided significant competition for labor in the region. Although companies such as Microsoft and Amazon do not provide direct competition in aerospace, demand may be more intensive for engineers in fields such as power systems and telecommunications.
- **There are no launch facilities available in the state.** Given the latitude and geography of Washington state, developing local launch facilities for space-related applications is difficult. This has meant that certain activities that rely on easy access to launch facilities would not be able to locate to the state and region. While this may not be a significant obstacle to space-related businesses, it has provided one mechanism for growth in places such as Texas, Florida, Virginia, and California.

OPPORTUNITIES

- **Significant future growth is expected in the commercial space economy.** The commercialization of space sector is expected to result in significant economic growth into the future. Future projections vary by source, but some estimates suggest that the sector could grow from around $350 billion today to $1.1 trillion by 2040 or as much as $2.7 trillion by 2045. Additionally, much of this growth will be in products and services accessible to smaller firms such as satellite manufacturing and services, which has outpaced growth in the sector and forms 77% of the overall space economy.
- **The space economy represents high value-add economic activities.** Economic statistics indicate that the space economy is a high value-added industry, representing a specialized, high-tech field with higher overall employee wages. Growth in the space economy would align with the advanced industries in Washington state and the shift towards highly skilled, knowledge-intensive activities in the central Puget Sound region.
- **High quality of life is an important driver for attracting smaller firms in the space economy.** Location decisions made by highly skilled talent and knowledge-based businesses, especially smaller startup firms, are often related to access to appropriate resources and talent and less dependent than in the past on long-term investment in facilities. The high local quality of life found in the central Puget Sound region has been a major draw in attracting and retaining local talent for the economy, and maintaining and strengthening this quality of life in the long-term can help to support this advantage.
- **The position of the region as a high-tech hub can support business development.** The presence of a highly skilled workforce and major technology firms in the central Puget Sound region and Washington state not only provides space firms with the ability to access necessary labor, but also presents cross-disciplinary opportunities for collaboration in areas such as data processing and analysis, hardware and software development, and development of internet infrastructure.
- **Increased activity in space industries can support economic diversity in the broader sector.** As the aerospace sector overall is expecting more nominal growth, maintaining and developing space industries into the future will allow the state and region to support new markets and applications. New private companies provide attractive opportunities to diversify the sector and embrace the

growing commercialization of space, building upon existing resources while ensuring that the local market includes a healthy and diverse range of businesses and service offerings.

CHALLENGES

- **Aerospace is a mature industry in Washington state.** Overall, aerospace businesses provide significant economic benefits to the region and state, with $69.9 billion generated in business revenues and 93,800 workers directly supported in 2015 over the entire aerospace industry (CAI, 2017). However, long-term projections of employment and total wages in the aerospace industry by the state and federal governments suggest that growth will be outpaced by other sectors, and the sector will decline as an overall share of the state economy (OFM, 2017). Although this is dependent on multiple factors, this suggests that diversification of the industry may be important to support long-term economic health.
- **Restrictions on international labor will further limit the labor pool.** Employment on applications directly related to launch vehicles and other sensitive technologies are limited by federal requirement from the International Traffic in Arms Regulations (ITAR). Beyond the existing limits to the workforce pipeline, this also serves to limit the available labor pool for space-related applications further.
- **Demands for labor in this sector could leave less-skilled workers behind.** Although the space economy can be attractive because of the high added value to the regional and state economy, the challenge is that the demand for labor in lower-skilled technician positions may decline. The sector should be encouraged to accommodate a range of employment opportunities where possible.
- **There will be significant competition for this sector across the country.** Although the central Puget Sound region and Washington state are well-positioned to promote growth in the local space economy, competition with other regions will be significant. California, Texas, Virginia, Colorado, and other areas have historic connections to the aerospace industry, and can leverage local resources to support growth in new private businesses. Other jurisdictions have been successful in attracting startup firms that may not be dependent on proximity to local supply chains.
- **International competition will increase in the space economy.** Although the manufacture of certain space-related products is restricted by arms export control regulations in the US, international competition in the space economy will increase over time. This includes developing and managing commercial launch facilities, especially in areas close to the equator, as well as building, maintaining, and providing services from inexpensive satellites for less sensitive applications.
- **Vertical integration may challenge firms in local supply chains.** Although the availability of a local supply chain can support local space-related businesses, many companies in the space industry have moved to incorporate lower tiers of the supply chain as internal processes. Although this provides opportunities for quality control and cost management, it can reduce flexibility and increase risk when attempting to adjust to new market demands, and may shrink market opportunities for businesses in the regional aerospace supply chain.

Conclusions

The space economy worldwide is positioned for significant growth in multiple areas, and the central Puget Sound region has been the location of several exciting opportunities in the field. Building on the long tradition of aerospace manufacturing in the region, there are several steps that stakeholders can pursue to help the regional space economy leverage existing advantages and support space-related businesses in the region:

- **Support state tax credits for spacecraft and satellite manufacturing.** Multiple attempts have been made to extend previous tax credits to space-related businesses in the state which have not been successful to date. Providing tax credits comparable to those provided to commercial aircraft manufacturing can help to retain these activities within the state and can promote additional space-related manufacturing in the region.
- **Assistance with venture capital can be essential for smaller space companies to grow and thrive.** The modern commercial space economy has thrived because of the investment of strong sources of private capital. Ensuring that smaller space companies have access to sufficient capital as they start operations can be key to developing new businesses in the region with the potential to flourish in this new market.
- **Other services, potentially through a business incubator/accelerator, may also provide benefits for new companies.** Space-related startups may have different requirements than other types of startups for office and manufacturing space. Likewise, the need for supporting services such as assistance with ITAR waivers may require special attention that would not otherwise be needed for general high-tech startups. This may suggest the need for specific space-related business incubators or accelerators, which can provide new space businesses with a suite of tailored facilities and services designed to address typical needs in the field.
- **Efforts to capture more economic impacts should also focus on supplier relationships.** There are significant opportunities for retaining more economic value within the region by developing new supplier relationships between businesses located in Puget Sound. Opportunities should be explored both to link upper-tier manufacturers and OEMs with existing lower-tier suppliers, and to attract, grow, and retain new suppliers that can support growing demands for a space-related supply chain.
- **Future efforts in developing the workforce may require looking at a broader range of programs and occupations.** Although the central Puget Sound region is a high-tech hub that has a skilled workforce, there are some expected challenges in the future with attracting and retaining the needed employees for space-related businesses. This may be exacerbated by the larger companies both within and outside aerospace competing for a limited pool of employees. Boosting the number of students in STEM programs more broadly and integrating more space-related education into engineering and technical programs may help to ensure that the local talent pool is better suited to meet long-term needs for the space industry.

Exhibit 13. Space incentive programs, by state

State	Space Incentives	Description	Status
Alabama	None	Overall business-friendly climate; large space incentives crafted on case-by-case basis	N/A
Florida	Manufacturing and Spaceport Investment Incentive	Sales tax exemption for existing manufacturers that were not increasing productive output enough to be eligible for the standard manufacturing machinery and equipment sales tax exemption.	Not current, expired 2013
	New Business in Spaceport and Manufacturing Activities	Tax exemption for industrial machinery for new business or businesses expanding by more than five percent in spaceport activities or that manufactures, processes, compounds, or producing items of tangible personal property at a fixed location purchasing industrial machinery.	Current
	Qualified Defense Contractor and Space Flight Business Tax Refund	Tax refunds for businesses bidding on new competitive contracts or consolidating existing defense or space contracts, in partnership with cities and counties.	Not current, expired 2014
	Semiconductor, Defense, or Space Technology Sales	Tax exemption for industrial machinery and equipment used in space technology facilities to design, manufacture, assemble, process, compound, or produce defense technology products or space technology products for sale or use; certified businesses may designate state universities or community colleges as recipients of up to 100% of the amount of the exemption, if the institution agrees to match the funds with equivalent cash, programs, services, or other in-kind support, for research and development projects requested by the certified business.	Current
	Space Business Incentives Act	Tax credits to business creating 35 new jobs in Florida and investing $15 million or more in Florida on a spaceflight project in the three previous taxable years; first-come, first-serve.	Current, no applications received as of June, 2017

Exhibit 13. (continued)

State	Space Incentives	Description	Status
Florida	Space Flight Activities	Sales tax exemption for the sale, lease, use, storage, consumption, or distribution of any orbital space facility, space propulsion system, space vehicle, satellite, or station of any kind possessing space flight capacity; sale, lease, use, storage, consumption, or distribution station of any kind possessing space flight capacity; the sale, lease, use, storage, consumption, or distribution or tangible personal property placed on or used aboard any orbital space facility, space propulsion system, space vehicle, satellite, or station of any kind; not affected by failure of a launch or the destruction of a launch vehicle or any components thereof.	Current
	Space Florida	State-empowered agency with authority to conduct off balance sheet financing transactions, qualifying for operating lease treatment; conduct conduit financial transactions where land ownership is not possible (e.g., improvements on federal installations and at airports); equipment financing; fund infrastructure for improvement within the Florida Spaceports territory; provide access to additional financing and workforce recruiting and training support.	Current
New Mexico	Space Gross Receipts Tax Deduction	Tax Deduction for activities associated with the operation of a spaceport, including launching, operating, and recovering space vehicles or payloads; preparing payloads; research and development, testing, and evaluation for the US Air Force Operationally Responsive Space Program.	Current
Oklahoma	Oklahoma Space Industry Development Authority	Manages the Oklahoma Air & Space Port for public and industrial use, the only US spaceport with an FAA-approved spaceflight corridor not in restricted airspace or Military Operation Areas. Has bonding authority and can rent space facilities. Sales and purchases through spaceport users are exempt from sales tax.	Current
	Other	Overall business-friendly climate, including Foreign Trade Zones, case-by-case incentives for space, and incentives for the aerospace industry.	N/A

Exhibit 13. (continued)

State	Space Incentives	Description	Status
Texas	Spaceport Trust Fund	Cost-reimbursement for expenditures for the development of infrastructure necessary or useful for establishing a spaceport.	Current
Virginia	Enterprise Zone	Zone providing grant-based incentives for job creation and real property investment established at MARS	Current
	Foreign Trade Zone	Zone established at MARS that allows postponing payment of applicable import tariffs and duties until the product formally enters the US market, and if the imported good is re-exported to another country, applicable import tariffs and duties may be altogether eliminated.	Current
	Freedom of Information Act (FOIA) Relief	FOIA relief when doing business with VCSFA	Current
	Spaceflight Liability and Immunity Law	Space flight entities are not liable for a participant injury resulting from the risks of space flight activities in Virginia	Current
	Virginia Commercial Space Flight Authority (VCSFA)	Political subdivision of the Commonwealth of Virginia, providing full-service launch and drone testing facilities at the Mid-Atlantic Regional Spaceport (MARS)	Current
	ZeroGravity, ZeroTax	State income tax incentives to locate and headquarter flight launch and training business operations in Virginia	Current

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Appendix: Regional and State Space Companies

In addition to the companies that are listed as being involved in the core space economy in the report, there are firms across the central Puget Sound region that play an active role in supporting the access and use of space. This list outlines the companies in the central Puget Sound region that are involved in the space economy as suppliers, manufacturers, service providers, and users of space-related goods and services.

Aerogo, Inc., Seattle
Aerojet Rocketdyne, Inc., Redmond
Allstar Magnetics, Vancouver
Amazon.com, Seattle
Anseres Research & Technology LLC
Argosy Component Sales, Inc., Bellevue
Avaliant, Bellevue
Blue Origin, Kent
BRPH, Renton
bSpace Corporation, Seattle
Canflex USA, Inc., Anacortes
Carlisle Interconnect Technologies, Kent
Cascade Gasket & Manufacturing Co, Inc., Kent
Central Trading Agency, Kenmore
Chempoint.com, Bellevue
Cobalt Enterprises, Granite Falls (HQ)/Lake Stevens/Everett
Corsair Engineering, Kirkland
Crane Aerospace & Electronics, Lynnwood (HQ)/Redmond
Datalight, Inc., Bothell
e3 Elite Engineering Services, Redmond
Eagle Harbor Technologies, Seattle
Electroimpact Inc., Mukilteo
Engineered Software, Inc., Lacey
Esterline Engineered Materials, Bellevue
Fabrication Technologies LLC, Anacortes
Fidelitad, Inc., White Salmon
Fluke Networks, Inc., Everett
Front Panel Express LLC, Seattle
Gaco Western LLC, Tukwila
General Dynamics Corp., Seattle/Moses Lake
General Dynamics Ordnance and Tactical Systems, Bothell
General Plastics Manufacturing Co., Tacoma
Heatcon, Inc., Seattle
Helion Energy, Redmond
Hi-Rel Labratories, Spokane
Hill Aerosystems, Inc., Enumclaw
Hobart Machined Products, Hobart
Honeywell International, Redmond
Idea-International Inc., Mukilteo
Janicki Industries, Inc., Sedro Woolley
Jorgensen Forge Corporation, Seattle
Kitsap Composites Inc., Port Orchard
Kymeta Corporation, Redmond
LiftPort Group, Tacoma
M42 Technologies, LLC, Seattle
Metal Motion, Arlington
Microsoft Corporation, Redmond
Mistras Group, Inc., Kent
MSNW, Redmond
MTorres America, Bothell
NetAcquire Corporation, Kirkland
Neumeier Engineering, Inc., Kent
Nova-Tech Engineering, Inc., Lynnwood
Pacific Aerospace & Electronics, Wenatchee
Pacific Integrated Handling, Tacoma
Paine Electronics, Wenatchee
PCC Aerostructures, Bellevue
Planet, Bellevue
Planetary Resources, Redmond

PowerLight Technologies, Kent
Primus International Inc., Bellevue
PSI Solutions, Inc., Federal Way
Pulse Electronics, Inc., Vancouver
RBC Signals, Seattle
Renton Coil Spring, Renton
Roberts Precision Machine Inc., Monroe
RTC Aerospace, Fife
Safeware Engineering Corporation, Seattle
Safran Electrical & Power, Everett
Sakco Precision Inc., Auburn
SeaCast Inc., Marysville/Seattle
Space Exploration Engineering, Friday Harbor
Spaceflight Industries, Seattle
SpaceX, Redmond/Seattle
Spectralux Avionics, Redmond
Stelia Aerospace, Kent
Systima Technologies, Kirkland
Teague, Seattle
Tethers Unlimited, Bothell
The Boeing Company, Renton/Kent
The Goebel Company, Leavenworth
Thyssenkrupp Onlinemetals LLC, Seattle
TLG Aerospace, Seattle
Triumph Group, Inc., Redmond/Spokane/Yakima
Trulife Engineered Solutions, Bellingham
Uniwest, Pasco
VM Products, Inc., Puyallup
Vulcan Aerospace (Stratolaunch), Seattle
Zepher Inc., White Salmon
Zonar, Seattle

Other nonprofit and trade organizations are also involved with the space industry, including:

Aerospace Futures Alliance, Everett
The Museum of Flight, Tukwila
Pacific Northwest Aerospace Alliance, Redmond