Please excuse errors in spelling and grammatical structures. We wanted to make sure the IDEAB Committee received a copy of the draft before the February 8th work session on LD 1923. These will be corrected in the final report.

The Maine Space Complex

Draft Strategic Plan Report

Prepared for:
The Governor of Maine
The Maine Legislature

Submitted by:
Maine Space Grant Consortium

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February 7, 2022

"...We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too."

President John F. Kennedy
Rice University Stadium, Houston, Texas
September 12, 1962

Financial support for the strategic planning process was provided by the Economic Development Administration under Investment #01-69-15038, the Maine Technology Institute under Award #20200329, and the Maine Space Grant Consortium.

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Introduction

Maine has long been characterized by the resourcefulness and ingenuity of its people. Whether harvesting its woods or waters, Maine has proven over again that it's capable of transforming its natural resources into industry, creating livelihoods for its citizens, and supporting its people. The origin of the Maine Space Complex started in much the same way; a small group of dedicated citizens from the space industry came together to ask if Maine had a more prominent role to play in the nascent but rapidly growing 'new space' industry.

As the 'new space' industry has emerged over the past 20 years, the Maine Space Grant Consortium (MSGC), a NASA funded non-profit, has been investing in a portfolio of innovative Maine-based space research projects that engage faculty, students, and businesses in aerospace-related research and educational programs and bolster the STEM pipeline for aerospace. Over the past 20 years, MSGC has invested $25 million to support inspiring space research across the state - from developing Mars landing systems to a sensor technology used to detect leaks in space habitats. Although innovative research has been occurring for years, Maine has not fully harnessed the true return of this investment due to a lack of instate space opportunities that could cradle and foster these students and opportunities to create sustainable, long-term economic growth for Maine's economy. While STEM education is critical to growing a next-generation workforce, it is not the sole strategy for economic growth.

Recognizing the immense potential of the new space economy, Executive Director of MSGC Terry Shehata asked a critical question – "How can space be used to drive not just research but true economic growth in Maine?" With this question, MSGC began a dialogue with Maine-based aerospace professionals to consider opportunities within the space industry Maine could harness. From these discussions, a unique natural advantage was revealed – Maine's easternmost position in the US offers ideal conditions to launch rockets into polar orbit from the coast. With this insight, the Maine Space Complex concept was born. Asking this novel question to set this group – and Maine - on a new trajectory to uncover big, bold ways the new space industry could integrate into our local economy, drive Maine's development into the future and create high-paying jobs for our graduates.

With a grant from the Maine Technology Institute in 2018, the MSGC undertook a market demand study to determine the public and private sectors' interests within Maine and outside in a proposed space complex. This study confirmed the public and private sectors' interest in accessing and using the complex and indicated that Maine is poised for a leadership role in the emerging and fast-growing market for nanosatellites by launching nanosatellites using small, low-cost launch vehicles. This study was followed by an award from the Maine Technology Institute (MTI) and the federal Economic Development Administration (EDA) in 2019 to develop a strategic plan to set forth the vision and mission of the Maine Space Complex, an integrated ecosystem of aligned interests and actors focused on achieving strategic goals to drive the development of Maine's New Space industry thereby creating value and opportunity for Maine's future generations. The following report, developed with guidance from the Maine Space Complex Leadership Council, outlines the roadmap for industry development and the anticipated impacts.

Opportunities in a New Space Economy

1. Role of Space

Humankind launched the first satellite into Space to claim superior technological prowess in the battle for global hegemony amidst the backdrop of the Cold War in 1957. Since the role of space has evolved considerably, achieving significant milestones along the way – from the first government-funded manned mission to the moon in 1969 to the introduction of private astronauts in 2021 – and many spin-off technologies, including radial tires, scratch-resistant lenses, enriched baby food, solar cells, portable cordless vacuums, and firefighting equipment, to name a few. Without recognizing it, most people already depend on satellites for daily conveniences such as cell phone navigation, listening to the radio, and watching television. Exploration and development of Space have and will continue to play an enormous role in our lives, imaginations, and the global economy over the coming decades.

2. Market Potential

Although space has historically been considered the exclusive domain of enormous government-funded projects, over the past decade, this paradigm has shifted toward commercial industry leadership due to advances in technology. Evolving hardware and software have significantly increased performance and reduced the cost and size of componentry for spacecraft development. This has precipitated the introduction of small form factor spacecraft like nanosatellites, the development of micro launch vehicles, and other enabling technology that have reduced the overall cost of launching payloads into space. This new cost-effective technology has, in turn lowered capital requirements and barriers to entry, attracting a wave commercial participant into the new space industry around the globe and here at home in Maine. This has unleashed a significant influx of private capital to finance research and development, creating innovation and unlocking value across the new space value chain. Poised for tremendous growth, 'New Space' is one of the fastest growing, high-tech future forward industries of this century.

Valued at $371 billion in 2020, the global new space industry is still in its infancy and analysts such as Goldman Sachs and Deloitte predict the market value will surpass $1 trillion in the 2040s. Approximately 95% of the market is derived from products and services produced by satellites in space for use on earth such as telecommunications, broadband internet delivery systems, earth observation capabilities, national security reconnaissance, and more. These technologies are largely an extension of the old space paradigm funded by government research in support of public interest, national security, and basic science. However, products and services intended to serve the economy in space like space tourism and space habitation are starting to enter the market opening another segment of the market.

Here on earth the driver of growth is the satellite market, which is large and growing. Small satellites refer to satellites ranging from .01 to 600kg among the fastest growing segments of the aerospace markets. While small satellites only represent about 3% of the market, they are expected to grow to 5% by 2030, with a value of over $25 billion annually.

- The largest components of the satellite market are information services, followed by ground equipment, satellite manufacturing, and launch.
- Nanosatellites will account for around 30% of the total small satellites market, while the highest value segments are the micro- and mini-satellite classes.
- The small satellite industry is expected to grow a market value of $69 billion by 2030 due to the rapid increase in small satellite demand; 82% of the demand for small satellites will be from North America and Asia
- The market value of nanosatellites is projected to reach $9.5 billion in 2030 largely due to their use in a broad range of commercial applications in all regions of the world.

While the large private companies such as SpaceX, Blue Origin, and Virgin Orbit routinely grab headlines in national media outlets, behind the scenes a plethora of private space companies have emerged into a nascent but increasingly robust industry ecosystem that has eclipsed the US government as the leader of the new space industry measured by payloads in space. Recognizing the potential of this newly disrupted market, a number of areas around the globe have positioned themselves to capture this growth and attract the industry to their respective region.

However, space is not only about the business of building and launching payloads into space, in fact the vast majority of the revenue and benefit comes from the products and services those satellites provide. Satellites are extremely useful in overcoming various limitations of the earth's geography. They can capture more data more quickly than a plane or drone because it is higher above the earth's surface. Satellites collect an immense amount of data using a variety of sensor and imaging technology (see Figure 3). This data is used in natural resource management, agriculture, forestry, aquaculture, fishing, oceanography and climate change science among many others. Harnessing satellite data can help professionals in those fields make better and more informed business management decisions.

3. What are Small Satellites?

Satellite size is categorized by weight, often measured in kilograms (kg). The Maine Space Complex is considering weight classes of satellites from Femto (0.01-0.09kg) up to mini satellites (weighing less than 300kg) as potential launch customers (Figure 1).

Figure 1: Satellite Classification

	Mass Class Name	Kilograms (kg)
Smallsats	Femto	0.01 – 0.09
	Pico	0.1 – 1
	Nano	1.1 – 10
	Micro	11 – 200
	Mini	201 – 600
	Small	601 – 1,200
	Medium	1,201 – 2,500
	Intermediate	2,501 – 4,200
	Large	4,201 – 5,400
	Heavy	5,401 – 7,000
	Extra Heavy	> 7,001

From FAA *The Annual Compendium of Commercial Space Transportation: 2018*

Nanosatellites (1-10kg) have grown in popularity over the past two decades due to the creation of cube sat reference design which became an industry standard for design and deployment of these satellites. This 10cm x10cm x 10cm cube shaped satellite is commonly used in academia and for some commercial test cases.

Due to the miniaturization, increased reliability and performance of many electronics inputs including commercial off the shelf (COTS) (as opposed to custom built electronics hardware) to build satellites have fallen dramatically. The benefits accrued by this miniaturization include:

- Decreased weight per payload allowing more satellites to be launched simultaneously – economies of scale
- Ability to be a primary or secondary payload. This means it can get to orbit at a decreased weight, sharing the cost as opposed to a dedicated launch.
- Frequently, small satellites are secondary payloads on a large rocket with a launch schedule dictated by a primary payload and as result can ride more cheaply

There are risks, however, and they include:

- The electronics are smaller and are therefore more sensitive to radiation and prone to failure
- Cannot carry large payloads with them
- Generally designed to last only a few weeks, months or years before ceasing operations (and for those in low Earth orbit, falling back into the atmosphere)

4. Innovations in Small Launch Vehicles

The satellite launch business was initially designed to carry payloads greater than 1000kg into low Earth orbit (LEO), approximately -1,200 miles or less from the earth's surface (Figure 2). The launch vehicle industry has only started to adapt to the proliferation of small satellites with the development of smaller launch vehicles. While small satellites can find rideshare opportunities as a secondary payload on a much larger rocket, such as SpaceX's Falcon 9, they are often relegated to the primary payloads schedule and have less control over the launch timing and orbital trajectory. A new class of emerging launch vehicles called micro launch vehicles are tailoring their vehicles to cater directly to small satellites as a dedicated launch provider. This offers a couple of advantages in that the small satellites will be able to choose their own orbital trajectories and have greater control over the launch manifest and timing. It is the difference between an Uber (custom point-to-point transport) vs. a bus (generalized point-to-point transport).

Figure 2. Launch Vehicle by Weight Capacity

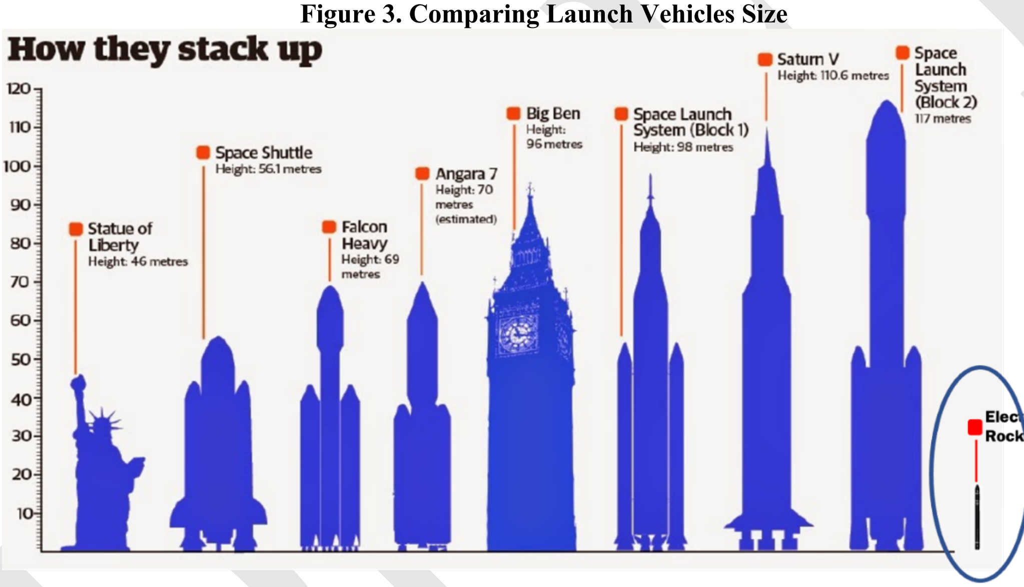
Launch Vehicle by Weight Capacity

Size	Payload Capacity
Micro	≤ 500kg
Small	500 – 2 tons
Medium-LV	2 to 6 tons
Heavy-LV	6 to 30 tons
Super Heavy	>30 tons

☐ Dedicated small sat launch vehicle
☐ Smallsats travelling as secondary payloads
*1 ton = 907 kg/ 2,000 lbs

The first commercially viable U.S. based small launch vehicle is Rocketlab's Electron rocket which measures 59 feet in height and 3 feet 11 inches in diameter (Figure 3). As a point of comparison, the Falcon 9, SpaceX's reusable rocket frequently launched from Kennedy Space Center, stands 230 feet and 12 feet in diameter (larger than the Statue of Liberty). The Space X Falcon Heavy first launched on February 6, 2018, is the world's most powerful rocket and includes 3 Falcon 9 cores. The Maine Space Complex launch services will focus on the launch of small satellites using micro launch vehicles.

Figure 3. Comparing Launch Vehicles Size



5. Potential Applications

Due to miniaturization, small satellites can now achieve more in a smaller format than ever before opening a breadth of innovation. According to the International Organization for Economic Cooperation and Development (OCED), Space does not have international standards for industrial classification, which means worldwide national space statistics differ in definition, coverage and methodology, generating a lack of international comparability. The structure of space economy data is therefore highly fragmented, and the space sector standardized data collection and reporting to support the evaluation of socio-economic impacts. However, with the impetus of the OECD, a global dialogue has paved the way towards shared definitions, starting with the expanding space value chain (Figure 4).

Figure 4: New Space Value Chain – Upstream & Downstream

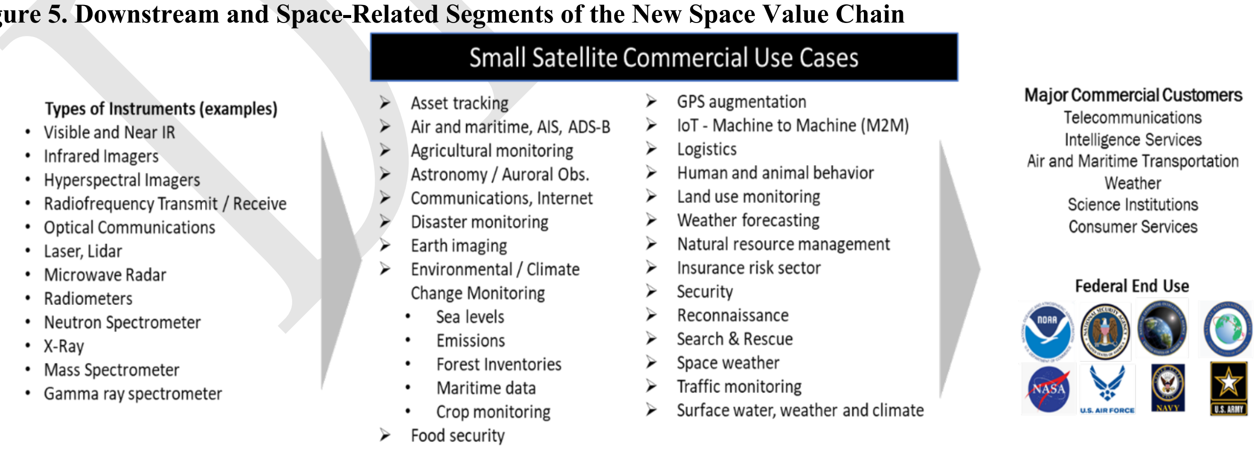
The space industry value chain includes upstream activity, which includes the design, manufacture and launch of spacecraft (satellites and rockets) that collect data and provide services that are then transmitted back to earth in downstream portion of the value chain, which includes space infrastructure operations, "down-to-earth" products and services that rely directly on satellite data and signals to function. The OECD defines three space segments setting up the perimeters of space activities, products and services as follows:

- UPSTREAM SEGMENT includes R&D, manufacturing (satellites, rockets, ground stations and systems that connect satellites to earth) and launch services. Activities include fundamental and applied research, scientific and engineering support, material and components supply, manufacturing of space systems, subsystems and equipment, telemetry, tracking and command stations.
- DOWNSTREAM SEGMENT - includes operating the infrastructure downlinking of data from space operations for terrestrial use, products and services which rely on satellite technology (e.g., satellite broadcasting, selected GIS, GNSS-enabled devices).
- SPACE RELATE SEGMENT - includes space applications, products and services from spin-offs or technology transfer from the space sector, which use satellite technology but do not depend on it (low incorporated quantities of "space" components).

The Maine Space Complex will focus on developing both upstream and downstream segments of the market (Figure 5). With regard to the downstream market, small satellites contain a variety of instrumentation in their payloads for an even broader set of use cases for a variety of industries. The most prevalent use cases for polar LEO payloads are:

- Earth Observation (EO): electro-optical and radar observation of Earth used for meteorology and Earth-science/climate related research.
- Telecommunications (Satcom): satellites for commercial and government operators providing broadband communications.
- Information: satellites providing narrowband communications services (IoT and Machine-to-Machine) and collecting data from ground, aerial and atmospheric sensors.
- Security: satellites for space surveillance and tracking, missile early warning, near-Earth object monitoring, electrical intelligence and space weather.
- Technology: satellites primarily from academic and government, built to test new technologies such as sensors and other components.

Figure 5. Downstream and Space-Related Segments of the New Space Value Chain

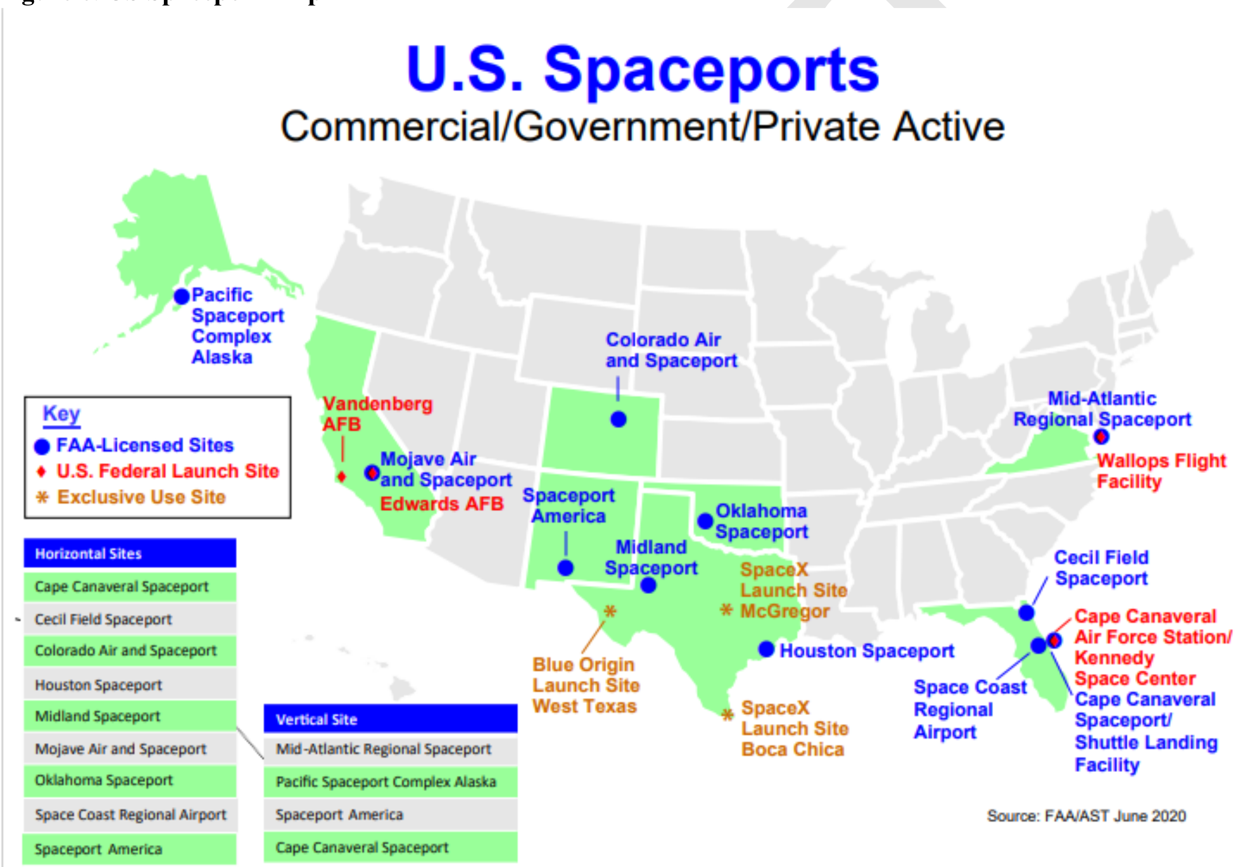


A number of these use cases are applicable to Maine industries including agriculture, maritime navigation and communication, environmental and climate change monitoring, land use monitoring, forestry, aquaculture and fishing, natural resource management and weather forecasting among others.

Existing FAA-Approved Spaceports

The United States is currently home to 13 FAA-licensed spaceports and one government operated site at Vandenberg SFB (Figure 6). There are a total of nine horizontal launch sites and five vertical launch sites, two of which regularly host polar orbit bound launches for small launch vehicles. The nine horizontal launch sites are located at the following facilities: Cecil Field (FL), Colorado Air & Space Port (Front Range), Houston Spaceport (TX), Midland International Air & Space Port (TX), Mojave Air & Space Port (CA), Oklahoma Spaceport (OK), Space Coast Regional Airport (FL), Space Florida Launch & Landing Facility (SLF), Spaceport America (NM).

Figure 6. US Spaceport Map



The five vertical launch spaceports: Mid-Atlantic Regional Spaceport (MARS) (VA), Pacific Spaceport Complex Alaska, Space Florida Launch Complex 46, Spaceport America (NM) and Vandenberg SFB (CA). Spaceport Camden (GA) was granted FAA approval for vertical launch in December 2021.

Blue Origin (Launch Site One) and SpaceX operate private launch sites in West Texas and Boca Chica, Texas respectively.

1. Pacific Spaceport Complex (Vertical)

The Pacific Spaceport Complex achieved five commercial launches between 2018 and 2021 and hosts companies like Astra and Northrup Grumman. The complex is one of the few in the United States that can accommodate polar launch. It is also home to a very active scientific ballooning community. The launch complex, under the management of the Alaska Aerospace Corporation, turns a yearly net operating profit, with $2.6 million in net operating profit in 2020. The Pacific Spaceport Complex is expected to generate a cumulative total economic impact exceeding $100 million to the region by 2028.

2. Vandenberg Space Force Base (Vertical)

Vandenberg Space Force Base in southern California represents the most-frequented polar launch facility in the United States, hosting 19 commercial launches between 2018 and 2021. With over 16 launch facilities and complexes, Vandenberg hosts companies like Firefly Aerospace, SpaceX, United Launch Alliance, and Northrup Grumman. Located on over 100,000 acres, Vandenberg provides 16,000 jobs and generates $4.5 billion annually for Santa Barbara and San Luis Obispo counties.

3. Space Florida Launch Complexes (Vertical & Horizontal)

Florida, with its rich launch history was the first U.S. launch site and most frequently associate with the space age, has several spaceports operated by different entities. Kennedy Space Center and Cape Canaveral Space Force Base operate vertical launch sites. Space Florida, the public-private partnership representing a state effort to facilitate launches and commercial space ecosystem growth leases space from Cape Canaveral to achieve their launches. These three bodies achieved 65 commercial launches between 2018 and 2021. Florida hosts rocket companies SpaceX, United Launch Alliance, and Astra for launch. Whereas Blue Origin, and Harris Corporation have manufacturing and operational facilities onsite. The yearly economic impact of Florida's space coast from NASA operations alone exceeds $5.9 billion.

4. Spaceport America (Vertical & Horizontal)

Spaceport America facilitates both horizontal and commercial launches on their $220 million site. Famously home of their anchor tenant Virgin Galactic, which provides horizontal space tourism launches, they also host UP Aerospace that conducts vertical sub-orbital launches at the complex. Spaceport America has also seen large success in hosting its Spaceport America Cup – with over 1,700 students and faculty competing on designed launch systems. Spaceport America experiences a yearly net operating loss of over $5 million dollars but provides annual economic impacts exceeding $50 million per year in 2019. By 2029, Spaceport America is expected to generate close to $200 million in total yearly economic impact.

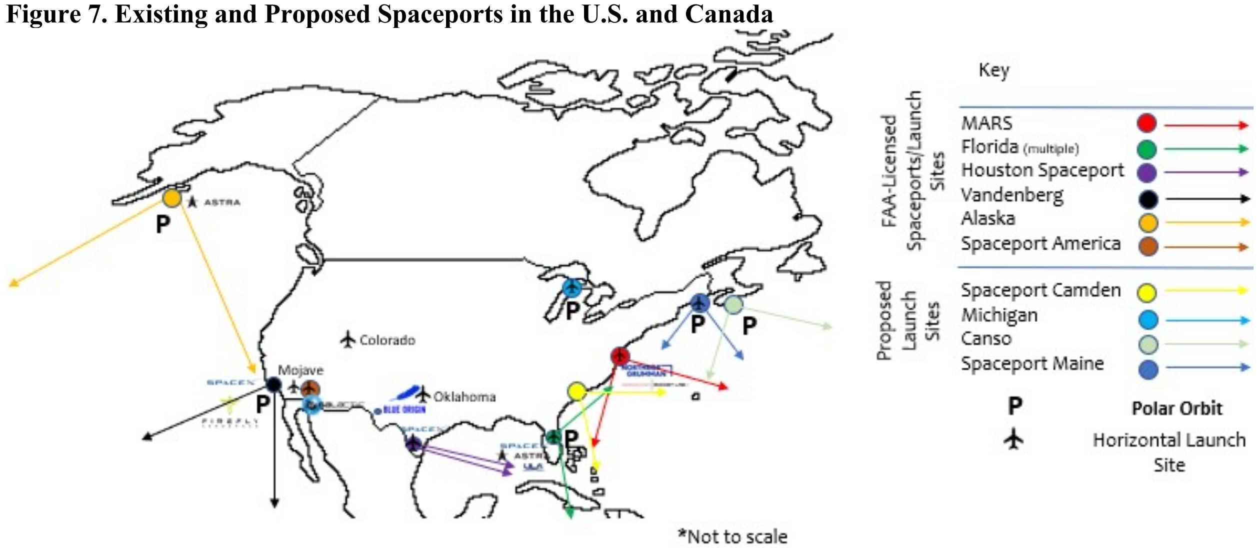
5. Mid-Atlantic Regional Spaceport (MARS) (Vertical)

The Mid-Atlantic Regional Spaceport is home to the ISS re-supply missions launched by Northrup Grumman and has recently announced it will host RocketLab's Electron rocket. MARS was conceived with the idea that the State of Virginia would benefit from a more coordinated and local effort to build a space ecosystem on top of what NASA's Wallops Flight Facility had already started. It has been seen as a success - while MARS experiences similar income statement losses as Spaceport America, the total infrastructure on Wallops Island, including the NASA facility located there, generates a total economic impact of $1.37 billion annually for the State of Virginia.

Planned Spaceports

The proposed sites at Michigan and the Canso Spaceport in Nova Scotia represent current efforts to open additional launch infrastructure that can serve small satellites and polar orbits (Figure 7). Alongside these direct competitors to the Maine Spaceport Initiative are the myriad sites currently licensed but not yet operational for horizontal launch in the United States. Maine would combine these capabilities and served each launch method. Aside from the proposals in Michigan and Canso is the threat of existing spaceports expanding their footprints to cater to under-serviced areas of the market, including polar and SSO launch of small satellites.

Figure 7. Existing and Proposed Spaceports in the U.S. and Canada



1. Michigan Spaceport (Vertical & Horizontal)

The Michigan Spaceport, led by the Michigan Aerospace Manufacturers Association, envisions both vertical and horizontal launch sites, with access to polar orbits and SSO being integral to their plans. A launch site on the Upper Peninsula would allow a vertical launch northward over the great lakes to avoid overhead flight. Horizontal launch is planned to be located at the Oscoda-Wurtsmith Airport, a former Air Force base in the Lower Peninsula. The Michigan Spaceport has been funded by the State of Michigan to the tune of $2 million to undergo the feasibility and site study, with the hopes that the Michigan Aerospace Manufacturers Association can take the baton and leverage private equity money to build the facility. Operations are expected to begin by 2025.

2. Canso Spaceport (Vertical)

Canso Spaceport in Nova Scotia, envisioned and managed by Maritime Launch Services, has taken the unique approach of privately financing the spaceport infrastructure. In May of 2021 it had secured $10.5 million from a Toronto investment bank and seeks to host its first launch in 2023 if construction is able to move forward as planned. Canso has traction, securing a launch agreement with Nanoracks, a Texas-based commercial payload provider which also offers satellite services to the Canadian Space Agency. Alongside this payload partnership, Canso plans to host the Ukrainian-built Cyclone-4M rocket, which has 877 successful missions under its belt. Canso plans to provide polar-orbit access to small satellites.

3. Vandenberg + Florida Spaceports Expanding Existing Capacity

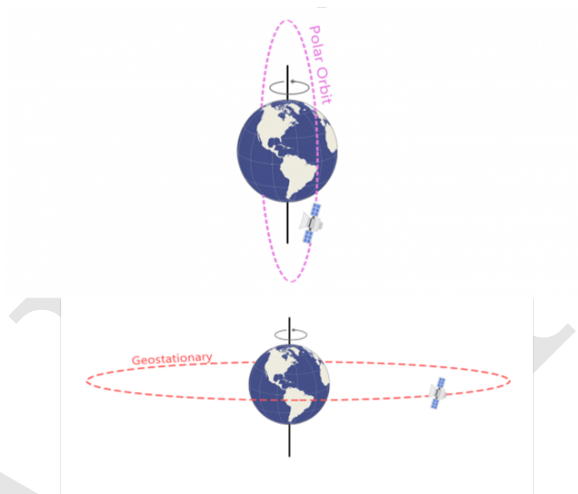
Existing spaceports have the ability and are planning to increase their capacity to accommodate small launch vehicles and polar launches specifically to capitalize on the growing demand in the marketplace. Vandenberg represents a large threat in this category, with a planned “Commercial Space Enterprise Zone” to bring in companies to use the base’s existing infrastructure and to build new and improved launch sites to increase the cadence of launches. Florida also represents an area of growing interest to provide polar launches – with technological advancements in Automated Termination Systems, cost-effective on large-scale rockets, providing a tolerance by the FAA for some overhead flight. There are 5 polar launches planned in Florida in the coming months.

Maine Assets for A New Space Economy

1. Maine has a unique geographic advantage to access space.

Maine is uniquely positioned in the northeastern most corner of United States that projects out over the Atlantic Ocean presenting coastline that is well suited for launch activity due to a clear path southward. With little interference from established airflight patterns, minimal overflight of densely populated areas, Maine presents an excellent opportunity to launch southerly into a polar orbit that passes close to or directly over the poles. This is a desirable orbit for many low earth orbit (LEO) missions operating, which is the orbit of choice for most commercial operations in space.

Figure 8: Polar and Geostationary Orbit



2. Maine is already home to a small but thriving space industry.

The economic development of an industry often begins by leveraging local assets and capabilities as a platform for future growth to build upon pre-existing strengths, expand capacity and ensure efficiency in resource allocation. Establishing the current state of the aerospace industry within Maine was the first area of focus in the strategic planning process. The Maine Aerospace Industry Assessment considered the number and variety of companies in Maine participating in the aerospace and space industries, the level at which they participate in the industry supply chain and the related skills and capabilities of these companies' workforce.

The industry analysis included companies directly engaged in the new space industry (n=20), the broader collection of companies serving the aerospace industry (n=85), inclusive of space, and an overview of companies serving adjacent industries with skills and capabilities applicable to but not in service of the aerospace industry at this time (n=127). The analysis indicated that a small but thriving new space industry exists within Maine focused primarily on the upstream portion of the new space value chain engaged in the manufacturing of hardware components and subsystems (mWave, Texas Instruments, AVX Corp., Comnay and Garmin), high temperature carbon fiber composite systems (FMI and Auburn craning services (Greison Aerospace), and a host of machining companies (Kennebec Technologies, Hunting Dearborn, Northwood Machine, PTE Precision Machining, Cascon Inc. Numberall Stamp and Tool Co.) and consulting services (Maine Aerospace Consulting and Hanna Consultants).

A. Launch Vehicle Systems

Maine is home to two launch systems designers, VALT Enterprises and BluShift Aerospace, who are developing micro-launch vehicles specifically for small satellite delivery into Low Earth Orbit (LEO). They have been recipients of various types of US Government funding including prestigious SBIR awards to continue R&D on their path toward commercialization. Although still under development, they are poised to become key contributors to the space economy with a competitive advantage in that they are environmentally sustainable solutions. VALT is focused on hypersonic delivery systems and can deploy from a vertical or horizontal launch, whereas bluShift is vertical only.

B. Composite Systems & Advanced Materials

Another company included in the study was Fiber Materials Inc., which develops and manufactures high temperature materials and carbon-reinforced composites for use in industrial, commercial, and aerospace applications. FMI fabricated the thermal protection system for the Mars 2020 transport/entry aeroshell and was recently awarded a $24 million contract from NASA to provide thermal protection systems (TPS) to support several emerging missions to Mars. As a recognized leader in the manufacture of high-temperature composite materials, FMI produces components and products that serve a range of applications from industrial insulation and friction hardware, and from thermal protection systems to rocket motors to nose tips. FMI materials can be found inside industrial furnaces, at the National Air and Space Museum, and on the surface of Mars. Other companies showing participation in the space industry included Flagsuit LLC, which provides advanced materials and textiles for space suits in Southwest Harbor.

C. Hardware Componentry

Another medium sized business, mWAVE specializes in custom antennas that are used on satellites, bringing capabilities across many radio frequencies like KA bands, KU bands, X bands, U bands, across many applications. Several companies specializing in ground stations and satellite management and control services, have also expressed interest in establishing operations in Maine, building upon our legacy as home to the ground station for Telstar, the first US communications satellite launched in 1962. Not only does Maine, have a legacy in space, but it also has the potential to thrive and grow with the industry as it expands in the future. Texas Instruments with its componentry and chip focus as an organization contributes to the new space economy and has a presence in South Portland. VX Corp, a Kyocera subsidiary in Biddeford, Maine is a global manufacturer of advanced electronic components, including antennas. Comnav Engineering produces microwave filters for wireless communication and navigation systems in Portland. Last on the list is Garmin, located in Yarmouth which provides downstream global positioning data and devices to the consumer market. Cascon Inc is a custom componentry developer in Yarmouth, specializing in pumps.

D. Machining Services

Kennebec Technologies is a machining shop in Augusta. Southern Maine Specialties provides anodizing, electroplating, and metal finishing technologies. Hunting Dearborn provides drilling, boring, and other machining services in Fryeburg. Northwood Machine is a CNC machining shop in Thorndike. PTE Precision Machining is a full-service machining shop in Kittery. Numberall Stamp and Tool Company provides metal marking equipment for industries, primarily stamps that engrave serial, part numbers, etc. in Sangerville. Thermoformed Plastics of New England is a custom thermoforming company that offers complete design, prototyping, tooling and production services in Biddeford.

E. Professional & Technical Services

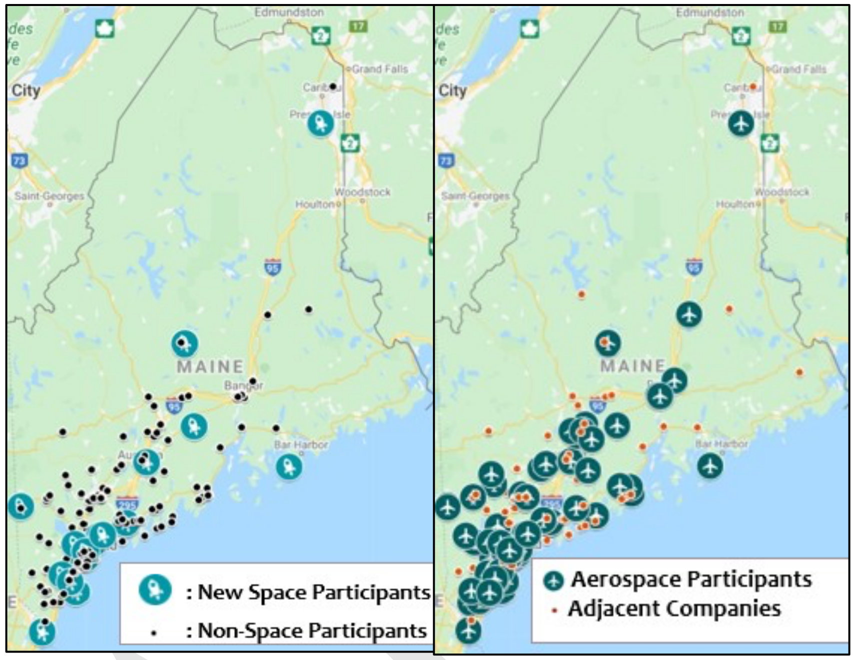
Hanna Consultants uses analytics to assist with dispersion analyses in Kennebunkport. Maine Aerospace Consulting provides industry-relevant engineering consulting in Falmouth. Greisen Aerospace provides advanced lift, craning, and loading/staging services in Brunswick.

3. Maine's Aerospace Industry & Workforce

The aerospace industry in Maine is comprised of 85 companies that serve the aerospace industry exclusively or that serve the aerospace industry in addition to other markets (non-exclusive) (Figure 9). The largest aerospace company in Maine is Raytheon subsidiary Pratt & Whitney, a tier 1 manufacturer of jet engines and after-market service and repair in North Berwick. Pratt & Whitney employ approximately 2,100 workers in North Berwick. Another, 36% of all aerospace industry participant companies are small to mid-sized machine shops serving multiple industries including aerospace as tier 3 component suppliers. Few of these companies are poised to expand their role in the aerospace industry due to a lack of industry certification (AS9100), a quality control standard required by many companies across the value chain. Maine's companies show depth in machining and modest progress toward automated processes. Adjacent industries, such as defense and manufacturing among others, have capabilities transferable to the space sector and could support future industry growth. Many aerospace participant companies are not aerospace-focused, but contribute to the aerospace value chain

We conducted a gap analysis to inform recommendations on how a Maine Space Complex could address local gaps in the value chain and workforce capabilities to create stronger linkages to the local and national space/aerospace industry to foster participation across the new space value chain in Maine. Findings show that Maine is missing links largely in the downstream end of the new space value chain, and the study identifies a consortium-driven effort of higher education institutions and private sector companies to utilize the complex's center of innovation to spur innovation in downstream activities.

Figure 9. Locations of Maine's New Space and Aerospace Participants.



A qualitative study distributed by the Manufacturers Association of Maine (MAME) to its members on behalf of the Maine Space Initiative analyzed the level of interest of MAME's member companies to participate in the new space industry. The survey received 12 responses. The strongest responses that resonated the most included "No central resource to get answers about industry need" "Limited workforce to staff my company", "Asset needs to meet industry demands", "Limited space for manufacturing (physical capacity of plant", and "high insurance costs to participate". It is clear that at this juncture, the space industry provides more questions than answers for Maine companies. Not enough certainty or insights exist for companies in Maine to understand how they can best fit into the supply chain. One MAME member was quite clear with their needs: "Access to the decision makers in engineering and purchasing at the manufacturing companies to become a valued resource and supplier to them." Maine's industrial players are at a disconnect to the needs of the mainstream space market currently.

Alongside participants like bluShift, FMI, and VALT Enterprises, there is interest from commercial launch vehicles solutions providers to become an additional tenant launch supplier in the proposed Maine spaceport. With continued developmental success, these parties could provide a launch or two per year starting in 2025, with subsequent ramping up of launches over the years to come from an appropriately developed Maine launch site to the tune of 1-2 launches per month by 2035. Launch services are a linchpin for future industry development as regular access to polar orbit in the US is currently limited primarily to operations on the West Coast – Vandenberg AFB and Kodiak Island, Alaska.

A. Adjacent Capable Companies

Adjacent companies included in the study represented companies who served industries other than the aerospace industry, but display capabilities that would be applicable to the aerospace industry. Examples of an adjacent company fit to serve the aerospace industry could be as obvious as a machining shop not already serving the aerospace industry, to as broader as a boat builder working with composite materials that display skills and capabilities that could be used in an aerospace function.

B. Industry 4.0 Practices and Maine's Ability to Compete

Industry 4.0 practices are characterized by adoption of automation, additive manufacturing, IoT solutions, et al., with data becoming the primary driver of productivity to improve conformity, quality assurance, and alleviate hiring pressures facing manufacturing firms globally. The study identified this theme toward adoption of Industry 4.0 practices across the Aerospace and New Space value chains, with companies like Relativity Space promising mass-produced rockets in a matter of days and weeks versus what previously took months or years to build.

Table 1 shows how Maine's aerospace participants were keeping up with the advancement of industry toward Industry 4.0 skills and practices. On a scale from 0-4.75, the analysis considered 0 to be not at all prepared, and 4.75 to be in a leadership position in categories relevant to Industry 4.0 – Organization, Technologies, Testing and Development, and Management. Under Organization the study graded the cohort of companies on their Industry 4.0 Strategy, their Industry 4.0 Leadership, and their Quality Standard Certification. Under Technologies, the study considered the cohort's Machining processes, Digitization of their Production, Engineering, and Data Utilization. Testing and Development broke down a company's ability to prototype and interlace good quality assurance practices in their business. Lastly, Management was broken down into financial resources and staffing. Overall, the study found that the cohort of Maine firms ranked at a position of 2 out of 4.75, concluding that Maine is not keeping up with the needs of new Industry 4.0 positioning. Maine's engineering capabilities earned it its highest category marks on the matrix.

Table 1. Industry 4.0 Maturity Matrix

			0 - Beginner	1 - Intermediate	2 - Experienced	3 - Expert	4 - Top Performer	Score
Organization	Industry 4.0 Strategy	Explanation	Status quo; protecting against risk reacting to demand but not planning for it	Company leaders are aware of IR4.0 but unsure what it actually means in practice	Familiar with industry 4.0 technology and its value; has planned to implement some aspects	Comprehensive roadmap to implement industry 4.0 developed and ihas started adopting	Leaning into industry 4.0 and adopting it for competitive advantage against industry peers	1
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Industry 4.0 Leadership	Explanation	Not aware of industry growth trends or future state of industry	Aware of where the industry is heading - has a general picture of the future state, but has no active plan to evolve.	Familiar with future state of industry trends and understands benefits. Has high-level plans to get involved with trends.	Actively planning on 4.0 development strategy with holistic approach to capturing value in future economy with their firm.	Fully onboard and implementing 4.0 into operations for competitive advantage today.	1.5
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Certifications	Explanation	Not aware that certifications exist for their industry.	Aware of standards but too costly or burdensome to follow.	Planning to be ISO or AS9100 within 1 year	ISO certification	AS9100 Certification	1.75
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
Technologies	Machining	Explanation	2-axis/ 3 axes (X,Y and Z)	3-axis machining - CNC work remains very labor-intensive.	5-axis machining capabilities with limited capacity.	Fully/semi-autonomous 5-axis machining that has minimized the amount of set-up time and labor involved.	>5-axis fully/semi-autonomous machining.	1.75
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Digitization of Production	Explanation	No Automation; all manual	Some hybrid of manual and computer-aided shortcutting.	Computer aided manufacturing software utilized partially automated with some advantages	Computer aided manufacturing software utilized, fully-automated faster machining speeds, high yields, ability to manufacture very large-sized parts, etc.	Fully automated	2.25
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Engineering	Explanation	No engineering team, no technicians on board with CAD abilities.	CAD capability of technicians to employ plans into production	CAD capability to modify existing plans to fit specific machine, process, or conformance.	Design capabilities based on user specifications and provided engineering specs.	Full-suite designing and development capabilities.	3
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Data Utilization	Explanation	All analog processes, unable to produce cost of goods sold calculation (cash versus accrual).	Keep internal productivity data, internal accountant/bookkeeper to keep track of financial records.	All production runs standardized, cost estimated, and automatically facilitated. Runs associated with lot numbers for quality assurance.	Management of production able to establish key performance metrics, oversee cost of production, and understand plant capacity and efficiency.	Data collected and used at a productive rate, with central repository to facilitate all business processes.	2.25
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
Testing & Development	Prototyping	Explanation	Cannot produce prototypes	Quoting process, Expensive prototyping process	Produces prototypes based on provided plans with limited functionality, able to quote scalable pricing.	Able to provide plans, develop prototypes with 30 day turnaround and give scaleable quote.	Able to develop prototypes and give scaleable pricing quote within 2 weeks.	2.75
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Quality Assurance	Explanation	No intention of quality assurance implementation, no standard practices	Systemic quality assurance in written processes or forms	Forms and processes that ensure allowable quality assurance with a proven track record.	Quality assurance that meets ISO/AS9100 certification standards	Full scale quality assurance department	2.5
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75 Quality	4 / 4.25 / 4.5 / 4.75	
Management	Financial Resources	Explanation	Need Financial Resources	Have Financial Resources, unwilling to invest	Have financial resources, evaluating next investment	Recently made significant investment	Has long-term growth plan and strategic vision for capital expenditures	1.75
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
	Staffing	Explanation	No intention of future hiring	Currently hiring vacancies, unable to fill	Able to fill vacancies to keep up with job demand.	Able to fill vacancies in a timely manner.	Able to fill vacancies in a timely manner. On site training and workplace safety standards.	1.75
		Score	0 / 0.25 / 0.5 / 0.75	1 / 1.25 / 1.5 / 1.75	2 / 2.25 / 2.5 / 2.75	3 / 3.25 / 3.5 / 3.75	4 / 4.25 / 4.5 / 4.75	
								2

4. Maine Physical & Infrastructure Assets

A. Brunswick Landing, operated and managed by the Midcoast Regional Redevelopment Authority, is Maine's Center for Innovation and a progressive and innovative business campus located at the former Naval Air Station Brunswick (NASB) which was decommissioned in 2011. The 3,200-acre property is equipped with some state-of-the-art facilities, close to 2 million square feet of commercial and industrial space, and a world class aviation complex which hosts hangar space, a runway, and rocket engine testing capabilities. It is also home to a small aviation and aerospace cluster on site. Brunswick Landing can meet the needs of businesses looking for small, medium and large industrial space, maintenance and repair facilities and professionally appointed administrative offices. The campus includes a variety of equipment lessees have access to and is optimized for composites and advanced materials, light manufacturing, aviation/aerospace, biotech/biomed, information technology and renewable energy businesses. Shared manufacturing equipment includes 3 axis CNC touter, 3D printer, plasma cutter, drill press, vertical & horizontal band saws, Mig Welder, and many other tools that are utilized by TechPlace tenants like a Rohner Oven (21'x15'8"x10'), Grieve Oven (4'x4'x3'), Spray Booth (24'x16'x8'8"), and Freezer (12'x12'x 8'). In just over a decade since decommissioning of the military operations, nearly 150 businesses and 2,600 workers now call Brunswick Landing, home.

- **TechPlace,** Brunswick Landing's Technology Accelerator, supports the business development needs of early-stage companies in a shared workspace. TechPlace gives entrepreneurs a place to network with others, research and develop ideas, build prototypes, test products, assemble, grow, and become successful manufacturing and technology companies. The target industries for TechPlace are Aviation / Aerospace, Biotech / Biomed, Composites and Advanced materials, Renewable Energy, and IT.
- **Brunswick Executive Airport** offers two 8,000-foot runways, 650,000 square feet of hangar space and maintenance facilities, over 103 acres of taxiways and aircraft parking apron space, an advanced glycol recovery de-icing system, jet engine test and maintenance facilities, and a new instrument landing system.
- **First Light Data Center** is another asset offered at the Brunswick landing. It offers ITAR compliant data center services, carrier grade infrastructure, both light and dark fiber for the transmission of data and a private, public and/or hybrid cloud solution. It can be leveraged for use by data analytics companies for data storage on campus and low latency for advanced analytics compute.

B. Loring Commerce Centre, home of the former site of the U.S. Air Force Base, is dedicated to the economic development using the facilities of the former base. With aerospace-specific infrastructure on site like large hangars, a runway that is the same size as Spaceport America's at 12,000 feet by 300 feet, a turn-key data center space, fiber optic linkages to greater New England, manufacturing space, and office space, there is certainly much to offer to any company willing to work in a more remote and private environment. With a position along Maine's fiber optic line, low electromagnetic interference, and plenty of land available to use, perhaps the most friction-free use of Loring by the space industry could come in the form of Ground Station development and operations.

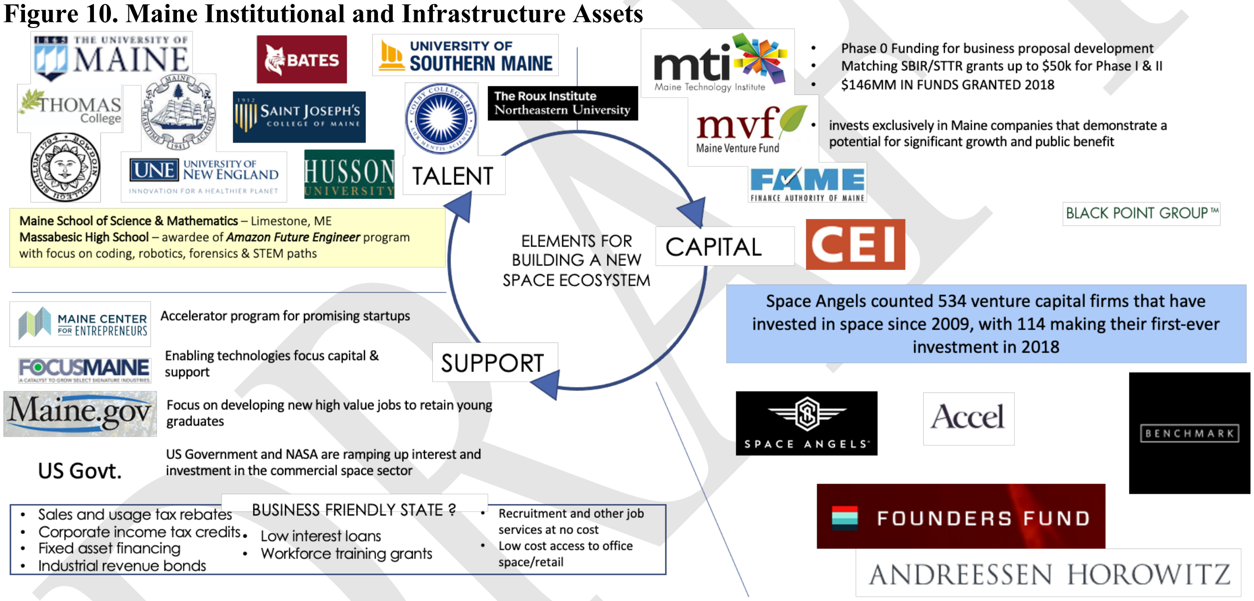
C. Maines Geographic Advantage. The state has a geographic advantage to launch satellites into polar and sun synchronous orbits without the risk of overland flight. This risk cannot be alleviated by competing spaceports on the eastern seaboard such as Cape Canaveral, Camden, Mid-Atlantic Regional Spaceport. The nearest launch opportunity for SSO and PO orbit access without the risk of overland flight is California and Alaska. California's launch site is controlled by the United States Space Force, making accessing and utilizing the site difficult for commercial vendors. Alaska causes a logistic struggle due to the isolated nature of the launch site.

D. Maine's Low Population Density. Maine has an advantage in its low population density, which limits the electromagnetic interference associated with densely populated areas. This is ideal for ground station operators, and places like Loring Commerce Centre could be potential host sites to develop for this use. Maine also has low light pollution in its remotely populated areas, which lends itself well to astronomical observation and science hobbyists. Thinking of itself as a conservator of dark skies in remote areas is another way for Maine to capture value from its existing strengths and signal its significance to the new space industry.

5. Maine Institutional Assets

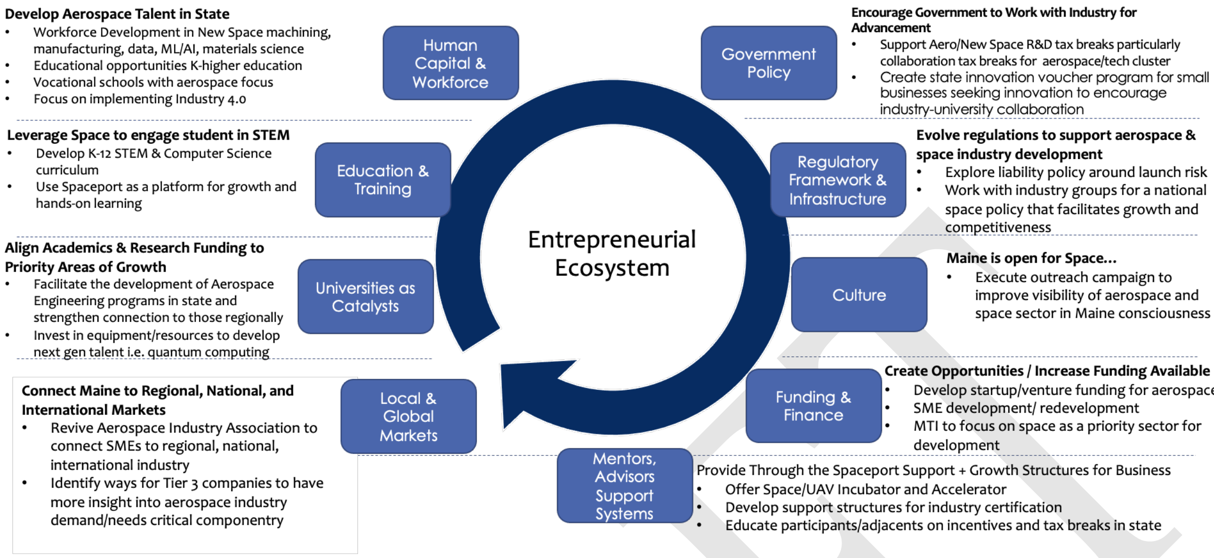
As shown in Figure 10, Maine has some infrastructure in place to create the talent, capital and support required to develop a New Space Ecosystem. Although Maine has many of the ingredients available to spur entrepreneurship, it has not activated its resources around the concept of New Space, which will be required to develop the industry. Although some of the ingredients are in place, the scale of resources is not sufficient to drive the economic development of a new space industry without assistance and support from outside of Maine. Federal funding and national risk capital networks will be critical to financing the development of the space complex.

Figure 10. Maine Institutional and Infrastructure Assets



Developing a thriving space industry requires coordinated action across the entrepreneurial ecosystem to build capability and facilitate growth. Nascent industries depend heavily on academic research, resources and government support as they take shape prior to reaching growth stages. Figure 11 below illustrates all the segments of entrepreneurial ecosystems that must be orchestrated to achieve a common vision in order to successfully introduce and grow a new industry within the state.

Figure 11. Developing an Entrepreneurial Ecosystem



There is no such organizing body for the new space industry within Maine. The Maine Space Corporation (as proposed in LD 1923) would provide such a body, to not only implement the Maine Space Complex, but also organize the various aspect.

6. Maine Research and Education Assets

Maine has a variety of educational resources and research capabilities that can support the development of the space economy across its institutions of higher education – University of Maine, University of Southern Maine and the Roux Institute – with areas of research capability in geospatial analysis, data analytics, composites and advanced materials, cube sat development and engineering among others. Technical schools whose graduates are in short supply within the space/aerospace industry is also an opportunity for engagement between the *Complex* and Maine's community college and technical schools.

University of Maine

- **College of Engineering.** The mission of the College of Engineering at the University of Maine is to produce the graduates and new technologies needed to move Maine's economy forward. As a UMaine signature area, the College continues to play a vital role in our state and beyond. The College of Engineering at the University of Maine is Maine's only educational institution to offer 11 ABET accredited engineering and engineering technology degree programs including mechanical and electrical engineering with an aerospace engineering certificate available.
- **Advanced Structures and Composite Center.** One of the most-notable assets in terms of its track record in gaining funding for large-scale projects and generating intellectual property that can be spun out to the private sector is the UMaine Advanced Structures and Composite Center. With an incredibly organized structural testing center focusing largely on new materials and composites, the world's largest composite 3D printer, and an incredibly capable workforce of professionals, students, and staff, this asset is an important piece to the puzzle of asserting Maine's excellence and growth in composite materials.
- **Versant Power Astronomy Center.** Noted largely for its potential input to educational endeavors and its ability to generate interest in the space industry, the Versant Power Astronomy Center is led by passionate people with involvement in space educational endeavors external to just the programming of the largest-domed planetarium (seats 50 people) in Maine and the observatory on-campus.

- **WiSe-Net Lab.** The WiSe-Net Lab led by Dr. Abedi is a glowing example of how our institutions can continue research for the space industry. Largely focused on the growing field of wireless sensor technology, with modules tested on the International Space Station for leak detection, communications technology, and potential applications within the realm of quantum research, the WiSe-Net Lab will not only continue to be an important contributor to Maine's space economy, but also to the potential development of future mobile networks.
- **Advanced Manufacturing Center.** With milling, turning, and miscellaneous machining tools and equipment, UMaine's Advanced Manufacturing Center specializes in applied techniques to both teach students at UMaine and collaborate with the private sector on projects. Recently they have added their Center for Additive Manufacturing, housing an area to refine the process and engineering behind additive manufacturing of metals.

University of Southern Maine

- **Department of Engineering.** Baccalaureate degree programs include electrical engineering and mechanical engineering. In addition to the regular program, electrical engineering has the option of a computer engineering concentration. The mechanical engineering program emphasizes electromechanical systems. Graduate-level coursework in engineering may be pursued through the Accelerated Graduate Pathway and facilities are new or recently renovated. It provides Eensive contact with local industry with opportunities for internships and cooperative education as well as employment upon graduation.
- **Southworth Planetarium.** USM's Southworth Planetarium seats 65, with capacity for up to 80 people. Like other planetariums, the study considered its ability to disseminate and enhance educational initiatives related to space. The unique medium of presenting within a planetarium, while traditionally focused on space, can play a wide array of educational and entertaining presentations.
- **Maker Innovation Studio.** Research and development initiatives, shared licenses to software programs, new-tech tooling and equipment. CubeSat initiative operating within the lab, with advanced capabilities in biomedical 3D printing and prototyping.
- **Composite Engineering Research Laboratory (CERL).** USM's Composite Engineering Research Laboratory is an industry-focused facility specializing in custom composites. Offering services such as applied engineering expertise in process development, optimization, and manufacturing, as well as advanced analytical services with a variety of non-destructive testing techniques, focused educational training, and prototype manufacturing.

Other Institutions

- **The Roux Institute (Northeastern University).** Established in 2020 with a $100 million gift from David Roux and matched with another $100 million gift from the Alfond Foundation, the Roux Institute is a center for graduate and professional studies with an R1 research designation. It is focused on nurturing an environment for high-impact research and innovation in computer and data science, digital engineering, the advanced life sciences and medicine, and other tech fields. The Roux helps entrepreneurs launch businesses focused on and powered by technology.

7. Maine Business Incentive Programs

States with the strongest economies are supported by the healthiest business ecosystems. The development and maintenance of a healthy, innovative business ecosystem within a state's economy can be fostered by the use of business incentives (Table 2). Such incentives include tax breaks - such as tax credit or tax exemptions - and funding opportunities that included grants, bonds, loans, and equity to support business growth and expansion. States that offer competitive private incentive packages are often those with the strongest industrial ecosystems and tax bases. While state level private sector incentives can be an important tool for growing and attracting companies to take root or relocate in a business environment, it is often one of a variety of considerations companies consider when they are deciding on a location.

Table 2. Business Location Strategy Considerations

	Categories	Included Items
Policy Driven	Tax Breaks for Businesses	Tax Credits, Tax Exemptions
	Aerospace Business Grant/Loan Opportunities	Grants, Equity, Loans, Bonds
	State/Local Contribution	State Funding from A&D Taxes
	Federal Tax Contribution	Federal Funding from A&D Taxes
	Income Tax	Measured by Income Tax Level
	Corporate Tax	Measured by Corporate Tax Level
	A&D Economic Output $$	Measured in Millions
Industry Health	A&D Workforce	Total of workforce for Direct and Supply chain companies in A&D
	Aerospace Cluster	Measured by total number of companies participating in Aerospace operations
	Aerospace Engineering Degree Programs	Measured by total number of Undergraduate and Graduate Aerospace Engineering Programs
	Aerospace Association	Measured by advocate organizations in state
	Quality of Life	Information used from US news best rankings of states

Maine currently has a limited amount of private sector incentives that can be considered "marginally competitive" to attract and retain both business and talent (Table 3). In regard to aerospace and new space specific industries, the current landscape of incentives will not be a primary driver for locating in Maine.

Table 3. Overview of Maine's Private Sector Incentives

Competitive Maine Incentives	Incentive Type
Pine Tree Development Zone	Tax/Financial
Educational Opportunity Credit	Tax Credit
Municipal Tax Increment Financing (MTIF)	Tax Credit
Maine Capital Investment Credit (MCIC)	Tax Credit
Business Equipment Tax Exemption (BETE)	Tax Exemption
Business Equipment Tax Reimbursement (BETR)	Tax Reimbursement

Multiple interviews were conducted to uncover the top criteria businesses considered when considering location/relocation strategy. We asked a CEO of a launch provider, "Where would you relocate and why?" We received the following response, "It would be California, not because of the tax incentives, but for the talent pool that you can pull from there. Florida for the same reason." Another interview was conducted with the Aerospace & Defense Industry Champion located out of the Colorado Office of Economic Development & International Trade. Colorado is currently ranked #1 in per capital aerospace employment with multiple leaders in space industry such as Boeing, Lockheed Martin, and United Launch Alliance having significant operations and facilities. In the conversation talent arose multiple times as the only reason the cluster was not growing further, "Our biggest impediment is finding enough highly qualified skill talent to fill the jobs. Both from a higher ed and technical schools." These interviews offered clarity into understanding the importance of talent and business clustering. To better Maines's business incentive landscape and the health of its business ecosystem an analysis was conducted against competing states who have a robust aerospace business clusters and talent pools, an FAA approved spaceport launch site, or are in the process of obtaining a FAA approved spaceport launch site. The following results are summarized in Table 4.

Table 4. State Matrix of Policy Driven and Industry Health Variables

State	Policy Driven							Industry Health					
	Tax Breaks for Businesses	Aerospace Business Grant/Loan Opportunities	State/Local Tax Contribution	Federal Tax Contribution	Maximum Personal State Income Tax Rate	Corporate Tax Rate	A&D Economic Output $$	A&D Workforce #	Aerospace Cluster	Aerospace Degrees Awarded in 2019	Aerospace Engineering Degree Programs	Aerospace Association	Quality of Life
Florida	17	9	$1,388	$4,378	0%	4.46%	$40,203	115,261	2,300	730	6		#10
California	14	8	$6,021	$14,156	13.3%	8.84%	$119,877	310,281	609	1,159	24		#24
Washington	52	3	$2,060	$6,770	0%	0%	$137,427	260,627	1,300	128	1		#1
Colorado	18	15	$271	$809	4.55%	4.55%	$6,443	21,033	290	324	2		#16
Virginia	15	13	$409	$1,133	5.75%	6%	$16,653	64,835	285	230	2		#7
Texas	15	9	$115	$4,163	0%	0%	$90,487	201,727	1,700	451	6		#31
Michigan	9	9	$262	$770	4.25%	6%	$18,047	42,359	900	247	2		#38
Maine	23	14	$132	$279	7. 15%	3.5%-8.93%	$6,139	18.267	85	0	0		#27
Alaska	9	6	$2	$10	0%	0%-9.4%	$84	394	11	0	1		#45
New Mexico	19	3	$20	$58	5.90%	4.8%-5.9%	$1,022	3,536	80	43	1		#48

Legend	
Color	Impact Scale
	None
	Low
	Medium
	High

Maine currently struggles against states within the observed study in both policy-driven and industry health indicators. As seen in the matrix, Maine does not have a category where it is considered competitive in attraction of business or talent relocation. The current tax incentives in Maine will struggle to recruit businesses that heavily rely on business incentive packages. In regard to funding, Maine can be competitive due to organizations like Maine Technology Institute (MTI), Maine Venture Fund (MVF), and Financial Authority of Maine (FAME). Talent and business clustering are currently moderately competitive and have to be accelerated through active recruitment and business development in addition to longer term educational strategies to produce a talent of pipeline that will support industry growth. As one business professional said, "We've got to move people off the basic spreadsheet. It is a relationship-based process that we have in Maine. We are not going to win on the lowest common denominator. It does not have to be the best offer but it has to be marginally competitive." Companies have very specific needs and talent requirements, and the financial benefits that business incentive programs offer are often not the bottom line.

A multi-pronged approach will be required to create a business incentive landscape that addresses policy driven and industry health indicators to support growth for Aerospace and New Space industries. Legislation will need to be introduced to increase the impact of existing incentives, while the introduction of new incentives to aid in spaceport operations and development will ensure in attracting anchor tenants and customers to the state.

Benefits of Engaging Maine in the New Space Economy

1. Talent and Innovation

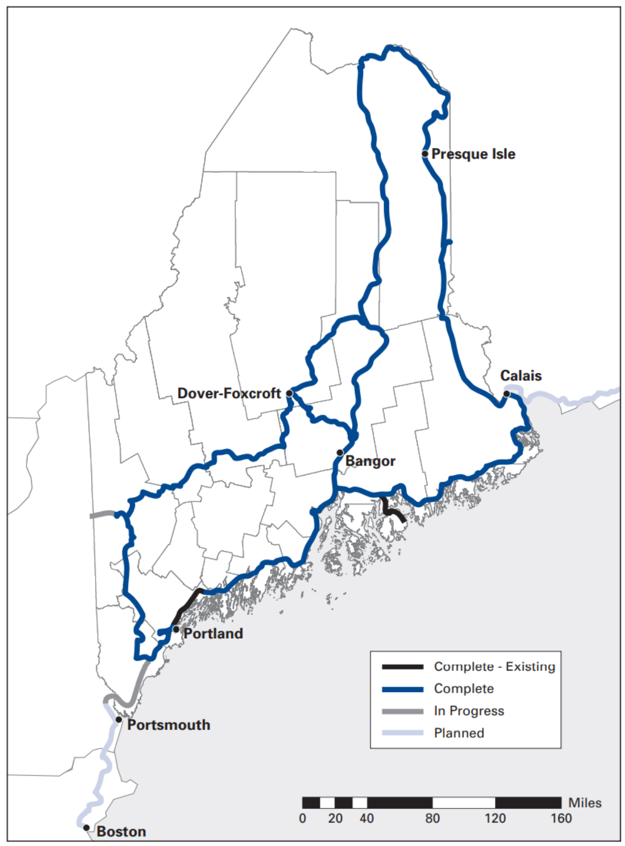
- Help train and retain Maine's students and Immigrants graduating with aerospace-related STEM degrees
- Attract highly skilled workers and their families from out of state

- Encourage startups and spur development in all seven technology sectors
- Develop globally based applications for both commercial and consumer uses
- Facilitate STEM learning opportunities for Maine high school and higher education students.
- Increase demand for broadband, quality roads, and housing
- Promote economic aspirations for All Mainers
- Advance Maine to a new competitive level in a fast-growing Knowledge Economy.

2. Support for Broadband Expansion and Road Infrastructure Investments

Internet infrastructure is an important driver of growth and economic opportunity in modern society. Acknowledging this, Maine completed the "Three Ring Binder" project in 2012 implementing over 1,100 miles of fiber optic capable to increase broadband access throughout the State and support a faster, more reliable internet to ensure its citizens are connected to the digital economy. With the implementation of the Maine Spaceport Complex, there is an opportunity to further expand the fiber optic network to support spaceport operations and its local communities across Washington and Aroostook County.

Figure 12. Maine's Three Ring Binder



Washington county currently has three transportation departments that are responsible for serving 31,822 people across an area of 2,563 miles. In Washington county worker transportation commute times are over 25 minutes for 31% of the population. Also, it is important to note that public transportation systems are extremely limited for its current population. The majority of the population relies on personal transportation methods creating the need for efficient and well-maintained road infrastructure. With the development of the Maine Spaceport Complex, the initiative will support ongoing road infrastructure investments to aid both the community and fortify infrastructure for spaceport operations.

3. Promotion of Destination of Place and Potential Impact on Tourism

Few topics capture the imagination and have mass appeal like space and today the intrigue has become more widespread than ever before as humankind progresses further into the final frontier. On January 31, 2021, local rocket company bluShift Aerospace drew a crowd of nearly 75 onlookers to watch from their cars as the company executed its first test launch in bitterly cold temperatures from Loring Commerce Centre. With no tourism infrastructure to host the eager public viewers, they attracted a sizable crowd with some travelling over 6 hours to observe the launch. On the other end of the spectrum, NASA's Kennedy Space Center, a launch facility with a well-established 42-acre Visitors Complex that leverages its historic role in development of the United States Space Program drew an estimated 1.7 million tourists to its facilities in 2016 resulting in ~$1.8 billion of income according to the Florida Space Coast Office of Tourism. With over 37 million tourists visiting Maine each year, the Space Complex presents an opportunity to become a premier tourist destination drawing visitors beyond the popular Acadia National Park endpoint up into Washington County. With appropriate planning and investment, developing space tourism under the auspices of the *Complex* could have big economic implications for rural locations and the hospitality industry at large in Maine.

The Maine Space Complex

Between February 28 and March 1, 2018, MSGC hosted a two-day visioneering workshop to discuss the potential of the ***Maine Space Complex** (Complex)* opportunity for Maine. The group brainstormed a vision to galvanize both Maine's citizens and multiple sectors of the State's economy to invest in research and education infrastructure for a new space economy. Over 60 people participated, including representatives from the education, research, government and private sectors, NASA and the FAA. Participants agreed that Maine is poised for a leadership role in the emerging and fast-growing market for small satellites using small, low-cost launch vehicles and leveraging, in a coordinated and collaborative effort, the assets in Maine previously described, and in partnership with other institutions, organizations and businesses in the New England region and other parts of the country. The *Maine Space Complex* was proposed as the strategy to orchestrate and increase Maine's engagement in the new space economy.

After the workshop, the Consortium conducted an MTI-funded market feasibility study on the viability of the *Maine Space Complex*. Some of the major findings of the study included: (a) NASA, DOD, Draper Labs, several small and large aerospace companies, and academic institutions in the Northeast region are highly interested in using the *Complex's* launch facilities; and (b) the *Maine Space Complex* must follow a path different from the existing FAA-approved spaceports, which have struggled due to the lack of large launch vehicles.

1. Maine Space Complex Business Units

The MTI-funded study developed a *Complex* operating model with three business units of the *Complex* as described below and illustrated in Figure 13.

A. Maine Space Data & Advanced Analytics Center of Excellence

The Space Data & Advanced Analytics Center of Excellence will be a cloud based, digital platform resourced to import/downlink, store, cleanse, manage and analyze satellite data in concert with terrestrial data for the purposes of solving local business and public policy issues in innovative ways. This will be a distributed network of nodes, offering portals from various locations (ex. Roux Institute, University of Maine, Governor's Office, etc.) to access satellite data (and other relevant data sets) for data science applications (ML/AI). It will be resourced with human capital that can offer specialization in satellite data and advanced analytics to drive the application of data toward the advancement of local industry and policy use cases in addition to provide support and mentorship to data centric startups and companies. It will require a cloud configuration with a network equipped with the hardware and software to import/downlink, store, cleanse, manage, and analyze satellite data in concert with terrestrial data for the purposes of solving business and public issues in innovative ways and supporting the development of data focused startups creating new data products and services.

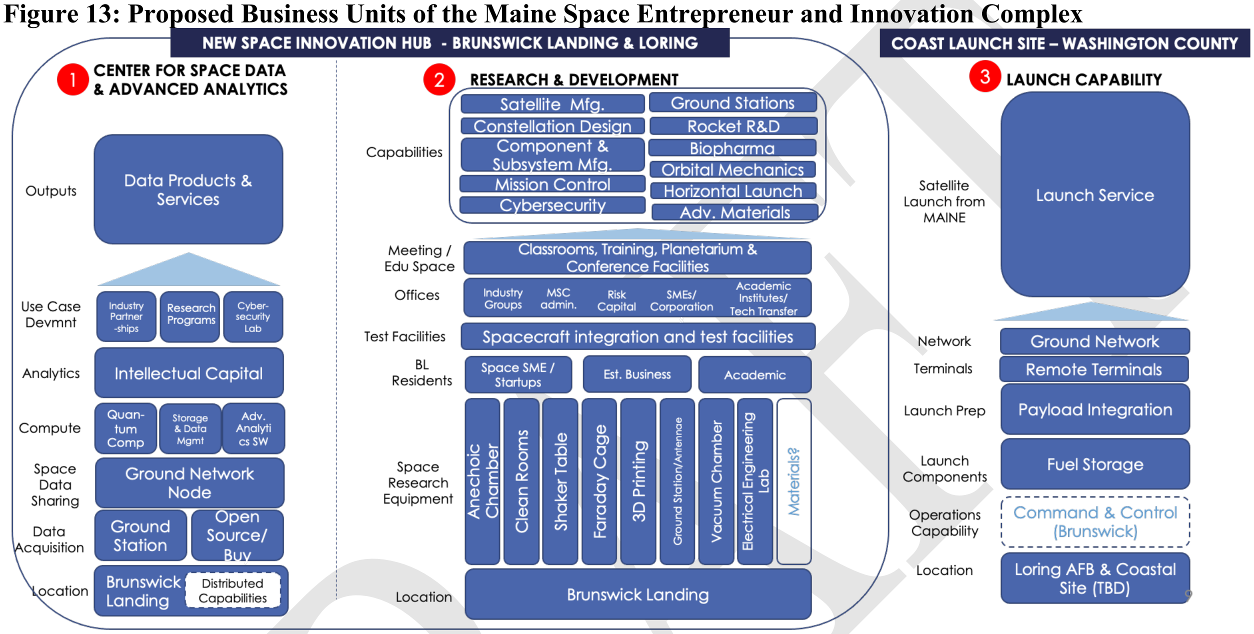
B. Maine New Space Innovation Hub

Located at Brunswick Landing, with a spoke at Loring Commerce Centre, is envisioned as a knowledge and innovation hub for new business incubation and acceleration, facilities for hardware and materials component development as well as satellite and launch vehicle manufacturing and testing. The shared space must contain specialized equipment to facilitate R&D, academic and scientific inquiry. It will also house joint academic-industry research initiatives, an office of tech transfer, provide administrative office space for businesses, and conference facilities to host national/international events to draw users and attention to the Maine space industry. It will also act as an educational center providing classrooms for in-person and remote K-12 and higher education learning opportunities and events.

C. Maine Launch Sites & Services

Develop a low-cost, highly accessible LEO polar orbit launch site for small satellites with superior customer service to serve the commercial, academic/scientific and government sector. The site will create a need for credentialed and highly skilled technical jobs and offer workforce retraining opportunities. Launch capability will spur development of a knowledge cluster creating a foothold to capture future opportunities as the industry matures and develops. It will leverage the current capabilities Maine is building in rocketry, data and geospatial analytics, to become a more visible national and international aerospace industry destination.

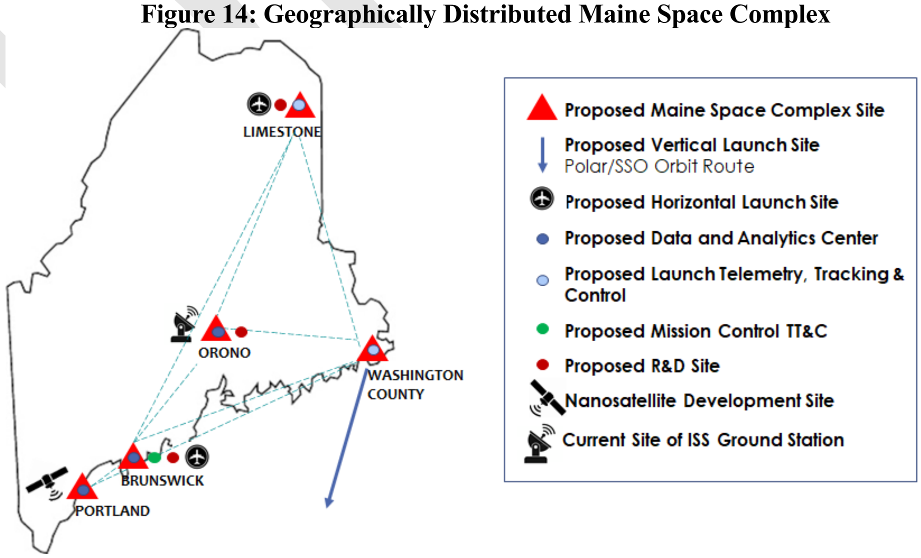
Figure 13: Proposed Business Units of the Maine Space Entrepreneur and Innovation Complex



2. Geographically Distributed Maine Space Complex

The Maine Space Complex will be geographically distributed bringing benefit to multiple counties throughout the State as shown in Figure 14. Geographically distributed capabilities offer the best opportunity to align with the market demand, and to facilitate growth of Maine space offerings.

Figure 14: Geographically Distributed Maine Space Complex



3. General Launch Site Requirements

[To be added in the final report]

4. Plug and Play Business Model Built on Sustainability

The proposed Maine Space Corporation would have direct oversight into the development and operations of the Launch Site and establishing anchor tenants at the launch complex. Anchor tenancy is a common financing strategy to provide up front capital investment for a specific tenant that will have priority use of the facilities. The goal of the launch services pillar of the *Complex* is to establish anchor tenancy and also develop a multiuse launch pad that can accommodate a variety of small launch vehicles in an effort to cater to an emerging but not yet commercialized group of rocketry providers.

The *Complex* will work closely with Brunswick Landing and Loring Commerce Center to establish new space operations under the umbrella of the Maine Space Complex. The *Complex* will facilitate new space business development, supporting the growth of companies locally and bringing companies into Maine to develop the local ecosystem. Agreements with both entities will outline the revenue share for such activities and placement.

5. Vision, Mission, Performance Goals, and Objectives

A. Vision Statement: By 2045, Maine's is an integral player in the emerging global network of suborbital and orbital transportation to space providing significant return on investment as an engine of economic growth workforce development.

B. Mission Statement: The Maine Space Complex provides faculty, teachers, students, businesses, partners and entrepreneurs from within and outside the state, access to a plug and play infrastructure where innovations, ground-breaking research and development, problem solving, spacecraft launch, a world class space data and analytics capability, and dreaming big are routine occurrences, and from which virtual learning is available to teachers, students and others.

C. Performance Goals: Achieving the vision is predicated on the three business units of the Maine Space Complex are fully functional and in use by costumers in the business, higher education, research, government, and k-12 communities. In turn, these functional units will enable the Maine Space Complex to achieve the following Performance Goals by 2045:

- Facilitate the creation of an estimated 4,500 new jobs in Maine, 30% of which will be credentialed and commanding an average annual salary of $77k.
- Capture at least 10% of the US small satellite market launch market
- Generate an estimated $_________ in annual revenues *(depends on results of revised economic impact analysis)*

D. Objectives

This plan lays out a pathway to position the Maine Space Corporation to achieve the Vision, Mission and Performance Goals through short-term and long-term objectives and action steps as outlined below.

D-1. Short-term Objectives (2 Years)

Objective #1: Establish a quasi-state body to oversee the development and growth of the Maine Space Complex.

> **Action:** Enact LD1923. This bill would establish the Maine Space Corporation as a body both corporate and politic, which would be tasked with implementing the strategic plan. The corporation

would be entrusted with leveraging Maine's capabilities in rocketry and geospatial analytics to become a more visible national/international industry destination and an authority in launching small launch vehicles and small satellites into polar orbit. The need for the proposed corporation now can be summarized as following:

1. **Timing** – With additional federal funds becoming available in the next several months, the proposed Maine Spaceport Corporation, as a quasi-state entity, would be the best vehicle for applying for these funds. Without a quasi-state entity status, progress would be inhibited and potentially cause the state's efforts to fall behind competition in other states such as Michigan.
2. **Funding -** A quasi-state entity would maximize funding opportunities (as opposed to a non-profit or strictly private company) by providing access to federal government and private sector funding, as well as future opportunities to levy bonds for construction.
3. **Precedent** - Virginia, New Mexico, Alaska established quasi-state space authorities at a similar point in their development between strategic planning and breaking ground on infrastructure
4. **Public Identity -** As the initiative progresses and begins public hearings it will be important to have the brand perception aligned to the Maine Spaceport Corporation itself rather than the Maine Space Grant Consortium, which has been shepherding the development to date.

Objective #2: Identify and secure a launch site in Maine for vertical launches.

Action: Solicit applications from coastal communities in Washington County that are interested in leasing land for launch sites. Issuance of a request for proposals must come after finalizing the generic launch site requirements and identifying incentives for communities to apply. Final site selection would be integrated with FAA approval for the launch site.

1. **Environmental Impact Assessment** – perform an environmental impact assessment to better understand the environmental impacts of launch operations in Washington County.
2. **Solicit Bids for Design + Construction** – put out an RFP using the finalized requirements develop during the strategic planning process for the design and construction of the spaceport
3. **Funding** – determine funding structure for
    a. launch operations and raise money as needed
    b. through federal, state and private sources
4. **Build** – build launch (mid-term objective)

Objective #3: Continue recruitment of businesses commercializing all aspects of the value chain working in proximity at Space Complex to intensify knowledge and skills transfer to facilitate the development of new technology and the growth of the New Space Economy within Maine.

Action: In next phase of work secure budget for business development activities to pursue companies identified as high value prospects in private sector analysis. This will include all actors across the value chain from components, subcomponents and spacecraft to the downstream data analytic companies.

1. **Attend industry events** – there are several key industry conferences each year that attract a variety of companies from the new space industry, including many that have been targeted as high value prospects. Continue to raise awareness through meetings, networking and speaking opportunities at these events.
2. **Targeted BD meetings**– follow up selectively with prospective tenants of companies that occupy a particular piece of the value chain absent from Maine's ecosystem for individual meetings.
3. **Develop Marketing Collateral** – develop brochures, decks and other collateral materials for prospective clients.

Objective #4: Continue engagement strategy and dynamic communications plan to ensure that the initiative is positively received within the state and supported by the government as well as external stakeholders.

Action: Continue to establish brand and raising awareness through both in person events (primarily focused in Washington County) and through earned and digital media.

1. **Social Media** – using Facebook and Instagram primarily, continue to develop engaging content to reach Maine citizens to inform them about the Maine Space Complex. Use LinkedIn to establish connection with professionals at other space companies to advertise the benefits of relocating to Maine.
2. **Print & digital media outlets** – ensure placement of timely development in various media outlets including but not limited to Bangor Daily News, Portland Press Herald, Boston Globe, and news media outlets
3. **On the ground presence** – continue to be an on the ground presence in Washington County as the spaceport evolves and takes shape.

Objective #5: In partnership with the Maine Composite Alliance, continue the development and implementation of training programs to update the skill sets of workers in the advanced materials industry to align with the new space economy.

Action: As composites become an increasingly important piece of the space industry, partner with MCA to better understand members capabilities and to determine their ability to participate in the new space economy.

1. **Establish Industry Roadmap -** develop a roadmap to understand the future technology and materials needs of the space industry as well as the evolving technologies within the advanced materials and composites industry
2. **Assess capabilities -** work with MCA to assess capabilities of current composites and advanced materials manufacturers and markets served with focus on aerospace/space
3. **Workforce Development** – determine the technical, scientific, and business skills and capabilities gaps that exist in Maine's MCA membership and address the skills through training
4. **Market these skills/capabilities to Industry** – ensure space industry participants are aware of Maine's pool of technical skills/capabilities as it is seen as a benefit to some space companies such as launch vehicle manufacturers

Objective #6: Set industry topics and initiatives for Maine industries – agriculture, aquaculture, fisheries, lobster, forestry - that can benefit from satellite data and research RF remote sensing, mapping and other small sat data services to improve competitiveness.

Action: Work with industry members and universities to create a series of quick wins – establishing industry uses cases and ways that satellite data is addressing private and public issues/problems effectively.

1. **Engage with leading community/industry stakeholders –** in order to better understand the issues that Maine based industries need solutions for in order to identify high value industry use cases
2. **Engage with State and Local Government** – understand the issues that Maine government is addressing and how satellite data can be used to build a resource called space data for better government
3. **Collaborate with NASA to access Maine data –** NASA has an extensive satellite fleet that collects a myriad of data from space that can be cleansed to provide data specific to Maine for use cases identified**.**

Objective #7: Set research topics and initiatives in line with Maine's capabilities and emerging opportunities especially in data analytics.

Action: Work with universities to create a series of quick wins – establishing uses cases and ways that satellite data is addressing private and public issues/problems effectively including climate change.

1. **Climate Change** – in collaboration with the Roux Institute and Governor's Climate Council we are looking for opportunities to leverage satellite data to solve terrestrial issues and inform better policy and management decision making
2. **Advanced Materials/Composites for Space –** as new opportunities for the advancement of spacecraft emerge design emerge work in collaboration with industry to leverage this knowledge cluster at UMaine
3. **Continue engagement w/Roux Institute** – the Maine Space Complex has sponsored a class at the Roux Institute with a focus on developing use cases for Maine industries using satellite data.
4. **University of Maine GIS** – similar focus on developing use cases for Maine based industry and government using satellite data.
5. **University of Maine Advanced Structures & Composites Center** – use findings of roadmap and industry assessment to develop research topics for space related advanced materials use.

Objective #8: Promote STEM curriculum including PhD programs advanced math and computer science in K-2 to build the capabilities that will develop next generation resources for high growth data rich industries to prosper.

Action: Increase the level of engagement with the Space Complex and space as a subject in the K-12 through PhD programs across the state.

1. **Teacher Training** – with funding develop teacher trainings to promote the use of space in teaching STEM/computer science/data analysis skills
2. **K-12** – engage students in onsite events, create remote learning opportunities with classrooms, visiting space professional day and field trips.
3. **Community Colleges/Technical Schools –** engage the technical workforce to fill positions needed for launch operations at the spaceport
4. **College/University** – develop a consortium of in-state and out-of-state schools that are affiliated with the Maine Space Complex and engage them on field trips, research opportunities, internships, and launch visits.
5. **Masters/PhD** – sponsor research for advanced degrees that aligns to spaceport priority areas of focus
    - **Space-for-earth research –** develop a track for space-for-earth focused research whose applications drive the majority of commercial activity and are gaining wider adoption
    - **Space-for-space research** – develop a track that focuses on space research for products and applications used in space that will continue to grow as space tourism and space habitation advance and become commercial

Objective #9: Establish collaborative agreements with the Midcoast Regional Redevelopment Authority and the Loring Commerce Centre to access facilities and resources critical to the development and growth of the Maine Space Complex.

Action: The Maine Space Complex seeks to leverage preexisting resources and assets within Maine to the best of its ability to ensure there is economy in development to stand up the three pillars of the Maine Space Complex – Launch Site(s), Innovation Hub, and Space Data and Advanced Analytics

Center of Excellence. : The *Complex* will pursue business development activities to attract new space tenants to one of its sites and share in the benefit.

Objective #10: Secure federal grants and state investments through bond issues to support the renovations and constructions of the Space Innovation Hub at Brunswick Landing, manufacturing, and integration facilities at Loring Commerce Centre and one or more launch facilities.

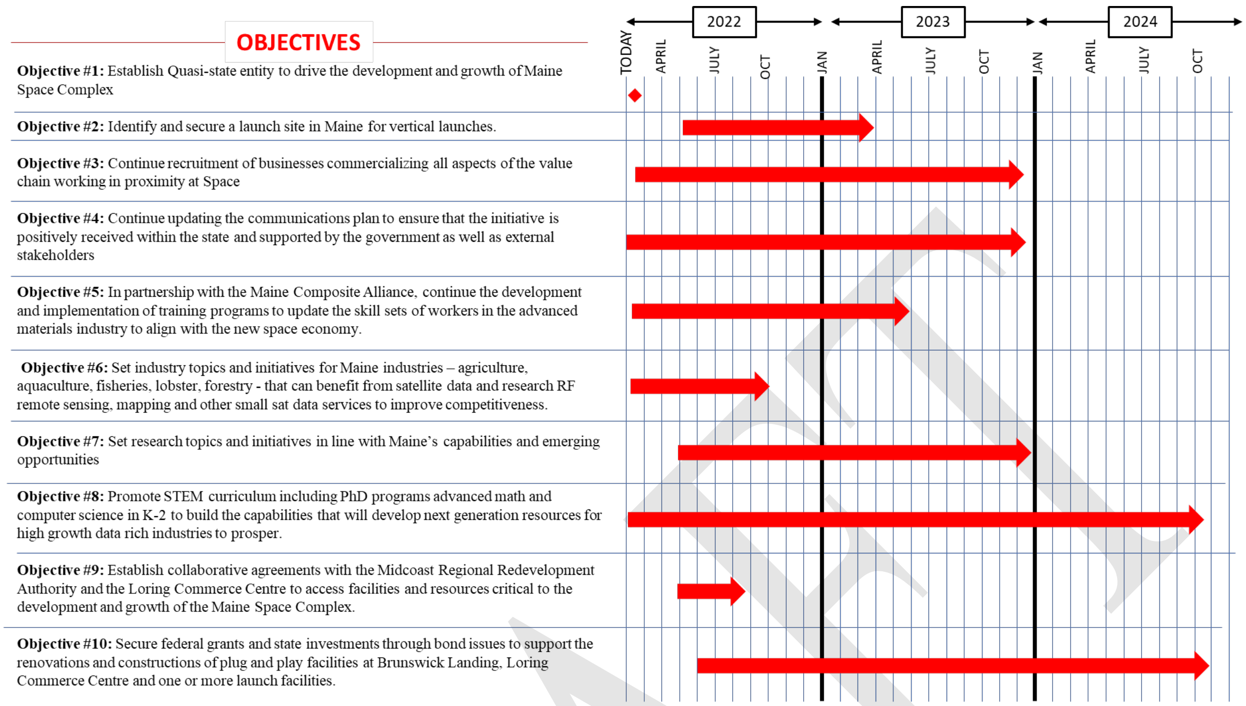
Action: Seek to identify first private funding and establish anchor tenants that will ensure demand for spaceport launch facilities. Once this avenue has been exhausted look for and secure opportunities for federal funding to develop infrastructure and support development of the Innovation Hub and Space Data & Analytics CoE.

D-2. Mid- to Long-term Objectives (3 Years- Ongoing)

Based on progress made, the Maine Space Corporation will re-calibrate its pathway forward and revise or set new performance metrics. Regardless of the re-calibration, the Corporation is likely to continue pursuing the following objectives:

- Continue to build capability within the academic sphere through alignment of programs and further development of research priorities, partnerships with industry, development of effective tech transfer and creating a workforce strategy to ensure talent pipeline in Maine and the region
- Create and strengthen the connective tissues between academia and industry through internships, site visits, career exploration, industry sponsored projects/research initiatives
- Raise and secure funding for Introduce New Space Innovation Hub to encourage new ways of collaborating and working, expand academic capability and capacity
- Continue to build upon Maine's strategic resources and capabilities to develop an integrated and robust value chain of space related businesses and activities within Maine
- Continue to focus on developing specialization in emerging areas of the new space value chain including the use of composite and advanced materials
- Continue to focus on helping Maine existing industries mitigate threats they are facing through dedicated use of the Maine Space Complex assets.

6. Implementation Timeline



Projected Cost Estimates of the Maine Space Complex

We conducted a rough order of magnitude cost estimate based on the proposed vision of the Maine Space Complex and analogous project costs at other miscellaneous spaceports. We weighed three scenarios of development for the vertical launch site, representing a beta site that would serve to temporarily accommodate launch companies, a minimum viable product for a permanent launch facility, and a maximum potential vertical launch site that would include industry-leading facilities.

We also examined how three benchmark spaceports – Mid-Atlantic Regional Spaceport (MARS), Pacific Spaceport and Spaceport America - were funded. We considered the various stages of development and aligned that to funding sources from planning to construction and finally operations. Each case study provided an overview of facilities, stages of development and funding associated with each stage entity formation, and the progression to construction phase that proceeded. The funding mechanisms and subsequent capital and operational expenditures that occurred were examined. Revenues were studied in great detail as were operational costs as their capital footprint scaled. Finally, the study conducted a comparison of each spaceport's operational profits or losses and the economic impact in the region, to identify whether these spaceports provide an adequate return on investment for the local economies.

Rough order of magnitude cost estimates identified that a vertical launch complex could cost between $5,305,000 and $90,000,000 depending on the outfitting and phasing plans (Table 5), with a beta temporary-accommodation site estimated to cost between $5,305,00-23,305,000. The minimum viable permanent launch site resulted in estimates ranging from $13,580,000 to $32,280,000. The horizontal launch complex is estimated to cost $53,200,000, depending largely on individual site infrastructure needs like runway improvements. The center for data analytics and innovation is estimated to cost close to $1,295,000, depending on facility location and scope of initial build. The study also retained an independent engineering firm to provide a more-precise breakdown of specific costs in relation to the launch complexes. A substantial consideration for these estimates is dependent on the cost of building of traditional infrastructure like roads to the sites.

Table 5. Rough Order of Magnitude Cost Breakdown of the Maine Space Complex

Vertical Launch – Beta Scenario

Complex	Estimated Cost
Vertical Launch – Beta Scenario	\$5,305,000-\$23,305,000
CoE/Innovation Building	\$1,295,000
Total Cost	**\$6,660,000-24,600,000**
Horizontal Launch	**\$53,200,000**
Total Cost w/horizontal	**\$59,800,000-77,800,000**

Vertical Launch – Minimum Viable Product Scenario

Complex	Estimated Cost
Vertical Launch – Minimum Viable Product Scenario	\$13,580,000-32,280,000
CoE/Innovation Building	\$1,295,000
Total Cost	**\$14,875,000-33,575,000**
Horizontal Launch	**\$53,200,000**
Total Cost w/horizontal	**\$68,075,000-\$86,775,000**

Vertical Launch – Maximum Scenario

Complex	Estimated Cost
Vertical Launch – Maximum Scenario	\$45,000,000-\$90,000,000
CoE/Innovation Building	\$1,295,000
Total Cost	**\$46,295,000-91,295,000**
Horizontal Launch	**\$53,200,000**
Total Cost w/horizontal	**\$99,495,000-144,495,000**

Vertical Launch Complex - Beta Scenario

As shown in Table 6, we considered for the Beta Scenario that there may be a need to acquire land if not lease it - there would need a launch pad, a road to the launch pad, a payload processing area, and some facilities as a bare minimum to accomplish a launch. Estimates for the cost of a beta phase launch site come in at \$5.3 to \$23 million, depending on length of road needed and other exceptional considerations.

Table 6 Vertical Launch Beta Scenario Cost Breakdown

Component	Comparable Year	Comparable Complex	Description	Estimated Cost
Land Acquisition	-	-	Adequate land to facilitate safe launches according to FAA standards	\$1,250,000
Launch Pad (50 ft x 150 ft)	2015	Kennedy Space Center	50 x 100 foot launch pad supporting launch vehicles and associated mounts weighing up to 132,000 pounds when fully fueled.	\$900,000
Road to Launch Pad		General estimate provided by DOT to Ellsworth American	Road capable of handling weight of equipment, (1 mile)	\$2,000,000-20,000,000
Payload Processing Area		-	Temporary Building for Payload and Integration	\$1,000,000
Integration Area		-	Cleared area.	-
Recovery of Vessels	-	-	To be provided by launching party	-
Forklift/Misc. Lifting		-	To be provided by launching party	-
Craning Equipment		-	To be provided by launching party	-
Launch Rail		-	To be provided by launching party	-
Telemetry and equipment		-	To be provided by launching party	-
Insurance		To be quoted	To cover liability of complex	\$150,000
Restroom Facilities	-	National Average	Restrooms for operating parties on site, rental toilet (x2)	\$20,000
Fire/Rescue	-		Temporary Assistance from Local Resources	0
Mission Control Center	-		To be provided by the launch party	0
Parking Lot	-		Dirt Parking Lot	\$5,000

Total Estimated Cost: \$5,305,000-\$23,305,000

Vertical Launch Complex - Minimum Viable Product Scenario

In the Minimum Viable Product Scenario, we estimated costs between \$13.6 million to \$32 million, with the same variable considerations as the beta version (Table 7). Consider that both the beta and minimum viable have one launch pad, one plot of land, marked changes are the incremental improvements like telemetry and tracking equipment as well as restroom facilities, additional annual expenses associated with operating, mission control area, etc.

Table 7. Vertical Launch Minimum Viable Product Cost Breakdown

Component	Comparable Year	Comparable Complex	Description	Estimated Cost
Land Acquisition	-	-	Adequate land to facilitate safe launches according to FAA standards	$1,250,000
Launch Pad (50 x 150)	2015	Kennedy Space Center	50 x 100 foot launch pad supporting launch vehicles and associated mounts weighing up to 132,000 pounds when fully fueled.	$900,000
Road to Launch Pad	-	General estimate provided by DOT to Ellsworth American	Road capable of handling weight of equipment, 1 mile	$2,000,000- 20,000,000
Payload Processing Area	-	Cecil Spaceport	Building for Payload and Integration	$3,700,000
Integration Area	-	Houston Spaceport	Clean room for payload processing	$150,000
Recovery of Vessels	-	-	Subcontracted Services	$50,000
Forklift/Misc. Lifting	-	-	On site – one year of long term lease	$6,000
Craning Equipment	-	-	On site – one year of long term lease	$24,000
Launch Rail	-	-	Outfitted for each launch partner	$300,000-$1,000,000
Telemetry and equipment	2021	Pacific Space Complex	Telemetry and Tracking System cost estimates for 1 incremental additional launch pad.	$1,700,000
Insurance	-	To be quoted	To cover liability of complex	$150,000
Restroom/Wastewater Facilities	-	Wastewater estimates online	Restrooms for operating parties on site	$1,500,000
Fire/Rescue	-	-	Local Resources on site for launches	-
Mission Control Center	-	Cecil Spaceport	Building	$1,800,000
Parking Lot	-	Estimates found online	Paved 20-car spot with 8,000 sq ft	$50,000

Total Estimated Cost: $13,580,000-32,280,000

Maximum Scenario

In the Maximum Product scenario, we considered what an industry-leading or high-tier vertical launch complex may look like. Under this scenario, the cost of a vertical launch site estimates to around $50 million (Table 8).

Table 8. Maximum Scenario

Component	Comparable Year	Comparable Complex	Description	Estimated Cost
Land Acquisition	-	-	Adequate land to facilitate safe launches according to FAA standards	$1,250,000
Launch Pad	2015	Kennedy Space Center	Small/ligh lift launch pad	$3,500,000
Road to Launch Pad	-	General estimate	Road capable of handling weight of equipment, 1 mile	$2,000,000
Payload Processing + Integration Area		Cecil Spaceport	Payload preparation and integration facility	$3,700,000
Rocket Integration Area/Motor Test		Spaceport America	On site building/hangar	$20,000,000
Launch Rail	-	-	Onsite	$1,000,000
Insurance	-	To be quoted	To cover liability of complex	TBD
Utilities (Electric/Water/Sanitation)	-	National Average	Restrooms for operating parties on site	TBD
Mission Operations Control Center				$1,800,000
Range Radar, Optical, and Telemetry Tracking Instrumentation		Spaceport America		$10,000,000
Tracking and Command Destruct Systems	2020	Pacific Spaceport Complex		$5,500,000
Meteorological Modelling Software	2020	Pacific Spaceport Complex	Meteorological modelling software for launch range management and safety.	$1,000,000

Total Estimated Cost: $49,750,000

Horizontal Launch Complex

We explored what horizontal launch facilities would cost, as horizontal facilities are a part of the considerations for the Maine Space Complex (Table 9). We considered the approach of starting small, with a potential runway renovation (the $42,000,000 represents the cost of essentially tearing up and redoing the Loring runway at 12,000 feet, but there could be other sites with the potential for a smaller cost). Additionally, Loring's runway may not be in total disrepair and would need to be evaluated. Hangar space at Loring that the spaceport could potentially buy to lease out to users, as well as use for payload processing and integration, with some consideration for renovations needed was considered. Further evaluation of the condition of these hangars would need to be conducted to get a clearer picture of the cost associated with making each building operational. We also incorporated potential telemetry and equipment needed and some allocation for land to acquire to lease to ground station partners at sites at Loring

Table 9. Horizontal Launch Facility Cost Estimate

Component	Comparable Year	Comparable Complex	Description	Estimated Cost
Runway Renovation	2012	Spaceport America	Spaceport America spent $3.5 million per 1,000 feet of runway when extending their 10,000 foot runway in 2012.	$42,000,000
Hangar Space	2021	Loring Commerce Centre	126,303 sq ft hangar at Loring Commerce Centre, and renovations needed.	$1,250,000
Payload Processing Area	2021	Loring Commerce Center	41,114 sq ft hangar at Loring Commerce Centre, and renovations needed.	$750,000
Integration Area	2021	Loring Commerce Centre	22,260 sq ft hangar at Loring Commerce Centre, and renovations needed.	$500,000
Telemetry and equipment	2021	Pacific Space Complex	Telemetry and Tracking System cost estimates for 1 incremental additional launch pad.	$1,700,000
Land acquisition for Ground Station Leasing				$50,000-$250,000

Total Estimated Cost: $53,200,000

Data Analytics Center of Excellence/Center for Innovation

The cost estimates of the Center of Excellence/Innovation Center incorporate the physical building infrastructure needed for a data analytics innovation center, alongside a year's funding for an incubator program, accelerator program, sandbox program for educational and private sector collaboration, and a visitation and information area within the center. Considerations were made for staffing in these cost estimates (Table 10).

Table 10. Data Analytics Center of Excellence/Center for Innovation Cost Estimates

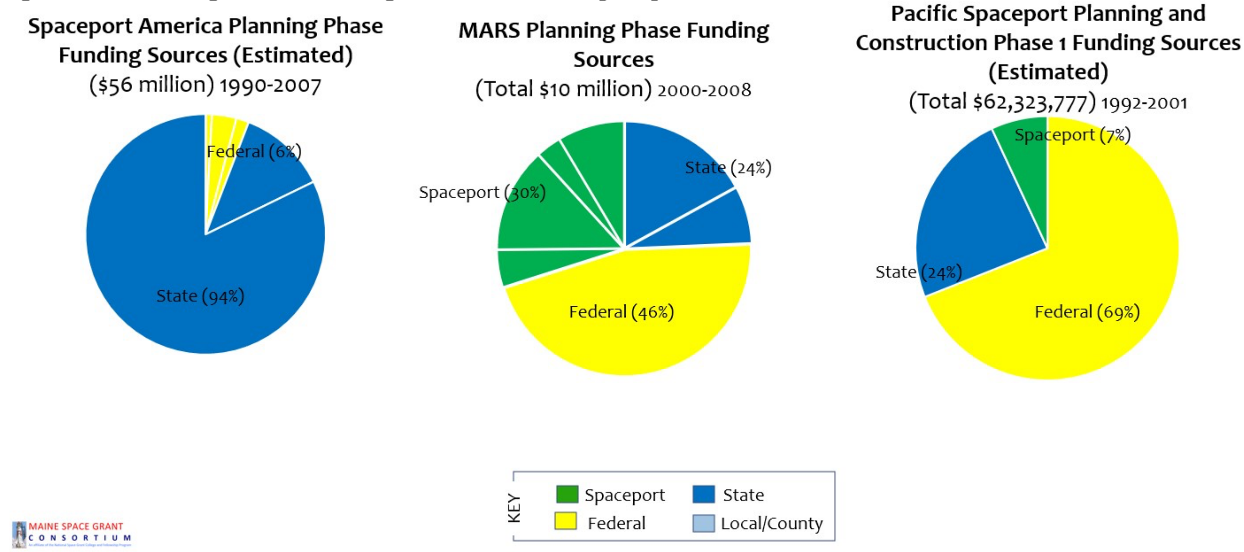
Component	Comparable Year	Comparable Complex	Description	Estimated Cost
Center of Excellence/Innovation Building	-	-	Building acquisition and needed renovations	$800,000
Incubator Yearly Funding	-	-	½ Compensation of Development Officer to oversee Incubator strategy and accelerator strategy and their interTactic with institutions, organizations, and clients ($40,000). Initial funding of incubator program ($75,000)	$115,000
Accelerator Yearly Funding	-	-	½ Compensation of Development Officer to oversee Incubator strategy and accelerator strategy and their interTactic with institutions, organizations, and clients ($40,000). Initial funding of accelerator program ($75,000)	$115,000
Sandbox Yearly Funding	-	-	Compensation of one education coordinator to facilitate strategy surrounding Maine's educational institutions Pre-K – Grad School ($75,000). One partnerships staff member to assist in maintaining relationships with institutions ($50,000). Initial program budget ($25,000).	$150,000
Visitation and Information Center	-	-	Office coordinator to facilitate visits and tours ($55,000), Furniture and interior ($10,000), Curated Materials ($50,000)	$115,000

Total Estimated Cost: $1,295,000

Funding Overview: Case Studies

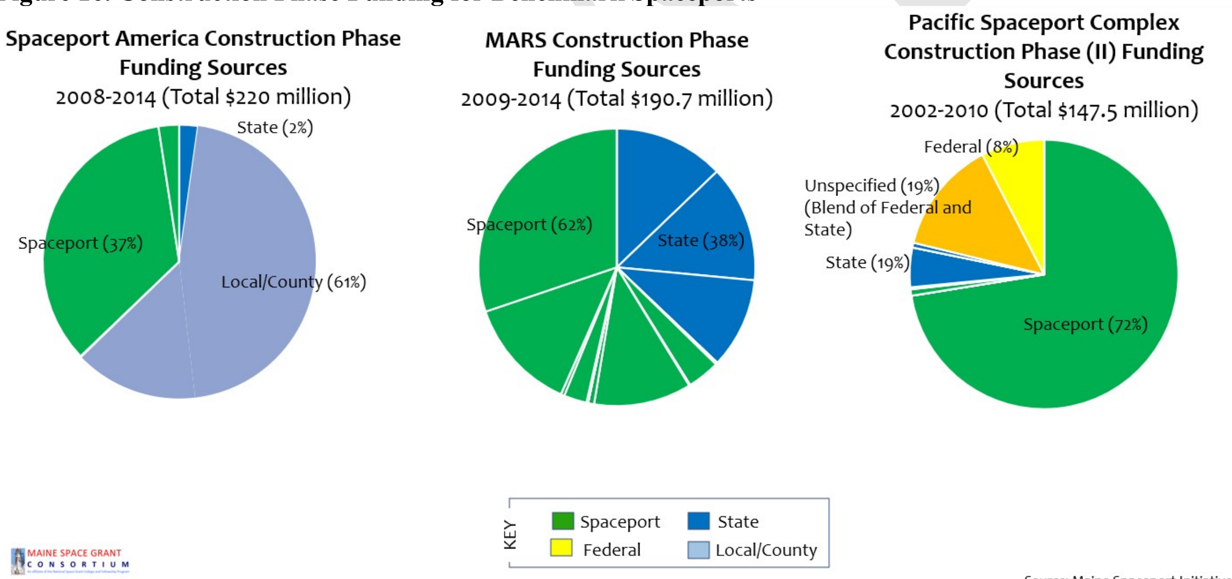
We compared the funding sources of Spaceport America, MARS, and Pacific Spaceport Complex broken down by phase of their development, comparing planning, construction, and management phases (Figure 15). A notable pattern emerges showing all three spaceports successful in utilizing federal funds to get the idea and planning stage to the point where the state felt comfortable committing much larger sums. A largely disproportionate piece of the Spaceport America Planning Phase Funding was from a State Appropriation at the very end of the planning phase from 2005-2007, representing an investment - $46.1MM - equal to 82% of the total sum of Planning Phase Funding.

Figure 15. Planning Phase Funding for Benchmark Spaceports



During construction of each spaceport (Figure 16), it is clear that the infrastructure-heavy projects need infrastructure-friendly funding sources at the state and local level. It is important to note, that as a spaceport gains initial revenues from one launch pad, it can continue to capture revenues while it builds up its complex.

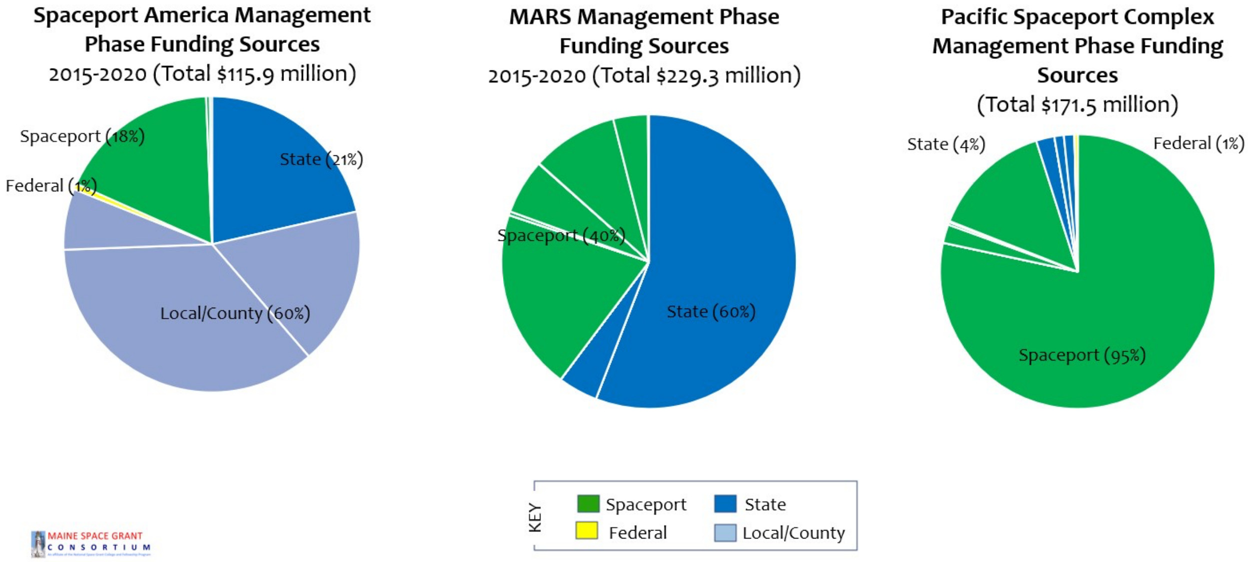
Figure 16. Construction Phase Funding for Benchmark Spaceports



Source: Maine Spaceport Initiative

In the management phase, there was not much federal involvement at all – spaceports are more reliant on operating revenue streams (Figure 17). Spaceport America perhaps is the exception, related to the market timing and commercial feasibility of Virgin Galactic relative to its initial estimates. As Virgin Galactic becomes economically viable and begins paying repeated launch fees, Spaceport America's pie will continue to look more like management phase MARS, and then Pacific Spaceport Complex in theory as it moves forward.

Figure 17. Management Phase Funding for Benchmark Spaceports



Return on Investment

The University of Southern Maine's Maine Center for Business and Economic Research is updating the analysis for the final strategic plan report.

The initial economic impact analysis from 2020 projected that at 10%-30% of the market share by 2040, the Maine Space Complex could facilitate the creation and retention of between 3,400 and 4,500 good-paying jobs annually and contribute between $1 billion to $1.5 billion per year to the state's GDP. This shows that the Complex will contribute to:

- The three Talent and Innovation outcomes in the state's Economic Development Strategy are attracting people to Maine's talent pool, growing the average annual wage, and increasing the value of what we sell per worker.
- MaineSpark's goal of increase the percentage of Mainers that hold the credentials valued by Maine's businesses and industries.

Contribution to the State's Economic Development Strategy

The proposed Maine Space Complex squarely addresses both overarching goals of Growing Talent and Facilitating Innovation and contributes to the Seven Core Strategies by attracting highly skilled workers to Maine and increase the average state wage. Specific contributions include:

- The Maine Space Complex is estimated to add between 3,400 and 6,700 high paying jobs by 2040 as projected by an economic impact analysis conducted by USM Center for Business and Economic Research (2020)
- Help train and retain Maine's students and immigrants graduating with aerospace-related STEM degrees (mechanical engineering, physics, computer science, etc.)
- Attract highly skilled workers and their families from out of state
- Develop Maine's workforce to participate in the fast-growing Knowledge Economy.
- Develop mechanism to facilitate startup growth and spur development in all seven technology sectors

- Facilitate STEM learning opportunities for Maine high school and higher education students
- Increase demand for broadband, quality roads, and housing
- Promote economic aspirations for All Mainers
- Develop globally based applications for both commercial and consumer uses

Community Concerns

Although the MSGC is starting conversations with stakeholders from across the state and more directly in Washington County, community concerns were raised in December 2021 by the citizens of Jonesport-Beals in reaction to bluShift Aerospace statement regarding its intention to establish a launch facility on Water Island. Among the chief concerns voiced were interference with preexisting fishing and lobstering operations as boats of any kind would be required to stay out of the rocket's trajectory path during launch windows. The other primary concern raised in reaction to bluShift's inroads was the lack of environmental impact detail, which was a big concern to environmentalists, citizens and those that depend on the natural resources of the surrounding area for their livelihoods.

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Appendices

To be included in the final report