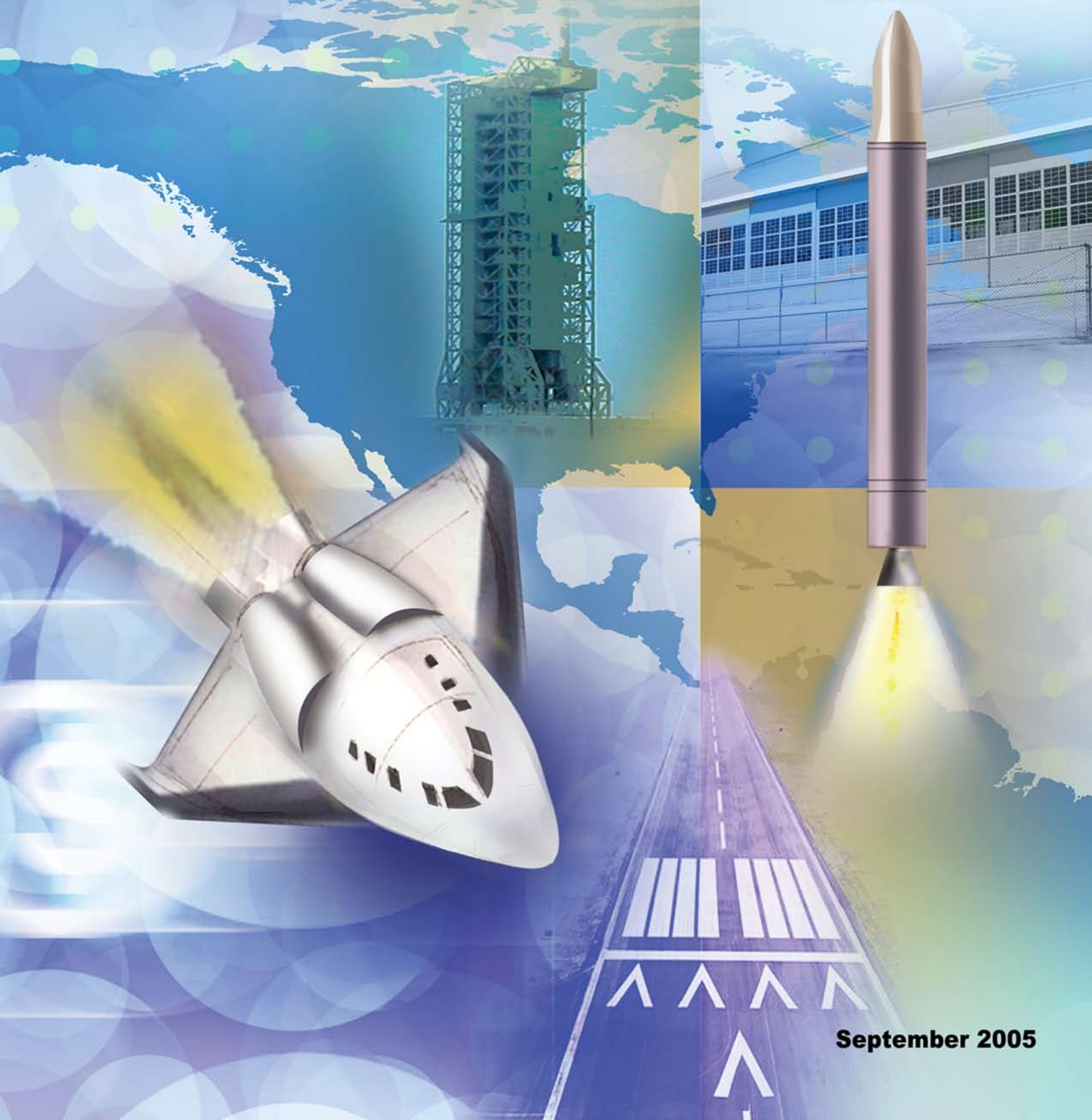
Feasibility Study of a Florida Commercial Spaceport

for Florida Space Authority



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EXECUTIVE SUMMARY

The past decade has witnessed a shift in the space transportation landscape: the number of medium- to heavy-lift orbital launches per year has fallen since the mid-1990s, while the number of small orbital and commercial suborbital launches has remained steady and is expected to increase. Smaller satellites, an emerging suborbital space tourism market, and an altered national security environment demanding quick launch capability have combined with broader economic pressures toward privatization, greater efficiency, and lower costs. The resulting space transportation marketplace favors commercial spaceports that can provide responsive, dedicated launch services with maximum flexibility and schedule assurance and minimal regulatory, bureaucratic, and price burdens.

The Florida Space Authority commissioned Futron Corporation to objectively assess the feasibility and potential economic impact of establishing such a commercial spaceport in Florida, either using existing facilities at Cape Canaveral or via separate facilities offsite. Futron arrived at the following conclusions:

- The concept of a Florida commercial spaceport is feasible from both a market and technical standpoint.
- Co-locating a commercial spaceport with NASA and U.S. Air Force facilities at Cape Canaveral is probably *not* feasible for political and regulatory reasons.
- If Florida chooses to establish a commercial spaceport, it is advised to do so offsite from Cape Canaveral. This presents two options: a "combined site," where new runways, launch pads, and other facilities would be constructed at the same place; or a "split site," in which a pre-existing airport runway, hangars, and other facilities would operate in conjunction with launch pads and other infrastructure built elsewhere.
- Of these two spaceport options, a split site configuration is recommended because it offers lower costs, lower risks, fewer complications, and a quicker timetable to operability.
- In the next decade, the primary market for any Florida commercial spaceport, regardless of configuration, will be the suborbital space tourism market.
- On balance, a commercial spaceport can be expected to benefit Florida economically, generating increased economic activity, earnings, and jobs, and raising Florida's profile as a space state.

Futron reached these conclusions by following a three-step methodology consisting of a concept and infrastructure feasibility analysis, a launch forecast, and an economic impact analysis.

CONCEPT AND INFRASTRUCTURE FEASIBILITY ANALYSIS

The conceptual feasibility of a Florida commercial spaceport hinges on awareness and support for the idea among both the vehicle developers who would constitute its primary customers and the government and military authorities who would regulate and oversee its operation. Futron interviewed 33 individuals, including launch vehicle developers, government and military officials, regulatory agency representatives, and other key members of the space community to gauge their support and awareness for a Florida commercial spaceport, and to gain insight into the infrastructure and operational requirements needed to make such a spaceport functional. Futron found a high level of support for and interest in a Florida commercial spaceport among vehicle developers, provided the spaceport offered competitive pricing, sufficient launch schedule assurance, minimal regulatory burden, and a fairly standard array of facilities. State and federal government authorities were also amenable to the Florida commercial spaceport concept, with certain caveats. They cautioned that a shared facility at Cape Canaveral would likely be infeasible due to political, regulatory, and administrative complications. Most respondents favored an offsite facility instead, and stressed the need for a firm, coherent, and realistic business plan before a Florida commercial spaceport is established.

If Florida develops an offsite commercial spaceport, it has two options: a combined site or a split site. The primary disadvantage of a combined site is the cost of constructing a new runway, which is by far the most expensive component of a spaceport. Since a split site uses a pre-existing runway by partnering with a functional airport, it represents a tenfold (or higher) cost savings over the combined site option: between **$10.5 and $28 million for the construction of a split site** versus **$185.5 to $278 million for a combined site** (see Figure E1).

Figure E1: Spaceport Development Cost Estimates, 2006-2008 (Combined vs. Split Site)

	Estimated Cost ($M)	
Infrastructure Category	**Low**	**High**
Land Purchase and Development	Dependent on size and location	Dependent on size and location
Runway (combined site configuration only)	$175.0	$250.0
Vertical Launch Pad and Tower	$5.0	$15.0
Hangar	$4.5	$10.0
Roads	Dependent on size and location	Dependent on size and location
Utilities Infrastructure	Dependent on size and location	Dependent on size and location
Environmental Impact Study	$1.0	$3.0
Combined Site Cost (Total)	**$185.5**	**$278.0**
Split Site Cost (Total)	**$10.5**	**$28.0**

LAUNCH FORECAST

Using a variety of resources, including previous Futron studies, FAA publications, and publicly available data, Futron forecasted Florida-addressable commercial and U.S. government small orbital and suborbital launches for 2006 through 2015. Futron found that during the next decade, orbital launch demand will likely remain flat, while suborbital demand is anticipated to grow steadily. Even under a robust scenario, it is unlikely that Florida would capture more than five orbital launches per year over the next ten years. Conversely, even under a constrained scenario, Florida could expect to capture dozens of suborbital launches per year by the end of the decade, barring unforeseen developments:

- Between 2006 and 2015, a Florida commercial spaceport could capture **between 5 and 29 orbital launches**.
- For the same period, a Florida commercial spaceport could capture **between 164 and 545 suborbital launches**.

A Florida commercial spaceport should therefore focus primarily on suborbital demand, while retaining the ability to accommodate orbital launches of small vehicles. This would allow Florida to capitalize on the emerging suborbital space tourism market while still appealing to developers of small commercial orbital launch vehicles, whose needs may not sufficiently be met by Cape Canaveral during the next ten years as the Cape instead focuses on larger orbital research and development missions.

ECONOMIC IMPACT ANALYSIS

Finally, Futron performed an economic impact analysis using the U.S. Department of Commerce's Regional Input-Output Modeling System (RIMS II). This analysis found that by 2010, a commercial spaceport could potentially benefit Florida by contributing **between $6.3 and $17.5 million of additional economic activity** from ongoing suborbital and orbital spaceport operations, and **between 35 and 115 new jobs**, depending on the market share captured by the state (see Figure E2). By 2015, Florida's economic benefit from a commercial spaceport could increase to **between $7.4 and $25.4 million of additional economic activity** and **50 to 165 new jobs** (see Figure E3). In both cases, the principal driver of economic impacts is expected to be the growing suborbital space tourism market.

Figure E2: Economic Impacts Generated by Spaceport Operations (2010)

Launch Market	Economic Activity ($M)	Earnings ($M)	Jobs
Suborbital	$3.6 – $12.1	$0.9 – $3.1	20 – 80
Orbital	$2.7 – $5.3	$0.7 – $1.3	15 – 35
Total	**$6.3 – $17.4**	**$1.6 – $4.4**	**35 – 115**

Note: Economic impact results are stated for high-end facility use fees: $100,000/launch (suborbital), $450,000/launch (orbital).

Figure E3: Economic Impacts Generated by Spaceport Operations (2015)

Launch Market	Economic Activity ($M)	Earnings ($M)	Jobs
Suborbital	$6.1 – $20.1	$1.5 – $5.1	40 – 130
Orbital	$1.3 – $5.3	$0.3 – 1.3	10 – 35
Total	**$7.4 – $25.4**	**$1.8 – $6.4**	**50 – 165**

Note: Economic impact results are stated for high-end facility use fees: $50,000/launch (suborbital), $450,000/launch (orbital). Use fees for suborbital launches are forecast to decline by 50% from 2010, however use fees for orbital launches are forecast to remain the same.

After evaluating a hypothetical Florida commercial spaceport using these three dimensions—conceptual and infrastructure feasibility, forecast market demand, and projected economic impact—Futron concluded that a split site commercial spaceport located outside Cape Canaveral and focused primarily on the suborbital space tourism market would yield economic benefits for Florida, allow the state to capitalize on the emerging commercial suborbital tourism and small orbital launch markets, enhance Florida's scientific and technological reputation, increase tourism, contribute to education, enable further aerospace workforce development, and position the state for integration within a future nationwide space transportation network.

INTRODUCTION

The opening years of the 21st century have seen a surge in demand for smaller, more responsive launch vehicles. The emergence of small satellites, which match many functions of larger satellites at a fraction of the expense, size, and weight, has led satellite operators to increasingly favor small launch vehicles over large ones for reasons of cost, schedule assurance, and reduced procedural complexity. The changing national security environment has necessitated a more responsive space capability—a need that small vehicles, able to launch frequently on short notice to deploy replacement space assets or provide quick strike capability, can serve more effectively than their larger counterparts. Additionally, the concept of space tourism has gained credibility. The success of SpaceShipOne has encouraged similar efforts to develop reusable suborbital and orbital vehicles offering quick launch turnaround. Business leaders, including Virgin Group executive Richard Branson and Amazon.com founder Jeff Bezos (who is funding Blue Origin), have made substantial investments in small reusable vehicles, spaceports, and infrastructure. Increasingly, space tourism is seen as commercially viable.

All this, considered alongside the decline in the annual number of medium- to heavy-lift orbital launches since the 1990s, suggests a shift in the space transportation landscape towards small, responsive, commercially-focused vehicles. Developers are marketing these new vehicles as low-cost solutions for both private and government clients, promising high launch tempos, easy payload integration, no-hassle technical maintenance, and shorter launch queue waiting periods. Yet even as entrepreneurial startups and longtime manufacturers alike turn to designing this new class of launchers, they face a restricted number of spaceports to accommodate them. Although the United States currently has twelve licensed federal and non-federal spaceports, a combination of geographic and technical limitations means that only a handful can effectively meet the needs of small vehicle developers.

Florida is uniquely poised to take advantage of this shift in the space transportation marketplace. Its large community of space professionals, geographic orientation, and historic legacy provide a solid foundation on which to build a commercial space industry that can foster economic development, create jobs, generate tourism, increase revenue, and further solidify Florida’s reputation as a space state. However, Florida also faces challenges that could prevent it from capitalizing on the opportunity presented by emerging small launch providers. While it has demonstrated its excellence in the traditional launch sector, it has not yet adapted to the shifting vehicle market. Small vehicle developers perceive Florida as a site characterized by high range costs, regulatory burdens, a cumbersome administrative structure, frequent launch delays, and antiquated facilities. Consequently, they have thus far chosen to launch instead from Kwajalein Atoll, Mojave Airport, Vandenberg Air Force Base, and Wallops Flight Facility.

This study details whether, and how, Florida can overcome these perceptions to develop a commercial spaceport that will capture its share of the emerging space transportation market. **For the purposes of this study, Futron defined *commercial spaceport* as a launch facility whose main target market is commercial vehicle operators, and whose primary mission is to generate revenue by offering competitive, responsive, and efficient launch services with minimal bureaucratic and regulatory burden**. This study specifies what vehicle operators seek in a spaceport from technical, regulatory, administrative, political, and business perspectives, as well as identifying Florida’s shortcomings along these lines and determining steps the state can take to remedy these shortcomings and attract more business. The study also analyzes the potential market for launches from Florida if a commercial spaceport is realized, and quantifies the overall economic benefit the state can expect from such an investment.

To produce these results, Futron Corporation developed a three-step methodology:

1) Concept and Infrastructure Feasibility Analysis

First, Futron evaluated the technical, administrative, and political feasibility of either converting portions of Florida's existing spaceport into a commercial range, or constructing an entirely new commercial spaceport elsewhere in the state. Futron conducted 33 interviews with vehicle developers, technical specialists, military officers, public officials, government representatives, organization heads, and other constituencies to gauge their support and awareness of a commercial spaceport in Florida, as well as the technological, engineering, and logistical challenges and benefits of the project.

2) Launch Forecast

Second, Futron performed a study of global demand for suborbital and small orbital launch vehicles, for both current and future ELV and RLV systems, over the next decade (2006-2015). Based on interviews with small vehicle developers, as well as an examination of technical requirements, market trends, and political factors, Futron determined what portion of the current and future suborbital and small orbital launch market can realistically be considered addressable by a commercial spaceport in the State of Florida, and constructed two scenarios that illustrate the effects of capturing different portions of the overall addressable market.

3) Economic Impact Analysis

Third, Futron used the results from the first two steps in its methodology to calculate the overall impacts, in terms of economic activity, earnings, and employment, that Florida can expect over the next ten years from the establishment of a new commercial spaceport. Futron's economic impact assessment relied on the Regional Input-Output Modeling System (RIMS II), developed by the U.S. Department of Commerce. In addition to quantifying how a new spaceport would impact Florida, Futron also assessed the potential economic benefits that a commercial spaceport could provide the state, such as a more robust satellite and launch vehicle manufacturing industry, a more developed satellite services industry, and increased tourism.

This methodology is mirrored in the organization of this report. The first section details the results of the concept and infrastructure feasibility study, the second provides the launch demand forecast, and the third highlights the broad economic impacts that a proposed commercial spaceport can contribute to the State of Florida.

FIRST DOCUMENTS AS A FRAMEWORK FOR FUTURE SPACEPORT PLANS

In performing this study, Futron also made extensive reference to the integrated national space transportation network envisioned by the Future Interagency Range and Spaceport Technology (FIRST) initiative. The FIRST working group, spearheaded by the National Aeronautics and Space Administration (NASA), the Department of Defense (DoD), and the Federal Aviation Administration (FAA), seeks to transform U.S. space transportation from a disjointed patchwork of spaceports serving specialized needs into a coordinated national network linked by communication and harmonized planning. The goal is to make spaceports more like airports: similarly designed, operationally flexible, safe, low-cost, and able to accommodate routine launches and landings.

In May 2004, the FIRST working group published a report titled “Needs Assessment: Enabling New Markets and Missions for Spaceports and Launch Ranges.” This document defines current and future infrastructure requirements needed for U.S. space transportation to become a coherent, integrated “system of systems” facilitating low-cost, routine, responsive, and safe access to space for both government and commercial stakeholders. The report highlights how American spaceports and ranges must transition facilities to improve spaceflight responsiveness, enhance tracking and telemetry, promote standardization and interoperability among vehicles, equipment, and other infrastructure, enhance safety, protect against security threats, maintain launch flexibility, support multiple concurrent launch operations, and optimize costs. The report notes that while the current U.S. launch infrastructure supports expendable launch vehicle (ELV), Space Shuttle, missile, and suborbital sounding rocket missions, future needs will include more complex missile tests, commercial orbital and suborbital reusable launch vehicle (RLV) flights, hypersonic vehicles, Crew Exploration Vehicle development, and Operationally Responsive Spacelift (ORS) missions. As such, the FIRST Needs Assessment advocates enhancing existing spaceports—including Florida’s—and ensuring that planned commercial facilities are more standardized, interoperable, rapidly responsive, and intelligently coordinated.

The concepts and recommendations that this report provides for a Florida commercial spaceport are consistent with the FIRST vision. This report not only lays the groundwork for the State of Florida to create a commercial spaceport that meets the needs of today’s market; it also provides for a facility designed to be easily integrated into the future national spaceport system that the FIRST initiative has defined.

PART 1: FEASIBILITY ANALYSIS

SUMMARY

Vehicle operators will likely be eager to fly from a commercial spaceport in Florida if it can provide inexpensive, easy, and convenient launch operations. There are three probable spaceport concept alternatives to pursue in order to provide such operations: co-location of a commercial spaceport on a Federal range (Cape Canaveral Air Force Station (CCAFS) or Kennedy Space Center (KSC)), a new commercial spaceport capable of providing vertical and horizontal launches at a single "combined site", or a new commercial spaceport that handles vertical and horizontal launches at two separate sites ("split site"). Figure 1 provides the major characteristics that affect the feasibility of developing these three alternatives. The most feasible of these options is the last, a split site where a currently operational airport is used for horizontal launches and new infrastructure is built at a coastal location for vertical launches. This option best addresses the three major obstacles that were found to likely impede spaceport development: politics, regulations, and cost.

Figure 1: Florida Spaceport Concept Alternatives

Spaceport Concept Option	Launch Infrastructure Location	Primary Regulatory Body	Primary Feasibility Obstacle
Co-location on Federal Range	Vertical and Horizontal: existing Federal range (CCAFS or KSC)	USAF/NASA	Political/Regulatory
New Combined Site	Vertical and Horizontal: new private coastal site	FAA	Cost
New Split Site	Vertical: new private coastal site and Horizontal: existing airport facilities	FAA/Airport	Regulatory

Futron conducted an extensive series of interviews to determine the feasibility of a commercial spaceport. Thirty-three individuals from the Federal government, launch vehicle developers, and other organizations in the space community were interviewed to gain insight into the necessary infrastructure and operational requirements for a commercial spaceport. These interviews, supplemented with additional data collection and research, provide extensive expert knowledge for the feasibility analysis.

Political issues are expected to affect primarily the willingness of officials to work with Florida Space Authority (FSA) in promoting spaceport operations and acquiring sufficient funding for the project. Using CCAFS and KSC for FSA-sanctioned commercial activities is probably not feasible because minimal political support exists from the Air Force and NASA to do so. Vehicle providers also do not want to operate under the perceived burdensome safety and flight prioritization regulations on the Federal ranges. The split site configuration will not involve supervision from the Air Force or NASA, but rather will require coordination with the FAA and the relevant airport authority for regulatory issues, which should increase the ease of operations over a co-located spaceport on a Federal range.

The spaceport operator needs to create clear regulatory procedures and flexibility for space launch activities. To fulfill this goal, a single point of contact for political and regulatory issues at the new spaceport—an operator's advocate—should be available so vehicle developers do not have the obligation of handling these issues on an individual basis. This goal would be easiest to enact at a non-Federal spaceport. An essential goal when developing a spaceport concept is the generation of a realistic business plan based upon a clear mission and objective.

Regardless of the spaceport location, there are some issues that will have to be addressed in order to have a successful spaceport. According to launch vehicle developer interview responses, there are certain items of infrastructure needed to conduct launches, which are summarized in Figure 2. According to these responses, three critical infrastructure components exist that must be present for a rudimentary commercial spaceport: a hangar for storage and processing, a runway, and a vertical launch pad. The launch operators can bring in all other items if the spaceport initially chooses not to include value-added infrastructure. An Environmental Impact Statement (EIS) and precise safety regulations will also have to be administered at any site.

Figure 2: Vehicle Developer Infrastructure Needs

Infrastructure Category	Launch Vehicle Developer Need
Non-Hazardous Hangars and Processing Bays (Vehicles and Payloads)	Most operators want hangars to store and service their vehicles, with a door height requirement of 30 feet. One operator reported that a 65-foot tall storage and maintenance silo would be useful.
HazMat Storage, Processing, and Supply	Most operators anticipated trucking in their own propellant and oxygen.
Power and Data Links	Standard 110/220 Volts would be used by most in the hangar and at the pad. Several operators want broadband data links (T1).
Vehicle Tracking and Telemetry	Most operators use GPS tracking. Some want a pre-certified off-the-shelf product for meeting range requirements. Operators anticipate using their own UHF equipment for telemetry. Cheap non-TDRSS space-based telemetry is desirable.
Flight Termination	Flight termination modes are not finalized for all vehicles. For crewed or reusable vehicles, non-destructive propulsion shutdown and return is needed. Several will have autonomous shutdown with command termination link from range. Orbital providers prefer non-explosive (one-piece) termination.
Gases and Fluids (nitrogen, oxygen, helium, etc.)	Most operators will use standard fluids and gases and could truck in their own, but would buy from an on-site supplier if it were cheap and convenient.
Ground and Range Safety	Operators want straightforward safety requirements and standardization across ranges.
Into and Out of Range Transportation	Most operators can carry their vehicles on trucks. Road access will be required that can carry a loaded tractor-trailer. One vehicle requires rail access to a coastal launch site.
Runways and Pads (with acoustic suppression/water deluge)	For the horizontal vehicles, a 10,000 by 200-foot runway is desired. For the vertical launches, a flat concrete pad about 50 feet by 50 feet is sufficient. Vehicles are small enough to require only cherry-picker access. One operator wants water deluge for flame and acoustic suppression.
Meteorology	Standard weather services are sufficient for winds aloft data.

The costs of developing a spaceport will depend on the amount and type of infrastructure to be included for launch activities. In addition to the three critical infrastructure items above, complementary logistical and construction activities will add cost to the spaceport development project. Costs will rise as value-added items are added to increase the spaceport's attractiveness to launch providers, such as packaged telemetry and tracking services or on-site fuel supplies. The split site option reduces costs relative to the other spaceport concept options. By operating from an airport for horizontal launch vehicles, the high cost of developing a runway and corresponding infrastructure is avoided. The cost range for constructing the critical infrastructure items at the split site is estimated to be between $9.5 million and $25 million. Comparatively, the cost for constructing combined site infrastructure is likely to range from $184.5 million to $275 million. Likewise, co-locating on a Federal range would allow for the use of previously constructed infrastructure components, which would reduce initial development costs, but the components would likely require some refurbishment and maintenance.

The overall feasibility of commercial spaceport development in Florida is dependent on a coherent plan that realistically weighs the costs and benefits of initial capital investment, on-going operational costs and procedures, the market for spaceport use, and the future of the space industry and economic development in Florida. Once this plan is developed, then the decisions for spaceport location, infrastructure, and procedures can be enacted with the best chance for success and the most benefit to the State of Florida.

INTRODUCTION

The objective of developing a commercial spaceport, geared to the needs of the current and anticipated user community, is a logical one for the FSA to pursue. The main questions to be addressed are the alternative approaches to this objective, the advantages and disadvantages of each, and their relative feasibility. In the end, the overall evaluation of this feasibility will have to include not only the preferred physical approach, but also the realities of market demand and the portion of this demand that can realistically be attracted by a Florida spaceport.

Part I of this study addresses the first of this series of issues—the alternative approaches, the advantages and disadvantages, and their feasibility. This involves the examination of the infrastructure needs of vehicle operators for a commercial spaceport, and comparison of those needs with the existing infrastructure at CCAFS. Futron identified the technical, environmental, and regulatory issues associated with converting existing Cape assets into a commercial spaceport integrated with the existing range facilities (the "on-site" approach). We also identified the minimal infrastructure required to build a new commercial spaceport outside of CCAFS (the "off-site" approach).

Important aspects of this evaluation include the perceptions, desires and biases of the key players involved. These factors all contribute, directly or indirectly, to the practical feasibility of implementing the concept of a commercial spaceport. They therefore represent a major input to this feasibility analysis, and were an important part of the data gathering, as described below.

METHODOLOGY

SPACEPORT MISSIONS AND VEHICLE TYPES

When describing the infrastructure elements for the proposed spaceport, Futron divided the vehicles in development into categories that will make a material difference for the kind of infrastructure required. Vehicles were first divided by orbital versus suborbital capability, and then divided according to whether the vehicle was designed to return and land at the spaceport versus vehicles that will be recovered at sea. Lastly, we considered traditional expendable vehicles, with stages discarded at sea.

VEHICLE DEVELOPER INTERVIEWS

Futron conducted 15 telephone interviews in May 2005 with developers of small orbital and suborbital vehicles to gauge their interest in such a project, determine what issues they would have with using the facility, and determine future steps to mitigate these issues to make the Cape more attractive to these companies. (See **Appendix A** for profiles of 22 vehicle developers that were selected as target interviewees.) Each interview lasted approximately 30 minutes, and was conducted by two Futron analysts. The interviewers followed a standard list of questions designed to cover all the major categories of infrastructure a vehicle requires while also allowing for an open-ended discussion concerning what the operators would like to see from their ideal spaceport (see **Appendix B**). Operators were also asked whether they have considered launching from Florida, their total anticipated launch rate, and the fraction of total launches they foresee departing from Florida.

Based on the interview results and additional research into the vehicle requirements, Futron created a profile of the ideal spaceport. We then grouped the vehicles according to similar infrastructure needs and described the minimum infrastructure required to support operations. Finally, we compared these requirements to existing Cape assets to determine what could be refurbished and what new infrastructure would be required. Cost estimates are presented for both converting existing Cape infrastructure or building a new spaceport from the ground up.

GOVERNMENT AND OTHER INTERVIEWS

A series of 18 interviews were conducted with government officials, ex-government personnel with knowledge of the industry, and individuals from organizations with an involvement in space issues. These interviews were structured to achieve the following:

- Determine the levels of awareness of, and support for, development of a commercial spaceport in Florida;
- Obtain opinions concerning the availability of existing infrastructure elements, and the coordination requirements with the government;
- Get a sense of the regulatory issues involved in developing a commercial spaceport, and the possibility of dealing with them;
- Determine some of the major milestones involved in reaching an operational commercial spaceport; and
- Enumerate some of the major obstacles in the way of achieving the vision for a commercial spaceport.

The interviewers used a standard set of questions for each interview (see **Appendix C**), but encouraged the participants to expand their answers as they felt appropriate. Interviews lasted from 30-60 minutes, depending upon the level of detail to which the subjects were comfortable in responding.

The interview subjects represented a broad range of government and non-government organizations, and included several former senior officials of some of these organizations, no longer formally connected with them, but highly knowledgeable about the subject. The organizations and individuals interviewed included Congressional staff, DARPA, the FAA, the Florida Aerospace Finance Corporation, former Florida Space Authority staff, NASA Headquarters, NASA KSC, the Space Foundation, and several current and former U.S. Air Force personnel. The interview results, while largely qualitative and subjective, were then analyzed for similar "themes", or consistently appearing comments, that could offer some insight into the prospects and feasibility of the proposed enterprise.

AWARENESS OF AND SUPPORT FOR A COMMERCIAL SPACEPORT

COMMERCIAL PERSPECTIVE

Operators consistently expressed interest in using a commercial spaceport in Florida. Futron found that the proportion of operators willing to participate in a telephone interview and make their needs and desires known far exceeded what was expected based on past experience with other studies. Many operators reported that they would consider relocating to Florida if the proposed spaceport met their needs. That said, operators face serious difficulties with the existing mode of operation at CCAFS. The overall commercial perspective is that launch range access is too expensive and regulations are overly burdensome. There is no central authority that can assist operators with all of their regulatory requirements. Existing range procedures do not allow for flexible operations and operators can experience delays of weeks or months due to the activity of other users. Many operators expressed a strong preference for a spaceport separate from government launch users, which have conflicting priorities. Any new spaceport would have to address these concerns to be successful.

IDEAL COMMERCIAL SPACEPORT CONCEPT

Through the course of interviews with vehicle developers, a very consistent picture emerged of the operators' ideal spaceport. Most importantly, operators want the lowest cost possible and look for minimal requirements they must fulfill. Many developers of suborbital reusable vehicles need only a runway or a pad and a wide-open space. These operators plan on using only a small launch crew, typically 15 people or less, and expect to truck in their own fuel and command equipment. All services would be purchased à la carte to minimize cost, but operators would take advantage of locally supplied fuel, oxygen, and other materials if they were convenient and reasonably priced. Environmental, safety, and all other requirements would need to be clearly defined so developers can work towards them early in the process.

The greatest obstacles operators face are cost and regulatory requirements. Most operators would like to pay no more than $100,000 in total range costs per flight, and in many cases would prefer that total to be in the $25,000 to $50,000 range. Vehicle developers see the cost of working with ranges and addressing each element of the launch approval process as a significant part of their overall costs. Currently vehicle developers must navigate on their own through multiple safety and environmental requirements from all levels of government. The ideal spaceport would allow for launch operations like general aviation aircraft. Under ideal conditions, operators would like to schedule flights on no more than a few days notice and not be subject to lengthy delays due to other range activity. Companies operating similar vehicle types would not have to go through lengthy approval processes independently. Meeting the safety requirements for one range would be transferable to other ranges, which is currently not the case. Also, the spaceport would already be sited under environmental regulations for the operation of space vehicles without the individual operators having to seek special permissions from local, state, or federal authorities.

Several interviewees suggested it would be very useful to have an operators' advocate at a spaceport. The advocate would be the single point of contact that could help the operator through each step of the regulatory process and assist in resolving problems. All of the requirements the developer must address would be known and disclosed up front. Among the most difficult scenarios facing developers are new requirements "discovered" late in the development process that introduce more delays and added cost. Currently the burden is on the developer to seek out appropriate officials to obtain permission for the details of launch operations from the handling of fuel and other chemicals to obtaining emissions credits from local authorities.

No spaceport offers this level of easy operation currently, but all operators expressed willingness to fly their vehicles from Florida if it were made easy and convenient. One interviewee specifically mentioned that a successful spaceport venture would have to resolve the "bait and switch" problem—senior-level officials are quite welcoming and promise flexibility during initial discussions, yet when the operator begins working with the lower-level "doers" at the range, the attitude is "here is what we require you to do to use the range" and the operator is unable to count on range flexibility. This causes the operator to incur added cost and to experience delays. Many interviewees spoke of the benefits of having a spaceport separate from CCAFS due to the competing goals of small commercial operators and national launch operators. "You don't see general aviation at SAC bases, because the requirements are so different," summed up the view of many small operators.

A summary of the main qualities of the ideal spaceport is described below:

- **Flexibility**: Ability to operate without interference from other range activity; schedule launches and tests on no more than a few days' notice
- **Very low cost**: À la carte services to allow operators to save money
- **Streamlined bureaucracy**: An operators' advocate would be the single point of contact for helping the operator through each step of the regulatory process
- **Consistency across ranges:** Requirements met at one spaceport should apply to identical requirements at all spaceports
- **Separated from government users:** The requirements of national users often conflict with and trump private users, introducing cost and delays

Operators expect to bring in much of their own support equipment and fuel. The ideal spaceport would be able to service a variety of orbital and suborbital vehicles with the following basic infrastructure elements:

- A flat pad at least 50 feet on each side (some users would require water deluge)
- A runway at least 10,000 feet long by 200 feet wide
- A hangar for vehicle storage and basic maintenance, with a 30-foot door

- Permission to use company-owned ground-based or space-based tracking and communications systems (or range-provided tracking and communications—whichever is least expensive for the operator)
- Into- and out-of-range access by road
- Wide-open spaces for vertically-landing vehicles

Government and Other Perspectives

There is a broad awareness, across nearly all organizations and individuals, of FSA's basic purpose and interests. However, there is a much lower level of awareness and understanding with respect to specific commercial spaceport plans.

Support ranges from neutral to strong among those who can be characterized as "non-Cape stakeholders", albeit with conditions in some cases. On the other hand, the government and military establishment at the Cape is not supportive, and is actually pessimistic about the feasibility of such a project if it were to be situated on-site at Cape Canaveral. There is skepticism in some government quarters about FSA, or any other organization, acting as a "middleman" in dealings with the commercial community. Funding does not appear to have any significant support at the Federal level, and dealing with it at the State level will require addressing what is currently perceived as a "Brevard County issue."

Some strong areas of support do exist at the national level: the FAA is inherently supportive of commercial spaceport activities, and perceives that part of its commercial space mandate is to assist and support such activities to the extent possible. The FAA also broadly supports states that promote their own space programs as these programs are viewed as a general benefit to the nation.

INFRASTRUCTURE

Basic Requirements

The types of vehicles flying from a commercial spaceport can be grouped into three broad categories, with the first two each having two subcategories. All are designed to fly with a minimum of ground infrastructure.

- **Suborbital Reusable Launch Vehicles**
  - Land Recovery (SRLV/LR): Vertical or horizontal take-off and landing at spaceport
  - Sea Recovery (SRLV/SR): Vertical or horizontal take-off at spaceport, sea recovery
- **Orbital Expendable Launch Vehicles**
  - (ELV): Vertical or horizontal take-off from spaceport, stages discarded at sea
  - With Recovery (RELV): Vertical or horizontal take-off from spaceport, recovery of stages at sea
- **Orbital Reusable Launch Vehicles (RLV):** Vertical or horizontal take-off and landing at spaceport

Figure 3 includes a list of vehicles likely to be used by target customers of the proposed spaceport. It is based on publicly available plans concerning the vehicle design and anticipated requirements. Many infrastructure elements can service multiple types of vehicles. At a minimum, a successful general-purpose spaceport must accommodate both horizontal and vertical take-off vehicles for both orbital and suborbital missions.

Several companies and vehicles, although technically within the realm of consideration for this study, were excluded from the list of likely targets for one or more of three main reasons: 1) the company or vehicle is under-funded (or not funded at all); 2) the vehicle has remained in conceptual design phase for an extended period, with little or no actual progress made on fashioning a prototype; 3) the vehicle was an Ansari X Prize contender whose development stalled or was abandoned after SpaceShipOne won the Ansari X Prize. These vehicles are shown in Figure 4.

The specific requirements of the three main categories of launch vehicles (suborbital reusable, orbital expendable, and orbital reusable) are described in greater detail in the succeeding sections, and in Figures 3 and 4.

Figure 3: Target Vehicles and Characteristics

Company	Vehicle Name	Vehicle Type	Takeoff	Recovery/Landing	Type	Interviewed
AERA (formerly American Astronautics)	Altairis	Liquid Fuel Rocket	Vertical/Land	Horizontal/Land	SRLV/LR	
ATK Elkton LLC	ATK Vehicle	Solid Fuel Rocket	Vertical/Land	N/A	ELV	X
Armadillo Aerospace	Black Armadillo	Liquid Fuel Rocket	Vertical/Land	Powered Descent/Land	SRLV/LR	X
Beyond-Earth Enterprises	Joshua	Solid Fuel Rocket	Vertical/Land	Parachute/Land	SRLV/LR	X
Blue Origin	(Not announced)	Liquid Fuel Rocket	Vertical/Land	Powered Descent/Land	SRLV/LR	
Garvey Spacecraft Corp.	NLV	Liquid Fuel Rocket	Vertical/Land	N/A	ELV	X
High Altitude Research Corporation	Liberator	Liquid Fuel Rocket	Vertical/Water Platform	Parachute/Water	SRLV/SR	
Interorbital Systems	Sea Star MSLV	Liquid Fuel Rocket	Vertical/Water	Parachute/Water	RELV	
	Neptune	Liquid Fuel Rocket	Vertical/Water	Parachute/Water	RELV	
Kistler Aerospace Corp.	K-1	Liquid Fuel Rocket	Vertical/Land	Parachute & Air Bags/Land	RLV	X
Lockheed Martin, Michoud Operations	Falcon prototype	Hybrid Engine	Vertical/Land	N/A	ELV	X
Masten Space Systems	XA	Liquid Fuel Rocket	Vertical/Land	Vertical/Land	SRLV/LR	X
Microcosm, Inc.	Eagle SLV	Liquid Fuel Rocket	Vertical/Land	N/A	ELV	X
Orbital Sciences Corp.	Pegasus	Aircraft, Solid Fuel Rocket	Vertical/Land	N/A	ELV	X
	Taurus & Minotaur	Solid Fuel Rocket	Vertical/Land	N/A	ELV	
PanAero	Condor X	Multi-pod Rocket Glider	Horizontal/Land	Glide/Land	SRLV/LR	
Rocketplane Limited Inc.	Pioneer XP	Liquid Fuel Rocket/Jet Spaceplane	Horizontal/Land	Horizontal/Land	SRLV/LR	X
Scaled Composites	SpaceShipOne/ White Knight	Two Stage Aircraft, Rocket	Horizontal/Land	Glide/Land	SRLV/LR	X
SpaceX	Falcon I & V	Liquid Fuel Rocket	Vertical/Land	Parachute/Water	RELV	X
Space Launch Corp.	SLC-1	Aircraft, Rocket	Horizontal/Land	N/A	ELV	
Space Systems/Loral	Aquarius	Liquid Fuel Rocket	Vertical/Water	N/A	ELV	X
SpaceDev	Dream Chaser	Hybrid Engine Spaceplane	Vertical/Land	Glide/Land	SRLV/LR	X
TGV Rockets	MICHELLE-B	Liquid Fuel Rocket	Vertical/Land	Powered Descent/Land	SRLV/LR	X
XCOR Aerospace	Xerus	Liquid Fuel Rocket Spaceplane	Horizontal/Land	Glide/Land	SRLV/LR	

Figure 4: Vehicles Excluded from Analysis

Company	Vehicle Name	Vehicle Type	Takeoff	Recovery/Landing	Type
Acceleration Engineering	Lucky Seven	Liquid Fuel Rocket	Vertical/Land	Parafoil/Land	SRLV/LR
E'Prime Aerospace Corp.	Eaglet/Eagle	Solid Fuel Rocket	Vertical/Silo	N/A	ELV
Fundamental Technology Systems	Aurora	Liquid Fuel Rocket Spaceplane	Horizontal/ Land	Glide/Land	SRLV/LR
Micro-Space	Crusader X	Bipod Rocket Sled	Vertical/Land	Parafoil/Water	SRLV/SR
Space Transport Corporation	Rubicon	Solid Fuel Rocket	Vertical/Land	Parachute/Water	SRLV/SR
Vanguard Spacecraft	Eagle	3 Stage Rocket	Vertical/Land	Parachute/Water	SRLV/SR

SUBORBITAL REUSABLE LAUNCH VEHICLES (LAND AND SEA RECOVERY)

Suborbital reusable launch vehicles are designed to use a minimum of ground infrastructure that does not deviate substantially from a general aviation airport. A runway of at least 10,000 feet by 200 feet and a basic concrete pad measuring 50 feet by 50 feet are sufficient to support both horizontally- and vertically-launched vehicles. A few vertically-launched vehicles would also require a four-inch water supply for flame and acoustic suppression. A spaceport or airfield with wide-open spaces is required for parachute or powered vertical landings. Since these vehicles are designed to take-off and return to the same facility, downrange tracking is typically not required. Of the vehicles designed for recovery on land, most will make use of the runway. For vehicles designed for recovery at sea, essentially all the vehicles are designed for vertical take-off, either from a land- or sea-based platform. It is not strictly necessary for the spaceport to provide services related to the recovery of vehicles at sea; operators can supply or contract their own recovery vessels.

Most operators either have GPS for guidance onboard or say they could easily accommodate space-based tracking, although the current lack of acceptable standards for space-based tracking is considered a risk. Operators expect to use their own ground-based equipment for command and telemetry. Space-based telemetry is a possibility, but operators cited a strong preference not to use the Tracking and Data Relay Satellite System (TDRSS) due to excessive cost and restricted availability. Other space-based telemetry might be possible, but technical issues such as Doppler shifting and high-altitude operation would need to be worked out. Cost would be the overall driving factor when considering ground-based or space-based telemetry. Also, operators would have to be confident that their space-based telemetry system would be compatible with spaceport requirements. Some operators expressed the desire for approved off-the-shelf telemetry and tracking packages that they could install without having to pay the time and expense of getting the system certified for their individual vehicles.

Some suborbital vehicle operators plan to expand their services to offer the launch of very small orbital satellites. Such flights would involve deploying an expendable upper stage containing a very small satellite (typically 200 pounds or less). Such a flight might require downrange tracking to monitor payload separation. Alternatively, since these missions would be designed to be low-cost and simple, the payload may simply call in to its operating ground station upon successful deployment and forego telemetry from release through upper stage separation. A space-based tracking solution would be desirable, but cost will be the determining factor. TDRSS is considered too expensive for most suborbital reusable vehicle developers.

Many of the suborbital reusable vehicle developers plan to carry paid passengers. Additional facilities designed to facilitate an ongoing public space transportation enterprise might be useful, but are not required to start operations and none of the interviewees mentioned things like medical facilities, training, entertainment, or other services for public space travelers and their families. Operators are only focusing on the bare minimum necessary to begin operations. A summary of the basic requirements for suborbital reusable vehicles is shown in Figure 5.

Figure 5: Typical Requirements for Suborbital Reusable Vehicles

Non-Hazardous Hangars and Processing Bays (Vehicles and Payloads)	Most operators expressed a desire for hangars to store and service their vehicles, but it would not be an absolute requirement for them to use the spaceport. No interviewee cited the need for a hangar with a door higher than 30 feet, although one said a 65-foot storage and maintenance silo would be nice to have. Hangars should have standard electrical power (110/220 volts).
HazMat (e.g. Propellant) Storage, Processing, and Supply (Vehicles and Payloads)	Most operators anticipated trucking in their own propellant and oxygen. However, they would buy from an on-site supplier if it were inexpensive and convenient. Many vehicles will use kerosene and liquid oxygen.
Power and Data Links	Standard 110/220 volts would be useful for most operators. Several operators also expressed the desire for broadband data links (T1).
Vehicle Tracking and Telemetry	Most operators expressed a desire for GPS tracking. It would be great if an off-the-shelf product were pre-certified for meeting range requirements. Operators anticipate using their own UHF equipment for telemetry—space-based is too expensive. TDRSS is prohibitively expensive for most operators and does not even offer adequate availability. Other space-based telemetry would be desirable, but all technical and regulatory issues would need to be addressed.
Flight Termination	Some operators have not finalized their flight termination modes. For any crewed or reusable vehicle, the operator is planning on propulsion shutdown and return (non-destructive). Several will have autonomous shutdown for off-nominal operation with command termination link from range.
Gases and Fluids (nitrogen, oxygen, helium, etc.)	Most operators will use standard fluids and gases. Most operators could truck in their own, but they would buy from on-site supplier if it were inexpensive and convenient.
Ground and Range Safety	Operators want straightforward safety requirements and standardization across ranges. New or "discovered" requirements late in the process need to be avoided.
Into and Out of Range Transportation	Most operators can carry their vehicles on trucks. Road access that can accommodate a loaded tractor-trailer will be required.
Runways and Pads (e.g., acoustic suppression/water deluge)	The spaceport must accommodate vertical and horizontal take-off vehicles. For the horizontal vehicles, a 10,000-foot by 200-foot runway will be required for both take-off and landing. For the vertical launches, a flat concrete pad about 50 feet by 50 feet will accommodate most vehicles. One operator expressed a desire for water deluge for flame and acoustic suppression (4-inch main). The vertically launched vehicles will require a wide-open space for landing, or will be recovered at sea. Some thought standard power (110/220 volts) would be useful.
Meteorology	Standard weather services are sufficient for winds aloft measurements.

ORBITAL EXPENDABLE LAUNCH VEHICLES (STAGES DISCARDED OR RECOVERED AT SEA)

The new generation of small, expendable orbital launch vehicles under development is also designed to require much less ground infrastructure than previous vehicles. Most operators report that their vehicles can be delivered to the pad by truck, and do not require extensive launch preparations on the site. Typically a square flat pad, at least 50 feet on each side, would be adequate for most systems. A water system for deluge would be necessary for at least one operator (SpaceX), so a way to deliver the water and collect run-off would be required. The operator added that a flame trench is not strictly necessary. Having a source of electrical power (110/220 volts) would also be useful at the launch site. SpaceX and Interorbital Systems both expect to recover spent stages at sea. This does not affect launch operations or requirements at the spaceport. Operators are not expecting services from the spaceport related to the recovery of their vehicles at sea; they can provide or contract their own recovery vessels.

Orbital flights will require downrange tracking and telemetry. Vehicles are already incorporating GPS, but they will need some sort of downrange communications link. Operators are open to space-based solutions, but cost and regulations will decide what they will use. One operator reported the cost of using a downrange commercial link as $100,000 per launch, which they regard as too expensive. A practical space-based telemetry system would need to be available, preferably something that is pre-approved for use and is not too expensive for the operator. TDRSS is regarded as too expensive and of limited availability.

Operators of vehicles in this class can typically carry their vehicle in by truck. SpaceX reported that they would need access to a class 10,000 and a class 100,000 clean room for payload handling. As for hazardous materials, they will use ordnance for stage separation and anticipate using Star motors (integrated with the payload) for future Falcon V missions to GEO or deep space.

The feature that all interviewed operators said they wanted most was flexibility to operate on their own schedules. It is costly for operators to have delays resulting from other range activity. Operators expressed some frustration at the inability to schedule tests or other activity when they are ready due to competing requirements from government vehicles. Also, one operator described how questionable safety requirements cause added delays. When using the White Sands Missile Range, the operator’s liquid oxygen truck had to wait at the gates for a range-provided safety escort to drive across the open desert, when the same commercial vehicle can travel the public highways without an escort. Operators also want transferability between ranges such that safety requirements met at one range will apply to identical requirements at other ranges, which is not currently the case.

A summary of requirements for the typical small orbital expendable launch vehicle is shown in Figure 6.

Figure 6: Typical Requirements for Orbital Expendable Launch Vehicles

Non-Hazardous Hangars and Processing Bays (Vehicles and Payloads)	Most operators expressed a desire for hangars to store and service their vehicles, but it would not be an absolute requirement for them to use the spaceport.
HazMat (e.g. Propellant) Storage, Processing, and Supply (Vehicles and Payloads)	Most operators anticipated trucking in their own propellant and oxygen. However, they would buy from an on-site supplier if it were inexpensive and convenient. Many interviewees will use kerosene and liquid oxygen. SpaceX will use ordnance for stage separation, and eventually plans to use Star motors for geostationary or deep-space missions
Power and Data Links	Standard 110/220 volts would be useful for most operators. Several operators also expressed the desire for broadband data links (T1).
Vehicle Tracking and Telemetry	Most operators expressed desire for GPS tracking. It would be great if an off-the-shelf product were pre-certified for meeting range requirements. Operators anticipate using their own UHF equipment for telemetry—space-based is too expensive. TDRSS is prohibitively expensive for most operators and does not even offer adequate availability. Other space-based telemetry would be desirable, but all technical and regulatory issues would need to be addressed.
Flight Termination	Some operators have not finalized their flight termination modes. Several will have autonomous shutdown for off-nominal operation with command termination link from range. Prefer non-explosive (one-piece) termination.
Gases and Fluids (nitrogen, oxygen, helium, etc.)	Most operators will use standard fluids and gases. Most could truck in their own fuel, but would buy from an on-site supplier if it were inexpensive and convenient.
Ground and Range Safety	Operators want straightforward safety requirements and standardization across ranges.
Into and Out of Range Transportation	Most operators can carry their vehicles on trucks. Road access will be required that can carry a loaded tractor-trailer. One vehicle (SS/Loral's Aquarius) requires rail access to a coastal launch site.
Runways and Pads (e.g., acoustic suppression/water deluge)	For the vertical launches, a flat concrete pad about 50 feet by 50 feet will accommodate most vehicles. Vehicles are sufficiently small enough to require only cherry-picker access.
Meteorology	Standard weather services are sufficient for winds aloft measurements.

ORBITAL REUSABLE LAUNCH VEHICLES

Orbital reusable launch vehicles require much of the same infrastructure as the expendable vehicles. Only vehicles that are designed for recovery on land would require special landing services from a spaceport. The only current vehicle in advanced development that meets these criteria is Kistler's K-1. Kistler stated that they require an open area for their vehicle to touch down, with a radius of at least 6,000 feet from the target point. The vehicle launches vertically, and will require a flame trench and a water deluge. They also require a runway in the range of 8,000 to 10,000 feet to accommodate the Beluga cargo aircraft that will carry the vehicle to the site. All other requirements are also applicable to the expendable vehicles.

Kistler also feels it is important to have the flexibility to launch on demand, with a maximum turn-around of about seven to nine days between flights. Cost is an extremely important factor when considering a launch site. They estimate the cost of a Florida launch at around $1 million, a figure they consider too high. Their costs at Woomera are a fraction of that amount, but they declined to quantify the amount.

VALUE-ADDED INFRASTRUCTURE AND SERVICES

In the interviews, operators mentioned several types of support infrastructure that would be "nice to have." These elements would make a spaceport more attractive if they made launch operations more convenient and were offered inexpensively. One such support service is the provision of fuel and gases, most notably kerosene, liquid oxygen, helium, and nitrogen. Operators indicated they could truck in their own fuel and gases, but could just as easily buy from an on-site source. Some operators expressed an interest in video services to track the vehicle in flight. Many others mentioned high-bandwidth data services (T1 or greater) for various kinds of telemetry and external communication. Most operators also said it would be convenient to have hangars to store and work on their vehicles. Such facilities would encourage operators to set up a permanent presence at one or more spaceports, if it were easy to roll out the vehicle and fly whenever they were ready.

FIRST-TIER COST ESTIMATES

Based on interviews with vehicle developers, three infrastructure items were identified as critical for a viable commercial spaceport and were the focus of the first-tier cost estimation: a processing and storage hangar, runway, and vertical launch pad. Specifications were attributed to the infrastructure items to meet the likely needs of the commercial launch service providers included in this study. The data for the cost estimates was collected from public sources describing comparable infrastructure projects previously completed and from contractors providing cost quotes for our specified needs. The estimates in Figure 7 provide a range for the potential costs of constructing these critical items for a vertical and horizontal launch commercial spaceport.

Figure 7: New Spaceport Infrastructure Cost Estimate

Infrastructure Item	Low-end Estimate	High-end Estimate	Item Description
Hangar	$4,500,000	$10,000,000	50,000 square feet, 30-foot tall door; includes utilities and fire suppression system (fire suppression is an estimated 5-10% of total cost)
Runway	$175,000,000	$250,000,000	10,000 foot by 200-foot runway
Vertical Launch Pad	$5,000,000	$15,000,000	Pad and tower convertible for multiple vehicles and includes water deluge system
Total Cost	**$184,500,000**	**$275,000,000**	**All critical infrastructure items for the spaceport**

All infrastructure costs will vary depending on the site selected and the desired specifications for spaceport facilities. For construction of a vertical launch facility, costs will depend on the size of vehicle the pad and tower will be capable of accommodating. The above estimate, based on needs specified by potential launch providers, includes an approximately 50 feet by 50 feet concrete pad and tower that is convertible for use by multiple vehicles and a water deluge system for acoustic suppression. Another launch pad alternative would be to relocate CCAFS Launch Complex 46 (LC 46), at a cost estimated around $3 million plus additional refurbishing costs. As a point of comparison for the construction of an entire vertical launch complex, the Kodiak launch facility was constructed with an initial cost around $40 million. This facility included a launch pad with tower, a second rudimentary pad with extremely limited vehicle capability and no tower; three processing, integration, and assembly structures, a launch control center, instrumentation field, and housing lodge. A commercial spaceport would not require all of these facilities, but they demonstrate the first-tier costs likely to be involved for constructing vertical launch infrastructure.

The processing and storage hangar cost figures were very consistent in the range between $5 million and $10 million, which includes the necessary building utilities and imperative hangar fire suppression system. The fire suppression system is estimated to cost approximately five to ten percent of the total hangar construction cost. Refurbishing an existing hangar could provide the necessary infrastructure for the launch providers, but the costs to refurbish are likely to be only slightly lower than new construction costs.

The most expensive single cost item will likely be developing a new runway because of the large runway dimensions desired by the launch service providers and the inherent high costs of runway construction. The Kodiak facility mentioned above was able to keep its costs relatively low by not constructing a runway, but consequently it cannot serve horizontal launch providers. As an alternative to new construction, in order to serve both vertical and horizontal launchers and minimize costs, FSA could consider purchasing or leasing a runway from a private or commercial airport.

Besides the critical infrastructure costs, there are other infrastructure and regulatory costs that may be incurred in developing a spaceport. As provided in Figure 8, additional infrastructure considerations may include the acquisition of land, transportation on the site, communications, and additional building structures, while regulatory compliance costs likely will include an environmental impact statement and range safety and security measures. The costs involved in developing the spaceport will vary depending on the inclusion or exclusion of each of these items and the specifications chosen for each. For example, internal roadways, which are necessary to connect the spaceport to the local transportation network and to provide ease of operations on the launch range, are estimated based on a range of unit costs per mile, so the total cost for internal roadways will be determined by the quantity desired and the size of the site selected. One mile of roadway is likely to cost between $850,000 and $1.6 million. The regulatory items must be considered for the development of a spaceport at any site, but the additional costs will vary according to the site selected. For example, an environmental impact statement is needed to obtain a license for launch site operations, so this must be completed at any site. The cost for preparing this statement is estimated to range from $1 million to $3 million, depending on the location and size of the site and the type of environment—wetlands, protected nature areas, and so on—that the site is being built on. The regulatory issues and costs will be more complex if the spaceport site is near populated areas, because of the environmental and safety concerns of noise, air pollution, hazardous materials permitting, and launch area safety zones.

Figure 8: Additional Cost Considerations

Infrastructure Costs	Purchase or lease of land
	Land preparation, permitting, landfill, drainage
	Road, rail, and/or port access
	Internal roadways
	Utility infrastructure for water, sewer, power, fuel/gas
	Communications access, broadband
	Control facilities
	Range radars and cameras
	Telemetry, tracking, and control equipment
	Payload processing facility, clean room
	Hazmat processing and storage
	Fuel handling facilities for solid, liquid, hybrid
	Ordnance/pyrotechnic facilities
	Office space
	Ground support equipment and vehicles
	Emergency response teams
Regulatory Compliance Costs	Environmental Impact Statement (EIS)
	Range safety
	Range security

Not all of the listed infrastructure items are imperative for a fully functional rudimentary spaceport, but they will certainly influence the launch providers' desire to use the spaceport and how space launch operations are conducted. Additions and upgrades to facilities, such as inexpensive telemetry and fuel storage or supplies, will provide users with greater ease of operations and will draw them to the spaceport.

On-Site Considerations

There is a large amount of suitable infrastructure potentially available at both the Cape and KSC, providing useful launch azimuths at efficient latitudes over the Atlantic Ocean, but access to and use of these facilities will require detailed and extensive coordination with the Air Force and NASA, and compliance with provisions of the Commercial Space Launch Act. Using Federal infrastructure and range support assets involves a heavy coordination burden, and mixing commercial and government activity without mutual interference is difficult, particularly if the government use has a clearly stated priority. Coordination and operation within government facilities would also have to overcome a strong negative bias toward any use of government facilities by an operational commercial spaceport. For example, the recently issued RFI for use of the Shuttle Landing Facility at NASA KSC makes clear that any such use would be restricted to research and technology demonstration flights; parabolic "zero-g" research and demonstration flights; commercial space flight research, technology demonstration, and logistical support; other research and technology demonstrations; use by current and future international partners of NASA; and other uses not listed here and not excluded in other parts of the RFI. While not explicitly excluded from the RFI, the type of use implied for a commercial spaceport, e.g., regular, frequent suborbital passenger flights, is conspicuously absent from this list of acceptable uses of this long runway.

These limitations are consistent with the views expressed by NASA concerning the priority of activities in support of its primary mission: supporting national space programs. The resulting lower priority of any commercial spaceflight activity could lead to delays or lack of timely access, which in turn could cause significant problems for both the spaceport operator and its users.

With refurbishments the existing pad and runway facilities at the Cape could accommodate most of the needs of any potential customer. But by being located within CCAFS, users would be subject to existing range safety and regulatory procedures and would also have to accept delays or other restrictions due to government-sponsored launch or test activity on the range. These are exactly the kind of restrictions potential users want to avoid.

LC 46, with its flat pad configuration, can currently accommodate only solid-fueled vehicles. Many of the vehicles under development by potential customers use kerosene and liquid oxygen. Many operators could launch from a flat pad (no flame trench), but some users will require a water deluge for flame and acoustic suppression. In addition, LC 46 has not been used since 1999 and would require additional upgrades to bring it back into service at its existing location. The tower at LC 46 can be moved on rollers, but some vehicles will not even require a tower. Operators expect to access the vehicle by cherry picker, or only erect the vehicle vertically for launch.

Launch Complex 36, with two pads and supporting facilities, is generally felt to be “convertible” to commercial use; indeed, pad 36-B was actively used for several years for the launch of commercial Atlas launch vehicles. There is, however, a potential for significant problems associated with any modification to the site, such as the requirement for environmental clean up. SpaceX has initiated a request to secure access to this site for their commercial Falcon vehicle launches.

The Air Force runway, at 10,000 by 200 feet, has the correct dimensions to accommodate essentially all the horizontal take-off vehicles currently under development. Yet, since the runway is an Air Force asset, operators would only be allowed to use it on a non-interference basis. Operators would strongly prefer access to a facility where their own interests do not have to compete with military or other national priorities.

Hangar C could be refurbished to accommodate new users, but the cost to do so may exceed that of new construction. The hangar, which is currently vacant and unused, is an Air Force-controlled facility. It is possible to construct taxiways to the hangar from the main runway facilities.

Most operators interviewed said that they are open to using space-based telemetry and tracking. Nearly all operators are already planning to use GPS in their vehicles, but an affordable alternative to ground-based communications is not yet available. Access to TDRSS is considered too expensive to most providers, and the technical and regulatory issues concerning other space-based options have not been fully developed.

It is significant that a consistent recommendation arising from the interviews with government and informed ex-government personnel is that FSA consider locating the commercial spaceport off-site from the Cape or KSC. However, only a few of the respondents noted that this alternative involves formidable challenges and costs.

OFF-SITE CONSIDERATIONS

When considering abandoning the existing Federal range facilities and establishing an independent spaceport at another location, infrastructure costs become a dominant factor in the evaluation. Developing a spaceport in Florida, particularly at a new location that has the necessary geographic characteristics allowing safe launch azimuths over the Atlantic Ocean, would involve large costs. These costs stem from the need to create infrastructure, not readily available, particular to space launch activities. Outside of KSC and CCAFS, Florida lacks existing infrastructure that could be used to reduce the cost of constructing a commercial spaceport. Oklahoma and Washington, for example, acquired unused airstrips (formerly government owned) for commercial spaceport use, reducing the major cost burden of constructing a large runway. Similar acquisitions could increase the feasibility of a commercial spaceport in Florida.

While one of the oft-stated desires of the potential user community is avoidance of the burden of regulatory compliance that they feel “comes with the territory” when operating from the Federal ranges, the reality is that compliance with the essential safety and environmental regulations will be required wherever the activity takes place. The main regulatory effect of shifting from a Federal range to a different, off-site, location will be the shifting of the regulatory implementation and oversight to the FAA as the licensing authority. While compliance with these regulations and requirements does carry a burden, they cannot and will not be waived just to keep costs low. The government’s responsibility to protect the uninvolved public from the hazards associated with any form of space flight will remain the top priority.

There are, however, different types of space flight under consideration for a commercial spaceport: traditional “rocket-like” vehicles, taking off vertically from a launch pad, and “aircraft-like” vehicles that will use a runway for take-off and landing. The rocket-like vehicles, whether carrying people or not, will require the same type of range safety considerations and controls as are required for launches from the Federal ranges, to ensure that the probability of damage or injury to third parties is acceptably low. Operations involving aircraft-like vehicles (e.g., White Knight/SpaceShipOne) require different, and generally less restrictive, safety regulations.

This fundamental difference in the operational and regulatory nature of the two types of systems may be the key to a rational off-site spaceport approach, namely, separating the locations of operations for the two types of vehicles. The rocket-like operation would require a relatively isolated coastal location, similar in geography to the Cape (although requiring a smaller area), with appropriate range safety provisions. The aircraft-like operation could be located at an existing commercial or general aviation airport, with the addition of the specialized facilities needed to support the unique requirements of commercial space customers. This split site approach would dramatically reduce these added infrastructure costs related to aircraft-like operations, since a new runway, the largest single cost element, would not be required. In addition, existing ground infrastructure, such as hangars, vehicles, and fuel supplies, could be used or leased at a cost lower than that required for construction at a new site.

There are several Florida airports suitable for aircraft-like horizontal launch vehicles. Figure 9 lists nine airports, with their geographic locations and specifications for their longest runways. The most important characteristics identified for aircraft-like horizontal launch capability are a solid surface runway in good condition and with a length above 5,000 feet, preferably around 10,000 feet. Among the airports that have an existing runway of this length, there are several attributes that make particular sites more attractive than others. Necessary considerations include the amount of highway, port, and rail access to the airport; noise and traffic pattern regulations caused by residential areas; volume of competing air traffic; amount of current operational ground infrastructure; proximity to the Eastern coast of Florida to fly safely over the Atlantic, and a location near potential vertical launch sites. The best airport for aircraft-like launch vehicles according to these criteria is Jacksonville's Cecil Field, but there are positive aspects at the other sites mentioned as well. In addition, this list is not exclusive: there could be other Florida airports used for space operations, especially if different criteria are used to determine the sites' suitability. For example, Orlando International Airport developed a master plan that considered future spaceport operations. This led to the purposeful construction of runways with sufficient length to support suborbital aircraft-like launch vehicles (9,000 by 150 feet), even though there would be a great amount of air traffic volume at the airport.

Figure 9: Potential Airport Sites for Spaceport

Airport	Location	Runway Name	Surface Type	Runway Dimensions (ft)
Jacksonville Cecil Field	Inland	18L/36R	Concrete/Asphalt	12500 x 200
Dade-Collier Training and Transition	Inland	9/27	Asphalt	10499 x 150
Miami Opa-locka Airport	Inland	9L/27R	Asphalt, Grooved	8000 x 150
Titusville-Space Coast Regional	Coastal	18/36	Asphalt, Grooved	7320 x 150
St. Augustine/St. Johns Co. Airport	Coastal	13/31	Asphalt	6939 x 150
St. Lucie County Intl. Airport	Coastal	9/27	Asphalt	6492 x 150
Boca Raton Airport	Inland	5/23	Asphalt, Grooved	6276 x 150
Martin Co. Airport - Witham Field	Coastal	12/30	Asphalt	5826 x 100
Miami Kendall - Tamiami	Inland	9L/27R	Asphalt	5001 x 150

Creating a commercial spaceport for rocket-like operations requires a large quantity of land in locations particularly suited for space launch activities. There must be a buffer zone between the launch area and the general population in order to maintain safety, security, and ease of operations. There must be launch azimuths available over non-populated areas. There are few locations in Florida that meet these criteria and that are not currently occupied by another party. Creating a spaceport at a new location on land with positive geographic characteristics will be difficult because of the increasing population density in Florida, especially in Brevard County and around the Cape.

The option to create a new commercial spaceport is complicated by environmental and safety regulatory issues—this is not exclusive to Florida. Established environmental and safety regulations must be followed, which is especially important if Federal land is to be acquired and developed. Changes to these regulations will be difficult to enact. Coordination must be carried out with relevant officials concerning these issues, which increases the complexity and cost of developing a spaceport. An environmental impact study will have to be carried out at any location where a new spaceport is developed. Coordination will have to occur with the FAA as well. These regulations are not prohibitive, but they will be a key impediment.

A spaceport that is dedicated to commercial entities can reduce governmental controls that obstruct normal operations and can focus on the specific needs of commercial launchers. Increased physical accessibility would be available since the facility would not be located on a military base or national launch site that is fundamentally concerned with security issues. Prioritization for government launches would no longer be an issue, allowing companies to work according to their own schedules with decreased conflict from government operations.

OBSTACLES

Based on feedback from interviewees, there are a number of obstacles standing in the path of realizing a commercial spaceport in Florida, whether within an existing Federal range or situated at a new site or sites independent of these facilities. These range from a clear articulation of the mission and vision of FSA and the spaceport plans, through the need for broad political support, to the critical issues of costs and regulatory compliance.

MISSION/VISION

FSA must develop a clear, focused, and well-structured vision of its mission. Without such a base upon which to build, it is difficult to define and describe the appropriate approach and form for the commercial spaceport. The spaceport planning and, if shown to be feasible, its implementation, must be integrated closely with this mission statement.

POLITICAL

Broad-based political support is absolutely critical to the success of any venture of the magnitude of creation of a commercial spaceport. This support must come from all sectors of the State of Florida, and if possible should include reinforcement from the Florida Congressional delegation, whether or not any Federal funding support is sought. The interviews conducted as part of this study clearly show that this broad support is not present today, at either the State or Federal levels. A common thread in many of the comments in this connection is that this is viewed as “a Brevard County problem,” rather than an issue of significant importance to the entire State of Florida.

Political support is also required from the operators of the Federal ranges at CCAFS and KSC. An understandable tension exists between the primary functions of these national space program support facilities and those of a commercial spaceport. If there are no benefits to NASA or the Air Force from accepting the burden of a commercial spaceport on their property, then this option will likely be rejected for reasons of range safety, security, and prioritization for assured national access to space. It is important that whatever form a commercial spaceport takes, it is seen as complementary to, and not competitive with, the Federal ranges. In this fashion, there will be a greater likelihood of cooperative support of the market niche targeted by the spaceport operators.

COST

The costs associated with development of a commercial spaceport will be substantial because of the need to create infrastructure particular to space launch activities. This cost burden will be more pronounced if it is determined that the best alternative is to separate the spaceport from the Federal range structure at CCAFS and/or NASA/KSC. In this latter case, it will be important to search for complementary approaches that can alleviate some of the cost burden. One example would be the use of an existing commercial or private airport, with adequate runway facilities for aircraft-like space operations, eliminating the costly requirement for a new runway.

As part of the planning and cost estimation, careful consideration must be given to the need for capital expenditures in the start-up phase of the venture that can result in greater efficiency, and thus more potential revenue generation, in the operational phase.

REGULATORY

All forms of spaceflight must deal with significant regulatory burden. While the potential commercial spaceport user community continues to voice frustration with the process and expresses a strong desire for a "streamlined" or simplified approach, the practical fact is that some form of these safety and environmental rules will be applied to any commercial spaceport operation and will require coordination with the relevant Federal authorities. Positioning of the spaceport within a Federal range, e.g., CCAFS, will require compliance with the existing Air Force range safety regulations, and similar rules will be applied by the FAA to a spaceport located outside the boundaries of a Federal range.

The consensus of the knowledgeable individuals interviewed for this study is that, while admittedly somewhat burdensome, the regulations are necessary, well understood, and have been dealt with repeatedly in the past, so should not pose a major hurdle to successful operation of the commercial spaceport. What may be implied as an important element of the spaceport planning is a function to provide a linkage between the user community and the regulatory bodies, to simplify and smooth the process of obtaining the necessary licenses and permits—a "one-stop shop" approach for regulatory compliance.

MILESTONES

BUSINESS PLAN

The starting point for successful implementation of a commercial spaceport is the creation of a realistic and comprehensive business plan, based on thorough market and competitor analysis, and including all factors involved in the decision process concerning the establishment of the spaceport either on-site at Cape Canaveral or off-site at one or more independent locations. This business plan must demonstrate who the target market is; who the competitors are and what strengths and weaknesses they bring to bear on the small suborbital launch services marketplace; what niche the commercial spaceport will address; that an appropriate revenue, operations and business model and legal structure have been identified; and that the business case will close. It must also address the financial investment options and recommended approach, as well as the expected financial performance (e.g. return on investment, breakeven period, etc.) that will accrue to the State of Florida and possible private sector investors.

It should also be recognized that this business plan must be treated as a "living document," i.e., it must be regularly updated and revised to incorporate and reflect changes in the underlying assumptions, the market evaluation, and the plans and estimates for infrastructure development and spaceport operation. Rather than being an indication of poor planning or uncertainty, these regular reviews and revisions will reflect a growing maturity of FSA and the spaceport process by incorporating the best information and sharpened projections, and provide a platform for the mandatory expansion of support.

POLITICAL SUPPORT

The first benchmark for measuring the broadening of political support will be the active participation of State legislators from districts outside the traditional Space Coast area, and of the Governor's office. The commercial spaceport must be seen as a "Florida issue" rather than a "Brevard County issue", as is currently the case. As noted above, a key element in this arena will be the ability to show that there is an overall benefit to the State of Florida from the operation of the commercial spaceport and its ancillary activities. This must also show a return on the required State investment, either direct or indirect through incentives.

The second major milestone will be the tangible support of the Florida Congressional delegation in sponsoring and promoting, where appropriate, legislation to permit the "streamlining" of the regulatory compliance process as it applies to commercial spaceport operations. This will only be possible after a thorough analysis of the specific approaches developed for range safety and the other factors subject to Federal regulation, the development of viable (streamlined) alternatives, and a broad, comprehensive educational effort addressing the entire Congressional delegation and their staffs.

ADEQUATE FUNDING

FSA is a state-sponsored entity, and thus inherently enjoys some degree of operational funding from the State of Florida. The significantly greater funding requirements to support the development of a commercial spaceport, either on-site at a Federal range or off-site at another Florida location(s), will only be met following successful completion of the two prior steps outlined above, when the persuasiveness of a comprehensive and definitive business plan is backed up by broad political support at the state level for the necessary funding.

A variety of funding options are available to the State of Florida for the development of this spaceport. Using a combination of federal, state, and private sector sources has been a successful financing model for the state for other space-related facility development. The financing mechanism selected must be closely aligned with the spaceport's responsive and low-cost operating philosophy. As noted in connection with the business plan itself, this will in all likelihood be an iterative process, and will require repeated cycles of evaluation, discussion, education, and persuasion before coming to fruition.

CONCLUSION

In the current and foreseeable political, regulatory, and business climate, the obstacles for the establishment of a comprehensive commercial spaceport are formidable. This is especially true for the case of situating the spaceport within the confines of the current Federal launch ranges in Florida, which does not appear to be feasible. However, the development of a commercial spaceport does appear to be feasible when an off-site approach is considered, and assuming that some of the obstacles can be overcome.

Futron evaluated two principal alternative spaceport configurations: a "combined site", in which a complete spaceport facility is constructed to service the full range of commercial vehicle operators, both rocket-like and aircraft-like; and a "split site" approach, with separate locations and facilities for the two different types of space operations. For either approach, there will be significant associated capital investments in customer-critical spaceport-related facilities and infrastructure. These include land, runways and taxiways, launch pad and service tower (if required), roads, and utilities (water, sewer, fuel/gas pipeline, communications, and power lines). There are, however, major differences between the two configurations.

The combined site approach will require provision of the entire range of infrastructure and facilities in a single location, meaning the acquisition of more land and essentially “starting from scratch” with respect to the facility and infrastructure requirements. It will encounter the greatest obstacles in terms of cost and regulatory constraints and is therefore less feasible for FSA, or any other Florida organization, to consider.

For the split site approach, a runway/taxiway facility belonging to an existing airport would be used for the aircraft-like operations, avoiding the costly requirement for new runway and support facility construction. Spaceport construction and infrastructure thus consists only of land, launch pad and service tower (if required), roads and utilities. The split site approach is a lower cost and lower risk option, since significantly less land would be needed, especially if the class of rockets to be served is relatively small, and new infrastructure and facility requirements would be substantially less than for the combined site approach. This is a more feasible approach to a successful commercial spaceport.

There are advantages and disadvantages to either approach. However, when viewed in the framework of the current projections of potential market demand, the garnering of political support, and the practical issues of funding and implementation, it is clear that the split site option offers a much higher probability of success. The spaceport’s ultimate feasibility will still be dependent on the specific details of a business plan and its associated assumptions and conditions. If this initial feasibility is clearly demonstrated, then the State of Florida may want to create a phased development concept for spaceport construction, starting with the split site approach and including provisions for a possible migration to a complete combined site if the market development warrants such an expansion.

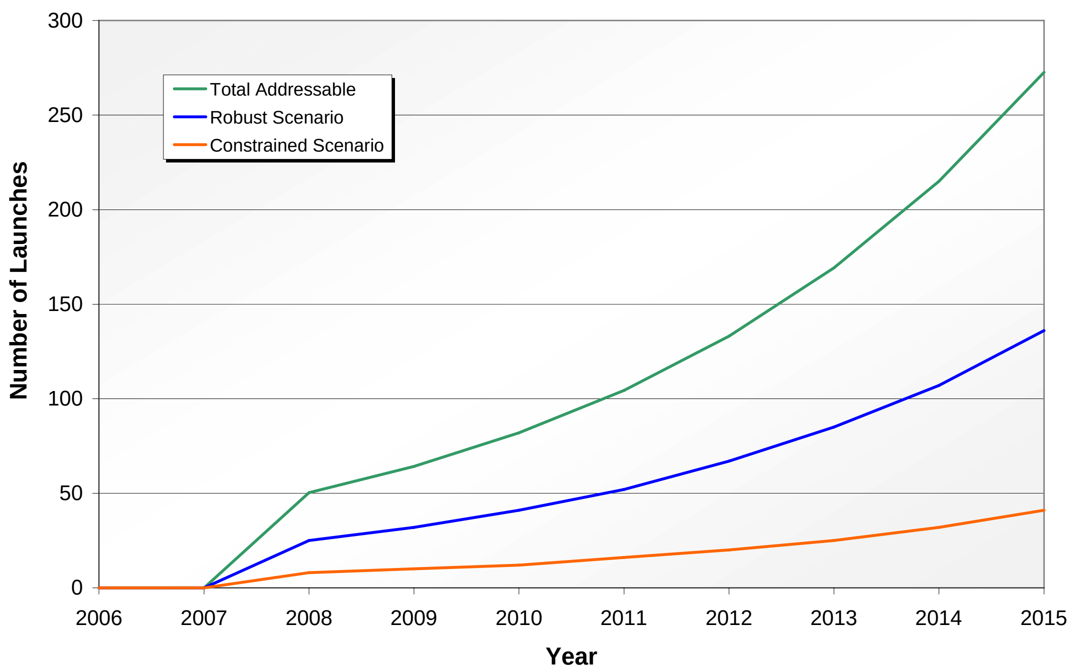
PART 2: LAUNCH FORECAST

SUMMARY

A key factor for the success of any new spaceport is the existence of a sufficient number of launches that the facility can host. To aid in this determination, this report forecasts the number of suborbital and small orbital launches, both for commercial and U.S. government customers, that could be served by a new Florida spaceport in the next ten years. This forecast includes two scenarios based on likely upper and lower limits on the fraction of such launches the facility might capture.

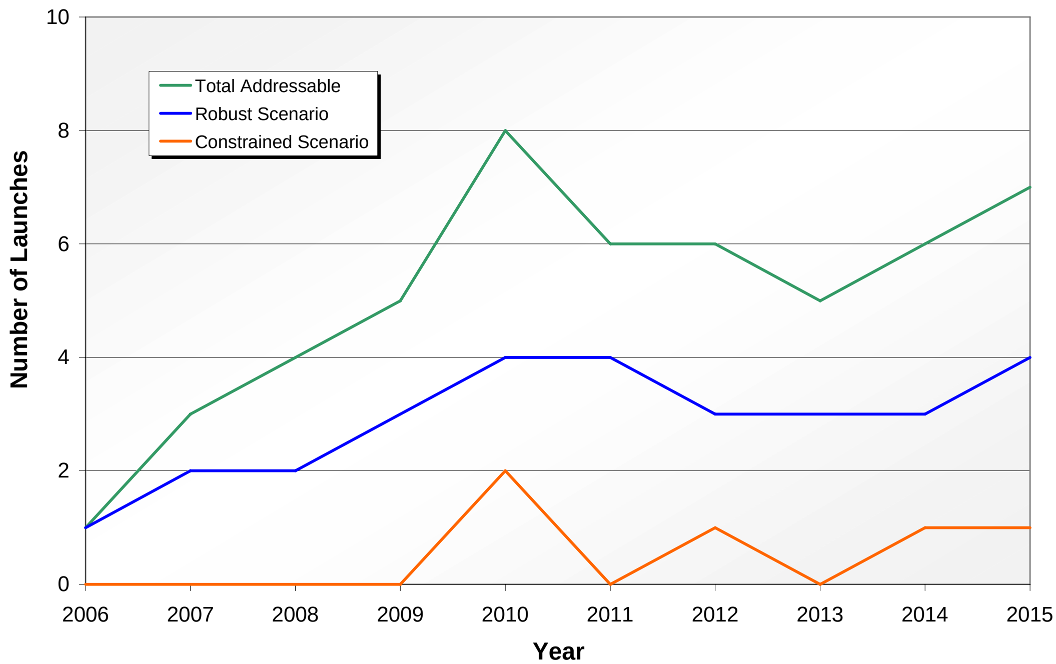
The forecast shows a dramatic difference between the suborbital and orbital markets. The suborbital market (Figure 10), driven primarily by growing demand for space tourism, is forecast to grow to over 250 launches a year by 2015, with a Florida facility likely to host between 41 and 136 suborbital flights by that time. This increase in the number of launches is based on forecast growth in passenger demand and the development of new suborbital vehicles designed specifically to serve suborbital space tourism.

Figure 10: Suborbital Launch Forecast, 2006–2015



The orbital market, however, is relatively flat by comparison; with fewer than ten addressable launches a year during the forecast period (Figure 11). Many small orbital launches worldwide cannot be served by a commercial Florida spaceport because they are either non-U.S. government missions and/or involve launching satellites into polar orbits. Even in the optimistic scenario, a new Florida spaceport would host no more than three to four launches a year, while the more pessimistic scenario calls for an average of less than one launch a year through 2015.

Figure 11: Orbital Launch Forecast, 2006–2015



Developers and operators of suborbital and orbital vehicles have larger estimates for the number of launches. Individual orbital vehicle operators predict conducting as many as 20–30 launches a year by 2015, with 25–50% of them taking place from Florida. Suborbital operators predict as many as 500 launches a year, with a similar fraction occurring in Florida.

INTRODUCTION

In addition to the requirements among potential users of a new Florida launch facility, a separate but equally important question is how much such a spaceport would be used. Even an ideally designed facility may be a failure if demand is too low to attract a sufficient level of launch activity. Knowing the amount of launch activity for the near term, and what fraction of the overall launch demand that a Florida facility could capture, is a factor in determining what launch facilities—if any—to build.

This section of the report offers a ten-year forecast for suborbital and small orbital launch vehicle activity that could use a new Florida spaceport. The potential markets range from launches of small orbital vehicles for NASA and Defense Department missions to the emerging suborbital space tourism industry. Using a variety of information sources, this analysis provides a forecast for addressable launches through 2015 as well as two scenarios for the market share of such launches that a Florida facility could obtain. These results are also compared to what vehicle developers themselves believe they will be launching, both overall and from Florida, in 2015.

METHODOLOGY

The future launch market is divided into three distinct segments: commercial suborbital, commercial orbital, and government orbital launches. (Government suborbital launches, which encompass civil sounding rocket and military missile tests, are excluded here since these are, by and large, wedded to existing vehicles and ranges and thus unlikely to shift to a new commercial launch facility.) These markets are each forecast differently, using techniques described below.

In general, the philosophy underlying these forecasts embodies a conservative approach. Past launch forecasts, particularly during the commercial boom in the latter half of the 1990s, tended to drastically overestimate the number of launches, leading to disappointment as the forecast number of launches failed to materialize. This forecast attempts to temper the enthusiasm surrounding new vehicles and markets with that past experience.

SUBORBITAL MARKETS

Commercial suborbital spaceflight is an emerging market whose development has been energized by the success of the $10-million Ansari X Prize competition, won in 2004 by Mojave Aerospace Ventures' SpaceShipOne. The primary and best-known market for commercial suborbital vehicles is public space travel, or space tourism. A number of additional markets also exist for such vehicles, including remote sensing, microgravity science, and space flight hardware qualification, but these markets have not yet been quantified to the same degree, and by all accounts are far smaller than space tourism. This forecast assumes that space tourism is the only commercial suborbital market that will drive launch demand during the forecast period.

This forecast uses Futron's *Space Tourism Market Study*, a 2002 report on the demand for orbital and suborbital space tourism. The study is based on a survey of 450 high net worth individuals performed by polling company Zogby International. Respondents were asked to indicate their interest in space tourism, their willingness to participate in such flights at various price points, and related factors. The results became the basis for the calculation of worldwide demand for space tourism through 2021.

The study's forecast for suborbital space tourism demand is used here, although the study's original start date of 2006 has been shifted to 2008 to reflect the current state of the industry and the likely introduction of commercial suborbital space tourism services. Because the study's forecast was in terms of passenger demand, two additional steps are taken here to translate that into a forecasted number of launches. First, this analysis assumes that the average suborbital space tourism vehicle will accommodate five passengers. This is based on published reports of the sizes of vehicles being contemplated, which can accommodate between one and seven passengers. Second, this analysis assumes that only half of the passenger demand will be met in any given year in the ten-year forecast. Given the growing demand for suborbital tourism during the forecast period, and the relatively gradual introduction of commercial vehicles, it seems unlikely that vehicle operators will be able to fully meet demand through the forecast period.

COMMERCIAL ORBITAL MARKETS

The commercial orbital segment of this forecast comes from the *2005 Commercial Space Transportation Forecasts*, a joint report of the FAA's Office of Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee

(COMSTAC) published in May 2005. The report provides a ten-year forecast (2005–2014) for commercial satellites and launches, based on market trends, interviews with major satellite and launch vehicle companies, and other analyses.

For this analysis we include only those launches forecast to use small launch vehicles, defined by the FAA as those vehicles capable of placing up to 5,000 pounds into low Earth orbit (LEO). This eliminates all commercial launches of geosynchronous orbit (GSO) payloads—which are too large to be launched on small vehicles—as well as some heavier LEO and other non-geosynchronous orbit (NGSO) payloads. The remaining launches primarily carry commercial communications and remote sensing satellites, as well as scientific satellites built by governments that elect to commercially procure launches. Because the *2005 Commercial Space Transportation Forecasts* report only goes through 2014, the 2015 data used in this analysis is based on an extrapolation of trends in the final years of the forecast.

Government Orbital Markets

The forecast for orbital government launches of small vehicles is derived from the Analysis of Space Concepts Enabled by New Transportation (ASCENT), a study performed by Futron for NASA between 2001 and 2003 as part of the Space Launch Initiative. ASCENT is a comprehensive forecast of orbital launch activity worldwide from 2002 through 2021, broken down by market sector, country, and vehicle class.

For this analysis, the forecast for U.S. government launches (civil and military) using small launch vehicles was extracted from the overall ASCENT forecast and updated with publicly available data. These launches primarily include NASA and Defense Department flights of small science and technology demonstration spacecraft. Also included is the Air Force's new interest in Operationally Responsive Spacelift (ORS), a program that would use small launch vehicles to launch small satellites on short notice. Because the military is still developing overall architectures for ORS, including the types of missions to be flown and the frequency of launch, it is difficult to estimate exactly how many ORS launches will take place over the next decade at this time. We have elected to take a conservative approach in estimating ORS launch activity, with the caveat that the actual number of launches could turn out to be significantly higher or lower.

Addressable Launches

The forecasts above describe the total number of suborbital, commercial orbital, and U.S. government orbital launches projected to occur over the next 10 years. However, even in a best-case scenario a Florida spaceport cannot capture all of these launches, regardless of the infrastructure available there. Existing launch contracts and the orbital requirements of some payloads will prevent some launches from taking place in Florida.

To compensate for these factors, some launches are removed from the above forecasts to provide a more accurate estimate of the total number of launches that would be addressable by a Florida spaceport. For the commercial orbital sector, those launches already manifested in the near term on vehicles operating out of other spaceports are removed, as well as those launches—primarily remote sensing missions—whose orbit requirements preclude a Florida launch. Similarly, U.S. government missions already planned for launch from other spaceports, as well as launches to orbits inaccessible from Florida, are also removed. The latter estimate is made more difficult by the military's uncertain plans for ORS, but the current emphasis on small launch vehicle designs that are easily transportable and have limited ground support requirements suggest that at least some of these are planned for locations outside Florida.

Given the relatively immature state of the commercial suborbital space tourism industry, all suborbital launches are assumed to be Florida addressable in this analysis. There is, theoretically, no reason why any suborbital launch could not take place from a Florida facility provided the proper infrastructure was in place, but practically it is unlikely a single spaceport—in Florida or elsewhere—will capture all suborbital tourism flights over the next decade.

FORECAST RESULTS

The total number of Florida-addressable suborbital and orbital launches is shown in Figure 12 below. The number of orbital launches is split evenly between commercial and government missions, while the number of suborbital launches ramps up significantly throughout the forecast period as the space tourism industry matures.

Figure 12: Total Florida Addressable Launches, 2006–2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL
Suborbital	0	0	50	64	82	104	133	169	215	273	**1091**
Orbital - Commercial	1	2	2	3	4	3	2	2	2	4	**25**
Orbital - Government	0	1	2	2	4	3	4	3	4	3	**26**
All Launches Total	**1**	**3**	**54**	**69**	**90**	**110**	**139**	**174**	**221**	**280**	**1142**

While this represents the likely upper limit on the number of launches that a Florida spaceport could support, many of these launches will take place from other facilities in the U.S. and overseas. Estimating a specific fraction of launches that will occur from Florida over the next decade is highly speculative, given the changing nature of existing and planned launch vehicles, spaceports, and launch markets. Instead, this report presents two scenarios designed to illustrate the likely upper and lower limits on launch demand for a Florida spaceport.

In the first, “robust” scenario, the Florida spaceport captures 50 percent of addressable suborbital and orbital launch demand. Fifty percent was selected for the robust scenario because it represents Florida’s greatest one-year market share over the last ten years. The number of launches, by year and market, is shown in Figure 13 below. In this scenario the spaceport would, by the middle of the next decade, host more than two suborbital launches per week. However, the number of orbital launches would remain small—three to four a year for most of the forecast period—given the relatively limited overall demand for small launches.

Figure 13: Robust Scenario for Florida Launches, 2006–2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL
Suborbital	0	0	25	32	41	52	67	85	107	136	**545**
Orbital - Commercial	1	1	1	2	2	2	1	1	1	2	**14**
Orbital - Government	0	1	1	1	2	2	2	2	2	2	**15**
All Launches Total	**1**	**2**	**27**	**35**	**45**	**56**	**70**	**88**	**110**	**140**	**574**

In the second, "constrained" scenario, the Florida spaceport captures only 15 percent of addressable suborbital and orbital demand. That fraction is similar to the average share of U.S. orbital launches, commercial and government, that have taken place from existing Florida facilities over the preceding decade. The number of launches, by year and market, is shown in Figure 14 below. In this scenario there would be only five orbital launches—two commercial and three government—from a commercial Florida spaceport during the entire ten-year forecast period. The number of suborbital launches would be greater, approaching one a week by 2015, but far smaller than either the robust forecast or the total addressable market.

Figure 14: Constrained Scenario for Florida Launches, 2006–2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL
Suborbital	0	0	8	10	12	16	20	25	32	41	**164**
Orbital - Commercial	0	0	0	0	1	0	0	0	0	1	**2**
Orbital - Government	0	0	0	0	1	0	1	0	1	0	**3**
All Launches Total	**0**	**0**	**8**	**10**	**14**	**16**	**21**	**25**	**33**	**42**	**169**

COMPARISON WITH OPERATOR ESTIMATES

The forecasts above are based on an impartial examination of the various launch market sectors, with no attempt to assign launches to specific vehicles. In addition to this forecast, however, individual suborbital and orbital launch vehicle operators have their own estimates regarding the number of launches they expect to perform. As part of the interviews conducted with these operators for Part 1 of this report, the operators estimated the annual number of launches they expect to carry out in ten years' time, as well as the fraction of those launches they predict will take place from a new Florida spaceport. All but one company interviewed for this report provided this data; the lone exception was Scaled Composites, which considers itself a vehicle developer, but does not plan to offer launch services.

In general, orbital launch vehicle operators were more forthcoming with launch estimates than suborbital vehicle operators, perhaps because of the uncertainty regarding the development of space tourism and other suborbital markets. Overall orbital vehicle operators estimated a total of 87–124 launches in 2015. Most individual companies estimated conducting between 2 and 12 launches a year, although a couple companies predicted carrying out up to 20–30 launches a year. For the suborbital market, operators estimated a total of 791–1022 flights in 2015, with individual company estimates ranging from a few dozen up to, in one case, 500. By comparison, the overall forecast calls for seven addressable orbital and 273 addressable suborbital launches in 2015.

That optimism remains, but is diminished somewhat, when operators estimate the share of launches they predict to take place from Florida. Only about half of the operators interviewed offered an estimate on the fraction of launches they estimate would occur from Florida; those who did typically estimated a range of 25–50%. One orbital vehicle company said they did not anticipate conducting any launches from Florida, while one suborbital operator believed they could carry out all their launches from Florida if a spaceport there met their needs and was cost-effective. Overall, companies estimated that they would carry out 9–22 orbital and 70–310 suborbital launches from Florida in 2015, as shown in Figure 15. These figures are closer to the forecast estimate, particularly for suborbital launch activity, but are still considerably higher than the number of small orbital launches from Florida in 2015.

Figure 15: Comparison of Developer Estimates and Forecast Scenarios for 2015 Launches

	Developer Estimates		Launch Forecast	
	Total Launches	Florida Launches	Addressable Market	Florida Scenarios
Orbital	87-124	9-22	7	1-4
Suborbital	791-1024	70-310	273	41-136

The developer estimates, while high, may still be somewhat "low" in the respect that not all vehicle developers were interviewed for this study, and many of those who were did not provide an estimate of the fraction of launches they believe could take place from Florida. It should be noted that while the aggregate sum of predicted launches from all the companies interviewed is much higher than the forecast, in most cases the number of launches each company predicts is not unreasonable, if one assumes that that company will obtain a predominant share of the overall market. While each company may predict success in the launch market, past experience shows that only a handful of launch ventures will meet their expectations.

CONCLUSION

The overall launch forecast offers diverging outcomes for orbital and suborbital launch activity. The relatively low demand for small orbital launch vehicles means that, even in a robust scenario, a Florida spaceport could hope to host only a few such launches a year. On the other hand, the strong demand for suborbital space tourism could result in dozens of flights a year even if Florida captures only a small fraction of the total addressable market. Vehicle operators in general tend to be more optimistic about both the orbital and suborbital markets.

There are a number of factors that could increase or decrease the number of launches independent of the development of a new Florida spaceport. If companies like SpaceX are successful in producing reliable, low-cost small launch vehicles, such vehicles could generate additional demand for launches from university, commercial, and government satellite developers not currently forecast. However, if suborbital launch vehicle companies encounter technological, financial, or regulatory problems with the development of their vehicles, it could depress the forecast for suborbital space tourism and/or delay the introduction of the market. These and related issues must be monitored in the years to come in order to gauge their effect on overall launch demand.

PART 3: ECONOMIC IMPACT

SUMMARY

The commercial spaceport has the potential to impact the State of Florida by realizing from $6.3-$17.4 million of additional economic activity and from 35-115 new jobs from suborbital and orbital spaceport operations in 2010, depending on the market share captured by Florida (see Figure 23). In 2015, the total economic impact, from both spaceport operations and tourism expenditures, grows to $8.7-$29.7 million of economic activity and 60-200 new jobs, as shown in Figure 16. Suborbital and orbital operations impacts account for the majority of the new economic activity and jobs, realizing from $7.4-$25.4 million of additional economic activity and 50-165 new jobs in 2015. The principal driver of economic impacts is the growing suborbital space tourism market. Tourism-related impacts derived from suborbital passenger spending are gauged to range from $1.3-$4.3 million and 10-35 new jobs in 2015. Additional economic impacts from vehicle operator spending, launch vehicle and satellite manufacturing, and satellite services are estimated to be relatively small during this timeframe, and are difficult to quantify.

Figure 16: Economic Impacts of the Florida Commercial Spaceport (2015)

		Economic Impact		
	Scenario	Economic Activity ($M)	Earnings ($M)	Jobs
Suborbital Operations	Constrained	$6.1	$1.5	40
	Robust	$20.1	$5.1	130
Orbital Operations	Constrained	$1.3	$0.3	10
	Robust	$5.3	$1.3	35
Tourism (suborbital passengers only)	Constrained	$1.3	$0.3	10
	Robust	$4.3	$1.1	35
Total	Constrained	**$8.7**	**$2.1**	**60**
	Robust	**$29.7**	**$7.5**	**200**

Spaceport construction-related impacts depend on which facility configuration is selected. For a complete facility with a new, dedicated runway and vertical launch pad with tower (combined site), the economic impact is anticipated to be approximately $554-$830 million of additional economic activity, and 3,865-5,800 cumulative new jobs during 2006-2008. A scaled-down facility consisting only of a vertical launch pad with tower and associated infrastructure (split site, utilizing an existing runway) generates a reduced level of impact of $31-$84 million and 220-580 new jobs (see Figure 17). Job creation related to construction activities is expressed in terms of full-time equivalent positions, and applies only to the three-year construction period. Construction-related impacts are not dependent on achieved market share.

Figure 17: Economic Impacts for Construction of the Florida Commercial Spaceport (2006-2008)

	Economic Impact		
	Economic Activity ($M)	Earnings ($M)	Jobs
Combined Site	$554-830	$138-207	3,865-5,800
Split Site	$31-84	$8-21	130

The spaceport is assumed to begin operations in the year 2008. Economic impacts for spaceport operations were calculated for the State of Florida for the operating years 2010 and 2015. All calculations are derived from the suborbital and orbital market projections for 2006-2015 presented in Part 2, which reflect Florida market share capture estimates of 50% (robust scenario) and 15% (constrained scenario). All economic impact figures represent current then-year dollars (deflated at an annual rate of 3.0 percent, the long-term rate of inflation).

INTRODUCTION

The launch forecasts described in the previous section provide a means of determining how much a future commercial spaceport in Florida would be utilized. However, another important metric is the effect of those spaceport operations on the state's economy. The economic impact of the construction and operation of the spaceport, measured in terms of the revenue it will generate and the number of jobs it will create, will likely be a key factor in the decision-making process regarding the development of such a facility.

To aid in that process, this section of the report provides a forecast of the economic impact generated by both spaceport construction activity and subsequent suborbital and small orbital launch operations. Futron's analysis employs a tested input-output economic model for gauging the total impact of new industrial projects, surveys of spaceport and airport construction costs, vehicle operator expectations of spaceport facility use fees, and the construction of a spaceport revenue model. Finally, we compare the projected total economic impact (output and jobs) of this project against impacts of spaceports and airports of interest elsewhere in Florida and the United States for purposes of perspective.

METHODOLOGY

Futron employed the Regional Input-Output Modeling System II (RIMS II) developed by the U.S. Department of Commerce's Bureau of Economic Analysis to calculate the anticipated economic impacts of spaceport construction, operations, and tourism. RIMS II tracks the regional flow of goods and services to determine the interconnection of producers and consumers, and it measures individual industries' contribution to regional economies. Quantitative economic impacts reported in this section refer to the goods and services demanded by the regional economy as a result of new "final demand" generated by spaceport construction and commercial operations activities.

Futron utilized the North American Industry Classification System (NAICS) codes to determine the appropriate RIMS II multipliers for the State of Florida. Figure 18 displays the multipliers used to calculate the potential economic impacts of the spaceport. The multipliers chosen in this study were those associated with industry sectors "Construction", "Airport Operations," and "Hotels and Motels"; we considered commercial airport operations activities a close analogue to future commercial spaceport operations activities from a business model perspective. Economic impacts were calculated for the regional economy of the State of Florida.

Figure 18: Florida Economic Impact Multipliers, RIMS II Model

				Multipliers		
NAICS Code	Spaceport Activity Category	RIMS II Industry Sector Description	Subsectors Included	Economic Activity (Output)	Earnings	Employ-ment
230000	Spaceport construction	Construction	Site preparation contractors; industrial building construction; highway, street and bridge construction; power and communication line and related structures construction; water and sewer line and related structures construction; oil and gas pipeline and related structures construction	**2.99**	**0.74**	**23.46**
48A000	Spaceport operations	Scenic and sightseeing transportation, and support activities for transportation	Airport operations	**3.07**	**0.78**	**22.39**
7211A0	Suborbital passenger spending, vehicle operator crew spending, and orbital customer crew spending	Hotels and motels, including casino motels	Hotels and motels	**2.57**	**0.63**	**25.23**

Because RIMS II is a static model, the same multipliers were used for each year the economic impacts were estimated (2006-2008 for construction, 2010 and 2015 for operations). The changes in operations-related economic impacts are due to increases in the estimated flight rate (and number of passengers) over a ten-year period (based on the 2006-2015 market assessment presented in Part 2), and assumed reductions in facility usage fees charged commercial vehicle operators over this same timeframe.

Economic impacts are measured in terms of economic activity (revenues or output), earnings and jobs, as defined below. Cumulative impacts were calculated for construction of the spaceport over a period of three years, and three- and eight-year impacts were calculated for operations of the spaceport (2010 and 2015).

The following definitions of terms are useful in understanding the economic impact methodology:

- **Economic activity (or output)** is the total additional dollar value of goods and services produced in an economy as a result of the increase in final demand due to the particular project under consideration. Each additional dollar delivered to final demand for a good or service generates a (multiplier x $1 dollar) change in output for all of the input industries required to produce the final good or service. Direct, indirect, and induced economic activity is included in the multiplier used.

- **Earnings** are the sum of all wages and salaries (including employee benefits) paid to employees in an economy as a result of the increase in final demand due to the project under consideration. Each additional dollar delivered to final demand for a good or service generates a (multiplier x $1 dollar) change in earnings for all employees of the input industries required to produce the final good or service. Direct, indirect, and induced earnings are included in the multiplier used.

- **Jobs** refer to the total number of additional (full-time equivalent) workers employed to produce goods and services as a result of the increase in final demand due to the project under consideration. The jobs multiplier is in terms of new total jobs generated per million dollars of additional final demand. Direct, indirect, and induced employment is included in the multiplier used.

RIMS II employs a top-level approach to determining regional economic impacts of new projects. Costly empirical “bottom-up” surveys conducted by the Department of Commerce have demonstrated that the RIMS II model can overestimate impacts by as much as 10%.[1]

Spaceport Construction

Estimates of the economic impacts of spaceport construction depend on which spaceport configuration is selected for development. As discussed in Part I, Futron has identified two principal configurations for an off-site facility: a combined site and a split site. For the combined site, a complete spaceport facility is constructed to service the full range of commercial vehicle operators; this option includes the construction of a dedicated 10,000-foot runway and associated taxiways. In the split site, a runway/taxiway facility owned by an existing commercial airport is used, such that new runway construction is avoided; spaceport construction and infrastructure thus consists only of land, launch pad and vertical tower, hangar, roads, and utilities.

The State of Florida may elect to adopt a phased approach to spaceport construction, starting with a split site and later migrating to the complete combined site once the market for space tourism is proven. The combined site is a lower-cost and lower-risk option that saves the State of Florida a capital expenditure of approximately $175-$250 million for runway construction.

Estimates for spaceport construction economic impact are provided on a cumulative basis for the period 2006-2008. Revenue, earnings, and employment impacts are generated from our estimates of spaceport development costs (see Part 1) summed over the three-year construction period. The RIMS II construction sector final demand multipliers for “Construction” (see Figure 18) are then applied.

[1] Department of Commerce, Bureau of Industry and Security, http://www.bxa.doc.gov/DefenseIndustrialBasePrograms/OSIES/DefMarketResearchRpts/TSVReportAppendix.htm

All of the economic activity, earnings, and employment impacts are not necessarily sustained at a constant rate for each year, nor are they indicative of future impacts that may occur beyond the initial three-year construction period. Jobs are expressed in terms of numbers of full-time equivalent positions at the construction firms, and indirect and induced jobs within other industrial and service sectors providing inputs to the spaceport construction activities during the three-year period under consideration. These jobs may not be sustained once construction is completed.

Land purchase expenditures were not included in the calculation of construction-related economic impact, because purchase costs can vary widely, depending on the site location and acreage, and this transfer of legal ownership is deemed to have little additional effect on job creation.

Spaceport Operations

Spaceport operations-related economic activity includes spaceport facility operations and commercial vehicle operator flight and flight preparation activities. In order to measure the quantitative economic impact of spaceport operations in the State of Florida, Futron estimated annual spaceport-related revenues resulting from both suborbital and orbital launch activity. Projected final demand here is taken as the spaceport revenues generated through commercial launch operations, principally in the form of facility usage fees charged to vehicle operators on a per-flight basis; these revenues are expected to be spent mostly in-state. In contrast, operator vehicle revenues are anticipated to flow largely out-of-state (in the form of profits and expenses such as hardware purchase or depreciation, financing and administrative costs), as all small vehicle manufacturers currently are located outside of Florida (see Figure 20). We anticipate, therefore, that vehicle operator revenues will generate little economic impact in the state, and that using the full value of launch prices charged to suborbital and orbital customers would overestimate spaceport-related economic impact in Florida.

SPACEPORT REVENUE MODEL AND FACILITY USAGE FEE STRUCTURE

Futron constructed a spaceport revenue model in an effort to estimate spaceport income for 2010 and 2015. Inputs to this model were the suborbital and orbital launch market forecasts for the 2006-2015 period (see Part 2), as well as a range of facility usage fees likely to be charged to customers. A high-low range for suborbital and orbital usage fees was determined on the basis of interviews with vehicle operators, a survey of existing launch range fees at government and commercial spaceports, an assessment of likely facility operating expenses to be incurred in locating suborbital activities at a commercial airport, and an assumption that the typical suborbital operator would be flying an average of five passengers per flight at approximately $200,000 per passenger (for a total revenue of $1.0 million per flight) during the initial years of commercial operation (see Figure 19).

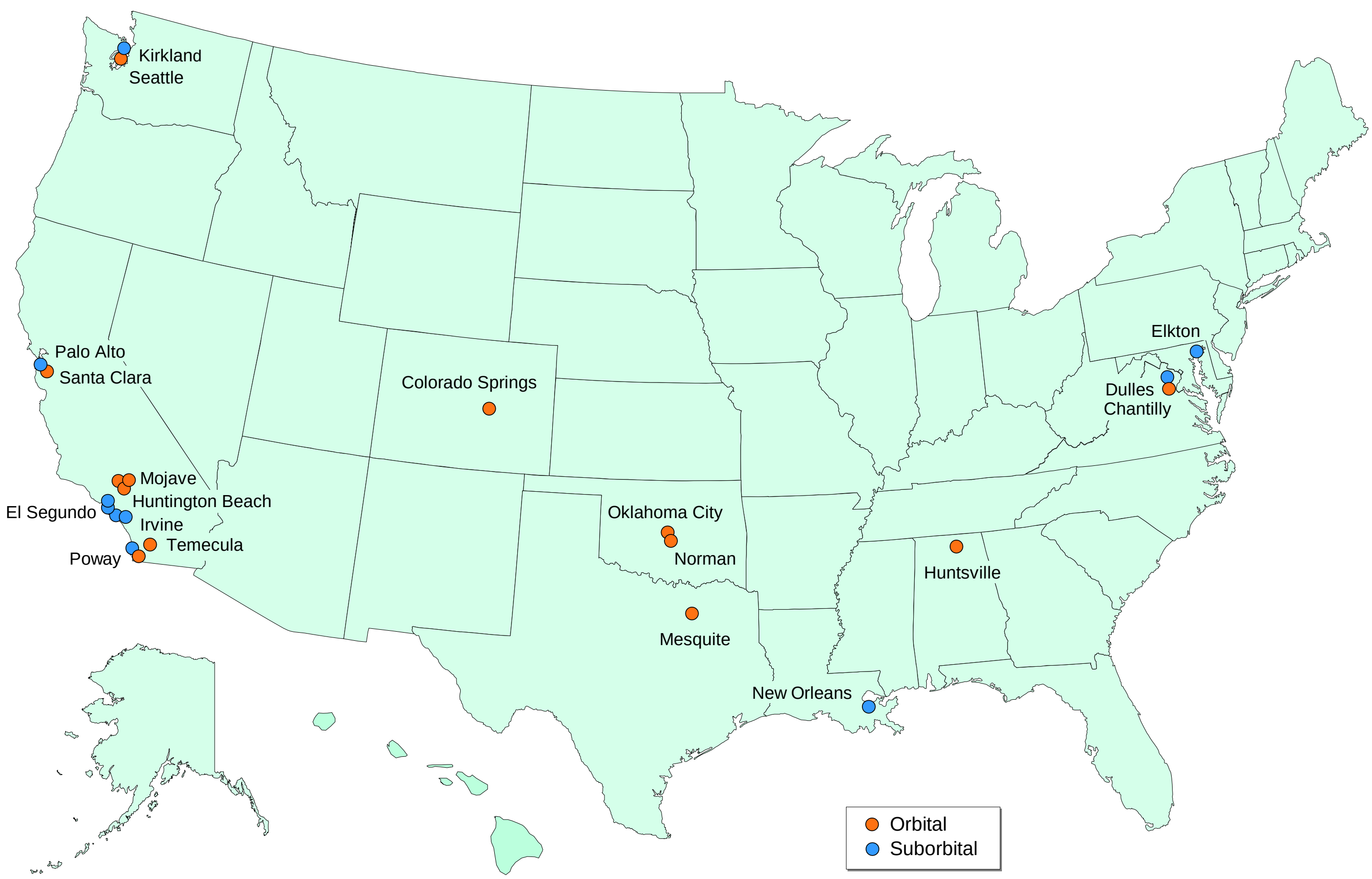
Figure 19: Spaceport Facility Usage Fees Employed in Spaceport Revenue Model

	Low	High
Suborbital Flights	$50,000	$100,000
Orbital Flights	$200,000	$450,000

From these inputs, Futron estimated that suborbital operators would be willing to accept facility usage fees in the range of 5-10% of passenger revenues, or $50,000-$100,000 per flight during 2008-2010, assuming total operator revenues per flight of $1 million; during 2010-2015, we project that suborbital facility usage fees decline by 50% to $25,000-$50,000 per flight, commensurate with an assumed reduction in price per passenger of 50% over this same period to $100,000. Orbital launch vehicle operators, faced with a smaller, less diverse customer base, lower flight rate, reduced price elasticity of demand, and more intensive utilization of range infrastructure, can support higher spaceport facility usage fees, which we estimated to be in the range of $200,000-$450,000 per flight. Orbital launch fees are expected to remain fairly constant through 2015, reflecting a stable market and relatively low flight rate.

Separate economic impact estimates are presented for suborbital and orbital launch activity, commensurate with their differing infrastructure requirements, market forecasts, launch rates and spaceport facility usage fee structures.

Figure 20: Map of United States Launch Vehicle Manufacturer Development Headquarters



LAUNCH VEHICLE OPERATOR SPENDING

Suborbital and orbital vehicle operator spending, which includes local crew payroll expenses, fuel purchases, and possibly administrative/legal/banking/accounting expenditures, for example, are not included in these economic impact estimates, due to their comparatively small levels and the high degree of uncertainty as to how commercial operators will conduct operations in Florida. It is anticipated that in the initial years of operation, when the flight rate is low, suborbital operators may choose to minimize local expenses by maintaining their crews outside Florida, and then flying in such personnel on an as-needed basis. Orbital launch vehicle operators are expected to maintain small crews in Florida only for the duration of a given launch campaign, which we anticipate to last a maximum of two weeks for the class of launch vehicles expected to be captured by the spaceport.

For these reasons, the economic impact results presented below are deemed to underestimate the economic activity, earnings, and employment impacts of spaceport operations activities.

We have assumed that the new commercial spaceport does not capture suborbital or small orbital launch customers from NASA KSC or Cape Canaveral; the determination of total economic impact does not, therefore, need to take into account a reduction in spaceport operations activities at these government facilities.

TOURISM, MANUFACTURING, AND SERVICES

In addition to impacts generated by commercial spaceflight operations, there exist several second-order activities such as tourism, vehicle and satellite manufacturing, and satellite services. Tourism-related activity includes space tourism passenger accommodations, meals, car rentals, and entertainment spending before, during, and after their space flight. Vehicle and satellite manufacturing refers to the placement in Florida of existing or new spacecraft design, test, assembly, and integration businesses in order to leverage the close proximity of commercial suborbital and orbital flight operations out of the spaceport. Satellite services are services such as GPS and broadcasting which also relocate, expand, or start up in Florida as a result of spaceport activities.

Of these, tourism is most likely to show an impact within the selected ten-year timeframe, as passengers flying out of the spaceport extend their stays in Florida by a few days to vacation at the beach or in cities such as Orlando, Fort Myers, and Miami. We assume that such visitor spending is in addition to their purchase of seats on suborbital flights.

Futron estimated an order-of-magnitude goods and services final demand for tourism-related spending based on the above-mentioned space tourism market projections (see Part II), an approximate visitor length of stay, and visitor vacation spending-per-day statistics for Miami International Airport. We employed here the RIMS II multiplier for the “Hotels and Motels, including casino hotels” industry sector (see Figure 18).

ECONOMIC IMPACT RESULTS

SPACEPORT CONSTRUCTION

The State of Florida will generate significant new economic activity and jobs as a result of building the spaceport during 2006-2008. As shown in Figure 21, construction of customer-critical runway/taxiway, vertical launch pad and tower, roads, and utilities infrastructure could bring from $554-$830 million (combined site, new runway) to $31-$84 million (split site, no new runway) of additional economic activity, and from 3,865-5,800 (combined site) to 220-580 (split site) new jobs to the State of Florida, through year three of the spaceport build-out phase.

Figure 21: Economic Impact of Spaceport-related Construction, Cumulative 2006–2008

	Economic Activity ($M)		Earnings ($M)		Jobs	
Spaceport Configuration	Low	High	Low	High	Low	High
Combined Site	$554	$830	$138	$207	3,865	5,800
Split Site	$31	$84	$8	$21	220	580

Impacts resulting from the demand for construction of the spaceport will create jobs in construction, related building and materials industries, and in other industries that provide inputs to the construction sector. This does not imply, however, that these jobs will necessarily be sustained beyond completion of spaceport construction activity that occurs within the projected three-year build-out phase.

These economic impact estimates are based upon our assessment of cumulative three-year construction costs for both spaceport configurations, as follows (see Figure 22):

Figure 22: Spaceport Development Cost Estimates, 2006–2008 (Combined and Split Sites)

Infrastructure Category	Comments	Estimated Cost ($M) Low	Estimated Cost ($M) High
Land Development		Dependent on size and location of spaceport	Dependent on size and location of spaceport
Runway (Combined site only)	10,000 feet by 200 feet, with taxiway and utility infrastructure	$175.0	$250.0
Vertical Launch Pad and Tower		$5.0	$15.0
Hangar	50,000 square feet	$4.5	$10.0
Roads	Cost per mile estimated at $850K to $1.6M	Dependent on size and location of spaceport	Dependent on size and location of spaceport
Utilities Infrastructure	Water, sewer, power, communications, fuel/gas	Dependent on size and location of spaceport	Dependent on size and location of spaceport
Environmental Impact Study	Based on New Mexico Spaceport estimate; Mandated by federal law	$1.0	$3.0
Combined Site Total		**$185.5**	**$278.0**
Split Site Total		**$10.5**	**$28.0**

As mentioned above, land purchase expenditures were not included in the calculation of economic impact.

Futron notes that additional costs for land development, roads and utilities infrastructure depend on facility location and size, and are thus not included in the impact assessment. A range safety and telemetry system may also be required to support some orbital launch customers.

Total capital investment costs are thus estimated at approximately $185-$278 million (combined site) and $10-$28 million (split site) over this three-year period, excluding land purchase costs. The subsequent addition of facilities such as administration and payload processing/integration buildings, or range and telemetry systems, would increase the total construction-related impact beyond these initial estimates, and extend such impact beyond 2008.

Spaceport Operations

Suborbital space tourism-related spaceport operations will generate about $3.6-$12.1 million of additional economic activity and about 20-80 new jobs in the State of Florida in 2010, depending on the market share capture scenario (see Figure 23); by 2015, this impact is projected to increase to approximately $6-$20 million and 40-130 new jobs, depending on the market share scenario under consideration (see Figure 24).

Orbital spaceport operations will generate about $2.7-$5.3 million of additional economic activity and about 15-35 new jobs in the State of Florida in 2010 (see Figure 23); by 2015, this impact is projected to change to approximately $1.3-$5.3 million and 10-35 new jobs, depending on the market share scenario under consideration, as a result of a projected decline in total orbital launches in 2015 vs. 2010 (see Figure 24).

Figure 23: Economic Impacts Generated by Spaceport Operations (2010)

Launch Market	Market Share Scenario	Economic Activity ($M)	Earnings ($M)	Jobs
Suborbital	Constrained (15%)	$3.6	$0.9	20
	Robust (50%)	$12.1	$3.1	80
Orbital	Constrained	$2.7	$0.7	15
	Robust	$5.3	$1.3	35
Total	**Constrained**	**$6.3**	**$1.6**	**35**
	Robust	**$17.4**	**$4.4**	**115**

Note: Economic impact results are stated for high-end facility use fees: $100,000/launch (suborbital), $450,000/launch (orbital).

Figure 24: Economic Impacts Generated by Spaceport Operations (2015)

Launch Market	Market Share Scenario	Economic Activity ($M)	Earnings ($M)	Jobs
Suborbital	Constrained (15%)	$6.1	$1.5	40
	Robust (50%)	$20.1	$5.1	130
Orbital	Constrained	$1.3	$0.3	10
	Robust	$5.3	$1.3	35
Total	**Constrained**	**$7.4**	**$1.8**	**50**
	Robust	**$25.4**	**$6.4**	**165**

Note: Economic impact results are stated for high-end facility use fees: $50,000/launch (suborbital), $450,000/launch (orbital). Use fees for suborbital launches are forecast to decline by 50% from 2010, however use fees for orbital launches are forecast to remain the same.

As mentioned above under Methodology, these impacts vary greatly with the spaceport facility usage fee structure assumed. Doubling the per-flight suborbital fee to $200,000 (during 2008-2010) would double the associated (suborbital) output, earnings and jobs impacts shown above; halving such fees by 50% to $50,000 (2008-2010) would reduce such impacts by half. The variance in these estimates is a result from adherence to the robust and constrained market share scenarios presented in Part II.

These impact figures for spaceport operations underestimate the additional economic activity, earnings, and jobs generated by the spaceport facility because they exclude the impacts accruing to local spending by suborbital and orbital vehicle operators for crew, maintenance, fuel, and management services.

TOURISM, MANUFACTURING, SERVICES

Tourism-related final demand is projected to be relatively small during the 2008-2015 timeframe under consideration. Futron estimates that by 2015, annual tourism-related direct spending by space tourism passengers and their families will be in the neighborhood of $0.5-2 million, with total economic impacts on the order of $1.3-$4.3 million and 10-35 new jobs (see Figure 25). These estimates assume visitor vacation spending per day of $175 per person, visit durations of one week, and that one family member accompanies each passenger to Florida. These figures may underestimate the extent of tourism-related impacts due to potentially higher average daily spending levels by wealthy passenger-tourists; they also do not include impacts due to sales of spaceflight merchandise and memorabilia, which are expected to be small, or out-of-state visitors coming to Florida to watch launches at the new spaceport, which are also expected to be of negligible impact.

Figure 25: Economic Impact of Tourism Spending, Suborbital Operations (2015)

Market Share Scenario	Economic Activity ($M)	Earnings ($M)	Jobs
Constrained Scenario	$1.3	$0.3	10
Robust Scenario	$4.3	$1.1	35

Impacts from launch vehicle and satellite manufacturing, and satellite services are anticipated to be negligible during the study period, given the historical difficulty of attracting new high technology businesses to Florida. Of these, attracting suborbital launch vehicle design and manufacturing to Florida appears to have the greatest chances of success, given the spaceport's proximity. Economic development and industrial incentive policies recommended by the recently-established Commission on the Future of Space and Aeronautics in Florida will have a large impact on the ability of Florida to attract or expand such aerospace and telecommunications enterprises (and associated workforce requirements) interested in building upon the existing commercial spaceport infrastructure and suborbital launch activities.

COMPARISON WITH RELATED SPACEPORTS AND AIRPORTS

We provide in Figure 26 below economic impact estimates for related spaceport and airport projects in Florida and other states for purposes of comparison. The Florida commercial spaceport impacts during the initial years of operation are quite modest in relation to those of other well-established airports and government and commercial spaceports. This is to be expected at the start of a new (commercial space tourism) industry characterized by a high level of uncertainty and risk, strong competitive pressures to keep costs and staffing at low levels, and a corresponding lack of experience.

Figure 26: Economic Impacts of Spaceports and Airports of Interest

Project		Economic Impact: Economic Activity	Economic Impact: New Jobs
Florida Commercial Spaceport (2015)			
Flight operations only, suborbital & orbital	Constrained Scenario	$ 7.4 M	50
	Robust Scenario	$ 25.4 M	165
(Excludes operator spending and tourism-related impacts)			
Alaska Kodiak Launch Center (2004) [1]			
Flight operations and construction (1 orbital flight)		$ 19.9 M	125 (Full-time & Part-time)
Miami Intl. Airport/Miami-Dade Airports (2003) [2]			
Passenger & air cargo operations		$ 7.7 B	77,000
Tourism spending impact (7.1 M visitors)		$ 8.7 B	157,000
NASA KSC (2004) [3]			
Flight operations and non-ops activities		$ 3.3 B	33,000
Tourism spending impact (901,000 visitors)		$ 25 M	688 (KSC only)

[1] Alaska Aerospace Development Corporation Report: *Economic Impact of the Alaska Aerospace Development Corporation on the Kodiak Island Borough*, May 2005.
[2] Miami International Airport Report: *Economic Impact of Miami-Dade County's Systems of Airports,* 2004.
[3] NASA Report: *Economic Impact of NASA in Florida FY2004*, 2004.

It is important to place these comparative economic impact estimates in context. Miami International Airport and NASA Kennedy Space Center are well-established commercial and government airport and spaceport facilities, with 50 or more years of operational experience behind them, and a proven diversified customer base of commercial airlines and government launch programs. The traffic passing through these facilities, in the form of vehicle flights, passengers, and visitors, represents a mature market for their services, which is decades old and much larger than the near-term space tourism market addressed by the new commercial spaceport. The State of Florida should exercise caution in making direct comparisons between a new commercial spaceport with only seven years of operational experience (in 2015) serving a nascent high-end market, and much larger and well-established commercial and government airports and spaceports.

It is worth noting that projected economic impacts are frequently offset by state, county, or municipal tax incentives offered to companies interested in locating their business to a new market. In such cases, the attendant loss of government tax revenues due to such incentives reduces somewhat the total additional final demand for goods and services accruing to the project under consideration.

CONCLUSION

Cost/Benefit Comparison of Spaceport Configurations

The foregoing analysis presents the results of Futron's estimate of economic impact for a commercial spaceport under constrained and robust market share scenarios. It is useful to consider such impacts in light of the total upfront capital investment required to develop the critical supporting facilities (see Figure 27).

Figure 27: Cost/Benefit Comparison of Spaceport Configurations

Spaceport Configuration/Activity		Upfront Cost: Capital Investment ($M)	Economic Impact: Economic Activity ($M)	Economic Impact: Jobs
Combined Site				
2006 - 2008	Construction	**$185.5 - $278**	$554 - $830	3,865-5,800
Split Site				
2006 - 2008	Construction	**$10.5 - $28**	$31 - $84	220-580
Operations and Tourism				
2015	**Suborbital Operations**			
	Constrained Scenario		$6.1	40
	Robust Scenario		$20.1	130
2015	**Orbital Operations**			
	Constrained Scenario		$1.3	10
	Robust Scenario		$5.3	35
2015	**Tourism (suborbital passengers only)**			
	Constrained Scenario		$1.3	10
	Robust Scenario		$4.3	35
Total 2015	**Constrained Scenario**		**$8.7**	**60**
	Robust Scenario		**$29.7**	**200**

It is important to note that the economic activity and jobs impacts are realized in all industry groups throughout the State of Florida providing inputs to construction and spaceport operations activities. Only a portion of these dollars will be available to directly offset the upfront capital investment.

Divergent Spaceport Business Models

The Florida commercial spaceport business model will differ greatly from those of existing government-run spaceports in Florida. The initial customer base will likely consist of mostly space tourism start-up companies with a strong focus on passenger total experience, flexibility of use, and streamlined operations. Jobs generated as a direct result of spaceport operations, both by commercial vehicle operators and the spaceport facility, are expected to include a mix of part-time and full-time positions, reflecting suborbital flight activity restricted principally to weekends, at least during the first year or two of operation. As the tourism market matures, we can expect to see more operators utilizing the spaceport, and a shift in the mix of employees towards an increasing proportion of full-time positions. Orbital flight operations will not be largely restricted to weekend timeslots, and may balance spaceport utilization and staffing schedules to include more weekday and full-time activity.

A strong focus on low-cost commercial operation is expected to exert a consistent downward pressure on employee wages, salaries, and benefits, both at vehicle operator firms and among spaceport facility staff. State of Florida agencies should, therefore, not expect the commercial spaceport to generate jobs with salaries and wages (and tax receipts) comparable to earnings levels currently enjoyed by NASA and Air Force personnel at KSC and Cape Canaveral.

Futron also considered the above commercial spaceport economic impact estimates from the perspective of Florida policy- and decision-makers in search of new industrial infrastructure projects which can offset the potential loss of aerospace jobs in coming years. We anticipate that the divergent spaceport business models, together with the fact that the new generation of commercial suborbital and orbital vehicles is expected to sustain far lower operations costs and associated jobs than traditional NASA space vehicles, will impact the ability of the commercial spaceport to significantly offset the potential loss of jobs at Florida government-run spaceport facilities, at least during the initial ten years of operation.

Spaceport Facility Usage Fee Structure

The total economic impact of the spaceport depends heavily on the operations/facility usage fees charged to suborbital and orbital vehicle operators by the spaceport. These fees should be set a level that enables the State of Florida to cover spaceport operations and financing expenses, and future investment, and capture a reasonable portion of the passenger revenues accruing to the commercial operators. Spaceport revenues are expected to remain in-state, as opposed to the (higher) end-user flight prices charged to passengers and payload customers, most of which we have assumed will be spent out-of-state in the form of profits and vehicle amortization and financing charges.

Futron has estimated economic impacts for two levels of spaceport fees: $50,000 and $100,000 per suborbital flight (during 2008-2010, declining to $25,000 and $50,000 by 2015), and $200,000 and $450,000 per orbital flight. **It is important to note that these estimated fees may or may not cover actual operating and financing costs of the spaceport.** An assessment of a feasible facility usage fee structure should be conducted as part of the creation of a spaceport business plan.

Spaceport Business Plan

Development of a formal business plan is the next step on the path to a go/no-go decision on the State of Florida commercial spaceport. The business plan is needed to assess the threats, strengths, and weaknesses of competing spaceports; to lay out an appropriate business strategy consistent with Florida economic development policy and goals; and to accurately estimate spaceport operating and financing expenses, and a spaceport fee structure sufficient to cover these costs; provide services competitive with those of other state and international commercial spaceports; and support future investment in Florida's space transportation infrastructure. The business plan should detail spaceport-financing options and instruments, capital costs, projected return on investment, payback period, break-even point, and the associated pro-forma financial statements (Income Statement, Balance Sheet, Statement of Cash Flows). Finally, the business plan process is an important opportunity to develop consensus within Florida's key agencies as to how the entity should be structured from a legal perspective (state-run vs. private), and as to how day-to-day operations at the facility ought to be conducted.

SUBORBITAL LAUNCH VEHICLE MANUFACTURING

The location of a major commercial spaceport dedicated to suborbital launch operations may provide an influential incentive to start-up companies and established firms seeking to establish a design and manufacturing base for their vehicles. Such a development would support Florida's stated objective of strengthening its manufacturing base and diversifying its economy outside the traditional service sector. It is in Florida's long-term interest to offer suborbital vehicle operators attractive terms (on spaceport facility usage fees, for example) to conduct operations in Florida; sharing operating costs among several commercial operators not only keeps usage fees low through economies of scale, but also builds a potential critical mass to locate suborbital and orbital vehicle R&D, design, and manufacturing facilities in-state, in close proximity to the spaceport.

CONCLUSION

More than technical issues, political and regulatory obstacles render converting part of Cape Canaveral into a commercial spaceport infeasible. Cape stakeholders, including the Air Force, NASA, and related parties at the state and national level, prefer not to share Cape facilities with, or relinquish operational authority to, a commercial spaceport venture. Moreover, the federal mandate that Cape Canaveral prioritize launches in the national interest reduces the appeal of a Cape-located commercial spaceport among potential customers, for whom launch flexibility and schedule reliability is a primary concern. This, taken with the perception that Cape Canaveral's safety and other regulations pose challenges, makes a Cape-located commercial spaceport impractical from the standpoint of vehicle operators as well as government interests.

However, building a commercial spaceport elsewhere in Florida would mitigate many of the issues associated with adapting Cape Canaveral, foster a new space transportation market in Florida complementary to the Cape's, and promise economic benefits for the state. An offsite spaceport operated by FSA would eliminate the need to share facilities with government and military operators. This would permit the operational flexibility and dedicated service commercial operators need to successfully market their vehicles. Such launch assurance would allow Florida to compete in the emerging commercial space market. A new FSA spaceport would allow Florida to more fully realize its reputation as a space state by providing a service in harmonious balance with the mission of the Cape: while the Cape would continue to devote itself to government, military, and larger commercial orbital research or testing flights, an offsite FSA spaceport would serve smaller commercial launches, the suborbital and space tourism markets, and select orbital missions. The FSA spaceport could become a "one-stop-shop," offering faster, easier, and more dedicated service to commercial users than the Cape—in its essential government and military role—could realistically provide.

If Florida decides to create an offsite commercial spaceport, it has two configuration options: a "combined site" or a "split site." A combined site would place both orbital and suborbital facilities, including runways, launch pads, and other infrastructure, within the same geographic launch site. A split site would employ a pre-existing airport runway for landings and suborbital takeoffs, while launch pads and vertical takeoff facilities could be built elsewhere. Although both the runway and vertical takeoff facilities would fall under the same authority, they would not be co-located.

Each configuration option carries benefits and drawbacks. Because a combined site would integrate horizontal and vertical takeoff and landing facilities in one area, it would necessarily entail constructing an entirely new spaceport, which would allow for uniform planning and the potential for a design featuring the latest state-of-the art infrastructure. In addition, combining all facilities at one site would increase convenience and efficiency, reduce coordination burdens, and promote greater ease of operations overall. However, a combined site also poses several disadvantages: a shortage of unpopulated, coastal land on which to build, the great expense of building an entirely new runway, the potential for local backlash, and the need to initiate entirely new environmental, safety, and other regulatory review processes.

A split site, on the other hand, would rely on partnership with a functioning airport for use of a runway already in existence, as well as hangars and other facilities. Since only the vertical takeoff infrastructure would need to be built, less land would be required, significantly reducing overall costs. Additionally, use of a pre-existing runway and facilities would speed regulatory review, since the airport and runway would already have been subjected to FAA inspection prior to gaining operational status. Moreover, the potential for the airport to increase business through publicity associated with its upgrade to a spaceport might improve local economic prospects, thereby reducing the risk of community backlash. A split site also has downsides, however. The need to share a runway and facilities with an operational airport poses organizational complications and may diminish space launch and landing flexibility, especially for vehicles that takeoff vertically but land horizontally.

Nonetheless, after weighing their respective pros and cons, this report concludes that on balance, a split site offers the better option. The main reason is that the outlook for suborbital launches over the next decade is superior to that for small orbital launches, and a split site, using a pre-existing runway to serve the landing and takeoff needs intrinsic to certain suborbital flights, can accommodate this suborbital demand more inexpensively, and sooner, than a combined site could.

Over the next decade, orbital launch demand is projected to remain flat, while suborbital demand is forecast to grow steadily. Even under a robust scenario, Florida would not be expected to capture more than five orbital launches per year over the next ten years. Yet even under a constrained scenario, Florida could reasonably expect to capture dozens of suborbital launches per year by the end of the decade, barring unforeseen developments. The number of suborbital launches is projected to increase dramatically in the next ten years, from zero in 2006 to up to 273 Florida-addressable launches in 2015.

A new Florida commercial spaceport, therefore, would be well advised to focus primarily on suborbital demand, while retaining the ability to accommodate orbital launches of small vehicles. Inherent uncertainty about evolving spaceflight demand in the long-run, combined with the fact that orbital launches—though expected to be infrequent—yield more revenue per launch, warrants building basic orbital launch capacity into a new commercial spaceport. Additionally, the Cape's emphasis on larger military, government, and research and development commercial orbital launches provides a Florida spaceport with a logical, complementary niche serving smaller commercial orbital vehicles. However, the principal launch market for next decade is expected to be suborbital transportation—particularly suborbital space tourism. Although suborbital vehicles will produce less revenue per launch than orbital flights, they will launch more routinely, thus constituting a more permanent in-state presence and a more reliable revenue stream. Therefore, while orbital launches may provide business during the next few years while the suborbital space tourism market is still nascent, over the next decade it is the suborbital market that will likely be the primary driver of growth, of spaceport revenue, and—by extension—of economic benefits for the State of Florida.

A split site spaceport built offsite from Cape Canaveral promises substantial benefits for the State of Florida in terms of increased economic activity, jobs, and earnings. Beyond these tangible rewards, a split site spaceport would solidify Florida's identity as a space state, enhance its scientific and technological stature, increase tourism, and contribute to education. Such a spaceport would fulfill the state's mission to promote space as an avenue for technological and economic development, align with the FIRST initiative's vision of a nationally-integrated spaceport system, and allow Florida to assume its place in the emerging commercial suborbital space transportation landscape.

APPENDIX A: Vehicle Developer Profiles

Appendix A provides brief profiles of vehicle developers that were considered as likely target customers for a commercial spaceport in Florida. The companies in **blue** are those that completed interviews for this study.

AERA CORPORATION

- Company HQ: Temecula, California
- Vehicle Name: Altairis
- Vehicle Type: Suborbital RLV
- Targeted Markets: Luxury space travel

AERA Corporation plans to produce a series of suborbital spacecraft, named Altairis, designed for a vertical launch and a horizontal landing. The rocket propulsion system uses an RP-1/LOX propellant combination. An assembly line system is being planned for production, with the first Altairis vehicle projected for completion in 2006. Passenger launches would include pre-flight training and a 40-minute ride. The Altairis vehicle has not yet been unveiled. AERA Corporation has signed a task order contract with the Florida Space Authority and a Letter of Intent with the U.S. Air Force to launch its space tourism/travel vehicles from Cape Canaveral, Florida in 2006.

ARMADILLO AEROSPACE

- Company HQ: Mesquite, Texas
- Vehicle Name: Black Armadillo
- Vehicle Type: Suborbital RLV
- Targeted Markets: Public space transportation and other emerging markets

Armadillo Aerospace is developing a suborbital vehicle concept for crewed flight. Its current design, Black Armadillo, will use liquid propellant engines to lift off vertically and achieve a maximum altitude of 108 kilometers, then perform a ballistic descent and land vertically under rocket power. Armadillo has performed a number of tests of engines and other vehicle technologies and incorporating those results into the design of the suborbital vehicle. The Armadillo flight concept was successfully demonstrated June 15, 2004, when a subscale demonstrator flew to 40 meters altitude and landed. However, a second demonstration flight in August 2004 failed when the vehicle crashed after exhausting its propellant supply. Despite this setback, the Armadillo team remains committed to maturing its design, and has completed work on a second demonstrator vehicle. Flight testing of the design is expected to resume in 2005.

ATK ELKTON LLC

- Company HQ: Elkton, Maryland
- Vehicle Name: Not determined. Generic name is “ATK Launch Vehicle (ALV)”; working name of suborbital prototype is X1
- Vehicle Type: Suborbital ELV as the first phase of a four-phase design and development arc leading to a future Orbital ELV.
- Targeted Markets: Military, government, responsive spacelift, possibly commercial

ATK Elkton LLC, a firm that has a long history of providing propulsion systems for spacecraft, has decided to leverage their on-board propulsion experience in order to enter the launch market. ATK is undergoing a four-phase development process that will ultimately lead to the development of a family of low-cost, operationally responsive launch vehicles capable of delivering 200 to 750 kg to LEO. The first phase, which is already in testing, will be a sounding rocket program launched from Wallops Flight Facility. The second phase, for which funding has already been secured, will consist of a two-stage, three-axis controlled vehicle capable of reaching suborbital heights of up to 2,000 kilometers. The unfunded third phase will be scaled-up version of the Phase Two vehicle capable of delivering 225-350 kg pounds to LEO, while the fourth phase, contingent on government funding, would involve an advanced vehicle based on new technologies. ATK expects to begin work on the third-phase vehicle in 2007 or 2008, and hopes that the success of the third-phase vehicle will attract government investment to allow development of the fourth-phase vehicle in 2008 or 2009.

BEYOND-EARTH ENTERPRISES

- Company HQ: Colorado Springs, Colorado
- Vehicle Name: Sapphire
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space memorabilia and related markets

Beyond-Earth's development program features recoverable suborbital launch vehicles eventually capable of flying to 100 kilometers. The latest flights of its test program took place on September 25, 2004, when the company launched a pair of one-third-scale demonstrators from Oklahoma. One Sapphire rocket reached an altitude of over 4,570 meters, after which its payload capsule landed by parachute and was successfully recovered. The company believes that there is a market for any item or object that has touched space. For fees as low as $80, the company is offering to launch small objects like business cards or photos on suborbital trajectories into space. Beyond-Earth hopes its suborbital rocket generates between $100,000 and $200,000 per flight. Each recoverable vehicle is expected to be capable of ten flights before retirement. This initial endeavor is expected to cost the company about $2 million. The company expects to have sufficient demand to allow at least one flight per month in order to keep its business and development plans on track.

BLUE ORIGIN

- Company HQ: Seattle, Washington, with test facilities near Van Horn, Texas
- Vehicle Name: Not determined; rumored to be called New Shepard
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space Tourism

Blue Origin, incorporated in 2000 by Amazon.com entrepreneur Jeff Bezos, is developing a suborbital space tourism vehicle able to take off and land vertically under its own propulsion using a liquid fuel rocket engine. Because Blue Origin is an unpublicized venture, few specifics are known. Newsweek reports that the vehicle is expected to cost $30 million to develop, and may be called "New Shepard" (after Alan Shepard). The vehicle is designed for three or more passengers. It would launch from a 165,000-acre range known as the "Corn Ranch," under development near Van Horn, Texas. Suborbital facilities, including a test and operations center, are under construction there. Bezos hopes his vehicle will be ready to carry suborbital tourists by 2011. He has also expressed interest in eventually developing an orbital vehicle.

GARVEY SPACECRAFT CORPORATION

- Company HQ: Huntington Beach, California
- Vehicle Name: Nanosat Launch Vehicle (NLV)
- Vehicle Type: Orbital ELV
- Targeted Markets: University and research organization payloads

Garvey Spacecraft Corporation is a small research and development company focusing on advanced space technologies and launch vehicle systems. Their Nanosat Launch Vehicle (NLV), currently in the development stage, is being constructed in conjunction with California State University-Long Beach for the California Launch Vehicle Initiative. The NLV is planned to be a two-stage liquid-propellant rocket with the capability to deliver a ten-kilogram payload to LEO. Initial developmental flight testing has been conducted at the Mojave Test Area. The company is also funding several internal projects that focus on reusable launch vehicles and associated technology validation flight testing. On May 21, 2005, the Prospector 6 rocket, a full-scale prototype of the NLV, was launched from the Mojave Test Area and recovered after reaching an altitude of almost 900 meters. The primary objective for the flight test was validation of the team's ability to develop and handle a full-scale rocket. Other notable accomplishments include the first-ever flight of a composite LOX tank (conducted in partnership with Microcosm, Inc.), the first-ever powered flights of a liquid-propellant aerospike engine, and the launch and 100% recovery of several prototype reusable test vehicles.

HIGH ALTITUDE RESEARCH CORPORATION (HARC)

- Company HQ: Huntsville, Alabama
- Vehicle Name: Liberator
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space tourism and atmospheric/microgravity research

The High Altitude Research Corporation Liberator is a single-stage design using two LOX/kerosene liquid-fuel engines. The vehicle is approximated to be 13.1 meters tall and weighs 4,550 kilograms when developed. HARC has substantial experience conducting launches from sea-borne platforms, which it plans to use for the Liberator vehicle. The main engines will fire for one minute, after which the booster stage will separate and parachute back into the ocean, while the crew cabin continues on its ballistic trajectory to 100 kilometers. Although the cabin is pressurized, the crew will wear pressure suits throughout the flight. During descent the cabin will deploy its own parachute and fall to an ocean landing point.

INTERORBITAL SYSTEMS

- Company HQ: Mojave, California
- Vehicle Name: Sea Star MSLV
- Vehicle Type: Orbital ELV
- Targeted Markets: Low cost payload deployment

Interorbital Systems is developing the Sea Star MSLV launch vehicle for microsatellite payloads and as a testbed for its larger Neptune orbital launch vehicle. These vehicles are constructed for design simplicity and for lowest cost over highest performance. The company believes these design principles will enable it to develop launch vehicles that are truly low-cost. Sea Star MSLV consists of three stages. The rocket body is constructed of aluminum and composite materials.

Sea Star does not require land-based launch infrastructure. Taking advantage of design elements derived from submarine-launched ballistic missiles, this vehicle will float in seawater and launch directly from the ocean. Interorbital Systems plans to launch Sea Star MSLV near California or in waters near the Kingdom of Tonga. Interorbital Systems aims to be the first company to a launch a satellite into orbit using a vehicle developed totally with private financing.

KISTLER AEROSPACE CORPORATION

- Company HQ: Kirkland, Washington
- Vehicle Name: K-1
- Vehicle Type: Orbital RLV
- Targeted Markets: Orbital payload deployments, ISS cargo re-supply and return missions, interplanetary missions

The Kistler K-1 is a two-stage vehicle designed for full reusability, launching vertically, and returning with a combination of parachutes and airbags. It is 36.9 meters in overall length, 6.7 meters in diameter and weighs 381,000 kg at liftoff. The vehicle, powered by liquid-propellant engines from Aerojet, is to be reused 100 times. The company intends the K-1 to become the reliable, low-cost provider of launch services for commercial, civil, and military payloads destined for LEO, MEO and GEO, as well as to and from the ISS. Orbital flight tests and commercial operations will be conducted from Kistler's commercial spaceport at Woomera, Australia. A second commercial spaceport is planned at the Nevada Test Site, with other possible sites in the United States also being considered.

LOCKHEED MARTIN SPACE SYSTEMS COMPANY, MICHOUD OPERATIONS

- Company HQ: Bethesda, Maryland (Michoud Operations: New Orleans, Louisiana)
- Vehicle Name: Falcon prototype
- Vehicle Type: Orbital ELV
- Targeted Markets: Low-cost orbital payload deployment

Lockheed Martin Michoud Operations is one of four recipients of the Defense Advanced Research Projects Agency (DARPA) FALCON small launch vehicle contracts to develop concepts for a low-cost and responsive launch vehicle. Lockheed Martin is conducting an initial design and development effort to mature its hybrid propulsion launch vehicle design for its FALCON concept. The concept is intended to use a two-stage rocket with a mobile launching system. Detailed design and vehicle fabrication contract activity is planned for 2005, with flight testing planned for 2007 to verify vehicle performance.

MASTEN SPACE SYSTEMS, INC.

- Company HQ: Santa Clara, California
- Vehicle Name: Extreme Altitude (XA)
- Vehicle Type: Suborbital RLV
- Targeted Markets: Suborbital research markets

Masten Space Systems (MSS) joined the commercial suborbital spaceflight development market in August 2004. MSS plans to develop a series of vertical-takeoff, vertical-landing (VTVL) rockets called Extreme Altitude (XA). The XA is being developed for research markets such as high-altitude atmospheric measurements, low-cost solar astronomy, Earth observation, and others. The XA-1.0 is planned to be able to lift a 100-kilogram payload to 100 kilometers, and be able to repeat that flight several times in a single day. Masten wants to offer flights for between $20,000 and $30,000. The company plans to design a suborbital version to earn revenue and gain operational experience before scaling up the design into an orbital version.

MICROCOSM, INC.

- Company HQ: El Segundo, California
- Vehicle Name: Eagle/Sprite Launch Vehicle series
- Vehicle Type: Orbital ELV
- Targeted Markets: Low-cost orbital payload deployment

Microcosm is developing the Scorpius series of ELVs, which includes the light-lift Eagle SLV and Sprite Mini-Lift vehicles. The Scorpius system is based on cost savings and quick launch pad turnaround times. All Scorpius orbital vehicles have three stages, based on a scaleable modular design featuring simple LOX/Jet-A pressure-fed motors without turbopumps and low-cost avionics equipped with GPS/Inertial Navigation System. Sprite is projected to loft a payload of up to 318 kilograms to LEO, while Eagle is projected to loft a payload of up to 667 kilograms to LEO. Eagle and Sprite are the two prototypes furthest along in development, with flight testing of one or both vehicles planned in the third quarter of 2007. Potential launch sites are proposed for Vandenberg AFB, Cape Canaveral AFS, and Wallops Flight Facility.

ORBITAL SCIENCES CORPORATION

- Company HQ: Dulles, Virginia
- Vehicle Name: Minotaur and Taurus
- Vehicle Type: Orbital ELVs
- Targeted Markets: Small orbital payload deployments

Orbital Sciences Corporation's Minotaur, Taurus, and Pegasus vehicles are currently operational. The Minotaur was developed under contract to the U.S. Air Force to launch small government payloads. The booster uses a combination of rocket motors from decommissioned Minuteman 2 ICBMs and upper stages from Orbital's Pegasus launch vehicle. The Minotaur's first two stages are Minuteman 2 M-55A1 and SR-19 motors, and the upper two stages are Orion 50 XL and Orion 38 motors from the Pegasus XL. The Minotaur made its debut on January 26, 2000, when it successfully launched the FalconSat and JAWSAT satellites from Vandenberg AFB. The Taurus ELV is a ground-launched vehicle based on the air-launched Pegasus. Orbital Sciences developed the Taurus under the sponsorship of DARPA to develop a standard launch vehicle to be set up quickly in new locations to launch small satellites that are too large for the Pegasus. The Taurus uses the three stages of a Pegasus, without wings or stabilizers, stacked atop a Castor 120 solid rocket motor that serves as the Taurus' first stage. Taurus also launches from VAFB.

PANAERO, INC.

- Company HQ: Chantilly, Virginia
- Vehicle Name: Condor X
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space tourism and other suborbital payloads

PanAero's most recent two-stage-to-orbit vehicle concept is the Condor X rocket glider. It is composed of a fuselage mounted in front of a large wing that supports eight rocket pods for propulsion. The flight profile calls for a horizontal takeoff followed by a slow climb to 35 kilometers at a speed of 370 km/hr. Once at that altitude, the vehicle pitches up for a near-vertical climb through 70 kilometers, after which the rocket engines are shut down. After burnout, the Condor X continues on a parabolic trajectory with a 100-kilometer apogee. Its large wing design serves as a speed brake and parachute during reentry to slow the vehicle down. The cabin is lowered by cables beneath the wing to enable the structure to act like a parachute for part of the descent profile, until the vehicle falls to an altitude of 6,000 meters. Following this, the cabin retracts, and a glider landing brings the vehicle back to Earth at the original takeoff airstrip.
If the Condor X design is successful, the company will then focus on payload-carrying suborbital missions in order to fund further activities. Serving space tourists is viewed as a secondary goal for the company's new vehicle.

ROCKETPLANE, LTD., INC.

- Company HQ: Oklahoma City, Oklahoma
- Vehicle Name: Rocketplane XP
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space tourism, microgravity research, small satellite deployment

Rocketplane Ltd. is developing its XP suborbital rocketplane. The 8,165-kilogram XP will take off under jet power from an airport and climb to about 6,000 meters, and then ignite its rocket engine for a two-minute burn. The vehicle flies a ballistic trajectory to an altitude of over 100 kilometers. After reentry the XP reignites its jet engines for a runway landing. The company plans to begin commercial flights of the XP from the Oklahoma Spaceport by January 2007. In October 2004 the company announced it had entered in a partnership with Incredible Adventures, of Sarasota, Florida, to market tourist flights on the XP once it enters service.

SCALED COMPOSITES, LLC

- Company HQ: Mojave, California
- Vehicle Name: SpaceShipOne
- Vehicle Type: Suborbital RLV
- Targeted Markets: Space tourism, research and development

Scaled Composites' suborbital vehicle program, Tier One, consists of two vehicles: a carrier aircraft called White Knight and a rocketplane named SpaceShipOne. SpaceShipOne is carried aloft by White Knight to an altitude of about 15,240 meters. At that point SpaceShipOne detaches from White Knight and fires its single rocket engine. The engine is a hybrid rocket motor using hydroxyl-terminated polybutadiene (HTPB), or rubber, fuel, and nitrous oxide oxidizer, and is provided by SpaceDev. The engine burns for up to 90 seconds, propelling the vehicle to a maximum altitude of over 100 kilometers and speeds in excess of Mach 3. Since the unveiling of the Tier One program in April 2003, Scaled Composites has put both vehicles through an extensive flight program at Mojave Airport, California. On November 6, 2004, Scaled Composites was awarded the Ansari X Prize for two SpaceShipOne flights made in September and October of that year. Scaled Composites has also received the world's first license for a reusable, suborbital, piloted launch vehicle from the FAA. The license, LRLS 04-067, became effective on April 1, 2004. The license covers SpaceShipOne launch activities from Mojave Airport and remains in effect for one year. Paul Allen and Scaled Composites CEO Burt Rutan formed a joint venture called Mojave Aerospace Ventures (MAV) that owns the intellectual property of the Tier One program. On September 27, 2004, MAV signed an agreement to license that technology to Virgin Group, run by Sir Richard Branson. Virgin has created a new subsidiary, Virgin Galactic, which plans to contract with Scaled Composites to build suborbital vehicles based on SpaceShipOne, but with the ability to carry up to five passengers. The first of those vehicles, designated Virgin SpaceShip (VSS) Enterprise, is expected to enter service in 2008.

SPACEDEV

- Company HQ: Poway, California
- Vehicle Name: Dream Chaser and Streaker
- Vehicle Type: Orbital ELV (Streaker) and Suborbital RLV (Dream Chaser)
- Targeted Markets: Quick response launch (Streaker); Space tourism (Dream Chaser)

SpaceDev has recently signaled its intent to enter the commercial suborbital vehicle market. In September 2004 the company announced plans to develop a suborbital RLV called Dream Chaser. The vehicle, similar in shape to NASA's cancelled X-34, will take off vertically using a single HTPB and nitrous oxide hybrid rocket motor. The vehicle, capable of carrying several passengers, will fly to 160 kilometers altitude before gliding back to a runway landing. SpaceDev plans to have the Dream Chaser enter service as soon as 2008 if the program is fully funded. SpaceDev plans to use a similar hybrid rocket motor for its low-cost small launch vehicle concept Streaker. This orbital ELV will offer responsive delivery of payloads with approximate masses of 500 kilograms to LEO.

THE SPACE LAUNCH CORPORATION

- Company HQ: Irvine, California
- Vehicle Name: SLC-1
- Vehicle Type: Orbital ELV
- Targeted Markets: Microsatellite and small payload deployment

The Space Launch Corporation is in the initial development stages of its SLC-1 launch system. The SLC-1 will use a small expendable booster, consisting of multiple, custom-built stages based on existing technology. The booster will be deployed from a turbojet-powered aircraft and be able to place payloads of up to 150 kilograms into a 500-kilometer orbit inclined at 28.5 degrees. The company is targeting microsatellites and other small payloads that would otherwise be launched as secondary payloads on larger vehicles.

SPACE SYSTEMS/LORAL

- Company HQ: Palo Alto, California
- Vehicle Name: Aquarius
- Vehicle Type: Orbital ELV
- Targeted Markets: Bulk supply orbital deployment

Space Systems/Loral has proposed Aquarius, a low-cost launch vehicle designed to carry small, inexpensive payloads, such as water, fuel, and other consumables that are inexpensive to replace in the event of a launch failure, into LEO. As currently designed, Aquarius will be a single-stage vehicle 43 meters high and 4 meters in diameter and powered by a single engine using liquid hydrogen and oxygen propellants. The vehicle is floated in the ocean before launch to minimize launch infrastructure and will be able to place a 1,000-kilogram payload into a 200-kilometer, 52-degree orbit. Located in the base of the vehicle, the payload will be extracted by an orbiting space tug for transfer to its ultimate destination. After payload extraction is completed, the vehicle will de-orbit and be destroyed. Funding of $1 million was provided in the fiscal year 2004 Defense Appropriations Act to develop a prototype of the low-cost engine for the vehicle. The engine would provide 1.8 million newtons of thrust, using liquid oxygen and liquid hydrogen as propellants. Space Systems/Loral has submitted a proposal for development of the large lightweight liquid hydrogen tank required for this vehicle, which is currently being considered for Federal funding.

SPACE EXPLORATION TECHNOLOGIES CORPORATION (SPACEX)

- Company HQ: El Segundo, California
- Vehicle Name: Falcon 1 and Falcon 5
- Vehicle Type: Orbital RLVs
- Targeted Markets: Orbital payload deployment

SpaceX is developing the partially reusable Falcon 1 and Falcon 5 launch vehicles. The first stage of this vehicle is to be recovered from the ocean after a parachute landing, refurbished, and reused. On May 28, 2005, SpaceX conducted a main engine test firing at its Space Launch Complex-3 West pad at Vandenberg AFB, California. Falcon's first launch is scheduled for September 2005 from Kwajalein to loft the Falconsat 2 experimental satellite for the Department of Defense. SpaceX anticipates two to three launches annually, eventually ramping up to five or six flights a year at a price of approximately $6 million per launch. SpaceX is privately developing the entire two-stage vehicle from the ground up, including the engines, cryogenic tank structure, and guidance system. The Falcon 5 vehicle is based on much of the same technology developed for Falcon 1. The larger Falcon 5 uses five SpaceX-developed Merlin engines in the first stage with an engine-out capability to enhance reliability. The second stage will use one Merlin engine. The first Falcon 5 launch is expected in mid-2006 from VAFB. For subsequent Falcon 5 flights, SpaceX is developing the Merlin 2 engine that is expected to enable greater lift capacity, up to 6,020 kilograms to LEO.

TGV ROCKETS

- Company HQ: Norman, Oklahoma
- Vehicle Name: Michelle-B
- Vehicle Type: Suborbital RLV
- Targeted Markets: Science and technology customers

TGV is developing a suborbital vehicle called Michelle-B. Michelle (Modular Incremental Compact High Energy Low-cost Launch Experiment), will be 15 meters tall and weigh 38,556 kilograms. The vehicle will use six pressure-fed liquid oxygen and kerosene engines. Michelle-B's flight profile calls for a vertical launch to an altitude of over 100 kilometers followed by a vertical descent with the assistance of a drag augmentation system involving drag panels deployed from the sides of the vehicle. The engines are used later for landing after the vehicle has descended below 3,000 meters. Unlike some other vertical take-off, vertical landing (VTVL) SRLV designs, the Michelle-B will be actively piloted during its descent. TGV has a working relationship with the University of Oklahoma, involving sponsored research for several students and professors. TGV is fully funded through its preliminary design review and anticipates initiating a flight-testing program by late 2007.

XCOR AEROSPACE

- Company HQ: Mojave, California
- Vehicle Name: Xerus
- Vehicle Type: Suborbital RLV
- Targeted Markets: Suborbital space tourism, microgravity research, microsat launch

XCOR plans to test suborbital RLV technologies from Mojave Airport in California. These tests will include the Sphinx demonstration vehicle, which is designed to fly within the Earth's atmosphere. For suborbital flight, XCOR is developing Xerus to conduct a variety of suborbital missions including microgravity research, suborbital tourism, and even the launch of very small satellites into orbit. Xerus is expected to have the capability to launch a 10-kilogram payload to LEO. The company expects to offer such flights for about $500,000 per launch. XCOR is not currently disclosing its schedule or certain design details of the Xerus, except that it will take-off and land from a conventional runway without a booster stage or carrier vehicle. Xerus will be powered by XCOR's own liquid rocket engines.

APPENDIX B: Vehicle Developer Interview Questions

1. What is most important to you when working with a launch site?

2. For the missions you plan to conduct, what are the core infrastructure requirements you need from a launch site?

   [Check list for core infrastructure components]

Non-Hazardous Hangars and Processing Bays (Vehicles and Payloads)	
HazMat (e.g. Propellant) Storage, Processing, and Supply (Vehicles and Payloads)	
Power and Data Links	
Vehicle Tracking and Telemetry	
Flight Termination	
Gases and Fluids (nitrogen, oxygen, helium, etc.)	
Ground and Range Safety	
Into and Out of Range Transportation	
Runways and Pads (e.g., acoustic suppression/water deluge)	
Meteorology	

3. Have you considered launching from Florida? What advantages or disadvantages do you see with launching from Florida?
   [What barriers, if any, have you experienced in working with the AF at the Cape?]

4. What capabilities or services would you like to see from a launch site that are not currently available? Would you consider launching from Florida if [description of proposed range and services provided in first part of question] was available?

5. If using space-based range infrastructure (GPS) instead of terrestrial were required, would this be an advantage or disadvantage for your existing/planned vehicle? And why?

6. What do you estimate is the maximum number of launches per year your vehicle could perform? What short-term surge rate, if any, does your vehicle have?

7. What would you say is the realistic number of launches your vehicle will perform in an average year, over the next five years? Do you expect this realistic number of annual launches to increase, decrease, or stay about the same over the next ten years?

8. What fraction of your future launches do you currently foresee taking place from Florida? Are there factors [such as regulatory burdens, existing business arrangements, orbital mechanics] besides the current spaceport and range that affect this?

9. What fraction of your future launches would you foresee taking place from Florida if the commercial spaceport concept became a reality?

APPENDIX C: Government Interview Questions

1. To what extent were you aware of the potential development of a commercial spaceport in Florida? To the best of your knowledge, how does your organization support FSA's development of a commercial spaceport in Florida? Why or why not?

2. To the best of your knowledge, what existing infrastructure could be available for use by FSA? What steps would have to be taken in order for FSA to use this infrastructure independently? What type of coordination efforts with CCAFS and KSC would you expect to be required of the commercial launch providers?

3. Do you think it would be possible to convert the former Atlas II and III facilities for commercial use? Can you comment on the accomplishments to date toward converting these facilities?

4. What regulatory limitations do you perceive might inhibit the development of a Florida commercial spaceport? Can these limitations be overcome? If so, how? If not, why not? [Including safety and environmental regulations]

5. What do you think are some of the major milestones that FSA must meet in order to reach a fully operational, commercial, responsive spaceport in Florida?

6. What do you see as some of the major obstacles standing in the way of FSA completing their vision for a commercial spaceport? What advice would you give FSA in addressing these obstacles?