National Spaceport Network Development Plan

Prepared by the Global Spaceport Alliance

for the Office of Spaceports
Office of Commercial Space Transportation
Federal Aviation Administration

June 1, 2020

EXECUTIVE SUMMARY

Space has become an indispensable part of everyday life in the 21st century, supporting not only our nation's military and intelligence capabilities, but also communications, navigation, weather forecasting, agriculture, financial transactions, disaster response, and even entertainment.

The Eastern Range, located at Cape Canaveral Air Force Station, Florida, and the Western Range, located at Vandenberg Air Force Base, California, have served as the military's primary launch sites for space launches and missile tests for more than 60 years. Many NASA and commercial space missions have also been conducted from those locations. Recently however, a number of commercial spaceports have been established by state and local governments, or by private companies, based on a desire to take advantage of the growing space economy, to minimize the federal regulatory burden, and to provide additional launch opportunities for civil and commercial space missions.

The development of a National Spaceport Network, consisting of current and prospective commercial spaceports, government-owned-and-operated launch & landing sites, and privately-owned-and-operated launch & landing sites, offers an opportunity to increase the safety, capacity, efficiency, and resiliency of the nation's space operations. Such a network could provide the framework for formal or informal public-private partnerships between federal, state, and local governments; the aerospace industry; and academia.

A key component of the operation of a successful network of spaceports is federal funding for infrastructure development. The federal government has traditionally provided substantial funding to develop, repair, or upgrade all forms of transportation infrastructure. Examples include funding for roads, bridges, and the interstate highway system; railroads; airports; and seaports. Incredibly, given the importance of space to our nation's defense and our national economy, there is no current federal program that provides financial support for space transportation infrastructure in general, or for spaceports in particular. Several potential options to provide such support have been evaluated, including the Airport Improvement Program, the Space Transportation Infrastructure Matching Grants Program, DOT Discretionary Grants Programs, and the Joint DoD/FAA Infrastructure Program; however, each would require significant modifications to be effective. As an alternative, the creation of a Spaceport Network Improvement Program is proposed as a comprehensive, time-phased, and sustainable approach to meet this urgent need.

To date, 44 specific spaceport infrastructure projects have been identified, from ten current and proposed commercial spaceports, with a total estimated cost of over $382 million. The complete list is included in the Appendix. As additional infrastructure projects are identified, the list will be updated appropriately.

The purpose of this National Spaceport Network Development Plan is to provide the information needed to assist in the development of a network of spaceports in the U.S. that would support civil, commercial, and national security requirements for access to space. The plan is intended to be an information resource for key stakeholders, including the FAA Office of Spaceports, the U.S. Department of Transportation, the Department of Defense, the National Aeronautics and

Space Administration, Congress, the National Space Council, launch vehicle developers and operators, and current and prospective spaceport operators. It includes an evaluation of space transportation market demands; recommended changes to spaceport policies, laws, and regulations; ideas for spaceport-related programmatic initiatives; and a list of specific spaceport infrastructure projects and cost estimates. The document will be updated annually, or more frequently as conditions warrant.

Credit: Spaceport America

Figure 1 – WhiteKnightTwo & SpaceShipTwo at Spaceport America

CONTENTS

EXECUTIVE SUMMARY **2**

INTRODUCTION **6**

EVALUATION OF SPACE TRANSPORTATION DEMANDS/NEEDS **7**
Current Status 7
National Security Space Transportation Demands 7
Civil Space Transportation Demands 7
Commercial Space Market Needs 8

INTERNATIONAL SPACEPORT DEVELOPMENT AND INVESTMENT **9**

CURRENT AND PROPOSED U.S. SPACEPORTS **10**

RANGE OF THE FUTURE **15**

DEVELOPMENT OF A NATIONAL SPACEPORT NETWORK **17**

NATIONAL SPACEPORT NETWORK GOALS **18**

PROPOSAL FOR A NATIONAL SPACEPORT POLICY **19**

EXISTING OPTIONS FOR FUNDING SPACEPORT INFRASTRUCTURE **20**
Airport Improvement Program 20
Space Transportation Infrastructure Matching Grants Program 22
DOT Discretionary Grants Programs 23
Joint DoD/FAA Infrastructure Program 24

PROPOSAL FOR A SPACEPORT NETWORK IMPROVEMENT PROGRAM **25**
Program Description 25
Potential Trust Fund Revenues 27
Grant Eligibility 28
Project Priorities 28
Grant Distribution 29

PROGRAMMATIC INITIATIVES **30**
Commercial Human Spaceflight Training 30
Spaceflight Training Education Program 30
Point-to-Point Transportation Through Space 31
Establishment of a Major Aerospace Prize 32

OTHER RECOMMENDATIONS **33**
Updating FAA Spaceport Regulations 33
Expediting the Processing of Spaceport License Applications 33

Streamlining the Environmental Review Process 33
Integrating Commercial Space Systems into the National Airspace 34
Support for Space-Related Education and Research Programs 34
Engagement with the International Spaceport Community 35

SUMMARY OF RECOMMENDATIONS 36

CONCLUSIONS AND NEXT STEPS 38

APPENDIX - SPACEPORT INFRASTRUCTURE PROJECTS 39
Projects for FAA-Licensed Spaceports 39
Projects for Proposed Commercial Spaceports 41
Projects for Private Launch & Landing Sites 42
Projects for Government Launch & Landing Sites 42

REFERENCES 43

ABOUT THE GLOBAL SPACEPORT ALLIANCE 44

FIGURES

Figure 1 – WhiteKnightTwo & SpaceShipTwo at Spaceport America 3
Figure 2 – Number of FAA-Licensed Launches and Reentries by Calendar Year 7
Figure 3 – Current and Proposed U.S. Spaceports 10
Figure 4 – Sierra Nevada Corporation Dream Chaser at Edwards AFB 14
Figure 5 – Potential Future Operations at Colorado Air & Space Port 16
Figure 6 – SpaceShipTwo Approaching the Mojave Air & Space Port 18
Figure 7 – Blue Origin's New Shepard at their West Texas Launch Site 19
Figure 8 – STIM Grant Awardees and Projects 23
Figure 9 – Minotaur IV+ at the Pacific Spaceport Complex - Alaska 24
Figure 10 – Falcon 9 and Crew Dragon at the NASA Kennedy Space Center 29
Figure 11 – Options for Point-to-Point Test Flights 32
Figure 12 – Atlas V and Starliner at Cape Canaveral Air Force Station 37
Figure 13 – SpaceX Starhopper at their Boca Chica Launch Site 44

TABLES

Table 1 - FAA-Licensed Spaceports 11
Table 2 - Proposed Commercial Spaceports 12
Table 3 - Private Launch & Landing Sites 13
Table 4 - Government Launch & Landing Sites 13
Table 5 - Projects for FAA-Licensed Spaceports 39
Table 6 - Projects for Proposed Commercial Spaceports 41
Table 7 - Projects for Private Launch & Landing Sites 42
Table 8 - Projects for Government Launch & Landing Sites 42

INTRODUCTION

The United States is currently undergoing a major transformation in its space programs, from a time in which the Federal Government was responsible for almost everything that happened in space, to a situation in which private industry is playing an increasingly important role. When Burt Rutan and his team at Scaled Composites won the $10 million XPrize in 2004 for showing that a private company could successfully launch people to the edge of space, it was clear that change was coming. More recently, Virgin Galactic's SpaceShipTwo has twice completed piloted missions that exceeded 50 miles in altitude as part of the testing required prior to the start of commercial space tourism operations. Meanwhile, Blue Origin has conducted a number of suborbital missions with their New Shepard reusable launch vehicle, and flights carrying people are expected to begin within the next 12 months. Finally, almost 9 years after the retirement of the Space Shuttle, SpaceX has successfully transported NASA astronauts to the International Space Station in a Crew Dragon spacecraft that was launched on a Falcon 9 rocket.

The environment is also changing when it comes to the nation's spaceports. Although most major civil and military space launches by the U.S. have taken place from Cape Canaveral Air Force Station, Vandenberg Air Force Base, or NASA's Kennedy Space Center, there are now 12 FAA-licensed commercial spaceports on the map, with another 12 sites having begun pre-application consultations for a license or having announced plans to do so in the future, plus 4 private launch sites that were developed by commercial launch operators.

Given the relatively small number of launches taking place each year, some have questioned the need for so many spaceports. However, because of the widely anticipated growth of the global space economy over the next 20 years, including the planned launch of thousands of satellites to provide world-wide Internet access, the expected commencement of suborbital space tourism, and the potential start of high-speed, long-distance, point-to-point transportation through space, it is not unreasonable to expect that the need for additional launch and landing sites will increase significantly in the years ahead. After all, following the Wright Brothers' flight in 1903, who could have predicted that today there would be 19,636 airports in the U.S. [according to the Bureau of Transportation Statistics]?

Development of a National Spaceport Network, consisting of current and proposed commercial spaceports, government-owned-and-operated launch & landing sites, and privately-owned-and operated launch & landing sites, would support the nation's civil, commercial, and national security needs for assured access to space, serve as focal points and technology hubs to strengthen the country's aerospace industrial base, and allow for a more robust and more resilient space launch infrastructure. The purpose of this National Spaceport Network Development Plan is to provide the FAA Office of Spaceports and other key stakeholders with all of the information needed to assist in the development of such a network.

EVALUATION OF SPACE TRANSPORTATION DEMANDS/NEEDS

- **Current Status.** In 2017, there were 26 FAA-licensed launches and reentries, more than in any previous year. In 2018 and 2019, the activity level was even greater, with 36 and 31 licensed launches and reentries being conducted in those two years (See Figure 2). Based on announced plans for the launch of several large constellations of satellites and the existence of a number of launch vehicle development programs, the level of activity is likely to continue to grow for the foreseeable future.

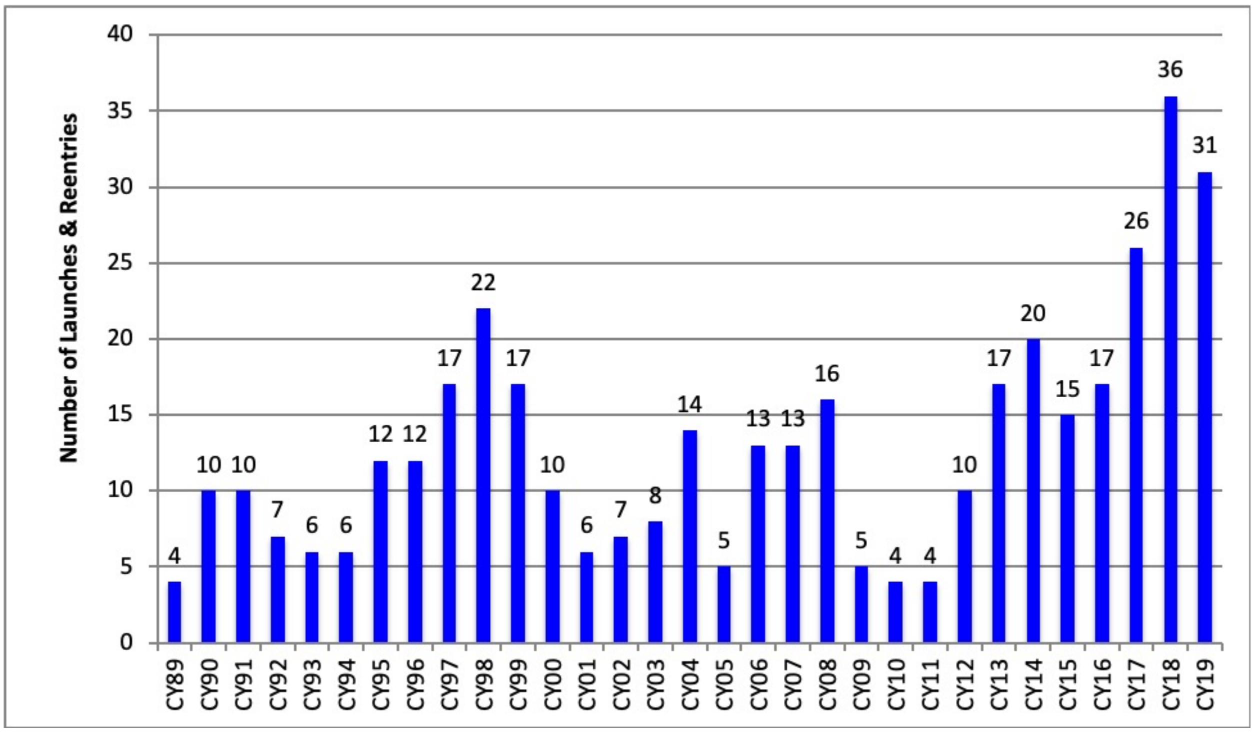

Figure 2 – Number of FAA-Licensed Launches and Reentries by Calendar Year

- **National Security Space Transportation Demands.** Given the recent establishment of the U.S. Space Force, and the stated necessity to treat space as a potential war-fighting domain, national security demands for space transportation are expected to increase. Activity drivers include the need to develop and field new technologies (such as those required for hypersonic vehicles) or systems to detect or defend against them; satellite servicing and/or inspection; and increased resilience through the use of large numbers of small spacecraft, rather than having fewer, more capable, but more expensive systems. Other important technologies include data management, cybersecurity, and space situational awareness.

- **Civil Space Transportation Demands.** NASA has a continuing need to support the International Space Station (ISS) through the purchase of commercial cargo services to provide food, clothes, propellent, scientific experiments, and equipment to the astronauts onboard. Starting this year, NASA will be counting on industry to provide crew transportation services to and from the station. Even after the ISS has been retired, NASA will have an ongoing need to conduct human spaceflight research in low Earth orbit, either on its own, or through commercial providers. NASA will also be continuing its programs for Earth and space science, technology development, and exploration. As part of the implementation of Space Policy Directive 1, NASA is working with international and private sector partners on an innovative and sustainable return to the Moon, followed by missions to Mars and beyond. In addition, if Congress decides to support the Administration's call to land astronauts on the Moon by 2024, that will result in the need for a significant increase in the pace of activity. That could require an expansion of the technical workforce, along with continued development of advanced technologies.

- **Commercial Space Market Needs.** According to a recent study by Bryce Space and Technology, the global space economy totaled more than $360 billion in 2018. That figure is likely to grow significantly in the years ahead. UBS, a Swiss-based multinational financial services firm, estimates that the space economy could reach $805 billion within 10 years, and $1 trillion within 20 years. Morgan Stanley analysts are projecting a $1.1 trillion figure by 2040, while Bank of America Merrill Lynch believes it could amount to $2.7 trillion by 2045.

  Aside from the markets for telecommunications and Earth observation, which are already well-established, there are a number of other commercial space markets that could be very significant in the future. These include satellite launch, commercial cargo delivery, commercial crew transportation, commercial space stations, satellite servicing, space tourism, education and training, point-to-point transportation through space, commercial moon bases, in-space resource extraction (including asteroid mining), on-orbit propellant depots, and solar power satellite systems. As an example of the kinds of commercial opportunities that are now available in low-Earth orbit, NASA recently issued an Interim Directive that will allow private astronauts to make short-duration visits to the ISS, where they will be able to conduct either commercial or marketing activities. Separately, several companies, including SpaceX and Amazon, have announced plans to deploy thousands of small satellites in low Earth orbit in order to provide broadband Internet capabilities throughout the world.

INTERNATIONAL SPACEPORT DEVELOPMENT AND INVESTMENT

- Based on its well-established and supportive regulatory framework, and its tradition of innovation and entrepreneurial activities, it seems clear that the U.S. is the international leader when it comes to spaceport development and operations. However, although quantitative data is not readily available, many other countries have ambitious plans for how they can participate in the future growth of commercial space activities. That international interest provides an excellent opportunity for mutually beneficial collaboration. At the 5th Commercial Spaceport Summit, which was conducted by the Global Spaceport Alliance on November 19, 2019, 4 of the 15 spaceports represented were from other countries (Ecuador, Brazil, Japan, and the United Kingdom). Previous Summits have included representatives from Portugal, Australia, Italy, and Guiana. Most of the international entities have, or are expected to have, significant government involvement in the development, funding, or operations of spaceports in their country.

- Russia is in the process of constructing a new spaceport, known as Vostochny Cosmodrome, in order to reduce Russian reliance on the Baikonur Cosmodrome in Kazakhstan. The first launch took place in April 2016. Construction cost is reported to be approximately $7.5 billion so far, with the final cost likely to exceed $13.5 billion.

- China has recently completed construction of a brand-new spaceport, the Wenchang Launch Center, on Hainan Island, at the southern tip of China, to support launches of the heavy-lift Long March 5 rocket. In addition to the infrastructure needed to conduct launch operations, the spaceport is surrounded by a number of economic development projects, including a space-related theme park.

- The United Arab Emirates has announced plans to convert the Al Maktoum Airport (also known as Dubai World Central) into a “multi-mode super port,” which would accommodate conventional aircraft, supersonic and hypersonic aircraft, and spaceplanes. In addition, the UAE Space Agency recently signed an agreement with Virgin Galactic to investigate flying SpaceShipTwo and its carrier aircraft from an airport in the UAE for space tourism and/or science and technology flights.

CURRENT AND PROPOSED U.S. SPACEPORTS

There are currently 12 FAA-licensed spaceports in the United States. That figure includes two licenses for Space Florida -- one for Launch Complex 36, and one for the Launch and Landing Facility (formerly known as the Shuttle Landing Facility). Twelve additional sites are engaged in pre-application consultation, or have previously expressed an interest in receiving an FAA license. There are also 12 government-operated launch & landing sites, and 4 private launch & landing sites, all shown in Figure 3.

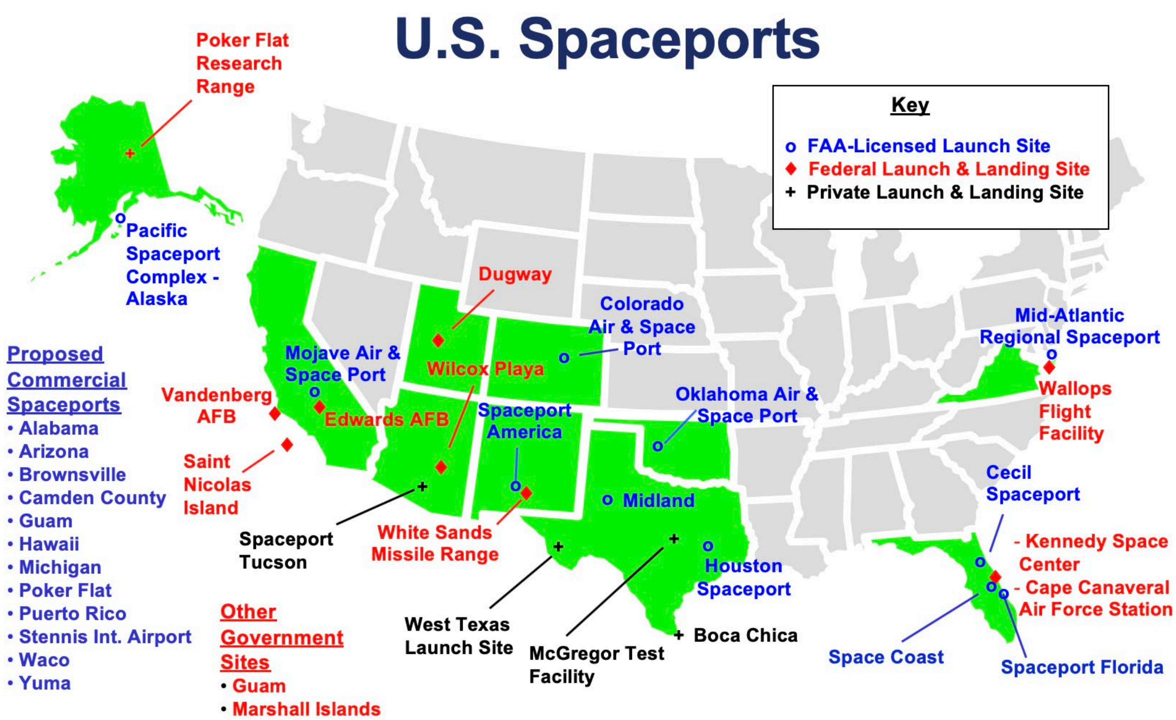

Figure 3 – Current and Proposed U.S. Spaceports

The following tables provide information on all of the current and proposed spaceports, including the spaceport name, state or territory, operator, category (orbital or suborbital), launch & landing type (vertical or horizontal), and payload class (small, medium, or heavy). The information is organized by group: Table 1 lists FAA-licensed spaceports, Table 2 lists proposed commercial spaceports, Table 3 lists private launch and landing sites, and Table 4 lists government launch and landing sites.

FAA-Licensed Spaceports

Spaceport Name	State or Territory	Operator	Category	Launch & Landing Type	Payload Class	Comments
Cape Canaveral Air Force Station	FL	Space Florida	Orbital	Vertical	Heavy	
Cape Canaveral Spaceport/Launch & Landing Facility	FL	Space Florida	Suborbital, Orbital	Horizontal	Small	
Cecil Spaceport	FL	Jacksonville Aviation Authority	Suborbital	Horizontal	Small	
Colorado Air & Space Port	CO	Adams County	Suborbital	Horizontal	Small	
Houston Spaceport	TX	Houston Airport System	Suborbital	Horizontal	Small	
Mid-Atlantic Regional Spaceport	VA	Virginia Commercial Space Flight Authority	Suborbital, Orbital	Vertical	Medium	
Midland International Air & Space Port	TX	Midland International Airport	Suborbital	Horizontal	Small	
Mojave Air & Space Port	CA	Mojave Air & Space Port	Suborbital, Orbital	Horizontal	Small	
Oklahoma Air & Space Port	OK	Oklahoma Space Industry Development Authority	Suborbital	Horizontal	Small	
Pacific Spaceport Complex - Alaska	AK	Alaska Aerospace Corporation	Suborbital, Orbital	Vertical	Small	
Space Coast Regional Airport	FL	Titusville-Cocoa Airport District	Suborbital	Horizontal	Small	
Spaceport America	NM	New Mexico Spaceflight Authority	Suborbital	Horizontal, Vertical	Small	

Table 1 – FAA-Licensed Spaceports

Proposed Commercial Spaceports

Spaceport Name	**State or Territory**	**Operator**	**Category**	**Launch & Landing Type**	**Payload Class**	**Comments**
Alabama Spaceport	AL	Alabama Space Authority	Suborbital	Horizontal	Small	
Antonio B. Won Pat International Airport	Guam	Won Pat International Airport Authority	Orbital	Horizontal	Small	
Arizona Spaceport	AZ	Arizona Spaceport Alliance	Suborbital	Horizontal, Vertical	Small	
Brownsville South Padre Island International Airport	TX	City of Brownsville	Suborbital, Orbital	Horizontal	Small	
Hawaii Air & Space Port	HI	State of Hawaii	Suborbital	Horizontal	Small	
Michigan Spaceport	MI	Michigan Aerospace Manufacturers Association	Orbital	Horizontal	Small	
Poker Flat	AK	Alaska Aerospace Corporation	Suborbital	Vertical	Small	
Spaceport Camden	GA	Camden County	Orbital	Vertical	Small	
Spaceport Puerto Rico	PR	Commonwealth of Puerto Rico	Suborbital, Orbital	Vertical	Small	
Stennis International Airport	MS	Hancock County Port and Harbor Commission	Suborbital	Horizontal	Small	
Waco Spaceport	TX	TSTC Waco Airport	Suborbital	Horizontal	Small	
Yuma Spaceport	AZ	Greater Yuma Economic Development Commissions	Suborbital	Horizontal	Small	

Table 2 – Proposed Commercial Spaceports

Private Launch & Landing Sites

Spaceport Name	State or Territory	Operator	Category	Launch & Landing Type	Payload Class	Comments
Boca Chica	TX	SpaceX	Suborbital, Orbital	Vertical	Heavy	
McGregor Test Facility	TX	SpaceX	Suborbital	Vertical	Small	
Spaceport Tucson	AZ	World View Enterprises	Suborbital	Vertical	Small	Extremely High-Altitude Balloon Launches
West Texas Launch Site	TX	Blue Origin	Suborbital	Vertical	Small	

Table 3 – Private Launch & Landing Sites

Government Launch & Landing Sites

Spaceport Name	State or Territory	Operator	Category	Launch & Landing Type	Payload Class	Comments
Anderson Air Force Base	Guam	U.S. Air Force	Orbital	Horizontal	Small	
Cape Canaveral Air Force Station	FL	U.S. Air Force	Orbital	Vertical	Heavy	
Dugway Proving Ground	UT	U.S. Army	Orbital	Vertical	Small	Boeing Starliner Landing Site
Edwards Air Force Base	CA	U.S. Air Force	Suborbital, Orbital	Horizontal	Small	
Kennedy Space Center	FL	NASA	Orbital	Vertical	Heavy	
Naval Outlying Field, Saint Nicolas Island	CA	U.S. Navy	Orbital	Vertical	Small	DARPA Launch Challenge Site

Poker Flat Research Range	AK	Geophysical Institute	Suborbital	Vertical	Small	Under Contract to NASA Wallops
Ronald Reagan Ballistic Missile Defense Test Site	Marshall Islands	U.S. Army	Suborbital, Orbital	Vertical	Small	
Vandenberg Air Force Base	CA	U.S. Air Force	Orbital	Vertical	Heavy	
Wallops Flight Facility	VA	NASA	Suborbital, Orbital	Vertical	Medium	
White Sands Missile Range	NM	U.S. Army	Suborbital, Orbital	Horizontal, Vertical	Small	Boeing Starliner Landing Site
Wilcox Playa	AZ	U.S. Army	Orbital	Vertical	Small	Boeing Starliner Landing Site

Table 4 – Government Launch & Landing Sites

Credit: Sierra Nevada Corporation

Figure 4 – Sierra Nevada Corporation Dream Chaser at Edwards AFB

RANGE OF THE FUTURE

The Eastern Range, located at Cape Canaveral Air Force Station, Florida, and the Western Range, located at Vandenberg Air Force Base, California, have served as the military's primary launch sites for space launches and missile tests for more than 60 years. A significant number of NASA and commercial space missions have also been conducted from those locations. Although improvements have certainly been made over the years, many of the facilities, including launch pads, vehicle processing facilities, propellant storage tanks, radars, communications networks, and command and control systems, are decades old and are desperately in need of renovation or replacement. Schedule constraints caused by the need to reconfigure hardware and software between missions have often limited the ability of both government and commercial customers to launch when they wanted to launch, and "getting a slot" on the Range schedule has sometimes necessitated interagency negotiations. Although the 45th Space Wing has adopted a "Drive to 48" goal to be able to conduct 48 launches within a 12-month period, even that rather ambitious pace of operations will likely not satisfy future launch requirements. At the same time, because of limited budgets and higher-priority needs in other areas, the Department of Defense has not been able to incorporate innovative approaches and advances in technology to the same degree that has been accomplished in the commercial space community. The development of reusable launch vehicles, recoverable payload fairings, fly-back boosters, and autonomous flight safety systems will definitely result in significant changes in how future space operations are conducted.

In response to these challenges, and in recognition of the potential for lower costs and the ability for industry to move at the "speed of business" rather than at the "speed of government," Air Force Space Command (now the U.S. Space Force) is reported to be looking at how to commercialize management of the Ranges, while still ensuring that national security needs can be met. This effort is sometimes referred to as the "Range of the Future." In September 2019, a Request for Information was issued for "Management and/or Operational Concepts for a National Spaceport with the spaceports collocated with the current Eastern and Western Ranges." The goal is to "transform its current ranges into flexible and agile sites utilized for both national security and commercial space launch missions." Adopting more commercial practices for acquisition, scheduling, and resource management will certainly offer the opportunity for more efficient operations. However, if this is accomplished by creating two taxpayer-supported "National Spaceports," it would make it very difficult for other spaceports to compete financially. Ideally, there would be a level playing field that would allow commercial spaceports to be considered for national security missions (as well as for civil and commercial launches), and the expected growth in overall space activity would provide the business case for an increased number of sites.

Even more importantly, if the Department of Defense were to rely solely on the Eastern Range (for satellites requiring easterly orbits) and the Western Range (for satellites requiring polar orbits), it would not appear to meet the intent of 10 U.S.C. § 2273, which calls for assured access to space for national security payloads. In addition to specifying the requirement for the availability of at least two space launch vehicles (or families of space launch vehicles) for national security payloads, this legislation also calls for actions to ensure "a robust space launch infrastructure and industrial base." Unfortunately our current spaceport ground infrastructure is fragile and rather vulnerable. Launch pads are typically designed and configured to accommodate a single kind of launch vehicle. Because of the possibility that a launch pad accident, a natural disaster (such as a hurricane, tornado, earthquake, or wildfire), or a terrorist attack could significantly damage one of those facilities, our nation's access to space is not guaranteed. In fact, after such an event, the recovery time could be many months, or even years.

Addressing this vulnerability does not mean that the United States needs to build additional copies of the Eastern and Western Ranges from scratch, at alternate locations. Fortunately, there are already a number of commercial spaceports and privately-owned-and-operated launch and landing sites in existence, plus a number of others that have been proposed. Some of these sites were originally military air bases, some have previously been or are currently serving as commercial airports, and others have been or will be built with state and local funding, or have been developed by commercial launch operators. Evaluating the nation's launch and landing site needs and capabilities as a whole, including the requirement to support civil, commercial, and national security space activities, and then applying strategic investments where appropriate, could significantly improve the options available for space access, and at a much lower cost than would otherwise be possible.

Credit: Colorado Air & Space Port

Figure 5 – Potential Future Operations at Colorado Air & Space Port

DEVELOPMENT OF A NATIONAL SPACEPORT NETWORK

An alternate approach to meeting assured access to space requirements for national security missions, in addition to satisfying space launch needs for civil and commercial users, would be to develop a National Spaceport Network, consisting of current and prospective commercial spaceports, which are required to be licensed and regulated by the FAA; government-owned-and-operated launch and landing sites; and privately-owned-and-operated launch and landing sites. Top-level oversight of the Network would be provided by the FAA Office of Spaceports, which would serve as the lead organization in a whole-of-government effort. The Office would be responsible for identifying, coordinating, requesting, and distributing the funding needed for spaceport infrastructure projects, and for ensuring public safety through the issuance of the appropriate standards, guidelines, and regulations.

Over time, this approach would allow the upgrade and modernization of national spaceport facilities, alleviate the congestion and schedule backlog at the Eastern and Western Ranges, lower costs through the use of advanced technologies and streamlined commercial business practices, and allow for a more robust and more resilient space launch infrastructure. An added benefit is that the Department of Defense could become "one of many customers" for spaceports, thus relieving the DoD of responsibility for managing spaceport facilities, and allowing it to focus on conducting its operational missions. Under this philosophy, spaceports would operate much more like airports, which can have military users in addition to civil and commercial ones.

It is important to recognize that not all spaceports are alike. However, in combination, they can support vehicles of different sizes, with different configurations (vertical or horizontal takeoff and/or landing, air-launched or ground-launched, purely rocket-powered or both rocket & turbine powered), flying different kinds of missions, for different kinds of customers, on either orbital or suborbital profiles, using a variety of trajectories, altitudes, and inclinations. They are also able to serve many different markets and take advantage of multiple sources for funding and investment.

Finally, the process of planning and developing a National Spaceport Network could allow a better understanding of the fact that spaceports can serve as more than just locations from which launches and reentries take place. Rather, they can also serve as focal points and technology hubs to enable the growth of the global space economy. Ideally, the activities at a typical spaceport could include aerospace manufacturing, research & technology development, education & training, workforce development, and point-to-point transportation.

NATIONAL SPACEPORT NETWORK GOALS

The strategic goals of the National Spaceport Network should be consistent with those of the U.S. Department of Transportation and the Federal Aviation Administration, but with a focus on space transportation. Four proposed top-level goals are:

- SAFETY: Continually improve the safety of space transportation operations that are conducted from the nation's spaceports.
- INFRASTRUCTURE: Invest in spaceport infrastructure to ensure safety, capacity, efficiency, and resiliency in providing timely and responsive access to space, and to stimulate economic growth, productivity, and competitiveness.
- INNOVATION: Lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the National Spaceport Network.
- ACCOUNTABILITY: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability.

Credit: Virgin Galactic

Figure 6 – SpaceShipTwo Approaching the Mojave Air & Space Port

PROPOSAL FOR A NATIONAL SPACEPORT POLICY

Over the last several years, some observers, including senior government officials, have expressed the concern that there may be "too many spaceports." However, as the FAA Reauthorization Act of 2018 pointed out, "A robust network of space transportation infrastructure, including spaceports, is vital to the growth of the domestic space industry and America's competitiveness and access to space."

Based on this assessment, and to clear up any potential confusion among key stakeholders, the U.S. Government should adopt and communicate the following National Spaceport Policy:

> ***"The U.S. Government strongly supports the development and operation of a National Spaceport Network, consisting of commercial, government, and privately-operated launch and reentry sites, that will allow assured access to space for all users, while enabling the United States to:***
>
> - ***Satisfy national security requirements,***
> - ***Maintain technological leadership,***
> - ***Enable international competitiveness, and***
> - ***Provide inspiration for students and the development of a robust aerospace workforce."***

Credit: Blue Origin

Figure 7 – Blue Origin's New Shepard at their West Texas Launch Site

EXISTING OPTIONS FOR FUNDING SPACEPORT INFRASTRUCTURE

The federal government has traditionally provided substantial funding to develop, repair, or upgrade all forms of transportation infrastructure. Examples include funding for roads, bridges, and the interstate highway system; railroads; airports; and seaports. Given the importance of space operations to our national security, technological leadership, and economic competitiveness, it is appropriate that comparable federal programs be established for the development, enhancement, and maintenance of spaceport infrastructure in order to enable those activities.

Several existing options were evaluated to provide the needed federal support, including use of the Airport Improvement Program, the Space Transportation Infrastructure Matching Grants Program, Department of Transportation Discretionary Grants Programs, and a potential Joint DoD/FAA Infrastructure Program. These options are described in the sections that follow.

- **Airport Improvement Program.** Financial support for airport infrastructure by the federal government really began during World War II. Prior to that time, airports were considered to be a local or private responsibility, although the federal government did provide a tax exclusion for interest on airport-related municipal bonds. After the war, Congress passed the Federal Airport Act of 1946, which created the Federal Aid to Airports Program. The Act called for the creation of a national plan for the development of airports in the United States, with the goal of creating a system of public airports that would meet the needs of civil aeronautics, including both air commerce and private flying. Appropriations were authorized from the general fund, at a level not to exceed $100 million per year (the equivalent of more than $1.1 billion in current dollars).

Twenty-four years later, Congress passed the Airport and Airway Development and Revenue Acts of 1970, which established eligibility criteria and distribution guidelines for grants, and created the Airport and Airway Trust Fund. Assessments on aviation users and fuel were used to provide the money needed to operate the Trust Fund. The current Airport Improvement Program was established by the Airport and Airway Improvement Act of 1982, which also directed the Secretary of Transportation to publish a biannual document, the National Plan of Integrated Airport Systems (NPIAS), that would identify airports considered important to the national aviation system. Eight years later, the Aviation and Airway Safety and Capacity Act of 1990 allowed airports to levy a Passenger Facility Charge (PFC) to raise additional revenue. It also established the Military Airport Program (MAP), which provided AIP funding for capacity and/or conversion projects at joint-use or former military airfields.

The most recent legislation on the issue, the FAA Reauthorization Act of 2018, funds AIP for five years, from FY2019 through FY2023, at a level of $3.35 billion per year. It also authorizes supplemental funding to the AIP discretionary funds of more than $1 billion per year over the same period.

There are actually five major sources of airport capital development funding: Airport Improvement Program (AIP) grants; passenger facility charges (PFCs); tax exempt bonds; state and local grants; and airport operating revenues, including such items as tenant leases and landing fees. The Airport and Airway Trust Fund, which provides the money for AIP grants, is funded through a 7.5% ticket tax, a $4.30 flight segment tax, a 6.25% tax on cargo waybills, and a tax on aviation fuel, which ranges from 4.4 cents per gallon to 21.9 cents per gallon, depending on aircraft type. Passenger Facility Charges are currently limited to $4.50, with a limit of $18.00 on the total that a passenger can be charged per round trip. System-wide, PFCs currently add up to more than $3.4 billion each year. According to Bond Buyer, a trade publication, airports also raised approximately $21.5 billion from 120 bond issues in 2019.

Examples of the types of projects that are eligible for AIP funding include:

- Runway construction/rehabilitation
- Taxiway construction/rehabilitation
- Apron construction/rehabilitation
- Airfield lighting
- Airfield signage
- Airfield drainage
- Land acquisition
- Weather observation stations
- Navigation aids
- Planning Studies
- Environmental studies
- Safety area improvements
- Airport layout plans
- Access roads located on airport property
- Removing, lowering, moving, marking, and lighting hazards

The Federal share of funding for AIP projects ranges from 75 to 90 percent, depending on the type and size of the airport.

Seven FAA-licensed spaceports are also airports that are eligible to apply for AIP funding; however, the FAA Office of Airports has determined that commercial space operations do not qualify as aeronautical activities, which means that space-related infrastructure projects may not be funded through AIP grants. Congress could eliminate that constraint by changing the definition of aeronautical activities to include commercial space transportation; however, funding spaceport infrastructure projects through AIP grants would have several disadvantages. For example, the only launch vehicle operators that financially support the Airport and Airway Trust Fund today are those whose systems incorporate carrier aircraft and have to pay taxes on the aviation fuel they use. Those companies include Virgin Galactic, which uses WhiteKnightTwo to launch SpaceShipTwo; Virgin Orbit, which uses a Boeing 747 to launch LauncherOne; and Northrop Grumman, which uses an L-1011 to launch Pegasus. Separately, for those spaceports that have launch pads instead of runways, it is not clear how or why the FAA Office of Airports would be able to effectively oversee their operations or evaluate their need for infrastructure projects. Finally, the overarching goals of a spaceport, including providing assured access to space, do not appear to be closely-aligned with the typical metrics for an airport, such as the number of passenger boardings per year, or the annual landed weights for cargo aircraft.

- **Space Transportation Infrastructure Matching Grants Program.** The Space Transportation Infrastructure Matching Grants (STIM) Program was authorized by Congress in 1994 as part of Public Law 103-272. The law states that the purpose of the grant authority is to "ensure the resiliency of the space transportation infrastructure of the United States." It describes commercial space transportation infrastructure development as including "construction, improvement, design, and engineering of space transportation infrastructure," as well as "technical studies to define how new or enhanced space transportation infrastructure can best meet the needs of the United States commercial space transportation industry."

Under the terms of the statute, the Federal share of infrastructure projects was limited to no more than 50 percent of the total cost, and the private sector was required to contribute at least 10 percent of the project cost.

Although Congress had authorized $10 million for the STIM grants program in 1994, no funding was provided until 2010. During FY2010, FY2011, and FY2012, the Secretary of Transportation awarded approximately $500,000 per year in STIM grants. Projects included construction of a solid rocket motor storage facility, acquisition of an emergency rescue vehicle, installation of an automated weather observing system, development of a spaceport master plan, and preparation of spaceport environmental assessments. A complete list of projects is provided in Figure 8.

Even though the spaceports receiving STIM grants were certainly appreciative of the funds received, the limited dollar amounts available (significant infrastructure projects cannot typically be accomplished for less than $500,000), and the requirement for a 50 percent match (including at least a 10 percent match from the private sector), definitely limited the effectiveness of the program. No STIM grants have been awarded since FY2012.

Launch Site Authority	State	Value	Year of Award	Purpose
Alaska Aerospace Corporation	Alaska	$227,195	2010	Construction of a solid rocket motor storage facility at Kodiak Launch Complex
East Kern Airport District	California	$125,000	2010	Acquisition of an emergency rescue vehicle based at Mojave Air and Space Port
Jacksonville Aviation Authority	Florida	$104,805	2010	Draft Cecil Field Spaceport Master Plan
New Mexico Spaceport Authority	New Mexico	$43,000	2010	Installation of an Automated Weather Observing System (AWOS) located at Spaceport America
Virginia Commercial Space Flight Authority	Virginia	$125,000	2011	Security and remote monitoring improvements at MARS
East Kern Airport District	California	$125,000	2011	Development of a Supplemental Environmental Assessment
New Mexico Spaceport Authority	New Mexico	$249,378	2011	Construction of a mobile structure to process launch vehicles before launch
East Kern Airport District	California	$23,750	2012	Acquisition of specialized firefighting equipment at Mojave Air and Space Port
Front Range Airport Authority	Colorado	$200,000	2012	Environmental assessment to prepare for Front Range Spaceport FAA launch site application
Hawaii Department of Business, Economic Development and Tourism	Hawaii	$250,000	2012	Environmental assessment to prepare for Spaceport Kalaeloa FAA launch site application

Figure 8 – STIM Grant Awardees and Projects, from The FAA Annual Compendium of Commercial Space Transportation: 2012

- **DOT Discretionary Grants Programs.** Since 2009, the U.S. Department of Transportation has provided more than $7.9 billion in discretionary grants under the Better Utilizing Investment to Leverage Development (BUILD) program. This program was previously known as the Transportation Investment Generating Economic Recovery (TIGER) program. Eligibility requirements allow project sponsors at the State and local levels to obtain funding for multi-modal, multi-jurisdictional projects that are more difficult to support through traditional DOT programs. Altogether, more than 609 transportation infrastructure projects have been funded in all 50 states, the District of Columbia, Puerto Rico, Guam, and the Virgin Islands. Grant awards to date have been limited to roads, bridges, transit, rail, ports, or intermodal transportation.

As part of the Coronavirus Aid, Relief, and Economic Security (CARES) Act, nearly $10 billion was made available to U.S. airports as part of a separate grants program. Funds are intended to keep airports in reliable, safe operation, to keep airport and aviation workers employed, and to keep airport credit ratings stable. These grants are appropriated from the General Fund, not the Airport and Airway Trust Fund, and they provide for a 100% Federal share for FY2020 grants. Although FAA-licensed spaceports are experiencing many of the same challenges as airports in responding to the coronavirus, spaceports have not been included in these grant programs to date.

- **Joint DoD/FAA Infrastructure Program.** The National Defense Authorization Act for Fiscal Year 2020, which became law on December 20, 2019, allows the Secretary of Defense, in coordination with the FAA Administrator, to carry out a program to enhance infrastructure and improve support activities for the processing and launch of Department of Defense small-class and medium-class payloads. The program is intended to include improvements to operations at both launch ranges and at FAA-licensed spaceports. Such a program may have significant benefits for spaceports involved in the launch of national security payloads; however, as currently defined, it would not appear to be applicable to launch sites that are focused on civil or commercial operations. A report describing DoD's plan for the program is to be submitted to Congress within 270 days after the date of enactment of the NDAA.

Credit: Pacific Spaceport Complex - Alaska

Figure 9 – Minotaur IV+ at the Pacific Spaceport Complex - Alaska

PROPOSAL FOR A SPACEPORT NETWORK IMPROVEMENT PROGRAM

Commercial spaceports today that have infrastructure needs are forced to rely upon state and local grants, tax-exempt bonds from local governments, or revenues from operations, such as tenant leases or launch and landing fees. As a consequence, the scope of potential projects is severely limited. Accomplishing major infrastructure projects at spaceports will likely necessitate federal assistance, just as it has for airports. However, because no existing federal program provides that kind of support for the nation's spaceports, a new program should be established to meet current and future requirements. If approved, the Spaceport Network Improvement Program (SNIP) would be a comprehensive, sustainable, 3-phase program that would support greater investments in spaceport infrastructure, both directly, through federal funding, and indirectly, by providing incentives for state and local governments, academic institutions, and private companies to invest. The program would take advantage of the experience gained and lessons learned from previous and existing infrastructure grant programs, while incorporating modifications as appropriate to meet the unique requirements associated with commercial space transportation. In accordance with the goal of establishing a robust and highly-capable National Spaceport Network, SNIP grants could be awarded to current and prospective commercial spaceports (which either are or will be licensed and regulated by the FAA), and to privately-owned-and-operated launch and landing sites.

A list of all current and proposed U.S. Spaceports was provided in Tables 1-4, beginning on page 11, along with information on the spaceport category, launch and landing type, and payload class. Tables 5-8 in the Appendix provide the spaceports' highest priority infrastructure projects, along with estimated costs for each project. As of the date of publication of this Development Plan, ten spaceports had submitted infrastructure project requirements, with 44 different projects identified, and a total estimated cost of over $382 million. When other spaceports are able to submit their infrastructure project requirements, the Plan will be updated to incorporate the new information.

Spaceports that are also airports may have some infrastructure projects that are strictly space-related, some that are strictly aviation-related, and some that support both space and aviation. As a result, spaceports should be allowed to apply for project funding from both the AIP and the SNIP; however, the Office of Spaceports should coordinate with the Office of Airports prior to releasing any funds, to ensure that the total value of the grants actually received will not exceed the maximum Federal share of the overall project cost.

- **Program Description.** The Spaceport Network Improvement Program would consist of three phases. Because of an urgent need for near-term investment, in conjunction with the expectation of limited revenues during this period, grants for the first two phases would be appropriated through the General Fund. However, given the anticipated growth in the global space economy, and in response to the infrastructure improvements that would be made during the early years, spaceport grants made during the third phase would be paid for through an industry-funded trust fund, much like airport grants are funded today.

Phase 1. During Phase 1, SNIP grants would consist of approximately $8.5 million worth of spaceport infrastructure grants (the amount remaining from the original 1994 authorization for STIM grants). These grants would be modeled on both the DOT Discretionary Grants programs and the CARES Act grants (in response to the impacts of the coronavirus), with speed and flexibility being key features. The goal would be to make grant awards as soon as possible, hopefully prior to the end of FY 2020. The primary purpose for these grants would be to address urgent, safety-critical facility needs; to ensure that spaceport equipment and facilities are being properly maintained and repaired; to keep spaceport workers employed; and to keep spaceport credit ratings stable. The grants would allow for a 100 percent Federal share (with no matching requirements).

Phase 2. During Phase 2, SNIP grants would be awarded using the processes previously established for the STIM grant program, but with two major modifications. First, the funding would be greatly increased (to allow more significant infrastructure projects to be accommodated). Second, the maximum Federal share of 50 percent would be changed to 90 percent, with the mandate for a 10 percent match by the private sector being eliminated. These changes recognize the limited financial resources available to most commercial spaceports today, and the fact that it will likely be many years before they are able to collect significant income from tenants, launch and landing fees, and concessions. The changes would also bring the program more closely into line with the matching requirements used in the AIP. Phase 2 would start in FY2021, and it would be funded at the level of $100 million per year. Depending on the results of the program plan being developed by the Secretary of Defense in accordance with the FY2020 NDAA, there may be opportunities for DoD to provide supplemental funding for certain FAA-licensed spaceports that have the potential to support national security missions.

Phase 3. During Phase 3, the Spaceport Network Improvement Program would evolve to become more like the Airport Improvement Program. The Program would continue to be funded at the $100 million per year level; however, grants would be paid from a newly established Spaceport and Spaceway Trust Fund. Because of the differences in propulsion systems for launch vehicles (liquids, solids, and hybrids) and the variety of propellants that are used, creating and administering an equitable fuel tax would be quite challenging. Likewise, implementing the equivalent of a Passenger Facility Charge does not appear reasonable or cost effective at the present time. Thus, money for the Trust Fund would come from a Cargo Tax (for satellites, payloads, and experiments) that would be analogous to the tax on cargo waybills in aviation, plus a Spaceflight Participant Ticket Tax. It is important that the transition to Phase 3 not begin too early, since levying taxes on space launches could have a significant negative impact on the industry. One possibility would be to start Phase 3 once the global space economy is independently and objectively assessed to total $1 trillion, a milestone currently estimated to occur by 2040, according to a number of financial services firms. At that point, the commercial space industry will hopefully be well-established and on a firm financial footing, thereby allowing users to help fund the needed infrastructure.

- **Potential Trust Fund Revenues.** A rough estimate of potential Trust Fund revenues is provided below.

  <u>Assumptions for Cargo Launches in FY2040:</u>
  - 30 commercial launches per year
  - Average cost per launch = $50 million
  - Cargo Tax of 6.25% (the same as the Cargo Waybill Tax in aviation)
  - Cargo revenue that could be collected for the Trust Fund = $93 million per year

  <u>Assumptions for Spaceflight Participant Launches in FY2040:</u>
  - Suborbital Launches with Spaceflight Participants
    - 6 suborbital launches per week, with operations conducted 50 weeks per year, resulting in 300 suborbital launches per year
    - Each suborbital launch carries 5 Spaceflight Participants, resulting in 1500 seats sold per year
    - Average ticket price per seat = $250,000
    - Spaceflight Participant Ticket Tax of 7.5% (the same as the ticket tax in aviation)
    - Suborbital Spaceflight Participant revenue = $28 million per year

  - Orbital Launches with Spaceflight Participants
    - 2 orbital launches with Spaceflight Participants per year, each carrying 2 paying customers, resulting in 4 seats sold per year
    - Average ticket price per seat = $25 million
    - Spaceflight Participant Ticket Tax of 7.5% (the same as the ticket tax in aviation)
    - Orbital Spaceflight Participant revenue = $7 million

  - Total Spaceflight Participant Revenue that could be collected for the Trust Fund in FY2040 = $35 million

  Adding up the estimated revenue for cargo launches and the estimated revenue for spaceflight participant launches, the total revenue that could be collected for the Spaceport and Spaceway Trust Fund in FY2040 is approximately $128 million.

  Note that if the commercial space transportation industry thrives, launch costs and ticket prices are likely to decrease; however, that may lead to a corresponding increase in demand and a greater number of launches and customers. Obviously, it is very difficult to predict market conditions years in advance. Therefore, the assumptions and projected revenues should be reviewed on a regular basis, and if appropriate, the anticipated tax rates could be adjusted to cover needed infrastructure expenditures without overburdening the industry.

- **Grant Eligibility.** The following entities would be eligible to apply for a Spaceport Network Improvement Program grant:

  1. Commercial spaceports holding an FAA license to operate a launch or reentry site.
  2. Private spaceports that are owned by an FAA-licensed launch or reentry vehicle operator.
  3. Commercial spaceports whose application for an FAA launch or reentry site operator license has been determined to be sufficiently complete.
  4. Private spaceports that are owned by a launch or reentry vehicle operator whose application for an FAA launch or reentry license has been determined to be sufficiently complete.
  5. Commercial spaceports who have completed pre-application consultation for an FAA launch or reentry site operator license.
  6. Private spaceports that are owned by a launch or reentry vehicle operator who has completed pre-application consultation for an FAA launch or reentry license.

  As indicated above, holding an FAA license is not a prerequisite to applying for a Spaceport Network Improvement Program grant. However, the applicant's status in the license application process is one of the factors that will be considered in determining the size of the grant, along with the potential benefits to the overall National Spaceport Network that completion of the infrastructure project would enable.

- **Project Priorities.** Grant applications will be prioritized based on the degree to which the completion of the project would have a positive impact on the performance of the National Spaceport Network in terms of:

  - **Safety** - Safety projects are intended to enhance the safety of operations at the spaceport, including improvements that will better protect the general public and property (both inside and outside the spaceport boundary), spaceport employees and facilities, launch operator employees, and other spaceport tenants.
  - **Capacity** - Capacity projects are intended to increase the number of launches that can be conducted from the United States during a given period of time, and to decrease the required turnaround time between launches. Although there is no need for a given U.S. spaceport to be able to accommodate every kind of launch vehicle and mission, the National Spaceport Network, taken as a whole, should have a full range of capabilities. Those capabilities should include being able to host suborbital, orbital, and point-to-point missions; using vehicles that launch and land either horizontally or vertically; carrying small, medium, or heavy payloads; either with or without crew; as well as supporting departure and arrival trajectories for any direction/azimuth.
  - **Efficiency** - Efficiency projects are intended to lower the cost of conducting space launch and landing operations. Related attributes include responsiveness, agility, and flexibility, in order to be able to quickly and easily adapt to new, different, or changing operational requirements.

- **Resiliency** - Resiliency projects are intended to provide the capability to recover from adverse conditions, such as having a launch pad, test stand, or runway incur significant damage due to a hurricane, earthquake, wildfire, or launch accident.

- **Grant Distribution.** Airport Improvement Program grants are distributed based on a combination of formula grants (also known as entitlements) and discretionary funds. Entitlement funds are allocated based on whether the airport is classified as a primary airport, a cargo service airport, or a general aviation airport. At some point in the future, it may be appropriate to distribute Spaceport Network Improvement Program grants in a similar fashion; however, for the time being, grants will be allocated on a case-by-case basis, after considering the grant project priorities discussed above.

As soon as possible, Congress should establish a Spaceport Network Improvement Program (SNIP) as a comprehensive, time-phased, and sustainable program that would support greater investments in spaceport infrastructure, both directly, through federal funding, and indirectly, by providing incentives for state and local governments, academic institutions, and private companies to invest.

Credit: SpaceX

Figure 10 – Falcon 9 and Crew Dragon at the NASA Kennedy Space Center

PROGRAMMATIC INITIATIVES

Commercial Human Spaceflight Training.

A key component of NASA's astronaut training program involves regular flights in a T-38 jet trainer. Although many high-performance or former military aircraft are owned by private citizens or companies, they are operated under experimental airworthiness certificates rather than type certificates. As a result, under current law, they are not allowed to be used for flights involving compensation or hire, such as for commercial spaceflight training. The FAA Reauthorization Act of 2018 defines a new type of vehicle, called a space support vehicle, that can be used to provide training for potential space flight participants, government astronauts, or crew. However, under the Act, space support vehicles are limited to vehicles that are already licensed under chapter 509 of title 51 as launch or reentry vehicles, or as components of such launch or reentry vehicles. Changing the definition in the statute to also include "a vehicle in development to become a launch vehicle, reentry vehicle, or a component of a launch or reentry vehicle; or an aircraft when it conducts a space support flight," and allowing their operation in accordance with a license or permit under chapter 509 of title 51, would enable commercial spaceflight companies to use high-performance or former military aircraft for their training programs, just like NASA does. Making this change would create and enable the rapid growth of a whole new segment of the industry, while providing significant business opportunities for commercial spaceports. Such operations could be performed under an "informed consent" regime, just like the one used for commercial human spaceflight missions under FAA launch licenses. Allowing this type of training to be conducted in high-performance aircraft prior to an actual launch would enable spaceflight participants to be better prepared for their space missions, thereby enhancing safety. It would also immediately enable human spaceflight training operations to be conducted at interested commercial spaceports, resulting in increased jobs and economic activity, even before those sites are able to host actual commercial space flights.

Congress should change the statutory definition of a space support vehicle to also include "a vehicle in development to become a launch vehicle, reentry vehicle, or a component of a launch or reentry vehicle; or an aircraft when it conducts a space support flight," and allow their operation in accordance with a license or permit under chapter 509 of title 51. This change would enable commercial spaceflight companies to conduct spaceflight training programs using high-performance or former military aircraft, just like NASA does.

Spaceflight Training Education Program.

Thirty-four years ago, NASA's Teacher in Space program was highly successful in attracting interest and engagement from students all over the country. After the Space Shuttle Challenger accident, the program was cancelled. Today, both Virgin Galactic and Blue Origin are expected to start regular suborbital spaceflights within the next 12 months. Although the primary focus of those programs is on space tourism and microgravity research, the government can take advantage of their capabilities by establishing a Spaceflight Training Education Program that would provide an opportunity for interested science, technology, engineering, and math teachers to personally experience spaceflight. Instead of having one teacher travel all the way to orbit, which was the plan for the original program, the new program would allow hundreds of teacher to fly on a suborbital spaceflight. For roughly $12.5 million per year, 50 competitively-selected teachers (one from every state) would have a chance to fly to the edge of space, and then return to their classrooms to share that once-in-a-lifetime adventure with their students. The FAA Office of Spaceports, in collaboration with the Commercial Space Transportation Center of Excellence, could take a lead role in administering this program, since much of the training and operations would take place at commercial spaceports. Additional partners could include NASA, the Department of Education, private industry, professional societies, and other interested parties.

A second element of the program would provide support to activities that would allow students to build and launch small rockets, like the very successful Team America Rocketry Challenge for middle and high school students (sponsored by the Aerospace Industries Association), and the Spaceport America Cup (organized by the Experimental Sounding Rocket Association), which is designed for college and university students.

A third element of the program would support opportunities for high school students to design and build CubeSats or other experimental payloads that would eventually be launched into space. An example of this type of activity is the Design/Build/Launch competition that is administered by the American Institute of Aeronautics and Astronautics (AIAA) and Blue Origin.

The FAA Office of Spaceports should take the lead in creating hands-on aerospace learning opportunities for students, through the use of innovative partnerships between government, industry, and academia. Such programs will be invaluable in inspiring, training, and engaging with the next generation, who will comprise the nation's future aerospace workforce.

Point-to-Point Transportation Through Space.

The ability to conduct high-speed, long-distance transportation, specifically point-to-point transportation through space, will be a major game-changer, both for national security, and for economic competitiveness. This is an area that the United States needs to lead. SpaceX is in the process of developing the Starship vehicle for future deep space exploration missions. According to Elon Musk, the SpaceX CEO, that same system could be used to carry hundreds of people from one side of the Earth to the other in less than 90 minutes. Richard Branson has also articulated plans for Virgin Galactic to offer rocket-powered, long-distance travel. The use of prizes, contests, and technology demonstrations for such a program, along with appropriate collaboration between government, industry, and academia, could incentivize and accelerate progress in this area. The Office of Spaceports could be a focal point for these initiatives, in anticipation of the day when point-to-point transportation through space is routinely available.

The U.S. Government should establish a goal of leading the world in Point-to-Point transportation through space. Accomplishing this challenging goal will require a

partnership between government, industry, and academia, and will involve not only advances in engineering and technology, but also work in policy, law, regulations, customs and security, flight and ground operations, market analysis, and economics.

Establishment of a Major Aerospace Prize.

Prizes have been an integral part of the development of aviation and space, from Louis Bleriot crossing the English Channel in 1909, to Charles Lindbergh winning the Orteig Prize by flying the Atlantic in 1927. In the late 1920s, Daniel Guggenheim offered $2.5 million in aviation-related grants and prizes through the Daniel Guggenheim Fund for the Promotion of Aeronautics (that would be worth more than $100 million today). More recently, Burt Rutan and Scaled Composites were awarded the $10 million XPrize, and NASA has given out significant prizes for its Lunar Lander and Centennial Challenge competitions. Note that not all of the prize money needs to come from the government; in many of the previous examples, funding was provided by the private sector. One spaceport-related idea would be to offer a series of prizes for successively longer reusable launch vehicle missions between FAA-licensed spaceports, as an encouragement for the development of safe and reliable point-to-point transportation. Some potential options for such flights are listed in Figure 9.

Options for Point-to-Point Test Flights

Potential Flight Plan	Distance (nm)
• Van Horn, Texas to Spaceport America	126
• Oklahoma Air & Space Port to Midland Air & Space Port	248
• Colorado Air & Space Port to Oklahoma Air & Space Port	382
• Spaceport America to Mojave Air & Space Port	592
• Houston Spaceport to Cecil Spaceport	713
• Boca Chica, Texas to Cape Canaveral	914

Figure 11 – Options for Point-to-Point Test Flights

The government should promote the establishment of a multi-million-dollar aerospace prize to advance the state of the art and generate interest and excitement in the media and the general public.

OTHER RECOMMENDATIONS

- **<u>Updating FAA Spaceport Regulations.</u>** FAA regulations concerning spaceports are found in 14 CFR Part 420 (License to Operate a Launch Site), and 14 CFR Part 433 (License to Operate a Reentry Site). These regulations were written more than 20 years ago, and are in need of revision. Part 420 in particular is highly prescriptive, and should be rewritten as a performance-based rule to allow for increased flexibility and innovation while still ensuring public safety. It should also take advantage of industry consensus standards and allow the use of a "safety case" approach for compliance. Recognizing that rulemaking projects can take many years to be completed, in the interim period the FAA should take full advantage of the provision of the Commercial Space Launch Act of 1984 that states that "The Secretary [of Transportation] can waive a requirement ... for an individual applicant if the Secretary decides that the waiver is in the public interest and will not jeopardize the public health and safety, safety of property, and national security and foreign policy interests of the United States."

  The FAA Office of Commercial Space Transportation should begin planning for a rulemaking project to update its regulations on the operation of launch and reentry sites to make them performance-based rather than prescriptive.

- **<u>Expediting the Processing of Spaceport License Applications.</u>** As the pace of space operations has increased, and as the news media and the general public have become more aware of ongoing commercial space activities, proposals for new spaceports have sometimes been met with rather vocal objections from certain segments of the aviation community, specifically, airport managers, airline officials, members of airline pilot associations, and on occasion, even senior executives from the FAA. In most cases, these concerns were based on a misunderstanding of the kinds of operations that were being proposed, the kinds of launch or reentry vehicles that would be involved, or the potential impacts on airport or airline operations that would likely result, if any. To address these concerns, the FAA Office of Commercial Space Transportation has attempted to be very proactive, transparent, and communicative about plans for future spaceports, by organizing public meetings, scheduling visits and tours, and holding telecons and face-to-face meetings with interested stakeholders. Although raising questions and concerns about proposed spaceport projects is certainly appropriate, there have been a number of recent examples in which the license application review process has been stretched out or delayed for years, based on complaints from specific individuals or organizations. This is a significant concern to the spaceport community since, even if a proposed spaceport is eventually approved, the time (and corresponding cost) required to obtain a spaceport license from the FAA is now likely to be much greater than it has been in previous years.

  The FAA Office of Spaceports should strive to ensure that spaceport license applications are processed quickly and efficiently, and that determinations are made in a timely manner.

- **<u>Streamlining the Environmental Review Process.</u>** Under current law, there is a requirement for the government to conduct an environmental review prior to issuing a license or permit for the operation of a launch vehicle, no matter how small or environmentally benign the vehicle may be. These kinds of reviews do not have to be accomplished prior to new aircraft being certificated; instead, aircraft are granted categorical exclusions. The ability to use categorical exclusions for the licensing or permitting of launch vehicles, at least under certain conditions, would save significant time and money for launch vehicle operators, since the environmental review process is typically the driver in determining how long it takes to complete the license application process.

Congress should allow the FAA to grant categorical exclusions to the requirement for conducting an environmental review as part of the launch license application process, for cases where the proposed operations are likely to have similar impacts, or lesser impacts, than previously analyzed activities.

- **Integrating Commercial Space Systems into the National Airspace.** In carrying out its responsibilities to regulate the operation of commercial and general aviation aircraft, drones, and commercial space activities, the FAA has done an outstanding job of ensuring public safety. In the past, due to the limitations of existing systems and technologies, that has required closing airspace and/or putting restrictions on its use in order to ensure safe separation between vehicles. Today, based on advances in technology, that approach is no longer necessarily required. In the future, the goal should be to safely integrate all users of the National Airspace System, including commercial space operators.

  To achieve this goal, the U.S. Government should adopt and communicate the following policy:

  The U.S. Government supports the aggressive pursuit of the development and implementation of advanced technologies, including space-based position determination, real-time telemetry, trajectory prediction, and autonomous flight safety systems, that will allow the safe integration of all users of the National Airspace System, including commercial space systems, without significantly impacting the efficiency of other users.

- **Support for Space-Related Education and Research Programs.** To ensure that the United States will always have a talented and motivated aerospace workforce, there is a need to objectively assess all aspects of space-related education programs, including research, K-12 education, community colleges, undergraduate and postgraduate university programs, and faculty recruitment and engagement. Successful programs should be expanded, replicated, and considered for additional funding, and programs that allow students to be exposed to new technologies or that provide training needed for the next generation aerospace workforce should be incorporated wherever possible. Currently, there are 16 Centers of Excellence in the Department of Transportation, involving hundreds of universities and affiliates, of which 15 are focused on the mature aeronautics industry. Only one, the Center of Excellence for Commercial Space Transportation (COE CST), is focused on the space industry. The 10 core universities in the COE CST perform research directly related to the current needs of the FAA Office of Commercial Space Transportation, including support for the recently established Office of Spaceports. As just one example, the COE CST has supported student experiments to validate the ability of an Automatic Dependent Surveillance-Broadcast (ADS-B) avionics system mounted on a small rocket to accurately determine its position via satellite navigation, and then transmit the information to air traffic control stations on the ground. Consideration should be given to expanding or extending the COE CST, or to establishing additional space-related Centers.

The National Space Grant College and Fellowship program, and the NASA Established Program to Stimulate Competitive Research (EPSCoR) program are excellent programs and have been funded by Congress to support faculty and students doing space-related research. Given that space-specific higher education programs are being funded by competitors and partners across the globe, expansion of the existing programs should be considered.

The Federal Government should continue its support of space-related education programs at all grade levels through grants, research programs, fellowships, and STEM initiatives.

- **Engagement with the International Spaceport Community.** People all over the world are interested in space, but only a handful of countries have their own space programs. However, given the continuing development of reusable launch vehicles and small expendable launch vehicles, it has become much more realistic for other nations to think about having a spaceport within their borders, especially if it can be co-located with an existing military airfield or commercial airport. In such a situation, the launch vehicles themselves could be operated by a U.S. company. This type of scenario would offer a number of potential advantages for the United States: it would provide additional business for American launch companies, it would allow the U.S. commercial space regulatory framework to be more widely adopted globally, and it could enable the start of an international dialog that will be necessary before beginning point-to-point intercontinental transportation through space, once the technology for such systems becomes available. A number of countries have already asked for information from the FAA concerning how best to regulate commercial space activities; with the establishment of the Office of Spaceports, the FAA has an opportunity to expand those talks and formalize the relationships for future cooperation.

The FAA Office of Spaceports should seek out opportunities to engage with, and partner with, other countries that are interested in commercial space transportation, spaceport development, and point-to-point transportation through space.

SUMMARY OF RECOMMENDATIONS

- ***The U.S. Government should adopt and communicate a National Spaceport Policy that supports the development and operation of a National Spaceport Network, consisting of commercial, government, and privately-operated launch and reentry sites, that will allow assured access to space for all users, while enabling the United States to:***

    - ***Satisfy national security requirements,***
    - ***Maintain technological leadership,***
    - ***Enable international competitiveness, and***
    - ***Provide inspiration for students and the development of a robust aerospace workforce.***

- ***As soon as possible, Congress should establish a Spaceport Network Improvement Program (SNIP) as a comprehensive, time-phased, and sustainable program that would support greater investments in spaceport infrastructure, both directly, through federal funding, and indirectly, by providing incentives for state and local governments, academic institutions, and private companies to invest.***

- ***Congress should change the statutory definition of a space support vehicle to also include "a vehicle in development to become a launch vehicle, reentry vehicle, or a component of a launch or reentry vehicle; or an aircraft when it conducts a space support flight," and allow their operation in accordance with a license or permit under chapter 509 of title 51. This change would enable commercial spaceflight companies to conduct spaceflight training programs using high-performance or former military aircraft, just like NASA does.***

- ***The FAA Office of Spaceports should take the lead in creating hands-on aerospace learning opportunities for students, through the use of innovative partnerships between government, industry, and academia. Such programs will be invaluable in inspiring, training, and engaging with the next generation, who will comprise the nation's future aerospace workforce.***

- ***The U.S. Government should establish a goal of leading the world in Point-to-Point transportation through space. Accomplishing this challenging goal will require a partnership between government, industry, and academia, and will involve not only advances in engineering and technology, but also work in policy, law, regulations, customs and security, flight and ground operations, market analysis, and economics.***

- ***The government should promote the establishment of a multi-million-dollar aerospace prize to advance the state of the art and generate interest and excitement in the media and the general public.***

- ***The FAA Office of Commercial Space Transportation should begin planning for a rulemaking project to update its regulations on the operation of launch and reentry sites to make them performance-based rather than prescriptive.***

- ***The FAA Office of Spaceports should strive to ensure that spaceport license applications are processed quickly and efficiently, and that determinations are made in a timely manner.***

- ***Congress should allow the FAA to grant categorical exclusions to the requirement for conducting an environmental review as part of the launch license application process, for cases where the proposed operations are likely to have similar impacts, or lesser impacts, than previously analyzed activities.***

- ***The U.S. Government should support the aggressive pursuit of the development and implementation of advanced technologies, including space-based position determination, real-time telemetry, trajectory prediction, and autonomous flight safety systems, that will allow the safe integration of all users of the National Airspace System, including commercial space systems, without significantly impacting the efficiency of other users.***

- ***The Federal Government should continue its support of space-related education programs at all grade levels through grants, research programs, fellowships, and STEM initiatives.***

- ***The FAA Office of Spaceports should seek out opportunities to engage with, and partner with, other countries that are interested in commercial space transportation, spaceport development, and point-to-point transportation through space.***

Credit: Boeing Space

Figure 12 – Atlas V and Starliner at Cape Canaveral Air Force Station

CONCLUSIONS AND NEXT STEPS

The development of a National Spaceport Network, consisting of current and prospective commercial spaceports, government-owned-and-operated launch and landing sites, and privately-owned-and-operated launch and landing sites, offers an opportunity to increase the safety, capacity, efficiency, and resiliency of the nation's space operations. Such a network could be implemented through formal or informal public-private partnerships between federal, state, and local governments; the aerospace industry; and academia.

The purpose of this National Spaceport Network Development Plan is to provide the information necessary to assist in the development of that National Spaceport Network, in order to support our civil, commercial, and national security needs for access to space. The Plan is intended to be an information resource for key stakeholders, including the FAA Office of Spaceports, the U.S. Department of Transportation, the Department of Defense, the National Aeronautics and Space Administration, Congress, the National Space Council, launch vehicle developers and operators, and current and prospective spaceport operators. In the event of any questions or comments concerning the proposals, or if follow-on briefings would be helpful, please notify the Global Spaceport Alliance using the contact information found at the end of the report. GSA would be happy to respond to email or phone requests, or to schedule a videoconferencing session for more in-depth discussions.

Following publication and review of the Plan, the next steps will be focused on implementation. The Plan provides a number of recommended changes to spaceport policies, laws, and regulations; several ideas for new programmatic initiatives; a proposal for a new approach to provide spaceport infrastructure funding; and a list of 44 specific infrastructure projects from ten different spaceports, with a total estimated cost of over $382 million. When other spaceports are able to submit their infrastructure project requirements, the Plan will be updated to incorporate the new information.

Some of the actions put forward in the Plan can be carried out by the spaceports themselves, or by interested stakeholders from industry or academia, while others would benefit from leadership by the FAA Office of Spaceports. Certain recommendations will require Congressional approval. In any case, the probability of success of the overall effort will be greatly increased if all of the interested parties are willing to communicate, cooperate, and collaborate with respect to the tasks at hand. GSA is committed to working with other stakeholders in meeting that challenge!

This document will be updated annually, or more frequently as conditions warrant.

APPENDIX - SPACEPORT INFRASTRUCTURE PROJECTS

The following tables provide information on proposed spaceport infrastructure projects and estimated project costs. The information is organized by group: FAA licensed spaceports, proposed commercial spaceports, private launch and landing sites, and government launch and landing sites. In addition to the Spaceport Network Improvement Program (SNIP) projects and cost estimates, the total estimated cost of all aviation projects for those sites that appear in the National Plan of Integrated Airport Systems (NPIAS) are also listed for reference and comparison.

Projects for FAA Licensed Spaceports

Spaceport Name	Infrastructure Projects	SNIP Estimate	NPIAS Estimate
Cape Canaveral Air Force Station	TBD	TBD	
Cape Canaveral Spaceport/Launch & Landing Facility	TBD	TBD	
Cecil Spaceport	Payload Preparation & Integration Facility	$3,700,000	$8,723,378
	Mission Operations Control Center Buildout	$1,800,000	
	Liquid Propellant Storage	$2,600,000	
	Rocket Motor Test Facility	$1,000,000	
	Common Use Infrastructure Corridor	$12,500,000	
Colorado Air & Space Port	Rocket Engine Test Facility	$30,000,000	$5,483,334
	Runway Improvements	$70,000,000	
	Security Fencing	$15,000,000	
	Water/Sewer Infrastructure Improvements	$12,000,000	
	Construction of Launch Vehicle Processing Building	$25,000,000	
Houston Spaceport	Runway 17R Extension	$16,000,000	$32,109,268
	Runway 4/22 Taxiway	$45,000,000	
	Payload Processing/Clean Room	$150,000	
	Spaceport Operations Hangar	$5,000,000	
	Spaceport Test Stand	$2,000,000	

Mid-Atlantic Regional Spaceport	TBD	TBD	
Midland International Air & Space Port	Rocket Engine Test Stand	$500,000	$1,787,347
Mojave Air & Space Port	TBD	TBD	$9,770,289
Oklahoma Air & Space Port	Spaceport Master Development and Business Development Plan	$350,000	$0
	ASR Installation	$2,500,000	
Pacific Spaceport Complex - Alaska	Environmental Assessment for Expanded Operations	$250,000	
	Security Enhancements	$500,000	
	Automated Weather Balloon Launcher	$1,200,000	
	LOX/N2 Cryogenic Production Plant	$1,400,000	
	Static Fire Test Stand	$1,500,000	
	New Small/Light-Lift Launch Pad	$3,500,000	
	Upgrades and Conversion of Launch Tower to Liquid Fuels	$8,600,000	
	ARFF-Like Emergency Station	$2,500,000	
	Tracking and Command Destruct System	$5,500,000	
Space Coast Regional Airport	TBD	TBD	
Spaceport America	Taxiway Construction	$20,000,000	
	Weather Instrumentation	$2,500,000	
	Construction of 2 Multipurpose Vertical Launch Pads and Rails with Utilities	$22,000,000	
	Construction of 2 Vehicle Processing Facilities (1 for Vertical Launches and 1 for Horizontal Launches)	$20,000,000	
	Construction of Storage Bunker, Engine Test Stand, and Propellant Storage and Handling Equipment	$8,000,000	

Spaceport America (continued)	Runway Lighting, ILS, and Ramp Space	$10,000,000	
	Acquisition of Maintenance Equipment for FOD Detection and Removal	$1,000,000	
	Acquisition of Range Radar, Optical, and Telemetry Tracking Instrumentation	$15,000,000	

Table 5 – Projects for FAA-Licensed Spaceports

Projects for Proposed Commercial Spaceports

<u>Spaceport Name</u>	<u>Infrastructure Projects</u>	<u>SNIP Estimate</u>	<u>NPIAS Estimate</u>
Alabama Spaceport	TBD	TBD	
Antonio B. Won Pat International Airport	TBD	TBD	
Arizona Spaceport	TBD	TBD	
Brownsville/South Padre Island International Airport	TBD	TBD	
Hawaii Air & Space Port	TBD	TBD	
Michigan Spaceport	TBD	TBD	
Poker Flat	Spaceport Master Plan	$250,000	
	Environmental Assessment	$250,000	
Spaceport Camden	Spaceport Master Plan	$600,000	
	Completion of Environmental Assessment	$450,000	
Spaceport Puerto Rico	TBD	TBD	
Stennis International Airport	Taxiway to Oxidizer Loading Area	$4,150,000	
	Oxidizer Loading Area	$200,000	
	Spaceport Master Plan	$300,000	
	RLV Processing Facility	$7,425,000	
	Payload Processing Facility	$362,500	
Waco Spaceport	TBD	TBD	
Yuma Spaceport	TBD	TBD	

Table 6 – Projects for Proposed Commercial Spaceports

Projects for Private Launch & Landing Sites

Spaceport Name	Infrastructure Projects	SNIP Estimate	NPIAS Estimate
Boca Chica	TBD	TBD	
McGregor Test Facility	TBD	TBD	
Spaceport Tucson	TBD	TBD	
West Texas Launch Site	TBD	TBD	

Table 7 – Projects for Private Launch & Landing Sites

Projects for Government Launch & Landing Sites

Spaceport Name	Infrastructure Projects	SNIP Estimate	NPIAS Estimate
Anderson Air Force Base	TBD	TBD	
Cape Canaveral Air Force Station	TBD	TBD	
Dugway Proving Ground	TBD	TBD	
Edwards Air Force Base	TBD	TBD	
Kennedy Space Center	TBD	TBD	
Naval Outlying Field, Saint Nicolas Island	TBD	TBD	
Poker Flat Research Range	TBD	TBD	
Ronald Reagan Ballistic Missile Defense Test Site	TBD	TBD	
Vandenberg Air Force Base	TBD	TBD	
Wallops Flight Facility	TBD	TBD	
White Sands Missile Range	TBD	TBD	
Wilcox Playa	TBD	TBD	

Table 8 – Projects for Government Launch & Landing Sites

REFERENCES

2018 Global Space Economy Report, Bryce Space and Technology, available at https://brycetech.com/reports, 2018.

"Air Force looking for ideas on how to turn launch ranges into 'national spaceports'," by Sandra Erwin, Space News, November 2019.

FAA Strategic Plan, FY 2019-2022, available at https://www.faa.gov/about/plans_reports/media/FAA_Strategic_Plan_Final_FY2019-2022.pdf.

Financing Airport Improvements, by Rachel Y. Tang, Congressional Research Service, updated March 15, 2019.

"Former FAA official calls for national spaceport policy," by Jeff Foust, Space News, October 15, 2019.

National Defense Authorization Act for Fiscal Year 2020, December 20, 2019.

National Plan of Integrated Airport Systems (NPIAS), 2019-2023, Report to Congress by the Secretary of Transportation, September 26, 2018.

Public Law 79-377, Federal Airport Act of 1946, May 13, 1946.

Public Law 103-272 [Established Space Transportation Infrastructure Matching Grant Program], July 5, 1994.

Public Law 115-254, FAA Reauthorization Act of 2018, October 5, 2018.

"Space: Investing in the Final Frontier," Morgan Stanley, July 2, 2019, available at https://www.morganstanley.com/ideas/investing-in-space.

"Space Tourism: Ready for blast-off?", UBS, March 1, 2019, available at https://www.ubs.com/microsites/wma/insights/en/investing/2019/space-tourism.html.

The Annual Compendium of Commercial Space Transportation: 2012, Office of Commercial Space Transportation, Federal Aviation Administration, February 2013.

"The Space Economy: An Industry Takes Off," Brian Higginbotham, U.S. Chamber of Commerce, October 11, 2018, available at https://www.uschamber.com/series/above-the-fold/the-space-economy-industry-takes.

U.S. Department of Transportation Strategic Plan for FY 2018-2022, February 2018, available at https://www.transportation.gov/sites/dot.gov/files/docs/mission/administrations/office-policy/304866/dot-strategic-planfy2018-2022508.pdf.

ABOUT THE GLOBAL SPACEPORT ALLIANCE

The Global Spaceport Alliance (GSA) was established in 2015 with the goal of creating a global network of spaceports that will allow increased access to space, and that can serve as focal points and technology hubs in growing the space economy. The group currently has 20 Member Spaceports and 9 Associate Member organizations, with representation from 5 different countries all over the world. GSA holds an annual Spaceport Summit in Houston in conjunction with the SpaceCom Conference, and it is actively involved in partnering with stakeholders at NASA and the FAA, with industry, and with academia.

For additional information about GSA, or for questions, comments, updates, or revisions to this document, please contact one of the following individuals:

- Dr. George C. Nield, GSA Chairman, george.nield@commercialspacetechnologies.com
- James D. Causey, GSA Executive Director, jcausey@spacecomexpo.com
- Steve Wolfe, GSA Deputy Executive Director, swolfe@spacecomexpo.com

Photo: Trevor Mahlmann

Figure 13 – SpaceX Starhopper at their Boca Chica Launch Site