



December 2020

COMMERCIAL SPACE TRANSPORTATION

FAA Should Examine a Range of Options to Support U.S. Launch Infrastructure

Accessible Version

GAO Highlights

Highlights of GAO-21-154, a report to congressional committees

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Why GAO Did This Study

Demand for commercial space launches is anticipated to increase in the coming years. FAA, the agency responsible for overseeing the sites where these launches occur, was directed by statute to submit a report—and update it every 2 years until December 2024—that makes recommendations on how to facilitate and promote greater investments in space transportation infrastructure.

The FAA Reauthorization Act of 2018 included a provision for GAO to review issues related to space transportation infrastructure. This report discusses launch providers' and site operators' views on the sufficiency of infrastructure in meeting market demand and assesses the steps FAA has taken to identify options for federal support of space transportation infrastructure, among other things. GAO reviewed relevant regulations; assessed FAA's actions against GAO-identified leading practices; and interviewed FAA officials, commercial launch providers, and representatives from U.S. commercial launch sites that GAO identified as having hosted an FAA-licensed launch since 2015 or having an FAA launch site operator license as of August 2020.

What GAO Recommends

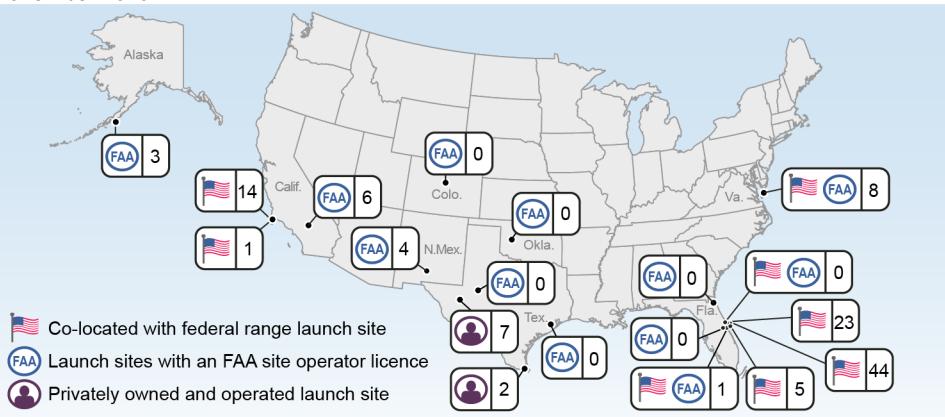
GAO recommends that FAA examine a range of potential options to support space transportation infrastructure and that this examination include a discussion of trade-offs. DOT partially concurred, noting that it would provide its mandated report to Congress but not conduct a new examination of a range of options. GAO continues to believe that such an examination is warranted.

View GAO-21-154. For more information, contact Heather Krause at (202) 512-2834 or KrauseH@gao.gov.

What GAO Found

Launch providers support the deployment of people and payloads, such as national security and commercial satellites or research probes, into space. The majority of these providers told GAO that U.S. space transportation infrastructure—located at sites across the country—is generally sufficient for them to meet their customers' current requirements. This situation is in part a result of the launch providers' investments in launch sites, along with state and local funding. Launch providers and site operators alike seek future improvements but differ on the type and location of infrastructure required. Some launch providers said that infrastructure improvements would be required to increase launch capacity at existing busy launch sites, while a few site operators said that new infrastructure and additional launch sites would help expand the nation's overall launch capacity.

U.S. Commercial Launch Sites with Number of FAA-Licensed Launches, January 2015 - November 2020



Sources: GAO analysis of Federal Aviation Administration (FAA) data and Map Resources. | GAO-21-154

The Federal Aviation Administration (FAA) was directed by statute to make recommendations to Congress on how to facilitate and promote greater investments in space transportation infrastructure, among other things. However, FAA's initial draft report was limited because it focused only on two existing FAA programs, rather than a range of options. FAA officials stated that they did not examine other options because of limited time and resources, and that the two identified programs could be implemented quickly because FAA has administrative authority to manage them. Leading practices in infrastructure investment emphasize the importance of conducting an examination of potential approaches, which can help identify how best to support national interests; avoid overlap or duplication of federal effort; and enhance, not substitute, participation by non-federal stakeholders. An examination may also help identify alternatives to making funding available, such as increasing efficiency and capacity through technology improvements. By focusing only on these existing programs, FAA may overlook other options that better meet federal policy goals and maximize the effect of any federal investment. Although FAA has already prepared its initial report to respond to the statute, it still has opportunities, such as during subsequent mandated updates, to report separately on potential approaches.

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Abbreviations

ARC	aviation rulemaking committee
AIP	Airport Improvement Program
AST	Office of Commercial Space Transportation
COMSTAC	Commercial Space Transportation Advisory Committee
COVID-19	Coronavirus Disease 2019
DOT	Department of Transportation
FAA	Federal Aviation Administration
LC	Launch Complex
LSSA	launch site safety assessment
NEPA	National Environmental Policy Act
SLC	Space Launch Complex
STIM	Space Transportation Infrastructure Matching

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE

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December 22, 2020

The Honorable Roger Wicker
Chairman
The Honorable Maria Cantwell
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Peter DeFazio
Chairman
The Honorable Sam Graves
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The space transportation industry provides launch services that make it possible to send national security and commercial satellites into orbit, research probes into the solar system, and spacecraft carrying humans or cargo to the International Space Station and, potentially in the future, to enable space tourism. Space transportation infrastructure is an essential component to support launch services. The type and design of infrastructure depend on the type of launch operation the site supports—such as a vertical or horizontal launch.

In 2000, recognizing the emergence of a commercial market in space transportation, the Federal Aviation Administration (FAA) within the Department of Transportation (DOT) began formally regulating the safety of commercial space launch and reentry sites.¹ Twelve launch sites currently hold site operator licenses, and agency records indicate that as of August 2020, nine additional entities are seeking licenses for 11 prospective U.S. launch sites. Since FAA began licensing launch sites, the industry landscape has changed, including more frequent launches, growth in the number of launch providers, and the development of new

¹In 1995, the Federal Aviation Administration (FAA) issued guidelines to regulate launch site operations. Several launch site operators were issued licenses under those guidelines. FAA Guidelines, *Hazard Analysis of Commercial Space Transportation* (Oct. 2, 1995). In 2000, FAA amended its commercial space transportation licensing regulations to add licensing and safety requirements for the operation of a launch site. Licensing and Safety Requirements for Operation of a Launch Site, 65 Fed. Reg. 62,812 (Oct. 19, 2000). Operations at such sites today may include both launch and reentry operations.

launch vehicles. As we have previously reported, funding streams for space transportation infrastructure have also changed, shifting from federal sources to state, local, and private sources.²

In addition to creating specific licensing and safety requirements, FAA's site operator regulations were intended to enable the development and use of launch sites that were not owned and operated by the federal government.³ To date, few FAA-licensed launch operations have taken place at these licensed sites, which are intended for use by multiple launch providers and are often referred to as spaceports.⁴ Rather, licensed commercial launch operations tend to take place at exclusive-use launch sites in the United States where a single company conducts launches either at its privately owned and operated site or at an exclusive-use launch complex that is on or co-located with a federal range. FAA officials told us that exclusive-use launch sites do not require a site operator license, as public safety requirements are met through that single launch provider's launch license.⁵

The FAA Reauthorization Act of 2018 included a sense of Congress that a robust network of space transportation infrastructure is important to the growth of the domestic space industry and the United States' access to space.⁶ The sense of Congress also stated that, among other things, DOT should seek to promote the growth, resilience, and capabilities of

²GAO, *Commercial Space Transportation: Improvements to FAA's Workforce Planning Needed to Prepare for the Industry's Anticipated Growth*, GAO-19-437 (Washington, D.C.: May 23, 2019).

³Historically, the federal government had operated and maintained its own space launch sites and infrastructure—called federal launch ranges—that it built beginning in the 1950s, to serve U.S. military and civil agencies' demand for launching satellites and missions into space.

⁴“Spaceport” is defined in the FAA Reauthorization Act of 2018 as “a launch or reentry site that is operated by an entity licensed by the Secretary of Transportation.” Pub. L. No. 115-254, 132 Stat. 3186, 3397. According to FAA, any launch or reentry site with an FAA site operator license is considered a “spaceport,” and is generally designed to support use by multiple commercial launch providers.

⁵Under its responsibility for regulatory oversight of the commercial space transportation industry, FAA issues two types of licenses: the previously mentioned site operator licenses and licenses for commercial launch or reentry operations (i.e., launch and reentry licenses). The latter license is issued to ensure protection of the public, property, and the nation's security and foreign policy interests, and is required regardless of whether an operation occurs at a site that has an FAA site operator license.

⁶FAA Reauthorization Act of 2018, Pub. L. No. 115-254, 132 Stat. at 3396.

space transportation infrastructure through policies and partnerships with state and local governments.⁷ The statute required FAA to, among other things, (1) establish an Office of Spaceports within its Office of Commercial Space Transportation; (2) evaluate the demands and the needs of the U.S. and international commercial space markets; (3) propose policies and programs designed to ensure that spaceport infrastructure supports these needs; and (4) make recommendations on how the federal government can promote and facilitate greater investments in spaceport infrastructure.⁸

The statute also included a provision for GAO to conduct a study of the spaceport application review process and mechanisms to provide federal funding to spaceports, among other things.⁹ This report discusses perspectives of key stakeholders—launch site operators and commercial launch providers—on (1) FAA’s site operator licensing process and regulations and (2) the sufficiency of space transportation infrastructure in meeting the commercial launch market’s demand. The report also assesses the steps FAA has taken to identify options for federal support of commercial space transportation infrastructure in response to the FAA Reauthorization Act of 2018.

To address all three objectives, we reviewed relevant statutes and regulations, including the FAA Reauthorization Act of 2018 and FAA’s regulations for site operator licensing. We interviewed officials from FAA’s Office of Commercial Space Transportation (AST) and Office of Airports and representatives from 18 of the 19 U.S. commercial launch sites that have hosted an FAA-licensed launch since 2015 or have an FAA launch site operator license as of August 2020.¹⁰ We also interviewed all 17 commercial launch providers that have conducted FAA-licensed launch activities or are in active consultations with FAA for a launch or reentry license. The views of the site operators and launch providers are not generalizable to all entities involved in launch activities, such as companies that only conduct research and development activities to support launches or potential site operators that are in preliminary

⁷The Act also provided the sense of Congress that state and locally owned or operated spaceports have significantly contributed to national launch infrastructure and that these investments should be encouraged by the federal government. *Id.* 132 Stat. at 3394-95.

⁸*Id.* 132 Stat. at 3395-96.

⁹*Id.* 132 Stat. at 3397.

¹⁰We attempted to contact one launch site operator numerous times, but we were unable to schedule an interview.

discussions with FAA about the site operator licensing process. However, we believe that the information provides a balanced and informed perspective on the topics discussed.

To describe key stakeholder perspectives on the sufficiency of space transportation infrastructure in meeting the commercial launch market's demand, we reviewed available white papers submitted to FAA by individual launch site operators and industry groups that represent launch providers and site operators in response to FAA's 2019 request. This request asked these groups to provide perspectives regarding challenges and opportunities for U.S. commercial launch sites.

To assess the steps FAA has taken to identify potential federal approaches to support commercial space transportation infrastructure, we identified leading practices that could be used to guide future federal involvement in funding spaceport infrastructure through a review of our prior work.¹¹ We then discussed with FAA officials their plans and actions to identify potential recommendations to support greater investment in space transportation infrastructure and assessed the extent to which FAA's actions followed the leading practices we identified. Appendix I provides more information on our scope and methodology.

We conducted this performance audit from April 2019 through December 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Space transportation is the movement of objects, such as satellites and vehicles carrying cargo, scientific payloads, or passengers, to or from

¹¹GAO, *Physical Infrastructure: Challenges and Investment Options for the Nation's Infrastructure*, GAO-08-763T (Washington, D.C.: May 8, 2008); *Intercity Passenger Rail: National Policy and Strategies Needed to Maximize Public Benefits from Federal Expenditures*, GAO-07-15 (Washington, D.C.: Nov 13, 2006); *Intermodal Transportation: Potential Strategies Would Redefine Federal Role in Developing Airport Intermodal Capabilities*, GAO-05-727 (Washington, D.C.: Jul. 26, 2005); and *Marine Transportation: Federal Financing and a Framework for Infrastructure Investments*, GAO-02-1033 (Washington, D.C.: Sept. 9, 2002).

space. In the United States, commercial space transportation is carried out using orbital and suborbital launch vehicles owned and operated by private companies. Key parties involved in all commercial space transportation activities include:

- The launch site operator—the entity that hosts the launch (or reentry, or both) of the launch vehicle from its launch site. Almost all launch site operators are either commercial launch providers or state or municipal government entities.
- The commercial launch provider—the entity that conducts the launch of a vehicle and the payload it carries.
- The launch customer—the entity that pays the launch provider to carry a payload into space. Customers include the U.S. government and private companies, such as satellite owners and researchers.

All launch and reentry sites have certain fundamental infrastructure components—some of which are required under FAA's site operator licensing regulations, such as lightning protection and public access controls. Other fundamental infrastructure components include launch support facilities, such as an adjacent control center, emergency response and firefighting equipment, and fuel and hazardous material storage. Beyond that, the type of infrastructure and its design depend on the type of operations that the site supports. For example, sites that support traditional vertical orbital launches—such as SpaceX's Falcon 9 vehicle—may require large expanses of land with reinforced concrete pads, steel structures to support the vehicle before launch, and rocket fuel pipelines and storage tanks. Sites that support suborbital unguided rocket launches may require a smaller launch pad or rail to launch but also require an open area, such as the ocean or vacant land, where the rocket may land and be recovered (see fig. 1).

Figure 1: Examples of Launch and Reentry Sites That Host Vertical Orbital and Horizontal Suborbital Launches



Launch site that hosts vertical orbital launches



Launch and reentry site that hosts horizontal suborbital launches and reentries

Source: Mid-Atlantic Regional Spaceport, Virginia (left) and Spaceport America, New Mexico (right). | GAO-21-154

In recent years, commercial launch providers have introduced new launch vehicles, in some cases requiring that launch sites have new and different types of infrastructure. For example, some commercial launch providers are moving toward reusable launch vehicles, which require infrastructure for reentry landings. Also, air-launch vehicles are being developed—such as Virgin Galactic's SpaceShipTwo to support future space-tourism flights—that operate similarly to an airplane until rocket ignition in the air. Such vehicles require a runway, hangar, and jet fuel to support horizontal take-offs and landings. As a result, some spaceports are co-located with airports to leverage existing infrastructure that can be used for horizontal launches.

FAA's primary means of overseeing the commercial space transportation industry includes licensing operators of non-federal launch sites (a site operator license)¹²; licensing commercial launch and reentry vehicle operations (a launch¹³ or reentry¹⁴ license); as well as conducting safety

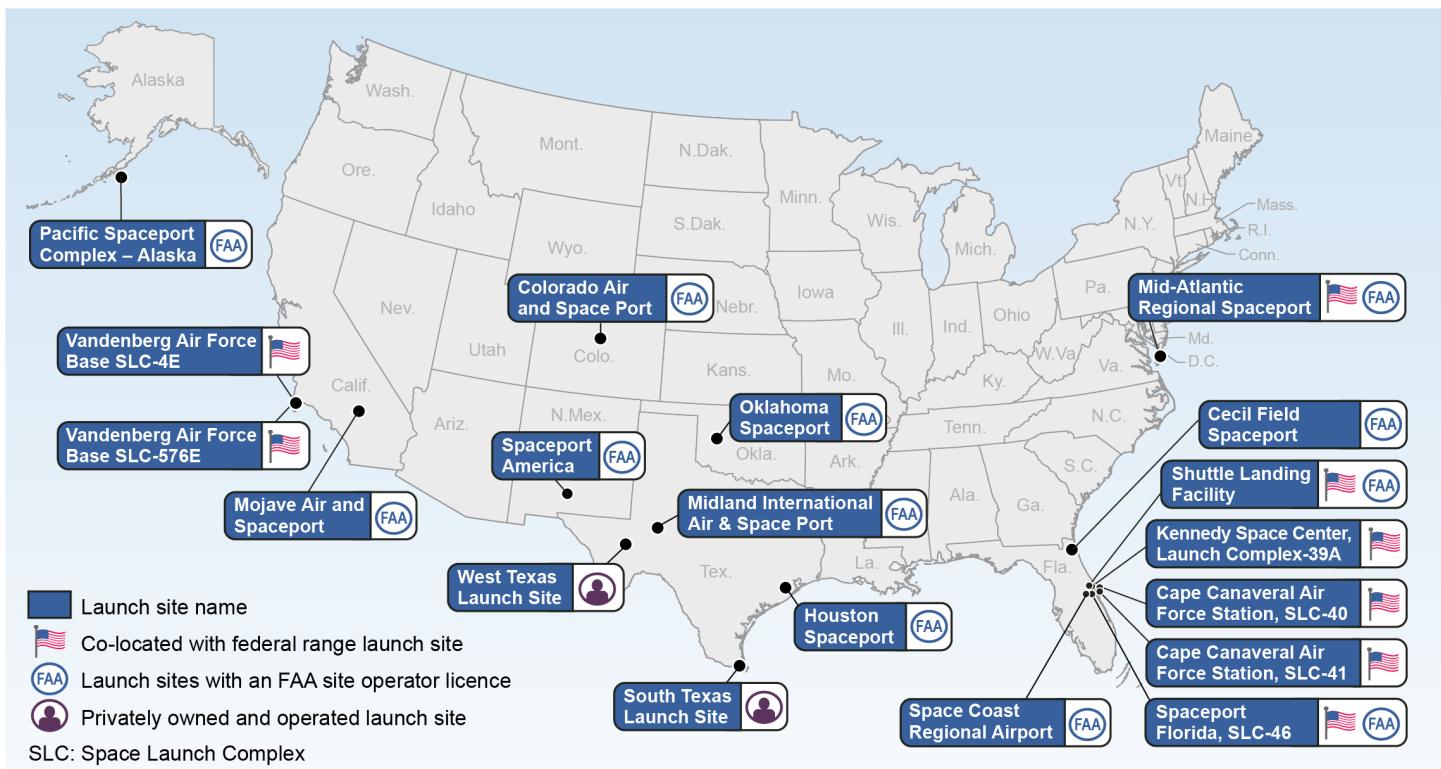
¹²14 C.F.R. part 420.

¹³14 C.F.R. part 415.

¹⁴14 C.F.R. part 433.

inspections of licensed launch providers and site operators.¹⁵ There are currently 19 U.S. launch sites that are licensed to host or have hosted, since 2015, commercial space launch operations (see fig. 2).¹⁶ Twelve of these 19 sites have an FAA site operator license (i.e., are “spaceports”).

Figure 2: U.S. Commercial Launch Sites That Are Licensed to Host or Have Hosted since 2015, a Commercial Space Launch, as of August 2020



Sources: GAO analysis of Federal Aviation Administration (FAA) data and Map Resources. | GAO-21-154

If a prospective launch site operator proposes to offer its launch site to others, that entity must obtain an FAA site operator license. If a commercial launch provider operates a site for its exclusive use, whether

¹⁵14 C.F.R. § 401.5. The FAA conducts a launch site safety assessment (LSSA), which is an assessment of a federal launch range to determine if the range meets FAA safety requirements. The LSSA documents a difference between range practice and FAA requirements.

¹⁶A federal launch range may include several launch sites, or launch complexes.

or not it is on or co-located with a federal range,¹⁷ it is not required to have an FAA site operator license. In addition, launch providers must obtain an FAA launch or reentry license, regardless of the site they use, including exclusive-use sites, for any commercial launch or reentry activities in the United States. According to FAA officials, launch providers that conduct commercial launches from their exclusive-use sites meet, through their launch license, both FAA's licensing safety requirements for operating as a site operator, as well as its licensing requirements for conducting launch operations.¹⁸

The site operator licensing process includes several phases, starting with initial discussions between the prospective site operator and FAA about the intended operations at the site and ending with FAA's issuance or denial of the license application (see fig. 3). The site operator licensing requirements focus on five areas that FAA deems critical to ensuring that operation of a launch site will not jeopardize public health and safety, the safety of property, U.S. national security or foreign policy interests, or international obligations of U.S. interests:

1. the environment,
2. policy considerations,
3. the siting of explosives and other explosive safety measures,
4. demonstration of launch safety at the proposed site, and
5. operational responsibilities.

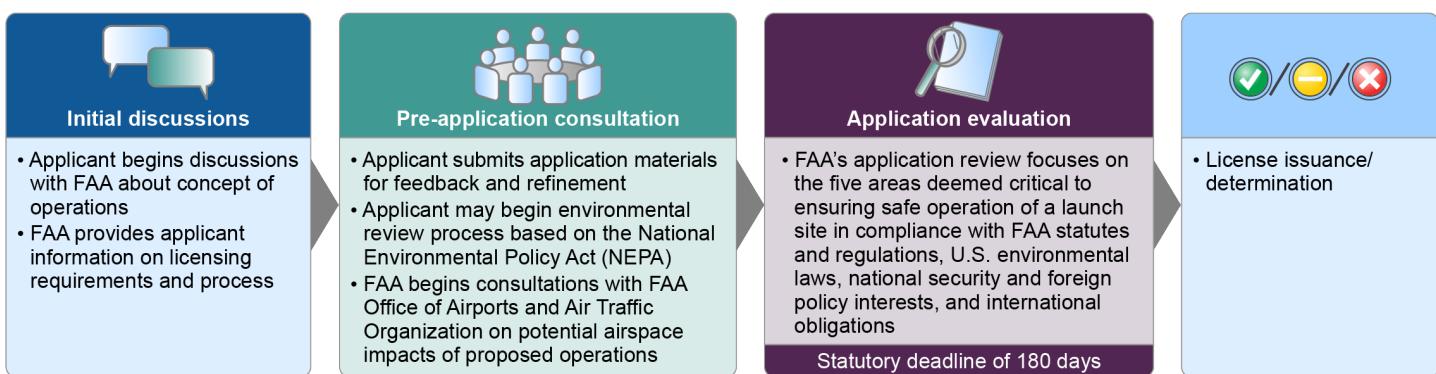
As part of the site operator license application, applicants must conduct an environmental review in compliance with the National Environmental Policy Act (NEPA) that assesses the environmental effects, such as noise

¹⁷Federal launch ranges today may consist of multiple different types of launch sites—or launch complexes—which include multi-user sites, requiring an FAA site operator license, as well as exclusive-use sites and government-operated sites, which are not required to have an FAA site operator license. A launch complex includes a launch pad and supporting launch infrastructure, such as operations control centers and launch vehicle and payload integration facilities—the facility where the launch vehicle is assembled before it is transported to the launch pad. It may also include down-range assets, such as radar and optics to support launches. The federal government still operates some launch complexes on its ranges. For example, the National Aeronautics and Space Administration (NASA) operates Kennedy Space Center, Launch Complex 39B, which it plans to use for its new Space Launch System—a launch vehicle for deep space human exploration.

¹⁸We have previously reported on FAA's efforts to amend its launch licensing regulations. See [GAO-19-437](#).

or air quality, of the site. For sites that do not yet have a launch provider's commitment to operate from the site, applicants can provide assumptions of operations based on a conceptual launch vehicle for any required analyses, such as for environmental and safety effects.

Figure 3: FAA Process for Site Operator and Launch Licenses, October 2020



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-21-154

Text of Figure 3: FAA Process for Site Operator and Launch Licenses, October 2020

1 Initial discussions

- Applicant begins discussions with FAA about concept of operations
- FAA provides applicant information on licensing requirements and process

2 Pre-application consultation

- Applicant submits application materials for feedback and refinement
- Applicant may begin environmental review process based on the National Environmental Policy Act (NEPA)
- FAA begins consultations with FAA Office of Airports and Air Traffic Organization on potential airspace impacts of proposed operations

3 Application evaluation

- FAA's application review focuses on the five areas deemed critical to ensuring safe operation of a launch site in compliance with FAA statutes and regulations, U.S. environmental laws, national security and foreign policy interests, and international obligations
- Statutory deadline of 180 days

4 License issuance determination

Selected Stakeholders' Views Differed on Concerns and Benefits of Site Licensing Process

Some Stakeholders Are Concerned That FAA's Regulations Allow Licensing of Sites That May Not Be Conducive for Launches

Launch providers and launch site operators we spoke with expressed concerns about two aspects of FAA's site operator licensing regulations and process. First, these stakeholders told us that FAA's regulations allow it to license sites that have limited potential to attract launch customers, although the sites may meet safety requirements. Second, some stakeholders noted that FAA's site operator licensing process does not adequately consider some potential effects, including effects on congested airspace and noise in surrounding communities.

Limited Potential to Attract Today's Launch Customers

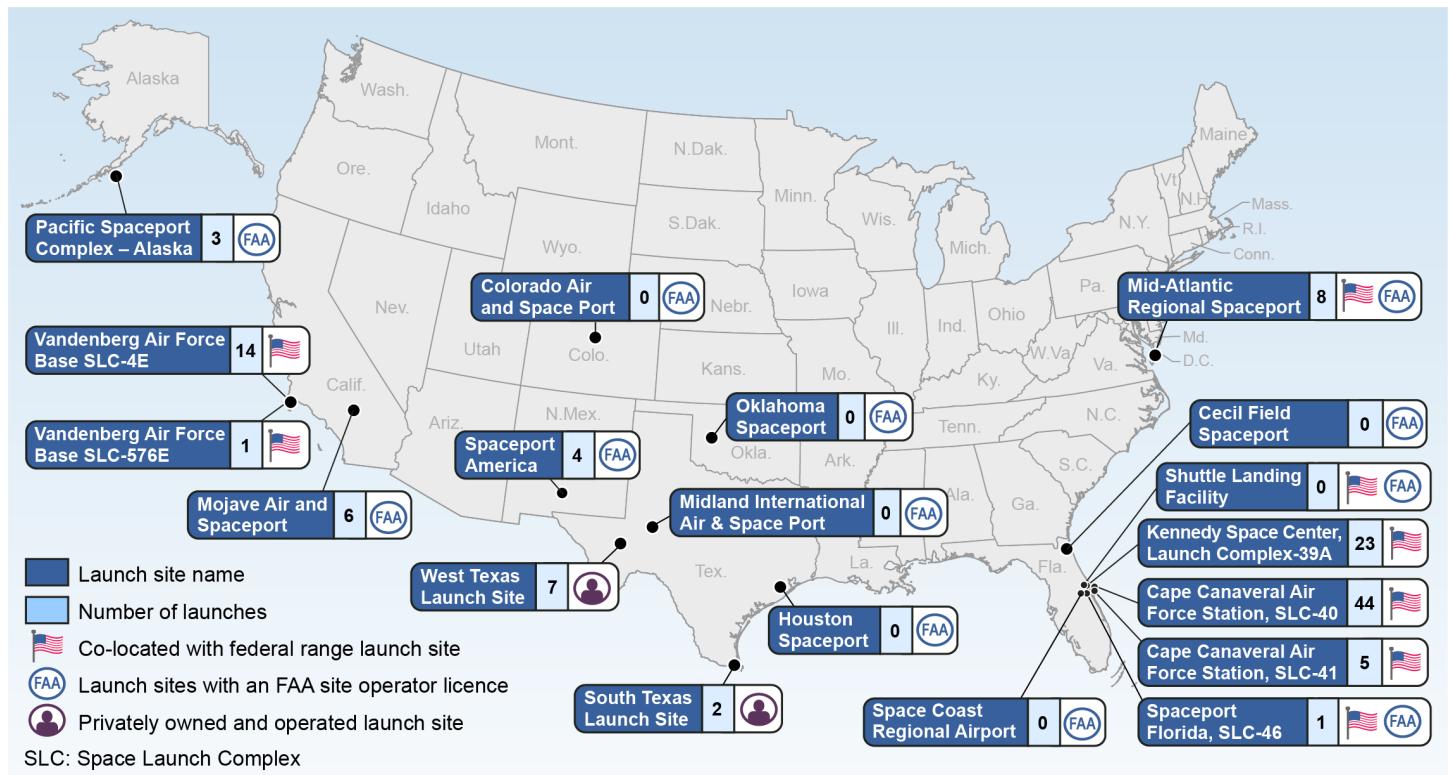
Operators of active spaceports and launch providers expressed concerns that FAA is licensing sites that may never host a launch, although other spaceport operators mentioned that the sites could be suitable for future operations. Representatives from four of the five spaceports that have hosted licensed launches said that FAA may be using its limited resources to review license applications for sites that may not be desirable to current launch providers—even though the sites may be determined by FAA during its licensing application review to be safe locations for launches. If a site is undesirable to current launch providers, it may never host a launch. For example, four launch providers that are seeking a location to conduct vertical launches told us that a site located inland—which describes almost half of the 12 existing spaceports—and near populated areas may be too risky for vertical launch operations. This risk is due to the potential public safety effects of a launch mishap, such as an explosion. Similarly, a fifth launch provider said that a site located on the coast or in a less populated area is more favorable for vertical launch operations to ensure public safety. One of these launch providers told us that even if the risk calculations would allow it to launch legally from an inland launch site, the company would prefer a different site,

particularly if the associated insurance costs of the inland site would be higher than other sites.¹⁹ However, a representative from an industry group that represents spaceports mentioned that spaceports that are not currently hosting launches may be suitable for future operations, depending on how the market for launch vehicles and launch operations evolve.

FAA officials said that any applicant that meets the requirements of its site operator regulations would be issued a license, and noted that the regulations do not require a proposed launch site to have an identified launch provider. Accordingly, FAA's application review does not specifically assess the extent to which the potential site is desirable to launch providers. Of the 12 licensed spaceports, seven have not hosted any FAA-licensed launch or re-entry activity since 2015. Further, officials told us that FAA has issued licenses to sites that have not, to date, hosted any licensed launches. Rather, as illustrated in figure 4, exclusive-use sites that are on or co-located with federal ranges—which are not required to be licensed by FAA—continue to host most launch and re-entry activity. FAA officials, two launch providers that operate exclusive-use launch sites, and two other stakeholders attributed this use to the benefits offered by federal ranges, such as coastal locations that are most often advantageous for orbital launches. FAA officials also told us that federal ranges offer other benefits, such as extensive available infrastructure.

¹⁹As part of a launch license, FAA requires launch companies to purchase insurance to cover losses to third parties or damage or loss to U.S. government property in the event of a commercial launch or reentry accident. 51 U.S.C § 50914; 14 C.F.R. §§ 440.5, 440.9. FAA calculates the insurance amount to reflect the maximum probable loss that is likely to occur because of a mishap that results in (1) third-party damage, including deaths and injuries on the ground and damage to property caused by anything that resulted from a launch or reentry, and (2) damage to government property. 14 C.F.R. § 440.7.

Figure 4: U.S. Commercial Launch Sites with Number of FAA-Licensed Launches, January 2015 - November 2020



Sources: GAO analysis of Federal Aviation Administration (FAA) data and Map Resources. | GAO-21-154

According to FAA, as of August 2020, nine entities were engaged with FAA in the site operator license application process for 11 prospective U.S. launch sites. Only four of these 11 prospective sites, according to FAA, have identified launch providers that plan to conduct launches at their sites. This situation could, according to four spaceport representatives, tie up FAA's resources with reviewing applications for potential future sites that do not have a clear operational benefit, while limiting its ability to serve spaceports that are actively supporting launch operations. While FAA could not provide a precise estimate on the amount of resources used to review an application, officials noted that the overall time from initial discussions to license determination can take several years, mostly due to consultation driven by NEPA requirements and review.

FAA officials said that applications that involve an unproven launch vehicle can take additional time to review, given the uncertainties associated with these vehicles' potential launch operations and effects. But officials said that review time for these applications has, to date, not

presented resource challenges.²⁰ Under FAA's site operator licensing regulations, a prospective site operator may apply for and receive a site operator's license on the basis of an unproven or conceptual vehicle that the applicant believes could operate at the site. The licensing regulations require the applicant to describe the assumptions it made about the launch vehicle's size; type; launch operations (i.e., horizontal versus vertical launch); and expected vehicle trajectory to show that it can meet the licensing safety requirements. Those assumptions may be based on a launch vehicle that has already launched or been tested successfully at other sites, or may be entirely conceptual.²¹

Members of an aviation rulemaking committee (ARC) established by FAA to examine spaceport issues recommended in the committee's final report in March 2019, that, among other things, FAA prioritize its resources toward license applicants for a site supporting an established launch provider over those applicants seeking a license to host launches based solely on a conceptual launch vehicle. FAA officials noted that, currently, only four of the 11 prospective applicants for a new or renewed site operator license have an identified launch provider. Accordingly, FAA officials told us that the amount of time or resources that FAA spends on application review in the near term should not delay the licensing of spaceports planning for future launch operations.

²⁰FAA officials also noted that the resources needed to oversee already licensed spaceports without launch activity are minimal, however. For example, FAA does not conduct site inspections unless the site has active launch operations and only reviews and approves license renewals every 5 years. FAA officials also told us that they requested and received additional resources that they are using to support all licensing activities, including those for site operator licenses.

²¹For example, in reviewing Front Range Airport's site operator license application, FAA based its analyses on assumptions provided by the applicant regarding the operations of a conceptual launch vehicle because the applicant did not have a commitment from a launch operator. FAA analyzed the location of propellant storage, mission preparation activities and related facilities, the surface movement of the conceptual vehicle, and the safety of the proposed launch activity itself at the site. Based on its assessment, in which the applicant demonstrated a proposed launch from its location complied with FAA public safety regulations, FAA approved the site that became Spaceport Colorado. FAA stated in its Programmatic Environmental Assessment that, if the spaceport were to have a prospective launch operator in the future, the spaceport would need to provide a separate environmental document that would be a more detailed analysis based on vehicle-specific operations and tied to the approved environmental assessment.

Consideration of Airspace and Community Noise Effects

Members of the ARC, including spaceport operators, launch providers, as well as representatives from the aviation industry, also raised concerns that site operator licensing requirements do not adequately consider the site's proximity to congested airspace, which can negatively affect the national airspace system, or noise effects on communities. Two spaceport operators that we spoke with noted that the location of a spaceport is an important consideration, because a spaceport located near busy commercial aviation routes would require airspace closures during launches. Likewise, congested airspace may hinder a launch provider's ability to launch when it desires, as FAA works to best "deconflict" and integrate commercial space transportation into the national airspace system.²² Although any airport that applies for a launch site license must discuss any proposed changes to its Airport Layout Plan and the use of airspace access around the site with FAA's Office of Airports and Air Traffic Organization, members of the ARC from the commercial space transportation industry said that this consideration of effects was not sufficient.

ARC members, both commercial space and aviation industry representatives, also reported that site operator licensing requirements do not take into consideration the combined noise effects of commercial space activities with aviation activities on surrounding communities. We have previously reported on issues of communities exposed to aviation and noise and the shared responsibilities of federal, state, and local governments, airports, and the aviation industry in addressing such noise effects.²³ Three spaceport operators noted that assessing the airspace and noise effects from operations of conceptual launch vehicles was particularly challenging for FAA because it was unknown what the actual effects would be with a vehicle that had not yet been developed.

²²We have previously reported on how a space launch affects the national airspace system. See [GAO-19-437](#).

²³GAO, *Aviation and the Environment: Systematically Addressing Environmental Impacts and Community Concerns Can Help Airports Reduce Project Delays*, [GAO-10-50](#) (Washington, D.C.: Sept. 13, 2010) and GAO, *Aviation and the Environment: Impact of Aviation Noise on Communities Presents Challenges for Airport Operations and Future Growth of the National Airspace System*, [GAO-08-216T](#) (Washington, D.C.: Oct. 24, 2007).

Spaceport Operators See Benefits of a Site License Even without Launch Activity

Seven spaceport operators told us that obtaining a site operator license has benefits, regardless of whether they host any launch or reentry activities in the near term. For example, four site operators that have not hosted licensed launches said that a license demonstrates that the operator has satisfied federal site safety requirements. This helps the operator attract space-related businesses—such as firms conducting research and development or manufacturing launch vehicle parts—even though an FAA site operator license is not required for those activities. For example, site operators have hosted research and development activities for launch vehicles and lunar landers. According to these site operators, those businesses in turn can help support the local economy by creating jobs; providing a location for research and development activities that advance the national space economy; and fostering academic and community interest in the space industry. One spaceport operator told us that having a site license helps better position the operator to receive funds from state and local entities to help fund infrastructure and future potential operations, which further provides opportunities for local economic development.

Two spaceport operators and two launch providers noted that an FAA-licensed site offers benefits to launch providers, including the ability to use common-use infrastructure that is designed for these typically multi-user launch sites and to leverage a spaceport's environmental analysis when a provider applies for a launch license. For example, launch providers would not need to provide for their own power or telecommunications services if provided by spaceport operators. Three launch providers told us that they might be able to leverage parts of the environmental analyses required by FAA for a site operator's license—which can take time and money to develop—and submit it as part of their own launch license application. For example, according to one launch provider, because a licensed launch site has been approved for the use of certain types of fuel and rockets at the site as part of its environmental analysis, the launch provider can use this information and add details specific to its launch vehicle when applying for a launch license.

FAA Plans to Update Site Operator Regulations in the Future and Has Efforts Under Way to Address Some Identified Concerns

FAA officials told us that they recognize that the site operator licensing regulations, which have been in place since 2000, need to be reviewed and potentially amended to ensure that they are appropriate for the current state of the commercial space industry. The process, according to FAA officials, is designed to ensure compliance with public safety regulations, which may include geographical considerations, such as population density or third-party risk exposure. As such, they said that any effort to amend regulations may include addressing some industry concerns regarding the process, but will also maintain the regulatory focus on public safety.

To address the issue of the use of FAA resources by launch site applicants that do not have planned launches, FAA officials said that it has short-term plans to develop criteria that prioritize its staff resources toward supporting spaceports and applicants that have an established launch provider relationship. As noted above, however, because only four of the 11 entities seeking a site operator license for a prospective site have an identified launch provider with plans to conduct future launches, FAA officials told us that their application review should not delay the licensing of spaceports planning for future launch operations. Consequently, officials told us that they have not yet needed to formalize the criteria and do not know when they will.

In the long-term, officials said they plan to amend the launch site operator regulations. They said they would begin this process after they complete the rulemaking process for streamlining launch and reentry licensing, a process that FAA is undertaking at the direction of the White House. On September 30, 2020, FAA issued the final rule to streamline the launch and reentry licensing requirements.²⁴ FAA officials said that they will be developing and publishing around two dozen related guidance materials in the form of Advisory Circulars until at least the end of 2020.²⁵ Officials

²⁴Federal Aviation Authority, Streamlined Launch and Reentry License Requirements, 85 Fed. Reg. 79566 (Dec. 10, 2020).

²⁵The final rule will take effect 90 days after publication in the Federal Register. FAA released three advisory circulars along with the rule, and FAA previously issued a Notice of Proposed Rulemaking. Streamlined Launch and Reentry Licensing Requirements, 84 Fed. Reg. 15296 (Apr. 15, 2019).

added that, along with efforts to support and oversee launch activities, this current rulemaking process has at times involved significant resources, including up to a quarter of AST's personnel. Officials noted that the first step in amending the launch site operator regulations would be identifying provisions in FAA's commercial space transportation regulations that are related to operating a launch or reentry site and prioritizing them for potential future revision. Officials said that they would not formally initiate any rulemaking process until at least spring 2021.

To address concerns about the effects on airspace, according to a representative of the most recently licensed site, FAA increased the extent to which applications are assessed for potential airspace effects by including the Air Traffic Organization more formally in the application review process. FAA officials told us they now also include other internal and external stakeholders more formally in this process. Further, in June 2020, FAA tasked its Commercial Space Transportation Advisory Committee (COMSTAC)²⁶ to recommend regulatory language for revising how FAA licenses launch and reentry sites.²⁷ In addition, the March 2019 final ARC report recommended that in advance of issuing a site operator license, FAA should, among other things, better assess (1) operational effects on airspace and (2) potential noise and other environmental effects in conjunction with existing airport noise. FAA officials said that they would consider the ARC recommendations as part of a holistic review of their site operator regulations.

Established Launch Providers Said Site Infrastructure Meets Current Mission

²⁶The COMSTAC consists of senior executives from the commercial space transportation industry that provides information, advice, and recommendations to the FAA Administrator on critical matters concerning the U.S. commercial space transportation industry.

²⁷In September 2020, COMSTAC members provided an update on five potential recommendations, which they plan to formally present at the next COMSTAC meeting.

Requirements; Views Varied about Future Improvements

Launch Providers Said Infrastructure and Location of Existing Sites Are Generally Sufficient to Meet Current Customers' Requirements

The majority of established launch providers—those that have completed FAA-licensed launch operations—told us that infrastructure at the sites where they launch is generally sufficient for them to meet the current demand for their operations. Specifically, launch providers discussed the importance of both the actual infrastructure at the site as well as whether the site location meets the individual mission requirements of its launch customers.

Existing infrastructure. Representatives from most launch providers said that the infrastructure available at existing U.S. launch sites meets the requirements for their launch operations. This situation is due in part to these launch providers having prioritized the capital investment required to build or upgrade infrastructure tailored to their operations. As we reported in May 2019, funding for infrastructure at U.S. commercial launch sites in recent years has shifted from federal sources to state, local, and private sources.²⁸ For example, at sites where most of the FAA-licensed activity has occurred, established launch providers have sometimes provided hundreds of millions of dollars in funding to modify existing launch sites—both co-located with federal ranges and elsewhere—to ensure the sites meet their unique launch vehicle needs and other requirements. SpaceX, for example, funded a number of improvements to two launch complexes at Cape Canaveral, including the construction of a vehicle assembly building, payload processing facilities, and an almost complete re-build of the launch pad at Launch Complex 39A, from which SpaceX recently launched NASA astronauts to the International Space Station.²⁹ Other launch providers have built launch

²⁸GAO-19-437.

²⁹Around the mid-20th century, the federal government began constructing the infrastructure that supports the majority of commercial orbital space launches today. For example, the Department of Defense constructed launch sites—some of which are now home to Cape Canaveral Air Force Station in Florida. SpaceX operates two Cape Canaveral launch complexes under a use agreement with NASA and the Air Force, respectively.

facilities from the ground up—such as Blue Origin’s West Texas launch site—to ensure the sites meet their particular requirements. Launch providers that are seeking an FAA launch license for future missions have also identified sites with infrastructure they believe is generally sufficient to meet the anticipated mission requirements of their future launch customers. Two of these providers noted that their mobile launch configurations are designed to be moved from one location to another and thus require minimal infrastructure, and in one case not much more than a concrete pad.

In other cases, spaceports—typically operated by state or local governments—have invested in new infrastructure or improvements as part of agreements with launch providers, while in some cases also leveraging federal funding. In one case, Spaceport America (an agency of the state of New Mexico)—which holds an FAA site operator license—collaborated with Virgin Galactic to invest more than \$200 million in a terminal and hangar facility for Virgin Galactic to provide space tourism flights at its site. In building the infrastructure at existing site locations, spaceport operators also have leveraged some federal infrastructure grants awarded by FAA. For example, FAA awarded \$1.5 million in Space Transportation Infrastructure Matching (STIM) grants to seven different spaceports from 2010 through 2012.³⁰ These grants supported projects such as environmental assessments, the construction of vehicle integration and storage facilities, and the purchase of weather-observation and security equipment.

FAA also awarded 10 Airport Improvement Program (AIP) grants between 2010 and 2020 to two different airports that also have an FAA launch site operator license. The grants totaled almost \$12 million and supported airport infrastructure, including runway rehabilitation, lighting, and taxiways that are used primarily for airport operations and, in some cases, may be used for space operations. Appendix II provides details on the spaceports and specific projects funded by the STIM and AIP grants.

Site location. In discussing the sufficiency of launch infrastructure, seven launch providers—most of which conduct or seek to conduct orbital launches—told us that the location of the launch site is important for a variety of reasons. For example, as noted above, a launch mission may require a specific geographic location that provides access to desired orbital trajectories or a surrounding open area, such as the ocean or

³⁰STIM was previously known as the Commercial Space Transportation Grants Program.

vacant land, where a suborbital rocket or element of a rocket may land and be recovered. Established launch providers that conduct orbital launches and whose launches make up the majority of FAA-licensed operations told us that coastal locations are necessary to launch their customer's payloads into desired orbits. Coastal locations can also be advantageous due to the safety implications of launching over the ocean versus over populated land areas. As noted above, one provider told us that even if the risk calculations would allow it to legally launch from an inland launch site, the company would prefer a coastal site, particularly if the associated insurance costs of launching at the inland site would be higher. In addition, one launch provider noted that for air-launch vehicles it could be more expensive to launch from an inland spaceport as it could require additional fuel and resources to launch to certain orbits. Another launch provider stated that launching from some inland spaceports offers a limited range of orbits due to their locations and FAA's regulations for protecting public safety during launches. Such factors may limit the amount of interest from potential customers. It is for these reasons that some launch providers say that inland launch sites may not be suitable for their operations, regardless of the type or condition of infrastructure present. On the other hand, two launch providers told us that they use inland locations that are in remote locations with airspace access because they are less costly to operate and less crowded than coastal locations.

Views Differed on the Type and Location of Infrastructure Required to Support Anticipated Future Demand for Launches

Established launch providers and some licensed site operators hold divergent views on the type and location of infrastructure needed to support the space launch industry in the future. Established launch providers tend to favor upgrades to outdated infrastructure at active launch sites, whereas some launch site operators and a trade association representing spaceports see benefits in creating new launch sites and making improvements at existing sites with currently little to no activity.

Eight of the 10 established launch providers discussed specific infrastructure improvements to active launch sites—both spaceports and exclusive-use sites—that they believe would allow them and others to increase their launch activity at those sites in the future.

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- Three of these launch providers mentioned that improvements to common-use infrastructure at sought-after coastal sites would help address potential issues as the number of operations and launch providers are anticipated to increase there. For example, a launch provider that plans to operate its own launch complex at Cape Canaveral, but that still relies on common-use infrastructure from the federal range, noted that upgraded utilities, such as fuel pipelines and electrical service, may be needed to support an increase in the number of launch providers.
 - Two of these launch providers noted that the launch support equipment (e.g., equipment used to track the position and status of the launch vehicle) at Cape Canaveral and Vandenberg cannot support multiple launches on the same day or back-to-back days by different launch providers. As launch frequency increases, this equipment may need to be improved in order for a launch provider to be able to meet its launch schedule.
 - Launch providers currently operating or seeking to operate at Cape Canaveral also noted that improvements to technologies used by FAA to integrate space launches into the national airspace system would be beneficial. Specifically, technological advancements may be able to shorten the duration of airspace closures required during launch ultimately reducing negative effects to the national airspace system as the number and frequency of launch operations are anticipated to increase.³¹
 - Two other launch providers said infrastructure improvements at inland sites that have hosted some launches would benefit them and other future providers. For example, according to one launch provider, any new provider seeking to launch from Spaceport America would need to make additional infrastructure investments, such as constructing payload processing facilities. Another launch provider highlighted the outdated nature of basic utilities at Mojave Air and Space Port. This representative said that it has to truck in power generators and water to areas of the launch site where it conducts testing.

In contrast, three licensed site operators and a trade association representing spaceports told us that improving infrastructure at sites that

³¹For example, FAA's proposed Space Data Integrator (SDI) technology is designed for air traffic controllers to receive real-time data on launch vehicle position and movement that would allow them to decide how to best manage the airspace, including the duration of airspace closures during launches.

have not hosted licensed launches and developing new launch sites would benefit the nation's space transportation infrastructure.

- A site operator without agreements from established providers said that it has been unable to attract new launch providers because it first needs to construct additional infrastructure, such as hangars and payload processing facilities.
- Some site operators and a representative from a spaceports trade association said that developing new U.S. launch sites could help create redundancy and resiliency in the nation's space transportation infrastructure. For example, one stakeholder said that if a human or natural disaster, such as a hurricane at Cape Canaveral, damages critical infrastructure, it could significantly interfere with the nation's access to space for many months. One launch provider, however, thought it would be highly unlikely that any disaster could, for example, cause disruptions at all the launch sites at Cape Canaveral. Further, if such a disaster occurred, it could delay some launches while the infrastructure was being repaired, but repairing that infrastructure would still be less expensive than building and maintaining a duplicate site elsewhere, according to this launch provider.
- In a report to FAA, the trade association representing spaceports stated that new infrastructure and new launch sites can support other segments of the U.S. space launch industry, such as research and development activities and education and training.³² According to the report, new infrastructure could also help drive progress in new types of launch providers, like those seeking to provide future point-to-point space transportation.³³ The trade association proposed that a national network of commercial spaceports and government-owned and operated and privately owned and operated launch and landing sites could increase the safety, capacity, efficiency, and resiliency of the nation's space operations.

Ultimately, the way the industry evolves will largely determine the type and location of infrastructure improvements necessary to support future operations. For example, if demand for vertical orbital launches continues to grow, it is likely that coastal launch sites will need improvements to

³²According to FAA officials, an FAA site operator license is not required to host space-related research and development and education and training activities at a spaceport.

³³*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.

accommodate the increased activity. Further, if there were growth in the development of air-launch vehicles, which can be used for both orbital launches and suborbital space tourism or point-to-point transportation, then the demand for inland launch locations with runways may increase. At the same time, FAA officials, the trade association for spaceports, and other stakeholders have acknowledged the considerable uncertainty around if, or when, point-to-point space transportation would actually occur.

FAA's 2020 forecast for commercial space launch and reentry operations also recognizes uncertainty as the industry continues to evolve. For example, while in the past FAA has developed 3-year forecasts for commercial space transportation launch and reentry operations, FAA determined that in 2020 it would be impractical to generate a credible, conservative forecast beyond the end of fiscal year 2021 because the commercial space transportation industry continues to evolve and innovate at such a rapid pace.³⁴ In fiscal year 2020, FAA licensed 33 launch and re-reentry operations. As of October 2020, there have been five licensed launch and re-entry operations in fiscal year 2021, while FAA forecasts between 35 and 51 additional licensed or permitted operations in fiscal year 2021. FAA and industry stakeholders also recognize that launch activity may be affected by various external factors. For example, selected stakeholders and FAA's forecast noted that a mishap could have drastic effects on the future of some companies and their operations for months or even years.

Further, while FAA officials explained that, although the agency generally relates an increase in demand for space launches to an increase in demand for space transportation infrastructure, they have not looked specifically at how launch characteristics, such as required orbits or sizes of payloads, could affect the types, amount, or location of infrastructure required to support launch activity. FAA officials told us that because some sectors of the commercial space transportation industry, such as suborbital horizontal launches, are in the nascent stage of operations, it is not yet clear how much spaceport infrastructure will be required to accommodate these types of launches. However, as the commercial launch industry evolves, the market may be best positioned to determine what infrastructure is required to meet launch market demand, as it has

³⁴We have previously reported on challenges FAA has faced in accurately forecasting launch activity. GAO, *Federal Aviation Administration: Commercial Space Launch Industry Developments Present Multiple Challenges*, GAO-15-706 (Washington, D.C.: Aug. 25, 2015).

been doing in recent years through investments from local government and private sources.

Overall, economic activity is also likely to play into the growth of the launch market. For example, a period of economic recession would likely hold down launch activity for a time, while years when the economy is growing fast would likely lead to greater launch activity. It is unclear how the outbreak of the Coronavirus Disease 2019 (COVID-19) global pandemic may affect FAA's 2020-2021 forecast.³⁵ However, despite not providing a specific forecast beyond 2021, FAA's most recent forecast states that based on proprietary information available to FAA, a steady increase in launch and reentry operations is still expected in the coming years.

FAA Has Not Examined Potential Approaches to Best Support U.S. Space Transportation Infrastructure

FAA Identified AIP and STIM as Potential Funding Options

As noted above, the FAA Reauthorization Act of 2018 required DOT to submit a report to Congress that, among other things, makes recommendations on how the federal government can support, encourage, promote, and facilitate greater investments in infrastructure at spaceports.³⁶ This report was due 1 year after enactment and is required to be updated thereafter every 2 years until December 2024. The report FAA prepared in response to this direction is, as of November 2020, under review within DOT, with a final release date yet to be determined.

³⁵We also have ongoing work that will discuss stakeholders' perspectives on the effects of the pandemic on the aviation system, including the commercial space transportation industry.

³⁶Pub. L. No. 115-254, § 580(c), 132 Stat. at 3396.

FAA officials told us that, in response to this direction, they identified two potential federal funding mechanisms—the STIM and AIP programs.³⁷

FAA officials said that a factor influencing their identification of these two programs to include as recommendations in their report to Congress was that the two could be implemented quickly because (1) the STIM program was previously used to support spaceport infrastructure and (2) FAA still has administrative authority to manage both programs under the current statutory scheme. Officials noted, however, that expanding the programs beyond existing program requirements would require statutory changes to FAA's authorities.

- **STIM.** Authorized in 1994, this program provided grants to spaceports for infrastructure-related projects³⁸ from fiscal years 2010 to 2012 when it was funded by FAA.³⁹ FAA officials told us that reinstating and simplifying STIM is their preferred approach over AIP because STIM remains authorized to fund spaceport infrastructure, although FAA has not received a specific appropriation for the program.⁴⁰ According to STIM's authorizing legislation, only public agencies are eligible for STIM grants.⁴¹ Under this criterion, the 12 spaceports—launch sites with FAA site operator licenses—would be eligible for the grants. Private companies operating exclusive-use sites or launch complexes on or co-located with federal ranges—where the majority of current activity is—would not be eligible.
- **AIP.** FAA officials told us that another option is broadening the eligibility of AIP grants to include projects for commercial space

³⁷FAA, in June 2020, tasked COMSTAC to recommend any needed changes to STIM or how other funding programs might be designed to support the nation's space transportation infrastructure. In September 2020, COMSTAC members voted to approve a recommendation that the federal government create a federal program for funding improvements at spaceports. COMSTAC did not recommend any specific program or mechanism.

³⁸51 U.S.C. § 51102.

³⁹FAA has not awarded STIM grants to spaceports since 2012.

⁴⁰The explanatory statement accompanying the statute making appropriations for FAA in 2010 provided for \$500,000 of FAA's appropriation for commercial space transportation activities to be for a commercial space grant program. H.R. Rep. No. 111-366, at 383 (2009). FAA also allocated \$500,000 in both fiscal years 2011 and 2012 for the program.

⁴¹51 U.S.C. § 51102(a); Space Transportation Infrastructure Matching Grants Program, 77 Fed. Reg. 14,462, 14,463 (March 9, 2012).

infrastructure.⁴² FAA officials noted that selected airports that are also licensed as spaceports are already eligible to receive AIP grants for airport infrastructure projects that in some cases may also be used for space operations, such as a runway used by both traditional aircraft and air-launch vehicles. Yet, FAA officials told us that the statutory requirements for AIP criteria have precluded grants for projects that specifically support space operations.

When identifying these two programs, FAA did not comprehensively assess their effectiveness to support spaceport infrastructure. For example, while FAA obtained some industry input from licensed spaceports, officials acknowledged that they did not, as part of this effort, solicit information from launch providers on their requirements for spaceport infrastructure. To obtain spaceports' input, FAA held a roundtable in April 2019 to which it invited representatives from all licensed spaceports to discuss and submit white papers on challenges and opportunities for U.S. commercial launch sites. We found through review of the spaceports' white papers and discussions with spaceport representatives, that infrastructure funding is only one of a range of challenges that spaceports face.⁴³

Moreover, launch providers and licensed launch site operators, including past recipients of STIM and AIP grants, raised concerns to us about using these federal programs in their current form. For example, two spaceport operators told us that the small STIM grant amounts, in combination with a large—relative to AIP—required matching amount from private and local government sources, made it difficult to fund infrastructure projects, which can be expensive.⁴⁴ One of these spaceport operators noted that the administrative burden of the application was large compared to the amount of money that was available, while one spaceport representative thought that AST did not have sufficient resources at the time to administer this type of program. Also, with regard to AIP, the program

⁴²The AIP grant program was authorized in 1982. Airport and Airway Improvement Act of 1982, Pub. L. No. 97-248, 96. Stat. 328, 676 (codified as amended at 49 U.S.C. § 47104).

⁴³Other challenges that spaceports reported included land use issues, ambiguous application of environmental rules, and site operator licensing issues, as discussed above, among others.

⁴⁴The STIM program's authorizing legislation allowed the FAA to make a project grant only if (1) at least 10 percent of the total cost of the project will be paid by the private sector and (2) the grant will not be for more than 50 percent of the total cost of the project. 51 U.S.C. § 51102.

already has more planned investments for airport infrastructure projects than it has available funding.⁴⁵ Many aviation stakeholders have publicly described the use of AIP for space operations as diverting funds from its intended use—aviation-related activities.

Examining a Range of Potential Approaches Could Help Federal Decision Makers

By focusing only on existing funding programs, FAA is overlooking other approaches—including alternatives to making funding available to spaceport operators—that could better promote space transportation infrastructure that supports national security, civil government, and commercial space customers at minimal cost to the federal government. FAA officials told us that they did not conduct a comprehensive review of AIP, STIM, or other potential approaches to support and promote infrastructure investments because of limited time and resources.

In examining federal investment approaches across many national activities, including transportation infrastructure investments, we have previously reported on the importance of conducting a comprehensive examination of different approaches that can help agencies achieve desired goals.⁴⁶ Table 1 shows a variety of funding and financing tools that the federal government has used in the past to support infrastructure improvements, ranging from grants to loan guarantees.

⁴⁵GAO, *Airport Infrastructure: Information on Funding and Financing for Planned Projects*, GAO-20-298 (Washington D.C.: Feb. 13, 2020).

⁴⁶GAO, *U.S. Infrastructure: Funding Trends and Opportunities to Improve Investment Decisions*, RCED/AIMD-00-35 (Washington, D.C.: Feb. 7, 2000); GAO-02-1033; and GAO, *Intermodal Transportation: Potential Strategies Would Redefine Federal Role in Developing Airport Intermodal Capabilities*, GAO-05-727 (Washington, D.C.: July 26, 2005).

Table 1: Examples of Federal Funding and Financing Tools Used in the Past That Could Be Examined for Potential Support of Space Transportation Infrastructure

Approach	Description
Grants	Grants consist of an award of financial assistance in the form of money, or property provided instead of money, made by the federal government to an eligible beneficiary organization, government, or individual, known as a grantee. It is a tool with the primary objective to stimulate or support spending by the recipient for a nationally important activity for which the recipient otherwise would have spent less. There are different types of grants (e.g., categorical and block) and specific design elements, such as matching requirements and reporting requirements that affect the targeting of grant funds, the substitution of the grant recipient's own source funds with new grants, and the balance between accountability and flexibility. Grants may also be contingent on various matching requirements. An example for spaceport infrastructure would be Space Transportation Infrastructure Matching or Airport Improvement Program grants.
Direct loans	Direct loan refers to a disbursement of funds by the federal government to a non-federal borrower under a contract that requires the repayment of such funds with or without interest. That is, the federal government lends money directly to borrowers. After making the loans, the government then services the loan (i.e., collects scheduled repayments from the borrowers) and forecloses or otherwise attempts to collect on the loan if a borrower cannot make scheduled payments. Loans may also be contingent on various matching requirements. An example is the U.S. Department of Transportation's Transportation Infrastructure Finance and Innovation Act loans, which are low-interest loans for highway and transit infrastructure projects.
Loan guarantees	Loan guarantee means any guarantee, insurance, or other pledge made by the federal government regarding the payment of all or a part of the principal or interest of any loan that a private lender, such as a commercial bank or mortgage lender, makes to a borrower. The government enters into a contractual agreement to make full or partial payment to the lender in case the borrower defaults on the guaranteed loan. The private lender originates the loan, secures the government guarantee, and services the loan according to government regulations. Loan guarantees may also be contingent on various matching requirements. An example is the U.S. Maritime Administration's Title XI program, which assists U.S. shipyards with modernizing their facilities for building and repairing vessels.
Tax incentives	Tax incentives allow corporations or individuals to defer, reduce, or eliminate a portion of their tax obligation. This tool allows the federal government to pursue its objectives, not by spending tax dollars it collects, but rather by allowing corporations or individuals to keep and spend dollars they would otherwise owe the government. An example is Private Activity Bonds, which are federal tax-exempt bonds for infrastructure projects.

Source: GAO-02-1033. | GAO-21-154.

FAA officials told us that they do not believe it is their role to advocate for any particular federal investment approach. However, FAA, with its strong ties to and deep understanding of the commercial space transportation industry, is in the best position to identify and assess trade-offs of different potential approaches to support spaceport infrastructure.

Examining a broad range of approaches can provide information to help federal decision makers determine which approach would best support national interests, while also maximizing the effect of any federal investment. For example, in the case of spaceport infrastructure, any federal investment approach should work to support the statutory goals of providing resilient and robust space transportation infrastructure to support national security and civil government launch capabilities and encouraging greater non-federal support. Due to security reasons,

launches supporting national security missions generally are conducted at launch sites on or co-located with federal ranges. One launch provider noted that funding for infrastructure improvements to support federal ranges could come through a variety of federal agencies like the Department of Defense, which could in turn benefit important government missions while also supporting the commercial space industry.

Such an examination can also provide information on which options may be most cost-effective and sustainable or best encourage investment by other stakeholders. It may also help identify alternatives to making funding available.

- **Cost-effective and sustainable.** The extent to which an option is affordable or financially sustainable over the long term—given known cost trends, risks, and future fiscal imbalances—is an important consideration, according to our prior work examining federal investments.⁴⁷ One site operator that we spoke with noted that the STIM grant the site received provided security cameras for site surveillance of a new launch pad and associated infrastructure—a multi-year, multi-million dollar project. This representative noted that without a defined, consistent revenue source for a grant program, it would be difficult to rely on it for large infrastructure projects.

Further, any funding or financing option needs a defined revenue source. FAA did not explore potential revenue options to support additional funding for spaceport infrastructure through either of these programs.⁴⁸ FAA's overall budget, which includes AST's operations budget and AIP accounts, is funded principally by the Airport and Airway Trust Fund. The Trust Fund receives revenues from a variety of excise taxes on commercial and general aviation activity, including aviation fuel and passenger tickets. Launch providers that use aviation fuel, such as those that conduct air launch activities, pay fuel taxes deposited into the Trust Fund. However, the majority of active launch providers do not use aviation fuel. Because of the decrease in commercial aviation activity due to the COVID-19 global pandemic

⁴⁷GAO, *21st Century Challenges: Reexamining the Base of the Federal Government*, GAO-05-325SP (Washington, D.C.: Feb. 1, 2005).

⁴⁸In 2010, Congress directed FAA to allocate funding for the STIM grant program. FAA officials said the agency funded STIM through AST's operations budget for the 2 years after. While the program continues to be authorized, FAA has not received a specific appropriation for the program. 51 U.S.C. § 51102.

and the temporary suspension of certain Trust Fund taxes.⁴⁹ Trust Fund revenues are experiencing a sharp decline. Any decline reduces the amount of funds available to FAA and the AIP program. Revenues deposited in the Trust Fund are subject to appropriations, and, in the past, FAA has also received appropriations from the general fund for its operations budget and for the AIP program. Two spaceport operators noted even before the COVID-19 pandemic began that it would likely be difficult to find a consistent, sustained revenue source for the STIM program.

- **Encourage investment by non-federal stakeholders.** To help maximize the effect of any federal investment, we have previously reported that it is important to supplement and enhance participation by non-federal stakeholders, rather than simply replacing their participation.⁵⁰ As discussed above, private launch site operators, in combination with state and local governments, have made significant investments to help ensure that they have the infrastructure available to meet their customers' demands for launch activity, as the industry has grown over the past several years. Examining a range of approaches could help identify those that would encourage continued participation by non-federal stakeholders. It could also identify which options would best support infrastructure improvements that, for a variety of reasons, may not otherwise be funded by the private sector, even though they are needed to support industry demand. For example, one launch provider noted that it tends to prioritize paying for infrastructure that is specific to its launch vehicle or operations, and is less inclined to pay for infrastructure shared by multiple providers (i.e., common-use infrastructure). Launch providers said that examples of common-use infrastructure that they would be less willing to pay for include: fuel facilities, emergency response and firefighting services, roads on the launch site, and internet—all of these infrastructure components they expect to be provided by the site operator.
- **Alternatives to making funding available.** Federal approaches could take forms other than making funding available to spaceport operators. Examples include technology improvements or other operational changes, which could increase the efficiency of launches, thereby increasing capacity without the need for investment in

⁴⁹CARES Act, Pub. L. No. 116-136, § 4007, 134 Stat. 281, 477 (2020) (codified at 15 U.S.C. § 9046). The CARES Act included a number of provisions designed to mitigate the economic effects of the Coronavirus Disease (COVID-19) global pandemic, including effects on the aviation industry.

⁵⁰GAO-05-727.

additional launch infrastructure. For example, FAA is currently developing technologies that could improve the efficiency of launch operations by better tracking a launch vehicle in real-time and communicating data to air traffic control to allow controllers to decide how best to manage the airspace. FAA reported that these technologies could help reduce the amount of time the airspace would need to be closed to other aviation users such as commercial aircraft, thereby, according to one launch provider, potentially allowing launches more frequently. This launch provider told us that when other providers are launching from Cape Canaveral and the flight path is over their launch complex, it requires them to shut down their ground operations, which could cause delays in upcoming launches. Two launch providers also noted that operational improvements at Cape Canaveral, such as reducing the time needed to reconfigure the range for launches, would also allow more launches and launch-related activities to take place.

In addition, certain infrastructure investment approaches may better align with other federal agencies' efforts to support spaceport infrastructure and therefore help both to avoid overlap or duplication of federal effort and to maximize the effect of any federal expenditure. For example, in September 2019, the Department of Defense solicited information on how to convert Cape Canaveral and Vandenberg Air Force Base into national spaceports in order to improve flexibility and agility for national security and commercial space launches. Its solicitation included a request for information on potential operational changes, including launch scheduling.⁵¹ While these changes may not directly influence the operation of licensed spaceports, any improvements at these federal ranges could affect the type and amount of overall U.S. space transportation infrastructure that may be required to meet future launch market demand.

Conclusions

A robust network of space transportation infrastructure is essential to the growth of the domestic space industry and the United States' ability to send government and commercial missions into space. As the commercial space transportation industry continues to evolve, it will be important that the type and amount of space transportation infrastructure

⁵¹FAA also tasked COMSTAC to provide input on how a National Spaceport Authority for Cape Canaveral Air Force Station and Vandenberg Air Force Base should be organized to both protect public safety and benefit the commercial space transportation industry.

keep pace with the demand for launches. FAA, by neither comprehensively reviewing the performance of the two funding programs it identified, nor examining other potential approaches, is likely overlooking options that could better position the federal government and Congress to make well-informed decisions about any investments in space transportation infrastructure. Without a comprehensive examination of potential options—both funding and financing tools, as well as alternatives to making funding available to spaceport operators—federal efforts may result in inefficient federal investments; unclear benefits to the nation’s overall launch capabilities; or unnecessary substitution of state, local, and private sector investment with federal investment.

FAA—as the oversight body of the commercial space transportation industry—is best positioned to understand the issues and assess the advantages and disadvantages of different potential approaches for U.S. space transportation infrastructure. Although FAA has already prepared its initial report to Congress, it still has opportunities to conduct such an examination of potential approaches, such as during subsequent mandated report updates.

Recommendation for Executive Action

We recommend that the Associate Administrator for AST provide Congress the results of an examination of a range of options—including funding and financing tools, as well as alternatives to making funding available—to support space transportation infrastructure. This examination should include a discussion of trade-offs and whether and how, if at all, each approach would contribute to national policy goals. (Recommendation 1)

Agency Comments and Our Evaluation

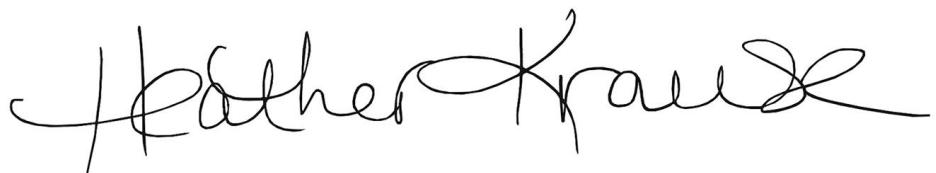
We provided a draft of this product to DOT for review and comment. In its comments, reproduced in appendix III, DOT partially concurred with the recommendation. FAA agreed that it would provide Congress the report mandated in the FAA Reauthorization Act of 2018 and is considering including funding options as recommended by industry. However, it did not agree to conduct a new examination to include a discussion of trade-offs and how each approach would contribute to the national policy goals. We continue to believe that by limiting the review of potential options to the two existing grant programs, FAA will not be providing key information

to help Congress make well-informed decisions about any federal investments. We also believe that FAA—as the oversight body of the commercial space transportation industry—is best positioned to assess the advantages and disadvantages of different potential approaches for U.S. space transportation infrastructure.

FAA also disagreed that the reason for launch providers meeting their customers' requirements is largely a result of launch providers' investments in launch sites. FAA believes that the report minimizes the significant amount of federal investment in launch sites over the years at federal ranges. We agree that a significant amount of federal investment was made at federal ranges and also recognize that private launch providers in combination with state and local governments have made significant investments to ensure that the launch site infrastructure is tailored to each launch provider's unique launch vehicle. We clarified this point in our report. DOT also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at 202-512-2834 or KrauseH@gao.gov. Contact points for our Office of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix IV.



Heather Krause
Director, Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

This report discusses perspectives of key stakeholders—launch site operators and launch providers—on (1) FAA's site operator licensing process and regulations and (2) the sufficiency of space transportation infrastructure in meeting the commercial launch market demand. The report also assesses the steps FAA has taken to identify options for federal support of commercial space transportation infrastructure in response to the FAA Reauthorization Act of 2018.

To address all three objectives, we reviewed relevant statutes and regulations, including the FAA Reauthorization Act of 2018 and FAA's regulations for site operator licensing. We reviewed relevant FAA documents, including its 2020 forecast for commercial space launch and reentry operations; the Spaceport Categorization Aviation Rulemaking Committee Recommendations final report submitted to FAA in March 2019; and reports relevant to spaceports from FAA's Commercial Space Transportation Advisory Committee (COMSTAC), such as the Commercial Spaceport Licensing Review and Recommendations White Paper issued in October 2012.¹ We also interviewed officials from FAA's Office of Commercial Space Transportation (AST) (the office responsible for overseeing the commercial space transportation industry) and the Office of Airports (the office that manages the Airport Improvement Program). And we reviewed information provided by FAA officials on Space Transportation Infrastructure Matching grants from fiscal years 2010-2012—the only years the program received funding—and Airport Improvement Program grants for co-located spaceports and airports from fiscal years 2010-2020.

We also reviewed relevant industry reports and white papers, including the Global Spaceport Alliance's² National Spaceport Network Development Plan provided to the FAA in June 2020 and white papers

¹This COMSTAC white paper included results from a survey of industry stakeholders on their views of the spaceport licensing process and recommendations for changes.

²Global Spaceport Alliance's mission is to provide spaceport stakeholders with the information to develop, fund, build, and operate their facility and to integrate into the developing global spaceport network.

submitted by individual spaceports and the Commercial Spaceflight Federation³ to the FAA as part of FAA's Spaceport Directors Round Table held in April 2019. FAA requested that these groups provide perspectives regarding challenges and opportunities for U.S. commercial launch sites. We also interviewed a representative from the Global Spaceport Alliance, the main industry organization that supports spaceports.

To discuss issues related to all three objectives, we conducted semi-structured interviews with representatives from 18 of the 19 U.S. commercial launch sites that have hosted an FAA-licensed launch since 2015 or have an FAA launch site operator license as of August 2020.⁴ We reviewed master plans and strategic plans that included planned infrastructure investments provided to us by these site operators. We conducted site visits to four of the 19 commercial launch sites—Launch Complex-39A at Kennedy Space Center, Florida; Shuttle Landing Facility at Cape Canaveral, Florida; Mojave Air and Space Port in Mojave, California; and Spaceport America in New Mexico. We selected these locations to provide diversity in geographic location; types of infrastructure (e.g., launch pads, runways, hangars, fuel facilities); and type of site operations (e.g., federal range, FAA-licensed site, exclusive-use, public-use airport). We excluded from this review launch sites that do not have a site operator license and have hosted only government-sponsored launch operations and those potential launch sites that are in active consultation with FAA but had not received a site operator license as of August 2020. See table 2 for a list of site operators that we interviewed.

Table 2: List of Launch Site Operators Interviewed with Associated Launch Site

Launch site operator	Launch site
Adams County	Colorado Air and Spaceport
Alaska Aerospace Development Corporation	Pacific Spaceport Complex – Alaska
Blue Origin	West Texas Launch Site
Houston Airport System	Houston Spaceport
Jacksonville Aviation Authority	Cecil Field Spaceport

³The Commercial Spaceflight Federation's mission is to promote the development of commercial human spaceflight and share best practices and expertise throughout the industry.

⁴We attempted to contact one launch site operator numerous times, but we were unable to schedule an interview.

Appendix I: Objectives, Scope, and Methodology

Launch site operator	Launch site
Midland International Air & Space Port	Midland International Air & Space Port
Mojave Air and Space Port	Mojave Air and Space Port
New Mexico Spaceflight Authority	Spaceport America
Northrop Grumman Innovation Systems	Vandenberg Air Force Base, SLC-576E
Virginia Commercial Space Flight Authority	Mid-Atlantic Regional Spaceport
Space Florida	<ul style="list-style-type: none">• Cape Canaveral Spaceport / Shuttle Landing Facility• Cape Canaveral Air Force Station, SLC-46
SpaceX	<ul style="list-style-type: none">• Kennedy Space Center, Launch Complex (LC)-39A• Cape Canaveral Air Force Station, Space Launch Complex (SLC)-40• Vandenberg Air Force Base, SLC-4E• South Texas Launch Site
Titusville-Cocoa Airport Authority	Space Coast Regional Airport
United Launch Alliance	Cape Canaveral Air Force Station, SLC-41

Source: GAO | GAO-21-154

Note: We also contacted California Spaceport operated by the Harris Corporation. According to a Harris Corporation official, the spaceport has terminated its lease of Space Launch Complex-8 at Vandenberg and transferred its commercial spaceport property to the Air Force. As a result, the company has since relinquished its FAA launch site operator license.

We also conducted semi-structured interviews to discuss issues related to all three objectives with 17 commercial launch providers that include all those that, as of May 2020, had 1) conducted FAA-licensed launch activities or 2) were in active consultations with FAA for a launch or reentry license. We included both active launch providers and those in consultation with FAA to obtain perspectives on the sufficiency of current infrastructure to meet their mission requirements. See table 3 for a list of launch providers that we interviewed.

Table 3: List of Launch Providers Interviewed

Launch Provider
Astra Space
Blue Origin
Boeing
Exos Aerospace
Firefly Aerospace
Generation Orbit
Interorbital Systems

**Appendix I: Objectives, Scope, and
Methodology**

Launch Provider

Northrop Grumman Innovation Systems

Rocket Lab

Sierra Nevada Corporation

SpaceX

Stratolaunch

United Launch Alliance

UP Aerospace

Virgin Galactic

Virgin Orbit

World View

Source: GAO | GAO-21-154

The views of the site operators and launch providers are not generalizable to all entities involved in launch activities, such as companies that only conduct research and development activities to support launches or potential site operators that are in preliminary discussions with FAA. However, we believe that the information provides a balanced and informed perspective across stakeholder groups on the topics discussed.

In addition to the activities described above, to assess the steps taken by FAA to identify potential federal approaches to support commercial space transportation infrastructure, we identified through a review of our prior work leading practices for making capital investment decisions. We selected those leading practices that were most relevant to identifying and examining potential approaches for future federal involvement in funding spaceport infrastructure.⁵ We then discussed with FAA officials their plans and actions to identify potential recommendations to support greater investment in space transportation infrastructure and assessed the extent to which FAA's actions followed the leading practices we identified.

⁵GAO, *Physical Infrastructure: Challenges and Investment Options for the Nation's Infrastructure*, GAO-08-763T (Washington, D.C.: May 8, 2008); GAO, *Intercity Passenger Rail: National Policy and Strategies Needed to Maximize Public Benefits from Federal Expenditures*, GAO-07-15 (Washington, D.C.: Nov. 13, 2006); GAO, *Intermodal Transportation: Potential Strategies Would Redefine Federal Role in Developing Airport Intermodal Capabilities*, GAO-05-727 (Washington, D.C.: Jul. 26, 2005); and GAO, *Marine Transportation: Federal Financing and a Framework for Infrastructure Investments*, GAO-02-1033 (Washington, D.C.: Sept. 9, 2002).

**Appendix I: Objectives, Scope, and
Methodology**

We conducted this performance audit from April 2019 through December 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Space Transportation Infrastructure Matching (STIM) and Airport Improvement Program (AIP) Grant Awards

Table 4: Space Transportation Infrastructure Matching (STIM) Grant Recipient, Project for which Grant Was Awarded, and Grant Amount (Fiscal Years 2010-2012)

Grant recipient (spaceport's name)	Project for which grant was awarded	Grant amount	Fiscal year awarded
New Mexico Spaceport Authority (Spaceport America)	Automated Weather Observing System	\$43,000	2010
Alaska Aerospace Corporation (Pacific Spaceport Complex – Alaska)	Rocket Motor Storage Facility	\$227,195	2010
Jacksonville Aviation Authority (Cecil Field Spaceport)	Spaceport Master Plan	\$104,805	2010
East Kern Airport District (Mojave Air and Space Port)	Emergency Vehicle	\$125,000	2010
Virginia Commercial Space Flight Authority (Mid-Atlantic Regional Spaceport)	Physical Security and Remote Monitoring Surveillance System	\$125,000	2011
East Kern Airport District (Mojave Air and Space Port)	Supplemental Environmental Assessment	\$125,000	2011
New Mexico Spaceport Authority (Spaceport America)	Roll-Back Vehicle Integration Facility	\$249,378	2011
East Kern Airport District (Mojave Air and Space Port)	Purchase of Specialized i.e. PyroLance Firefighting Equipment	\$23,750	2012
State of Hawaii ^a	Analytical Study and Draft Environmental Assessment	\$250,000	2012
Front Range Airport Authority (Colorado Air and Spaceport)	Environmental Study	\$200,000	2012

Source: Federal Aviation Administration. | GAO-21-154

Note: FAA has not awarded STIM grant to spaceports since 2012.

^aThe State of Hawaii received this grant as an applicant for a site operator license and ultimately did not complete the licensing process.

**Appendix II: Space Transportation
Infrastructure Matching (STIM) and Airport
Improvement Program (AIP) Grant Awards**

Table 5: Selected Recipients of Airport Improvement Program Grants to Airports That Also Hold FAA Launch Site Operator Licenses, Projects Funded, Grant Amount, and Fiscal Year Awarded (Fiscal Years 2010 – 2020)

Grant recipient	Project funded	Grant amount	Fiscal year awarded
Jacksonville Aviation Authority (Cecil Field Spaceport)	Rehabilitate Runway	\$4,324,123	2010
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway	\$150,000	2010
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway	\$2,065,734	2011
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway	\$3,112,869	2012
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway Lighting	\$330,967	2012
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway	\$222,000	2015
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Runway Lighting	\$150,000	2015
East Kern Airport District (Mojave Air and Space Port)	Extend Taxiway	\$1,364,086	2018
Jacksonville Aviation Authority (Cecil Field Space Port)	Rehabilitate Runway	\$1,254,614	2019
East Kern Airport District (Mojave Air and Space Port)	Rehabilitate Taxiway	\$8,554,706	2020

Source: Federal Aviation Administration. | GAO-21-154

Note: Primary airports are entitled to a certain amount of Airport Improvement Program funding each year based on passenger volume. If their capital project needs exceed their available entitlement funds, FAA can sometimes supplement their entitlements with discretionary funding. Grants for Jacksonville Aviation Authority included \$164,043 entitlement funds and \$4,160,080 discretionary funds. All grants for East Kern Airport District were entitlement funds.

Appendix III: Comments from the Department of Transportation



**U.S. Department of
Transportation**
Office of the Secretary
of Transportation

Assistant Secretary
for Administration

1200 New Jersey Avenue, SE
Washington, DC 20590

December 7, 2020

Heather Krause
Director, Physical Infrastructure Issues
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Ms. Krause:

The Federal Aviation Administration (FAA) is committed to the safety and growth of the domestic space industry and continues to work with other government agencies and private sector partners to successfully accomplish this growth. The FAA is currently finalizing a Report to Congress on the U.S. Spaceport industry, as required by the FAA Reauthorization Act of 2018.

The FAA offers the following comment to the GAO draft report:

- The FAA disagrees that the reason for launch providers meeting their customers' requirement is largely a result of launch providers' investments in launch sites. This minimizes the significant amount of federal investment in launch sites over the years at Federal ranges. The majority of commercial launches are from federal launch ranges developed over the decades with primarily federal funding.

Upon review of the GAO's draft report, the Department partially concurs with the GAO recommendation to "provide to Congress the results of an examination of options including funding and financing tools, as well as alternatives to making funding available to support space transportation infrastructure. This examination should include a discussion of trade-offs and whether and how each approach would contribute to national policy goals." The FAA agrees to provide Congress the report mandated in the FAA Reauthorization Act of 2018 and is considering including funding options as recommended by industry, but does not agree to conduct a new examination to include a discussion of trade-offs and how each approach would contribute to the national policy goals. We will provide a detailed response to the recommendation within 180 days of the final report's issuance.

We appreciate the opportunity to respond to the GAO draft report. Please contact Madeline Chulumovich, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if GAO would like to obtain additional details about these comments.

Sincerely,

A handwritten signature in blue ink that appears to read "Keith Washington".

Keith Washington
Deputy Assistant Secretary for Administration

Text of Appendix III: Comments from the Department of Transportation

December 7, 2020

Heather Krause

Director, Physical Infrastructure Issues

U.S. Government Accountability Office 441 G Street NW

Washington, DC 20548

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Sincerely,

Keith Washington

Deputy Assistant Secretary for Administration

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Heather Krause, 202-512-2834 or krauseh@gao.gov

Staff Acknowledgments

In addition to the individual named above, Heather Halliwell (Assistant Director); Gretchen Snoey (Analyst-in-Charge); Amy Abramowitz; Oluwaseun Ajayi; Joshua Garties; Dave Hooper; Delwen Jones; Maureen Luna-Long; and Patricia Powell made key contributions to this report.

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