COMMENTS

Commercial Spaceports: A New Frontier of Infrastructure Law

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While a "spaceport" may sound like a concept mostly confined to science fiction, several commercial spaceports are in operation in the United States and abroad, and more are being developed. As the name suggests, spaceports, or commercial space launch sites, are used to conduct launch and reentry operations to and from space, such as launching satellites into orbit or sending space tourists to the edge of space and back. A commercial space launch site can be operated by a nonfederal entity, such as a business, state or local government, or public-private partnership, and offers its infrastructure and related services to private space companies or federal agencies seeking to conduct launch operations.

Operating a commercial space launch site in the United States requires a launch site operator license (LSOL) issued by the Federal Aviation Administration's (FAA's) Office of Commercial Space Transportation (AST). Commercial launch operations require an additional launch operator license from FAA. Like other projects requiring federal agency approvals, FAA's licensing decision triggers numerous requirements under federal laws like the National Environmental Policy Act (NEPA).[1]

While some of this legal terrain is similar to other, more terrestrial infrastructure projects, licensing commercial space launch sites and launch operations raises numerous unique and complex considerations. Obtaining a license to operate a commercial space launch site requires integrating legal, technical, planning, and environmental considerations that are unlike other areas of infrastructure development. Focusing on the development and licensing of these sites, this Comment explains the rapidly growing commercial space industry, summarizes FAA's commercial space licensing regime, and identifies several considerations associated with the new frontier of commercial space transportation infrastructure projects.

I. The Commercial Space Industry

A. The Space Economy

The burgeoning commercial space industry comprises private ventures, public ventures, and public-private partnerships. Launch operations can be solely commercial or can provide services pursuant to government contracts with civil and/or defense agencies. Currently, the industry includes the following commercial activities:

- Orbital launches to place satellites and other payloads in orbit for public and private interests;
- Suborbital launches for space tourism and research;
- National Aeronautics and Space Administration's (NASA's) commercial cargo program (transporting cargo to the International Space Station (ISS) in partnership with the government); and
- NASA's commercial crew transport program (shuttling NASA astronauts to and from low earth orbit, including to the ISS).

U.S. companies have demonstrated success in all of these areas except, for the time being, NASA's commercial crew transport program.[2] However, Space Exploration Trans-

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1. 42 U.S.C. §§4321-4370h, ELR Stat. NEPA §§2-209.

2. After the termination of the space shuttle program in 2011, NASA has relied on Russia to shuttle its astronauts to and from the ISS, at a cost of about $82 million per seat. Skye Gould & Dave Mosher, *NASA Is Paying Russia More Than $70 Million to Bring an Astronaut Home in This Spaceship Tonight*, Bus. Insider, Sept. 6, 2016, https://www.businessinsider.com/space-travel-per-seat-cost-soyuz-2016-9. Domestic companies do not yet have the capability to provide these services.

portation Technologies (SpaceX) and Boeing are currently scheduled to return astronauts to the ISS in 2020.[3]

One of the major drivers of growth for the industry in recent years has been a substantial reduction in launch costs. Whereas it once took $50,000 to launch one kilogram of payload into space, it now costs around $2,500.[4] As costs have decreased, many companies have entered the market. Currently, 12 companies hold an active FAA launch operator license,[5] including companies founded by well-known billionaires Jeff Bezos (Blue Origin), Elon Musk (SpaceX), and Richard Branson (Virgin Galactic). Many other companies do not directly conduct launch operations, but are involved in the downstream economy surrounding commercial space launch sites and launch activities.[6] The downstream economy includes manufacturing spacecraft constituent parts and instruments, providing satellite communication services, and processing the vast amounts of data collected from satellites.[7]

Commercial space companies have bold plans to commercialize new innovations soon. For example, companies are racing to bring the first space tourists into suborbital space as soon as 2020. A seat with Virgin Galactic costs $250,000; the company has reported a backlog of 600 people on its waitlist, more than $80 million in deposits, and a goal of turning its first profitable year in 2021.[8]

More traditional, satellite-focused operations are breaking new ground as well. Advances in microelectronics have allowed for the creation of small satellites.[9] Harnessing small-satellite technology, Blue Origin is planning to provide Internet service to underserved parts of the world by placing more than 3,000 small satellites into orbit.[10]

All of this activity is reflected in the dramatic growth of the space economy over the past several years. In 2005, global revenues from the space industry were $175 billion; by 2017, they grew to nearly $385 billion.[11] Private investment in the industry has grown nearly tenfold in the same time frame—from $1.1 billion in 2000-2005 to more than $10 billion in 2012-2017.[12] While the sector suffered one down year in 2009, its growth was largely unaffected by the recession.[13] The industry's growth is expected to continue. Major financial firms are bullish on the industry's prospects: both Morgan Stanley and Goldman Sachs estimate that the industry will be worth approximately $1 trillion by 2040, while Merrill Lynch projects it to grow to $2.7 trillion.[14]

B. *Growing Infrastructure Demands*

As the number of companies participating in the space industry increases, and as launches become more frequent, more domestic and international launch capacity is on the horizon. Responding to this trend, new commercial space launch sites have been built in recent years in several states. As noted, a commercial space launch site is essentially an airport for space launch vehicles. More specifically, it is a site for the launch and/or reentry of "launch vehicles," such as SpaceX's Falcon 9 rocket, that enter orbital or suborbital space.

FAA licenses commercial space launch sites to host vertical launches, which involve upright launch vehicles, and horizontal launches, where the launch vehicle takes off like a plane under jet power and/or rocket power. Some commercial space launch sites in the United States, such as the recently licensed Colorado Spaceport, are authorized only to host horizontal launches, which primarily target the space tourism sector.[15] While commercial space launch sites are under the jurisdiction of FAA, several non-commercial launch sites, including certain launch pads at Vandenberg Air Force Base, Cape Canaveral Air Force Station, and Kennedy Space Center, are managed and regulated by other agencies, including the U.S. Air Force and NASA.

There are currently 11 domestic commercial space launch sites that hold an FAA LSOL, including sites in Alaska, California, Colorado, Florida, New Mexico, Oklahoma, Texas, and Virginia.[16] Several state and local governments have invested public money into these commercial space launch site projects. For example, New Mexico has invested $200 million in licensing and building Spaceport

3. NASA and SpaceX recently completed a final major flight test of the company's Crew Dragon spacecraft and Falcon 9 rocket before it begins carrying astronauts to the ISS under NASA's commercial crew transport program. James Cawley, *SpaceX Complete Final Major Flight Test of Crew Spacecraft*, NASA Blogs (Jan. 19, 2020), https://blogs.nasa.gov/commercialcrew/.
4. *Understanding the Space Economy*, HBR IdeaCast (May 28, 2019), https://hbr.org/ideacast/2019/05/understanding-the-space-economy (interview with Sinéad O'Sullivan, Entrepreneurship Fellow at Harvard Business Shool).
5. FAA, *Active Licenses*, https://www.faa.gov/data_research/commercial_space_data/licenses/ (last modified Oct. 31, 2019).
6. *See generally* SpacePolicyOnline.com, *Commercial Space Activities*, https://spacepolicyonline.com/topics/commercial-space-activities/ (last updated Dec. 29, 2019).
7. *See id.*; *Understanding the Space Economy*, *supra* note 4.
8. Michael Sheetz, *Here's Why Amazon Is Trying to Reach Every Inch of the World With Satellites Providing Internet*, CNBC, Apr. 7, 2019, https://www.cnbc.com/2019/04/05/jeff-bezos-amazon-internet-satellites-4-billion-new-customers.html.
9. Adam Mann, *Rocket Lab: Private Spaceflight for Tiny Satellites*, Space, Oct. 3, 2019, https://www.space.com/rocket-lab.html.
10. Sheetz, *supra* note 8.
11. Brian Higginbotham, *The Space Economy: An Industry Takes Off*, U.S. Chamber Com., Oct. 11, 2018, https://www.uschamber.com/series/above-the-fold/the-space-economy-industry-takes. Currently, most of the space industry's revenue comes from satellites and the services they provide (i.e., satellites that provide imaging, navigation, television, and telecommunication services). *Id.*; *see also Understanding the Space Economy*, *supra* note 4. These activities, along with launch services, constituted 76% of the global space industry revenue generated in 2016. FAA, The Annual Compendium of Commercial Space Transportation: 2018, at 9 (2018), https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2018_AST_Compendium.pdf. The remaining 24% consisted of government space budgets and commercial human spaceflight. *Id.*
12. Higginbotham, *supra* note 11.
13. *Id.*
14. Jeff Foust, *A Trillion-Dollar Space Industry Will Require New Markets*, SpaceNews, July 5, 2018, https://spacenews.com/a-trillion-dollar-space-industry-will-require-new-markets/.
15. John Aguilar, *Spaceport Colorado Lands License to Launch Tourists, Scientists Skyward From Front Range Airport*, Denv. Post, Aug. 17, 2018, https://www.denverpost.com/2018/08/17/spaceport-colorado-lands-license/.
16. FAA, Fact Sheet—Commercial Space Transportation Activities (Dec. 9, 2019), https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=19074; FAA, U.S. Spaceports: Commercial/Government/Private Active (2019), https://www.faa.gov/about/office_org/headquarters_offices/ast/industry/media/Spaceport_Map_Nov_2019.pdf.

America.[17] Other commercial space launch sites have been proposed in Georgia, Hawaii, and Michigan, and in other countries and territories such as Guam, Saipan, the United Kingdom, Italy, and Portugal.[18]

II. Spaceport Planning and Licensing

The Commercial Space Launch Act[19] and FAA's implementing regulations establish licensing procedures and requirements for commercial space activities. The most fundamental of these are the LSOLs required to operate a launch site, and the launch and reentry licenses required to launch a specific launch vehicle at a launch site or receive returning launch vehicles at a reentry site.[20]

Obtaining a license from FAA requires compliance with FAA's regulations for implementing the Commercial Space Launch Act. Several key considerations are addressed below, focusing on the process for securing an LSOL as opposed to a launch operator license.

A. Navigating the Application Process

The mechanics of FAA's license application and review process are themselves demanding to navigate.[21] An important feature of the application process is that, unlike many other types of federal agency approvals, FAA is required to make a license determination within 180 days of accepting an application as complete enough to commence review.[22] While the statutory deadline helps ensure timely review of license applications, the time line makes it even more important for applicants to prepare early, submit thorough applications that anticipate FAA concerns and additional information needs, and coordinate with FAA and other agencies and stakeholders along the way.

Prior to submitting an application, a prospective applicant must engage in informal pre-application consultation with FAA to better understand the licensing process, help identify unique aspects of their proposal, and develop a general understanding of FAA's requirements for submitting an application. Even before this step, applicants should assess the feasibility of potential launch sites and planned operations to gauge whether they are likely to meet public safety and other regulatory requirements. As discussed in more detail below, early evaluation of potential commercial space launch sites should consider a host of factors including, but not limited to, the types of launch vehicles proposed, potential flight trajectories, anticipated launch site boundaries, surrounding properties and other resources, potential environmental impacts, weather patterns, airspace coordination, and nearby population centers.

B. Site Selection Analysis

One of the first and most critical steps in developing a commercial space launch site is selecting a suitable and viable location. Regardless of whether multiple site options or only one is available, it is important to assess a location's long-term viability as a commercial space launch site at the very beginning of the project development process.

Several important operational and situational considerations go into siting a commercial space launch site. In order to reach orbital space, a launch vehicle and its payload must be delivered to a high altitude with sufficient horizontal velocity to stay in orbit. Without enough horizontal velocity, even launches that reach space will not remain in orbit, and will instead fall back to earth.

Because of the need for horizontal velocity, it is desirable to locate spaceports where they can harness earth's natural centrifugal force, which comes from its shape and west-to-east rotation around its axis. The lower the latitude, the greater the natural, horizontal velocity at earth's surface from centrifugal force—at the equator, the earth's surface moves laterally at about 1,040 miles per hour, while its velocity is zero at its north axis.[23] Launching eastward best captures this centrifugal velocity. This means that the closer a launch is to the equator, the more fuel-efficient it can be. Partly for this reason, most commercial space launch sites in the United States that are targeting near-equatorial orbital inclinations are located in southern states, including Florida, Texas, and New Mexico.

A related consideration is the desired launch azimuth, or the trajectory of a launch from a commercial space launch site. In many cases, the launch trajectories available from a commercial space launch site are a function of the site's surrounding features and the desired orbit. Similar to regulation of flight paths from airports, FAA's commercial space regulations require risk analysis and public safety requirements to be met before both commercial space launch sites and individual launches are licensed.[24] To control for public risk considerations from launch operations, most commercial space launch sites are located either along a coast, where launch trajectories are primarily over the ocean, or in other areas that are not densely populated.

Other siting considerations also come into play. The appropriateness of a proposed launch site may depend in part on whether the site will host horizontal or vertical launches. Horizontal launches require long runways, whereas vertical launches require launch pads. The construction footprint for supporting infrastructure and

17. Thomas G. Roberts, Center for Strategic and International Studies Aerospace Security Project, Spaceports of the World 52, 55-58 (2019), https://aerospace.csis.org/wp-content/uploads/2019/03/190313__SpaceportsOfTheWorld.pdf.
18. *Id.*
19. 51 U.S.C. §§50901-50923.
20. Launch and reentry-specific licenses authorize operators to conduct one or more launches and/or reentries within certain operational parameters. *See generally* 14 C.F.R. pt. 417 (2019); FAA, *Launch or Reentry Vehicles*, https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/launch_reentry/ (last modified June 27, 2016).
21. Application mechanics are primarily addressed in Part 414 of FAA's regulations. This Comment focuses on the current regulations, but FAA/AST has recently proposed some amendments to launch and reentry licensing requirements that remain under consideration. *See* FAA, Notice of Proposed Rulemaking Streamlined Launch and Reentry Licensing Requirements, 84 Fed. Reg. 15296 (Apr. 15, 2019).
22. 51 U.S.C. §50905.
23. Roberts, *supra* note 17, at 4.
24. *See* 14 C.F.R. §420.25 (2019) (addressing safety requirements where "a flight corridor or impact dispersion area defined by §420.23 contains a populated area").

potential operational impacts are closely tied to the type of launch vehicle proposed to operate from a site.

Environmental factors that cannot be controlled, such as weather patterns, can also be an important consideration. Areas with high winds or more frequent storms are less desirable to the extent the weather presents a higher risk of interfering with launch operations or other commercial space launch site activities. Soil stability can be another factor—without available bedrock to anchor launch pads, ensuring their stability may be more complicated and costly.[25] Of course, economic and other typical considerations are also important, such as the presence of existing infrastructure and a skilled work force.

All of these factors combine to inform a potential launch site's desirability from an operational perspective. Cape Canaveral, for example, is considered a very good location for launch operations, as it enjoys a low latitude along the coast, enabling it to offer eastward launch trajectories located primarily over the Atlantic Ocean that can take advantage of the earth's rotational forces.

C. *Establishing Compliance With FAA's LSOL Regulations*

The siting considerations discussed above intersect with several requirements under FAA's regulations, most notably FAA's launch site safety requirements. The primary focus of FAA's launch site safety review is determining whether representative launch operations at the proposed spaceport can be conducted safely, within the parameters of public risk requirements.[26] Relevant safety-related requirements include:

- Expected casualty. To gain approval for a launch site location, an applicant must demonstrate that at least one type of launch vehicle can be flown safely from the launch point proposed. For purposes of the regulations, a safe launch is one with a risk level, estimated pursuant to an accepted methodology, that does not exceed a total "expected casualty (Ec)" of 1 x 10^{-4} "to the collective members of the public expected to be exposed to hazards from the flight" (e.g., potential launch failures).[27] If an applicant proposes to have more than one type of launch vehicle or weight class flown from a launch point, the applicant must demonstrate that each launch vehicle and the heaviest weight class of each type of vehicle can be flown safely.[28]

- Overflight exclusion zone. FAA also requires applicants to be able to maintain overflight exclusion zones (OEZ) for expected flight corridors. The OEZ is an area where the public risk criteria of 1×10^{-4} is met if a single person were present in the open during launch operations.[29] An OEZ is generally located very close to a launch or reentry site, as individual risk quickly decreases with distance. Applicants should be prepared to demonstrate an ability to control public access to the OEZ during launch operations. This may require entering into agreements with other agencies of jurisdiction, such as an agreement with the U.S. Coast Guard to establish safety zones around navigable waters during launch operations, where public access is controlled to ensure the OEZ and EC requirements are met.

- Launch site boundary. A proposed commercial space launch site must also be able to meet the requirement for a launch site boundary. This area surrounding a launch site is primarily determined by the expected debris dispersion radius of the largest launch vehicle type and weight class proposed.[30]

- Explosive site plan and other requirements. Establishing the safe storage and handling of propellants is another important component of FAA's regulations. Applicants are required to identify and quantify the potential explosives at the commercial space launch site and develop an explosive site plan that can be submitted as part of the LSOL application.[31]

In addition to ensuring that safety-related requirements are met before issuing an LSOL, FAA coordinates with other agencies to ensure that the license would not conflict with any U.S. national security or foreign policy interests or obligations under any treaties.[32] Each of the requirements identified above contributes to the complexity of FAA's environmental review.

25. Concerns with both of these issues have been reported with respect to SpaceX's launch site near Brownsville, Texas. High ground-level winds damaged SpaceX's Starhopper, while the absence of bedrock required measures to be taken to ensure the heavy launch pad's stability. Dave Mosher, *Elon Musk Is Building SpaceX's Mars Rockets in a Tiny Texas Hamlet. But Getting Them Off the Ground There May Be Harder Than He Imagined.*, Bus. Insider, June 5, 2019, https://www.businessinsider.com/spacex-texas-starship-launch-site-development-challenges-2019-6.
26. FAA, *Launch Site Safety Review and Approval*, https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/launch_site/safety/ (last modified Nov. 17, 2006).
27. 14 C.F.R. §420.19(a) (2019); *id.* pt. 420, app. C. FAA has authority to accept alternative approaches to demonstrate an equivalent level of safety. *Id.* §420.1(b).
29. *Id.* §420.23.
30. *Id.* §420.21; *id.* pt. 420, apps. A, B.
31. *Id.* §§420.63-.71.
32. FAA, *Launch Site Policy Review and Approval*, https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/launch_site/policy/ (last modified Nov. 20, 2006); *see* 51 U.S.C. §50901. In addition to these review requirements, applicants must also navigate compliance with International Traffic in Arms Regulations, which restrict the dissemination of certain information about launch operations that have defense and military implications.

D. *Complying With NEPA and Other Special-Purpose Statutes*

Because FAA's issuance of an LSOL is considered a "major federal action," developing a commercial space launch site triggers the need to comply with NEPA. In many cases, compliance with other special-purpose environmental laws and regulations is also necessary.[33] Key compliance issues include:

- **NEPA**. Environmental review of a proposed commercial space launch site shares much in common with review of other infrastructure projects. For example, FAA's decision to prepare an environmental assessment or environmental impact statement depends on FAA's NEPA implementing procedures, FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, as well as the proposal's context and intensity.[34] Generally speaking, an environmental assessment may be more appropriate if the commercial space launch site can leverage existing infrastructure, such as a long runway at an established airport. However, several unique environmental considerations can arise with commercial space launch sites.

For example, the alternatives analysis may take on some unique dimensions, including with respect to launch vehicles, launch-pad configuration, landings, and trajectories. Some unusual effects also come into play during NEPA review of proposed commercial space launch sites. The impacts of launch failures, which are often referred to as "mishaps," also require assessment that is commensurate with the potential for impact. Finally, the multistage nature of FAA's review, where a launch site is licensed first and specific launch operations second, raises several NEPA considerations, including the level analysis required at the LSOL application stage as opposed to the launch operator license application stage.

- **Section 4(f)**. While the U.S. Congress likely did not have spaceports in mind in 1966 when it enacted §4(f) of the Department of Transportation Act, the law applies to space transportation projects because FAA is an administration within the U.S. Department of Transportation. To comply with §4(f), FAA must conclude that the proposed commercial space launch site will not constitute the "use" of any §4(f) properties.[35] Before approving a commercial space launch site that causes more than a de minimis use of a "§4(f) property," FAA must determine that there is no feasible and prudent alternative that avoids the §4(f) properties and that the project includes all possible planning to minimize harm to the §4(f) properties.
- **Coastal Zone Management Act**.[36] Locating a commercial space launch site on the coast gives rise to review requirements under the Coastal Zone Management Act (CZMA). If applicable, the CZMA gives states a role in reviewing proposed launch sites. The CZMA requires federal actions, such as FAA's licensing decisions, that are reasonably likely to affect any land or water use or natural resource of the coastal zone, to be consistent with enforceable policies of a state's federally approved coastal management program.

Like other infrastructure projects, a proposed commercial space launch site also triggers review under a variety of other laws, such as the National Historic Preservation Act where qualifying historic resources are present, the Endangered Species Act[37] where threatened or endangered species are present, and §404 of the Clean Water Act[38] where the discharge of dredge and fill to jurisdictional wetlands is required.

III. Conclusion

The rapid growth of the commercial space industry is opening a new frontier of project development. FAA's licensing process is fairly new, untested in the courts, and currently subject to proposed revisions. Against this backdrop, successfully securing a license to operate a commercial space launch site necessitates strategic navigation of FAA's existing regulations through the integration of legal, technical, and environmental considerations. Due to the interrelationship between specific site characteristics and potential impacts to the human and natural environment, development of commercial space launch sites poses challenges that are unlike those encountered in other areas of infrastructure development.

33. *See* FAA, *Environmental Program*, https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/ (last modified July 25, 2019).
34. 40 C.F.R. §1508.27 (2019).
35. Section 4(f) properties include significant publicly owned public parks, recreation areas, and wildlife or waterfowl refuges, or any publicly or privately owned historic site listed or eligible for listing on the National Register of Historic Places.
36. 16 U.S.C. §§1451-1466, ELR Stat. CZMA §§302-319.
37. 16 U.S.C. §§1531-1544, ELR Stat. ESA §§2-18.
38. 33 U.S.C. §§1251-1387, ELR Stat. FWPCA §§101-607.