



Report to the Chairman, Committee on  
Science, Space and Technology, House  
of Representatives

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August 2015

# FEDERAL AVIATION ADMINISTRATION

## Commercial Space Launch Industry Developments Present Multiple Challenges

# GAO Highlights

Highlights of [GAO-15-706](#), a report to the Chairman, Committee on Science, Space and Technology, House of Representatives

## Why GAO Did This Study

The U.S. commercial space launch industry has changed considerably since the enactment of the Commercial Space Launch Amendments Act of 2004. FAA is required to license or permit commercial space launches, but to allow the space tourism industry to develop, the act prohibited FAA from regulating crew and spaceflight participant safety before 2012—a moratorium that was later extended but will now expire on September 30, 2015. Since October 2014, there have been three mishaps involving FAA licensed or permitted launches.

GAO was asked to examine the changes in the commercial space launch industry and FAA's oversight of the industry. This report addresses, among other things, (1) changes in the industry over the last decade, (2) FAA challenges in addressing industry developments, and (3) FAA's launch licensing workload and budget. GAO reviewed FAA's guidance and documentation on its launch permit, licensing, and safety oversight activities; interviewed FAA officials, industry stakeholders, and experts who were selected on the basis of their knowledge of FAA's oversight of the commercial space launch industry; and visited the spaceports where the two 2014 launch mishaps occurred.

## What GAO Recommends

GAO recommends that FAA, in its budget submissions, provide more detailed information about the Office of Commercial Space Transportation's workload. FAA agreed with the recommendation but thought the report did not convey the extent of industry growth. GAO added information on challenges related to industry growth.

View [GAO-15-706](#). For more information, contact Gerald L. Dillingham, Ph.D. at (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov).

August 2015

## FEDERAL AVIATION ADMINISTRATION

### Commercial Space Launch Industry Developments Present Multiple Challenges

## What GAO Found

During the last decade, U.S. companies conducted fewer orbital launches in total than companies in Russia or Europe, which are among their main foreign competitors. However, the U.S. commercial space launch industry has expanded recently. In 2014, U.S. companies conducted 11 orbital launches, compared with none in 2011. In addition, in 2014, U.S. companies conducted more orbital launches than companies in Russia, which conducted four, or Europe, which conducted six.

The Federal Aviation Administration (FAA)—which is responsible for protecting the public with respect to commercial space launches, including licensing and permitting launches—faces multiple challenges in addressing industry developments. If Congress does not extend the regulatory moratorium beyond September 2015, FAA will need to determine whether and when to regulate the safety of crew and spaceflight participants. Most commercial space launch company representatives told GAO that they favor extending the regulatory moratorium beyond September 2015 to allow the industry more time to develop. Current bills propose extending it as well. In addition, according to FAA officials and industry stakeholders, FAA faces an increasing workload related to licensing and permitting launches such as NASA's commercial cargo and crew programs that involve transporting cargo and crew to the International Space Station; space tourism; and the launching of small satellites.

#### Virgin Galactic's SpaceShipTwo and SpaceX's Falcon 9



Sources: Virgin Atlantic and SpaceX. | GAO-15-706

FAA's budget requests for its commercial space launch activities generally have been based on the number of projected launches. However, in recent years, the actual number of launches has been much lower than the projections. For fiscal year 2016, FAA requested a 16 percent increase in staff for its commercial space launch activities to keep pace with industry growth. Office of Management and Budget guidance indicates that if an agency is requesting significant changes in full-time positions, it should provide a detailed justification of the changes and discuss alternative implementation strategies. However, FAA's fiscal year 2016 budget submission does not provide a detailed justification of the staffing changes and does not consider alternatives to hiring additional staff. Because FAA has not done this, Congress lacks information that would be helpful in making decisions about the resources needed for the agency's commercial space launch activities. FAA officials said that the agency lacked additional workload metrics, which officials are now developing to include in future budget submissions for its commercial space launch oversight activities.

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## Abbreviations

the act	Commercial Space Launch Amendments Act of 2004
CPI	Consumer Price Index
CRS	commercial resupply services
DOT	Department of Transportation
FAA	Federal Aviation Administration
ISS	International Space Station
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OMB	Office of Management and Budget
SpaceX	Space Exploration Technologies Corporation

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August 25, 2015

The Honorable Lamar Smith  
Chairman  
Committee on Science, Space, and Technology  
House of Representatives

Dear Mr. Chairman:

The U.S. commercial space launch industry, which the Federal Aviation Administration (FAA) reports had estimated revenues of \$1.1 billion in 2014, has experienced considerable change since the enactment of the Commercial Space Launch Amendments Act of 2004 (“the act”).<sup>1</sup> The act promoted the development of the emerging commercial human spaceflight industry and made the Department of Transportation (DOT) responsible for overseeing the safety of the new industry—a responsibility that DOT delegated to FAA. To allow the space tourism industry to develop, the act prohibited FAA from regulating the safety of crew and spaceflight participants<sup>2</sup> before 2012, except in limited circumstances. This regulatory moratorium, also called a “learning period,” was later extended to September 30, 2015.<sup>3</sup> The space tourism industry has not started as quickly as some companies had expected; however, it continues to develop despite some setbacks. For example, in October 2014, Scaled Composites’ reusable launch vehicle, SpaceShipTwo,<sup>4</sup> crashed in the Mojave Desert during a test flight, resulting in the death of the copilot. The customer for that vehicle, Virgin Galactic, is building another SpaceShipTwo and will fly its first paid spaceflight participants when the vehicle is ready for commercial operations.<sup>5</sup> Other companies continue developing their own vehicles for space tourism with various designs and business plans.

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<sup>1</sup>Pub. L. No. 108-492, 118 Stat. 3974 (2004).

<sup>2</sup>The act refers to “space flight participant” as “an individual, who is not crew, carried within a launch vehicle or reentry vehicle” (51 U.S.C. § 50902(17)).

<sup>3</sup>Pub. L. No. 112-95, § 827, 126 Stat. 11, 133 (2012), codified at 51 U.S.C. § 50905.

<sup>4</sup>The test flight vehicle was being developed for Virgin Galactic.

<sup>5</sup>The company declined to estimate when commercial operations will begin.

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FAA has been licensing an increasing number of commercial space launches in recent years, including those for the National Aeronautics and Space Administration's (NASA) commercial cargo program, which contracts with commercial launch companies to transport cargo to the International Space Station (ISS). However, in October 2014, one of those launches—Orbital Sciences' cargo rocket bound for the ISS—exploded shortly after liftoff from the Mid-Atlantic Regional Spaceport located at the NASA Wallops Flight Facility in Virginia, causing approximately \$13 million to \$15 million in damage to the launch pad.<sup>6</sup> In addition, in June 2015, a SpaceX rocket also bound for the ISS exploded during flight about 2 minutes after launching from the Cape Canaveral Air Force Station, FL.

FAA also will be responsible for licensing launches for NASA's commercial crew program after NASA certifies provider vehicles (post certification missions).<sup>7</sup> Under that program, the U.S. government for the first time will purchase services from commercial space launch companies to transport astronauts to and from the ISS and low-earth orbit.<sup>8</sup> According to FAA, out of 284 launches and re-entries (returning to earth) that the agency has licensed or permitted from 1989 through May 2015, the SpaceShipTwo accident is the only one that involved a fatality.

In 2006, we reported that FAA had provided a reasonable level of safety oversight regarding commercial launches, but that the agency faced several challenges in regulating and promoting space tourism.<sup>9</sup> These challenges included FAA's ability to estimate its future resource needs and determine the specific circumstances under which it would regulate the safety of crew and spaceflight participants. You requested that we review the extent to which FAA is prepared to address changes that have

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<sup>6</sup>The Mid-Atlantic Regional Spaceport—which is owned and operated by the Virginia Commercial Space Flight Authority, an independent authority of the Commonwealth of Virginia—owns and operates two launch pads at NASA's Wallops Flight Facility.

<sup>7</sup>By contrast to FAA, which is a regulatory agency, NASA is a civil research and development agency that does not regulate the commercial space launch industry.

<sup>8</sup>According to FAA, low-earth orbit refers to orbits that are typically equal to or less than 2,400 kilometers (1,491 miles) in altitude.

<sup>9</sup>GAO, *Commercial Space Launches: FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry*, [GAO-07-16](#) (Washington, D.C.: Oct. 20, 2006).

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occurred in the commercial space launch industry over the last decade and potential changes in the future. This report examines (1) how the competitive landscape has changed for the U.S. commercial space launch industry over the last decade, (2) challenges that FAA faces in licensing and regulating commercial space launches, (3) the status of developing industry standards for human spaceflight, (4) how FAA has projected its commercial space launch licensing workload for future fiscal years when submitting budget requests to Congress and how changes in the number and types of launches might affect its budget needs in future years, and (5) how changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for commercial launches. You also asked us to provide an update on FAA's actions to address our previous recommendations on its methodology regarding launch insurance calculations. See appendix I for this information.

To evaluate these issues, we reviewed FAA's program guidance, legal requirements and restrictions, and data on FAA's licensing, permitting, and inspection workload during the last decade. We visited launch facilities in Mojave, CA, and Wallops Island, VA, to review how FAA carries out its launch safety activities. We chose to visit the Mojave Air and Space Port because it is an FAA-licensed launch site where a number of companies are conducting space launch and development activities for both suborbital and orbital operations<sup>10</sup> and because it was the site of the SpaceShipTwo test flight accident in October 2014. In addition, we visited the Mid-Atlantic Regional Spaceport at NASA Wallops Flight Facility in Wallops Island, VA, because it is an FAA-licensed launch site located on a federal range<sup>11</sup> and was the site of Orbital Sciences' launch mishap in October 2014. At those facilities and elsewhere, we interviewed FAA officials, nine commercial launch companies, an industry association, an industry advisory group, and three experts about (1) industry international competition, (2) the challenges that FAA faces in

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<sup>10</sup>According to FAA, suborbital spaceflight occurs when a spacecraft reaches space but its velocity is such that it cannot achieve orbit. FAA also indicates that many people believe that in order to achieve spaceflight, a spacecraft must reach an altitude higher than 100 kilometers (about 62 miles) above sea level. By contrast, according to FAA, orbital spaceflight occurs when a spacecraft is placed on a trajectory with sufficient velocity to place it in orbit around the earth.

<sup>11</sup>NASA defines a range as an area in and over which rockets are fired for testing and tracking.

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space launch safety oversight given developments in the industry, and (3) the development of industry standards. We also interviewed representatives from the two launch sites that we visited regarding industry competition and FAA challenges. We chose these companies and industry organizations by reviewing FAA reports on the commercial space launch industry and other literature. We interviewed representatives from the majority of U.S. commercial space launch companies identified in FAA's 2014 annual report on commercial space transportation. Of the nine companies we interviewed, three conducted licensed launches in 2014. The experts whom we interviewed were selected from academia and private industry based on their knowledge of FAA's oversight of the commercial space launch industry. Two of the experts are professors who conduct research on commercial space launch activities at universities, and the third expert is the former associate administrator for FAA's Office of Commercial Space Transportation. Their views are not generalizable.

To study the competitive landscape regarding the commercial space launch industry, we reviewed FAA trend data, such as the number of launches conducted by U.S. and foreign companies during the last 10 years, and interviewed the representatives from the commercial space launch companies and the experts. To review how FAA projects its launch licensing workload, we examined metrics for the last 10 fiscal years such as the number of launch licenses and permits that the agency processed and the number of safety inspections conducted, and reviewed budget formulation guidance from the Office of Management and Budget (OMB). We also reviewed FAA's commercial space launch budget submissions for those years. In particular, we compared the number of launches that FAA projected during the last 10 fiscal years, which it generally used as the basis for its budget requests, with the actual number of launches that occurred. FAA provided information about the steps that it took to ensure the completeness and reliability of the data on the number of launches that the agency licensed and permitted and inspections that it conducted, as well as the data on overtime and compensatory expenditures. Based on our review of this information, we determined the data were sufficiently reliable for our purposes. To determine how changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for commercial launches, we discussed the factors affecting the government's overall exposure and indemnification for commercial launches with FAA officials, industry representatives, and an insurance company representative. Appendix II provides more details about our scope and methodology.



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We conducted this performance audit from January 2015 to August 2015 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.

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## Background

Space transportation is the movement of, or means of moving objects, such as satellites and vehicles carrying cargo, scientific payloads,<sup>12</sup> or passengers, to, from, or in space. Space activity in the United States is conducted by the civil, military, and commercial sectors. Commercial space transportation is carried out using orbital and suborbital vehicles owned and operated by private companies or other nonfederal organizations. Space tourism is a segment of the commercial space launch industry that would make space travel available to the public. The commercial sector officially began in 1984 with Executive Order 12465, which designated DOT as the lead federal agency for enabling private-sector launch capability.<sup>13</sup> Also in 1984, the Commercial Space Launch Act gave DOT the authority, among other things, to license and monitor the safety of commercial space launches and to promote the industry. Regulatory oversight for the commercial sector was given to the Office of Commercial Space Transportation, which was originally within the Office of the Secretary of Transportation but according to an FAA official was transferred to FAA in 1995.

In the past, the U.S. government was the sole entity launching civil and commercial payloads into orbit from the United States. However, as a result of the Space Shuttle Challenger accident in 1986, the U.S. government transferred responsibilities for commercial payload launches to the private sector. In the NASA Reauthorization Act of 2005, Congress directed NASA to foster the commercial spaceflight industry, as the end of the Space Shuttle program would leave the United States without a domestic capability to transport crew and cargo to and from the ISS.<sup>14</sup> This led NASA to establish the commercial cargo and crew programs to

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<sup>12</sup>Payload is what is being transported on the launch vehicle, for example, a research project or satellite.

<sup>13</sup>49 Fed. Reg. 7211 (Feb. 28, 1984).

<sup>14</sup>The Space Shuttle Program ended in 2011.

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facilitate safe, reliable, and cost-effective transportation services to low-earth orbit instead of purchasing seats on the Russian Soyuz and developing new government launch vehicles.<sup>15</sup> Two U.S. companies currently have a commercial resupply services (CRS) contract with NASA to carry cargo to the ISS—Space Exploration Technologies Corporation (SpaceX) and Orbital ATK.<sup>16</sup> In September 2014, NASA released a request for proposal for the follow-on CRS contract—CRS2—and expects to award the contract in the third quarter of fiscal year 2015. NASA expects new competitors for the CRS2 contract to drive lower prices and provide increase capacity per flight. Several companies have been involved in developing vehicles that will carry astronauts to the ISS, including Blue Origin, Boeing, Paragon Space Development Corporation, Sierra Nevada Corporation, SpaceX, and United Launch Alliance.<sup>17</sup> Boeing and SpaceX are the only companies currently under contract and are working on obtaining vehicle certification from NASA. Combined, the companies have received awards under the program that could total nearly \$8 billion. These include a minimum of two and a maximum of six post certification missions per provider for crew transportation to the ISS under the recently awarded contracts with NASA for the latest phase of the program.

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## Types of Vehicles

Historically, commercial space launches carried payloads, generally satellites, into orbit using expendable launch vehicles that did not return to earth. An expendable launch vehicle is a single-use vehicle that is used to launch a payload into space. Launch companies such as SpaceX and United Launch Alliance are also testing reusable elements of expendable launch vehicles. Figure 1 shows examples of expendable launch vehicles—Orbital ATK’s Antares, SpaceX’s Falcon,<sup>18</sup> and United Launch Alliance’s Atlas and Delta.

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<sup>15</sup>NASA’s Space Launch System, for example, involves the development of a launch vehicle to transport astronauts and cargo into deep space.

<sup>16</sup>A third company participated with NASA on the commercial cargo program, but its work was terminated in 2007.

<sup>17</sup>Excludes two companies that are unfunded partnerships. An unfunded partnership is a nonreimbursable space act agreement or other transaction authority agreement that involves NASA and one or more partners in a mutually beneficial activity that furthers NASA’s mission, where each party bears the cost of its participation and there is no exchange of funds between the parties.

<sup>18</sup>SpaceX plans to make the Falcon into a reusable launch vehicle in the future.

**Figure 1: Expendable Launch Vehicles**



Antares

Falcon 9

Atlas V

Delta IV

Sources: Orbital ATK (Antares), SpaceX (Falcon 9), and United Launch Alliance (Atlas V and Delta IV).  
Reprinted with permission. | GAO-15-706

The commercial space launch industry is changing with the emergence of suborbital reusable launch vehicles that are capable of being launched into space more than once and enable space tourism from state-sponsored or private launch sites, also known as spaceports. According to FAA, suborbital reusable launch vehicles are those that do not attain enough velocity to enter into a sustainable orbit around the earth. These vehicles are being designed to reach or surpass an altitude of 100 kilometers (62.5 miles) and enter space for a brief time. As shown in fig. 2, some of the reusable launch vehicles under development include:

- Virgin Galactic's SpaceShipTwo, a space tourism vehicle with seats for two pilots and six spaceflight participants. According to the company, about 700 people have already placed refundable

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deposits on the \$250,000 ticket price per flight that is to last for about 2 hours, including 5 minutes of microgravity.<sup>19</sup>

- XCOR Aerospace's Lynx, another space tourism vehicle with seats for one pilot and one spaceflight participant. The ticket price is \$100,000.
- Blue Origin's New Shepard vehicle, a vertical takeoff and landing vehicle designed to carry three or more crew. The crew capsule is designed to land with the assistance of parachutes.
- Stratolaunch System's Stratolaunch aircraft, which is being designed with a wingspan greater than 380 feet to be powered by six Boeing 747 engines, and a multi-stage booster to carry unmanned payloads and manned spacecraft to orbit. According to the company, the aircraft will be the largest ever constructed.

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<sup>19</sup>NASA defines microgravity as when the pull of gravity is not very strong and things appear to be weightless.

**Figure 2: Reusable Launch Vehicles under Development**



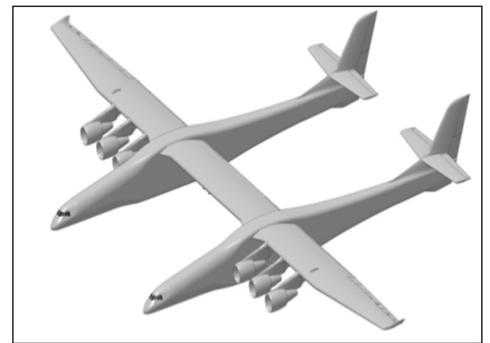
Virgin Galactic's SpaceShipTwo



XCOR's Lynx



Blue Origin's New Shepard



Stratolaunch aircraft

Sources: Virgin Galactic, XCOR, Blue Origin, and Vulcan Aerospace (for Stratolaunch). Reprinted with permission. | GAO-15-706

## Federal Roles and FAA's Budget

In 2004, the Commercial Space Launch Amendments Act gave DOT, among other things, the specific responsibility of overseeing the public safety aspects of space tourism, but the act prohibited DOT from regulating the safety of crew and spaceflight participants before 2012, except in response to high-risk events, serious injuries, or fatalities—a provision that in 2012 was extended to September 30, 2015. Under the act, in response to such events during the moratorium, the Secretary of Transportation may issue regulations governing the design or operation of a launch vehicle to protect the health and safety of crew and spaceflight participants that would:

- describe how such regulations would be applied in determining whether to issue a launch license,
- apply only to launches in which a vehicle will be carrying a human being for compensation or hire, and

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- be limited to restricting or prohibiting design features or operating practices that have (1) resulted in a serious or fatal injury to crew or spaceflight participants during a licensed or permitted commercial human spaceflight or (2) contributed to an unplanned event or series of events during a licensed or permitted commercial human spaceflight that posed a high risk of causing a serious or fatal injury to crew or spaceflight participants.<sup>20</sup>

At the same time, the act maintains FAA's authority over protecting the public with regard to commercial space launches, and FAA has issued regulations regarding that. If Congress decides not to extend the moratorium, FAA will have the discretion to propose regulations regarding the safety of crew and spaceflight participants without restriction after September 30, 2015.<sup>21</sup>

FAA's primary means of authorizing space launch activities is through its licensing process. Among other things, FAA's Office of Commercial Space Transportation is responsible for:

- licensing launch and reentry vehicle operations and launch and reentry site operations (spaceports) carried out by U.S. citizens or within the United States, except for those operations that are carried out exclusively by and for the government.<sup>22</sup>
- reviewing applications for experimental permits, which allow suborbital reusable rocket operations while conducting research and development showing compliance with licensing requirements or crew training;

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<sup>20</sup>51 U.S.C. § 50905(c).

<sup>21</sup>The Commercial Space Launch Competitiveness Act, S. 1297, 114<sup>th</sup> Cong. (2015), introduced by Sen. Cruz, Chairman of the Senate Commerce Subcommittee on Space, Science, and Competitiveness, would extend the regulatory moratorium by 5 years. The Senate passed this bill on Aug. 4, 2015. A bill that the House of Representatives passed on May 21, 2015, the Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act, H.R. 2262, 114<sup>th</sup> Cong. (2015), introduced by Rep. McCarthy, would extend the regulatory moratorium by 10 years.

<sup>22</sup>NASA and FAA agreed that NASA's cargo missions and the crewed post certification missions would be licensed.

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- reviewing safety approvals, which are determinations that safety elements such as launch or reentry vehicles or safety systems will not jeopardize the safety of public health or property when used or employed within defined parameters or situations;
  - conducting safety inspections and oversight regarding the licensed and permitted activities;
  - engaging in rulemaking activities; and
  - promoting the commercial space launch industry.<sup>23</sup>

FAA's overall budget request for fiscal year 2016 is \$15.8 billion and 44,333 full-time equivalent positions—a decrease of \$11.5 million and an increase of 120 full-time equivalent positions over fiscal year 2015 appropriations. For its Office of Commercial Space Transportation, FAA is requesting \$18.1 million and 92 full-time equivalent positions—an increase of \$1.5 million and 13 full-time equivalent positions over fiscal year 2015 appropriations.<sup>24</sup> In its budget submission, FAA indicated additional staff for the Office of Commercial Space Transportation are needed to conduct license and permit determinations within the legally mandated time periods, among other responsibilities. The Commercial Space Launch Amendments Act requires FAA to make its determinations within 180 days of accepting licensing applications and within 120 days of accepting experimental permit applications.<sup>25</sup> From 1989 through May 2015, FAA licensed 237 launches, 39 launches under experimental permits, and 9 licensed reentries. As of July 2015, 6 companies held 17 active launch licenses, and FAA had licensed 10 launch sites, 3 of which are located at federal ranges (see fig. 3). To date, no space tourism

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<sup>23</sup>We found in 2006 that FAA's promotional role has the potential to overlap with the Department of Commerce's role and recommended that FAA and Commerce develop a memorandum of understanding that clearly delineates the two agencies' respective promotional roles in line with their statutory obligations and larger agency missions. See [GAO-07-16](#). FAA has not implemented this recommendation.

<sup>24</sup>On June 9, 2015, the House of Representatives approved the fiscal year 2016 appropriations for FAA, which did not include a funding increase for the Office of Commercial Space Transportation. H.R. 2577, 114<sup>th</sup> Cong. (2015).

<sup>25</sup>51 U.S.C. §§ 50905 and 50906.

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companies have received a launch license.<sup>26</sup> In addition, as of May 2015, FAA had received portions of applications for an additional four launch sites.<sup>27</sup>

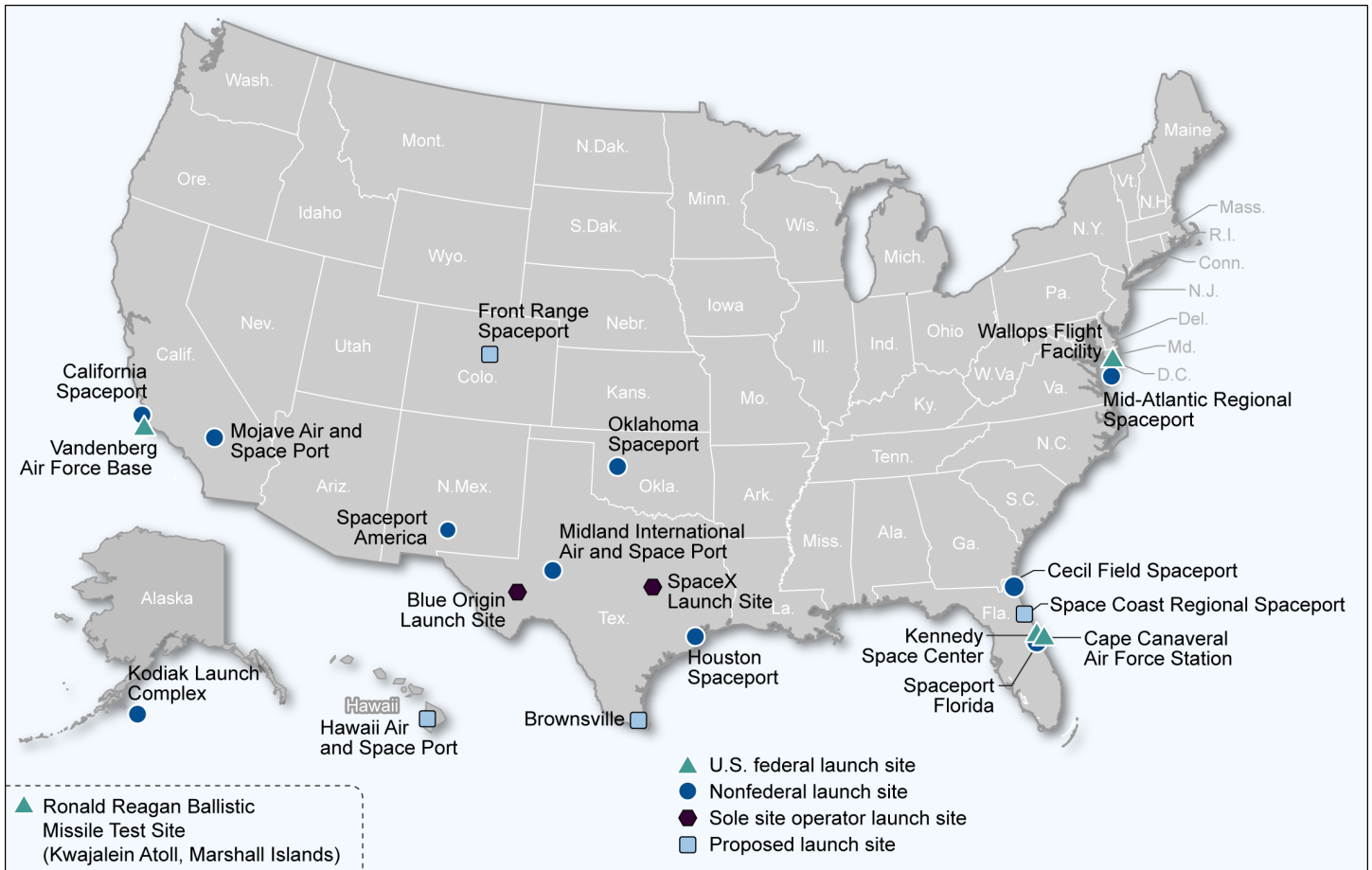
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<sup>26</sup>In 2013, Virgin Galactic applied for an operator's license, which, if approved, would authorize multiple launches, but in 2014 requested that its application be "tolled" (suspended) in an effort to allow Scaled Composites to continue flight testing. As discussed later in this report, under the Commercial Space Launch Amendments Act of 2004, companies may not hold experimental permits and licenses for the same type of vehicle.

<sup>27</sup>According to FAA, as of July 2015, it had received portions of applications for launch sites in Front Range, CO; Titusville, FL; Kona, HI; and Brownsville, TX. An FAA official said that the proposed launch site in Brownsville may be a sole site operator launch site, which would not need to be licensed. Other launch sites have been proposed in Shiloh, FL, and Camden County, GA.



**Figure 3: Commercial Space Launch Sites and Proposed Sites as of July 2015**



Sources: FAA and Map Resources. | GAO-15-706

Note: FAA did not require the two sole site operator launch sites to be licensed because they were for the companies' exclusive use.

Because some launch vehicles also may be operated as aircraft, another FAA office is involved in providing safety oversight—the Office of Aviation Safety, which regulates aircraft. The Office of Aviation Safety regulates nonlaunch flights of hybrid vehicles under airworthiness certificates

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authorizing the vehicles to fly.<sup>28</sup> For example, while being tested and operated as an aircraft for research and development purposes, the Office of Aviation Safety issued an experimental airworthiness certificate for Scaled Composites to fly SpaceShipTwo as an unpowered glider for flights not conducted under the company's experimental permit. In addition to FAA, other federal agencies are involved in commercial space launch activities. The Department of Defense (DOD), primarily through the Air Force, and NASA provide infrastructure, operations support, and range safety oversight for government and commercial launches at their launch sites. The Department of Commerce is also responsible for promoting the commercial space launch industry. In addition, the National Transportation Safety Board (NTSB) has asserted its authority to investigate commercial space launch accidents.

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## Launch Mishaps and Indemnification

Since October 2014, there have been three mishaps involving FAA licensed or permitted launches. On October 28, 2014, Orbital Sciences' cargo rocket bound for the ISS exploded shortly after liftoff from the Mid-Atlantic Regional Spaceport located at the NASA Wallops Flight Facility. FAA authorized Orbital ATK<sup>29</sup> to conduct the investigation under the agency's oversight. Under a 2004 agreement between the NTSB and FAA, lead investigative authority is determined based on the classification of the mishap, the phase of flight when the mishap occurred, impact location, and its consequences. This mishap was classified as an "incident" because it did not involve a fatality or serious injury or cause enough third-party property damage to trigger the provisions of the memorandum of agreement between NTSB and FAA. That agreement indicates that NTSB will investigate all commercial space launch mishaps involving (1) an impact outside of the impact limit lines designated by the launch range facility, or (2) a fatality or serious injury, or (3) more than \$25,000 in property damage outside of the range facility. FAA expects the results of the investigation will be publicly released in August 2015.

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<sup>28</sup>S. 1297 would require the Secretary of Transportation to report to Congress on approaches for streamlining the process for licenses and permits for vehicles with both expendable and reusable elements known as hybrid vehicles. H.R. 2262 would require the Secretary of Transportation to report to Congress on ways to "streamline requirements in order to improve efficiency, reduce unnecessary costs, resolve inconsistencies, remove duplication, and minimize unwarranted constraints."

<sup>29</sup>In February 2015, Orbital Sciences Corporation and Alliant Techsystems Inc. (ATK) completed their merger. Following the merger, Orbital Sciences Corporation became a wholly-owned subsidiary of a new parent company, Orbital ATK Inc.

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On October 31, 2014, Scaled Composites' reusable launch vehicle, SpaceShipTwo,<sup>30</sup> crashed in the Mojave Desert during a test flight, resulting in the death of the copilot. Because that mishap involved a fatality, it was classified under the memorandum of agreement as an "accident" and NTSB was designated as the lead investigative authority. The results of NTSB's accident investigation, released in July 2015, indicated that the probable cause of the accident was Scaled Composites' failure to consider and protect against potential human error that could result in a catastrophic hazard. According to NTSB, this set the stage for the copilot's premature unlocking of the feather system designed to slow the vehicle during reentry and subsequent in-flight breakup of the vehicle. NTSB made 10 recommendations, including 8 to FAA, about developing guidance on human factors,<sup>31</sup> improving FAA's experimental permit application review and safety inspection processes, and implementing a database of lessons learned from commercial space mishap investigations.<sup>32</sup>

In addition, on June 28, 2015, a SpaceX rocket bound for the ISS exploded during flight about 2 minutes after launching from the Cape Canaveral Air Force Station, FL. An FAA official indicated that SpaceX will lead the investigation of this mishap with FAA oversight.

The federal government provides for a conditional payment of claims in excess of the required insurance mandated by license. This conditional payment is popularly referred to as indemnification—catastrophic loss protection in the event of a launch accident—for all FAA-licensed commercial launches through the Commercial Space Launch Amendments Act. Thus, subject to congressional appropriations, the U.S. government may pay third-party liability claims for injury, damage, or loss that result from a commercial launch-related accident in excess of the required "maximum probable loss," which is calculated by FAA and is

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<sup>30</sup>The test flight was being conducted for Virgin Galactic by another company, Scaled Composites. Scaled Composites was under contract to Virgin Galactic for the design, manufacture, and flight test.

<sup>31</sup>Human factors involve the study of how humans' abilities, characteristics, and limitations interact with the design of the equipment they use, environments in which they function, and jobs they perform.

<sup>32</sup>For more information on NTSB's findings and recommendations regarding the SpaceShipTwo accident investigation, see NTSB's website at [http://www.nts.gov/news/events/Pages/2015\\_spaceship2\\_BMG.aspx](http://www.nts.gov/news/events/Pages/2015_spaceship2_BMG.aspx).

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capped at \$500 million per launch or amount available at reasonable cost.<sup>33</sup> The federal government, subject to the availability of appropriations, is then liable for claims over the maximum probable loss up to \$1.5 billion adjusted for post-1988 inflation which is about \$3.06 billion.<sup>34</sup> Launch companies are responsible for third-party liability claims up to the maximum probable loss and over \$3.06 billion.

The indemnification coverage will expire in December 2016 if Congress decides not to extend this date.<sup>35</sup> A bill that the Senate passed in August 2015 would extend the indemnification coverage through 2020, while a bill passed by the House of Representatives in May 2015 would extend the indemnification coverage until 2025.<sup>36</sup>

Launch licensees and experimental permit holders that launch from federal facilities are also required to insure up to \$100 million against any potential damage to government property.<sup>37</sup> The federal government provides indemnification only for third-party claims and does not indemnify those involved in a launch including crew and spaceflight participants onboard a vehicle against third-party claims.<sup>38</sup> The federal government also does not provide indemnification for experimental permit holders.

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<sup>33</sup>FAA makes this determination for each space launch by reviewing the specific circumstances of the launch, including the planned launch vehicle, launch site, payload, flight path, and the potential casualties and fatalities that could result from varying types of launch failures at different points along that path. FAA estimates the total cost of estimated casualties from a launch failure and uses this information as the basis for determining property damage.

<sup>34</sup>The Commercial Space Launch Amendments Act of 2004 requires that the \$1.5 billion maximum amount be adjusted for inflation. We used the Consumer Price Index (CPI-U) to calculate the adjustment to 2015 dollars.

<sup>35</sup>51 U.S.C. § 50915(f).

<sup>36</sup>S. 1297 and H.R. 2262.

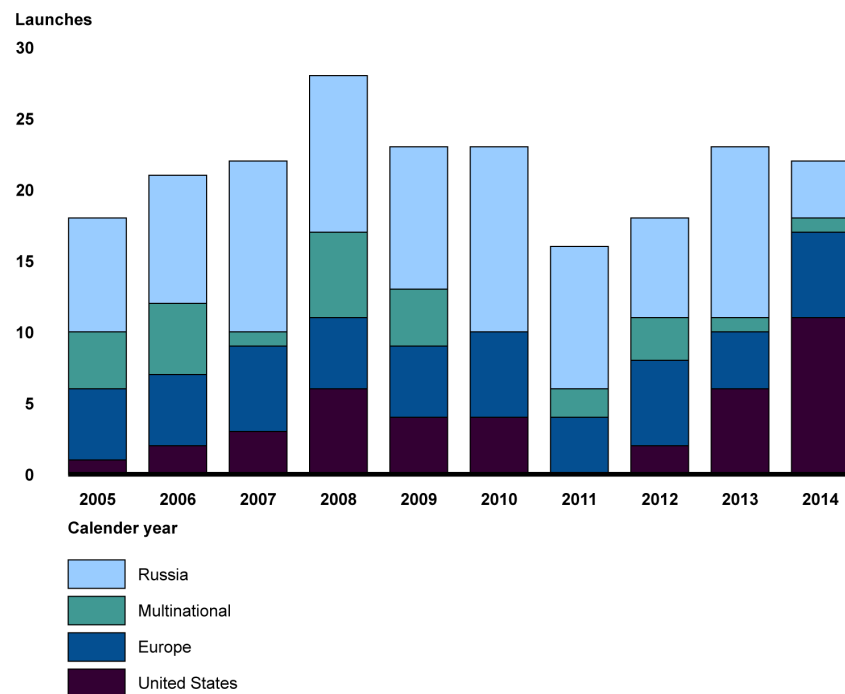
<sup>37</sup>51 U.S.C. § 50914((a)(3)(A)(ii).

<sup>38</sup>H.R. 2262 also provides indemnification coverage for spaceflight participants.

## The U.S. Commercial Space Launch Industry Has Expanded in Recent Years

During the last decade, U.S. companies conducted fewer orbital launches in total<sup>39</sup> than companies in Russia or Europe, which are among their main foreign competitors. However, in recent years U.S. companies have conducted an increasing number of orbital launches. As shown in figure 4 below, the number of orbital launches conducted by U.S. companies increased from zero in 2011 to 11 in 2014. Moreover, in 2014, U.S. companies conducted more orbital launches than companies in Russia, which conducted four, or Europe, which conducted six.

**Figure 4: U.S. and Foreign Orbital Commercial Space Launches, 2005 through 2014**



Source: FAA. | GAO-15-706

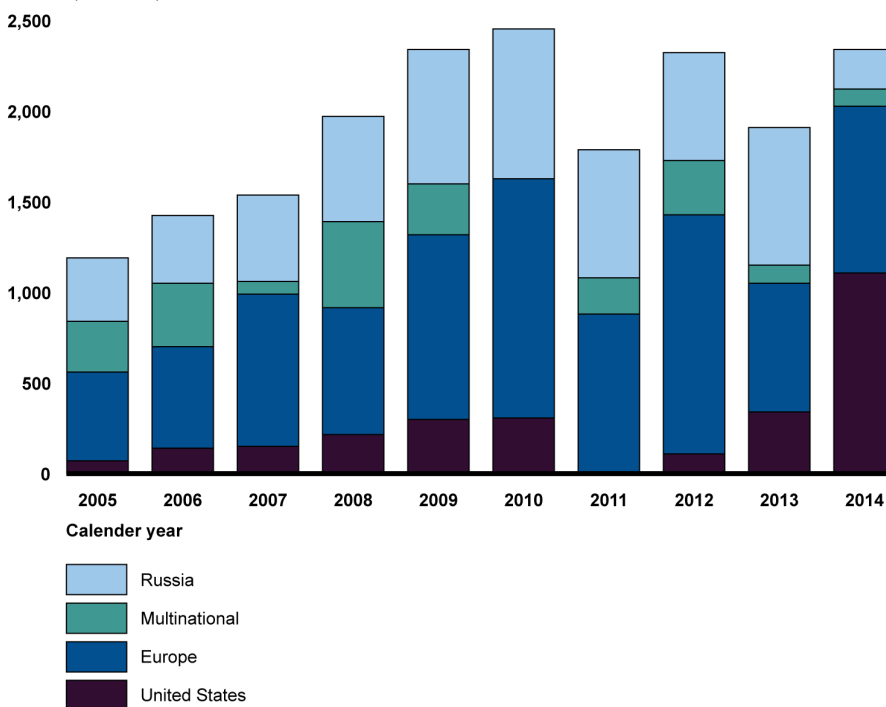
Notes: This graphic shows the number of orbital commercial space launches conducted by companies in countries that had the most orbital commercial launches. Some other countries that conducted orbital commercial space launches are not shown. Multinational represents the company Sea Launch.

<sup>39</sup>FAA data on international launch activity are only for orbital launches because, according to FAA, no commercial suborbital launch activity was conducted outside of the United States. Except for one licensed launch, the only suborbital launches conducted by U.S. companies from 2005 through 2015 were experimental. From 2005 through 2014, U.S. companies conducted a total of 39 orbital launches, compared with 96 conducted by companies in Russia and 52 conducted by companies in Europe.

Similarly, as shown in figure 5, during most years over the last decade, FAA data indicated that U.S. companies generated less orbital launch revenue than companies in Russia or Europe but in 2014, U.S. companies generated more orbital launch revenue than companies in Russia or Europe. According to FAA data, over the last 3 years, orbital launch revenue generated by U.S. companies increased from none in 2011 to \$1.1 billion in 2014.

**Figure 5: U.S. and Foreign Orbital Commercial Space Launch Revenue, 2005 through 2014**

Dollars (in millions)



Source: FAA. | GAO-15-706

Notes: This graphic shows orbital commercial space launch revenue generated by companies in countries with the most orbital launch revenue. Orbital commercial space launch revenue generated in some other countries is not shown. Multinational represents the company Sea Launch.

A number of factors are responsible for the recent expansion of the U.S. commercial space launch industry. First, federal government contracts, such as NASA's commercial cargo program, have supported the industry and have resulted in an increase in the number of U.S. commercial launches and revenues. For example, in 2014, SpaceX launched two

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cargo resupply missions for NASA, and NASA ordered three additional missions to SpaceX's CRS contract. NASA also procured eight launches from Orbital Sciences in 2008 that were scheduled to occur between 2014 and 2016. In addition to fulfilling government contracts, these companies also conducted launches for other customers. For example, in 2014, SpaceX conducted four commercial launches, three of which were for international customers, and Orbital ATK conducted two, both of which were for international customers.

Second, according to representatives from two commercial space launch companies, including SpaceX, and an advisory group and an expert who we interviewed, the growth in the U.S. commercial space launch industry is largely being led by SpaceX being more price competitive compared with foreign launch providers. The Chairman of the Commercial Space Transportation Advisory Committee said that SpaceX's prices are significantly lower than foreign providers. Moreover, some companies are seeking ways to further reduce costs. For example, Blue Origin is developing new main engine elements for United Launch Alliance's future expendable launch vehicles. Representatives from one company and an industry association and an expert told us that reusable stages will lower launch prices. In previous work, we reported that according to industry stakeholders, launch prices, along with launch vehicle reliability, were the major factors that customers focus on when selecting launch providers.<sup>40</sup> One expert noted, however, that although reusable stages will lower launch costs and prices may decrease, those decreases may not be enough to significantly affect demand because prices will be affected by many other parameters such as other nations' launch pricing schemes and possible shifts in consumer demand.

Third, the emerging space tourism industry and small satellite industry in the United States also may help the U.S. commercial space launch industry expand. As noted earlier, some U.S. companies are developing reusable launch vehicles to carry spaceflight participants on suborbital flights and to place small satellites into orbit. According to FAA, companies are also developing small expendable launch vehicles to deploy small satellites in space.

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<sup>40</sup>GAO, *Commercial Space Transportation: Industry Trends, Government Challenges, and International Competitiveness Issues*, [GAO-12-863T](#) (Washington, D.C.: June 20, 2012).

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Finally, the federal government's current indemnification of FAA licensed launches helps keep launch costs low. As we found in 2012, countries such as China, France, and Russia have indemnification regimes with no limits on the amount of government indemnification.<sup>41</sup> Representatives from five commercial space launch companies, three experts, an industry advisory group, an industry association, and a spaceport told us that government indemnification is critical to the U.S. launch industry. One expert, for example, said that indemnification is critical mainly because all other space-faring nations also have insurance or indemnification subsidy programs. He added that if in the future, the number of launches and companies expands greatly in the United States, a formal government indemnification program possibly could be replaced with an industry-funded insurance system. The federal government currently indemnifies launch operators by providing catastrophic loss protection covering third-party liability claims in excess of required launch insurance in the event of a commercial launch incident, subject to the availability of appropriations. Representatives from four companies said that the lack of indemnification in the United States could lead to higher insurance prices, which, if passed on, could lead to higher launch prices.

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## FAA Faces Multiple Challenges Regarding Developments in the Commercial Space Launch Industry

We asked FAA officials, representatives from nine commercial space launch companies, and three experts to identify the challenges that FAA faces—and is likely to face in the near future—to address significant developments in the commercial space launch industry over the last decade. The challenges for FAA that they identified included the following: (1) determining whether and when to regulate the safety of crew and spaceflight participants, (2) increased workload relating to licensing and permitting launches and launch sites, (3) creating a safety reporting system, and (4) responding to emerging business plans.

- **Determining whether and when to regulate the safety of crew and spaceflight participants:** In 2014, FAA released a set of recommended practices<sup>42</sup> on human spaceflight occupants' safety that the agency indicated could be a starting point for the industry to develop standards, or if needed, for FAA to develop regulations.

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<sup>41</sup>GAO, *Commercial Space Launches: FAA Should Update How It Assesses Federal Liability Risk*, [GAO-12-899](#) (Washington, D.C.: July 2012).

<sup>42</sup>FAA, *Recommended Practices for Human Space Flight Occupant Safety Version 1.0* (Washington, D.C.: Aug. 27, 2014).



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FAA officials said that if the moratorium is not extended beyond September 30, 2015, the agency has no plans to issue regulations regarding the safety of crew and spaceflight participants. The officials said rather than issuing regulations, FAA is looking to industry to develop industry consensus standards detailing validation and verification criteria that are needed to implement the agency's recommended practices. The officials also noted that if the moratorium remains in place, industry may not have an incentive to devote much time or energy to developing industry standards (discussed later in this report).

In 2006, we recommended that to be proactive about safety, FAA should identify and continually monitor space tourism industry safety indicators that might trigger the need to regulate the safety of crew and spaceflight participants before the moratorium expires (rather than responding only after a fatality or serious incident occurs) and issue guidance on the circumstances under which it would regulate the safety of crew and spaceflight participants.<sup>43</sup> FAA disagreed with our recommendation, stating that in light of its observation of safety risk management, safety assurance and a general safety culture in the commercial space launch industry and other factors, it found no compelling reason to issue guidelines on the circumstances under which it would regulate the safety of crew and spaceflight participants. During this review, an FAA official also said that in theory, the agency could promulgate regulations after an accident, but under the moratorium, it would be limited to the design feature that caused the accident. For example, he said that any regulatory action taken in response to the SpaceShipTwo accident would depend on the results of the NTSB's accident investigation. This official also said that the development of standards by industry may take less time than the years it would take for FAA to promulgate regulations.

Representatives from six of the nine commercial space launch companies that we interviewed, the three experts, the Chairman of

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<sup>43</sup>GAO-07-16.

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the Commercial Space Transportation Advisory Committee,<sup>44</sup> and the President of the Commercial Spaceflight Federation,<sup>45</sup> all recommended that the regulatory moratorium be extended beyond September 30, 2015. Among the reasons provided were allowing the space tourism industry and industry standards more time to develop and because of changing technologies. However, they had different opinions regarding about how long to extend the moratorium, ranging from 1 to 15 years. Representatives from two companies suggested that the moratorium be extended indefinitely. However, one of the experts said that the moratorium should not be extended for an unreasonably long time or indefinitely because there will a point in the future when start-up companies either become successful or fail. Rather, he suggested that the moratorium be reevaluated periodically to allow companies to conduct adequate business planning and for the government to collect information for future decision making on regulatory and budgetary issues. Another expert we interviewed said that although he supported extending the moratorium on regulating crew and spaceflight participant safety, he suggested that FAA and industry start discussions regarding what a regulatory framework would look like. In response, an FAA official said that the agency is concerned about how an extension of the moratorium would impact the practicality of such discussions, but that the moratorium would not prohibit FAA from engaging in such a dialogue with industry

These representatives and the experts we interviewed also provided various reasons why the space tourism industry has not already begun commercial operations, such as technological challenges, the amount of time needed for testing and engineering, and financing. By contrast, representatives from two of the nine companies that we contacted—both are companies

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<sup>44</sup>The Commercial Space Transportation Advisory Committee was established in 1984 to provide information, advice, and recommendations to the FAA Administrator on critical matters concerning the U.S. commercial space transportation industry. As of May 2015, the committee consisted of 27 members representing commercial space launch companies, spaceports, and others.

<sup>45</sup>The Commercial Spaceflight Federation is an industry association whose mission is to promote the development of commercial human spaceflight. As of May 2015, the association had 50 members, including commercial spaceflight developers, operators, and spaceports.

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that are focused on orbital operations—favored allowing the moratorium to expire. A representative from one company said, for example, that regulation is needed to provide protection against companies that may not be safe. He also said that the lack of FAA regulations defining what is considered “safe” for spaceflight participants will increase the vulnerability of the commercial human spaceflight industry to public outcry if loss of life occurs due to a mishap. However, he added that if there is a clear and justifiable safety regulatory framework, then a mishap will appear as a regrettable but inevitable part of any transportation industry’s growth.

An FAA official indicated that the agency’s position is that the moratorium should be allowed to expire. FAA officials explained that although the agency has no plans to regulate the safety of crew and spaceflight participants, if at some point FAA were to identify a systemic issue with existing vehicle designs or operations, the officials would like to be able to quickly initiate the development of appropriate regulations to address that issue. The bill approved by the Senate in August 2015 would extend the regulatory moratorium by 5 years through 2020, while the bill that the House of Representatives passed in May 2015 would extend the regulatory moratorium by 10 years through 2025.<sup>46</sup>

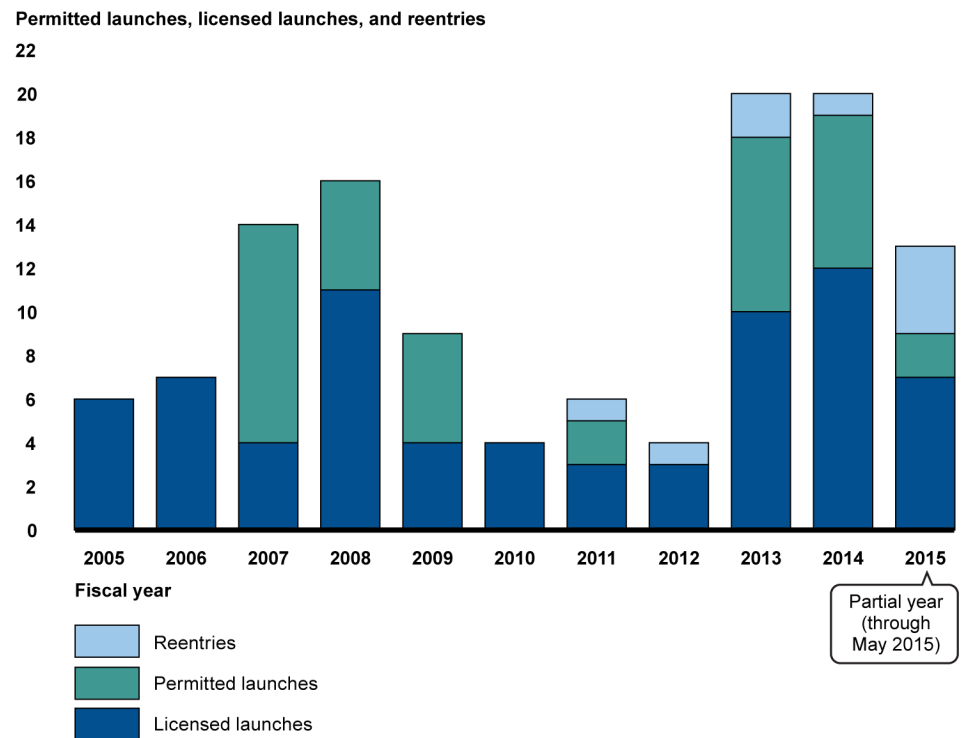
- **Increased workload relating to licensing and permitting launches and launch sites:**
  - **Licensing more launches:** In fiscal year 2014, FAA licensed and permitted 20 launches and re-entries, up from 6 in fiscal year 2005 and compared with an average of about 11 launches and re-entries during each fiscal year from 2005 to 2014. (Fig. 6 shows changes in the number of licensed and permitted launches and re-entries from 2005 through May 2015.) A large part of this increase is due to launches for NASA’s commercial cargo program, which involves transporting cargo to and from the ISS. One of the experts we interviewed said the impact of the June 2015 SpaceX launch mishap on NASA’s commercial cargo program and FAA’s launch licensing workload depends on several variables such

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<sup>46</sup>S. 1297 and H.R. 2262.

as the cause of the mishap, future program funding, and the availability of other international vehicles to supply the ISS. In the future, FAA also will need to license launches for NASA’s commercial crew program, which involves transporting astronauts to and from the ISS and is expected to begin in late 2017, following certification of the provider vehicles. Some launch companies are also preparing to launch small satellites. According to FAA, 20 percent of the projects in “pre-application coordination” for possible FAA authorization involved nonconventional satellite deployment, including small satellites and the use of hybrid launch vehicles.

**Figure 6: FAA Licensed and Permitted Launches and Re-entries from Fiscal Year 2005 through May 2015**



Source: FAA. | GAO-15-706

Note: The number of launches includes both orbital and suborbital operations.

- Conducting more inspections:** In fiscal year 2014, FAA conducted 223 commercial launch inspections, up from 15 in fiscal year 2005 and compared with an average of 70 inspections during each fiscal year from 2005 to 2014.

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According to FAA officials, an average of 20 to 30 inspections is required for each launch and inspections can take from 4 hours to 3 12-hour shifts to complete. Officials said that FAA has conducted more safety inspections, especially those associated with pre-launch and reentry activities, to allow the agency to identify safety issues early for correction and to avoid noncompliance with regulations and the conditions set forth in the launch license. FAA conducts different types of inspections such as launch and reentry operations and launch site operations, and FAA inspectors are present at launches.

- **Licensing new types of vehicles and technologies:**
  - Companies are developing a variety of new vehicles and technologies. For example, the space tourism industry is developing hybrid launch systems such as SpaceShipTwo, which have elements of both aircraft and rocket-powered components.<sup>47</sup> FAA officials said that hybrid vehicles are evaluated on a case-by-case basis to determine which regulations apply. As discussed earlier, some companies are testing the re-use of elements of launch vehicles, such as first and second stages of the vehicles, which FAA will need to review for licensing.
  - Some companies are also testing autonomous flight safety systems, which would allow a launch vehicle that is off course to be terminated without humans taking action. Most licensed launches to date have involved flight termination systems that were human-operated. FAA officials said that approving such autonomous systems will involve complicated software analyses.
  - An FAA official said that reentries from orbit carrying humans, including NASA crew from the ISS, will be significantly more complex and resource intensive for the agency to regulate and license compared with current

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<sup>47</sup>The Commercial Space Launch Amendments Act of 2004 defines the line between a rocket-powered airplane and a launch vehicle. According to the act, a suborbital rocket means a vehicle, rocket-propelled in whole or in part, intended for flight in a suborbital trajectory, and the thrust of which is greater than its lift for the majority of the rocket-powered portion of its ascent.

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launch and reentry regulation and operations. According to FAA, operators plan to maximize their flexibility to conduct successful reentries, using multiple reentry sites and dynamic decision making that could postpone the selection of a site and the vehicle's corresponding trajectory until just hours before the planned landing. An FAA official said that to adequately prepare for these sites to be used, the agency must evaluate all of them during its licensing process, develop and implement plans to manage the airspace around each site, and remain prepared to compute real-time aircraft hazard areas throughout a reentry operation.

- **Licensing more and complex launch sites:** Although launch sites traditionally have been located in coastal areas at federal launch facilities, last year FAA licensed an inland launch site that is collocated with a commercial airport in Midland, TX. FAA officials said that operating commercial launch sites located inland will require the Office of Commercial Space Transportation to work with other FAA offices to safely and effectively integrate launch vehicles into the National Airspace System to avoid interference with other air traffic. Furthermore, although commercial space launches have traditionally occurred at Air Force ranges, FAA is licensing more nonfederal launch sites. As of July 2015, there were 10 FAA-licensed commercial launch sites, compared with six in 2006. In addition, as of May 2015, FAA had received partial applications for four additional launch sites. (See fig. 3 for launch site locations.)
- **Responding to industry requests for changes in licensing and permitting:** Representatives from five of the nine commercial launch companies that we interviewed, the Chairman of the Commercial Space Transportation Advisory Committee, and the President of the Commercial Spaceflight Federation said they would like FAA to allow companies to hold experimental permits and licenses for the same vehicle design, which is currently prohibited. One company representative, for example, said this would allow continued testing and development of a vehicle while it is in commercial operation. FAA officials said they would like to be able to approve experimental permits and licenses for the same type of vehicle, but that it is not permitted under the Commercial Space Launch Amendments Act of 2004, so the act would

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need to be amended for this to be authorized.<sup>48</sup> Bills passed by the Senate in August 2015 and the House of Representatives in May 2015 would allow a launch license and experimental permit to be issued for the same type of vehicle design.<sup>49</sup>

- **Creating a safety reporting system:** Although FAA created a Commercial Space Transportation Lessons Learned System for industry to share safety data, as of May 2015, it contained only three submissions. An FAA official said that it is difficult to create a lessons learned database that is anonymous for those making submissions and that companies may be concerned about sharing proprietary information. However, FAA has established a voluntary safety reporting system for the airline industry called the Aviation Safety Action Program. This program encourages the voluntary reporting of safety issues and events by employees of companies that are FAA certificate holders.<sup>50</sup> FAA created the program to encourage aviation employees to voluntarily report safety issues even though they may involve alleged regulatory violations. Those reports are protected from disclosure, with certain exceptions.<sup>51</sup> The Office of Commercial Space Transportation's 2015 business plan contains a plan to determine the feasibility of a voluntary safety reporting system. According to FAA, legislative protections for voluntarily submitted safety data are likely to be needed. As discussed earlier, NTSB recommended as part of its investigation of the SpaceShipTwo accident that FAA implement a database of lessons learned from commercial space mishaps investigations.
- **Uncertain regulatory framework and authority for regulating emerging business plans:** Some companies are developing business plans that could present regulatory challenges for FAA. In December 2014, FAA informed Bigelow Aerospace that in principle, the agency supports the company's plans to develop a lunar habitat. Some companies are also considering mining

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<sup>48</sup>51 U.S.C. § 50906(g).

<sup>49</sup>S. 1297 and H.R. 2262.

<sup>50</sup>FAA's certification process determines whether airlines comply with regulations and safety standards.

<sup>51</sup>The exceptions include reports that involve possible criminal activity, substance abuse, controlled substances, alcohol, or intentional falsification.

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resources on the moon and asteroids. Although FAA plans to leverage its existing launch licensing authority to encourage such private sector investments, it is also concerned that the current regulatory framework may not fulfill the federal government's obligations under the Outer Space Treaty of 1967. That treaty established principles governing the activities of nations in the exploration and use of outer space, including the moon and other celestial bodies. FAA officials cited an April 2014 letter from the State Department to FAA indicating that the Department is concerned that the "national regulatory framework for nongovernmental space activities, in its present form, does not appear adequate to enable the United States Government to fulfill its obligations under [the Outer Space Treaty] with respect to the activities proposed by Bigelow." However, the Chairman of the Commercial Space Transportation Advisory Committee stated that FAA does not have regulatory authority over activities in space or on the moon. Representatives from two commercial space launch companies said that FAA should regulate activities in space, while a representative from another company thought that FAA should not have such authority. FAA officials told us that federal authority regarding activities in space should be clarified to prevent companies from going to other countries to operate their businesses. The bill that the House of Representatives passed in May 2015 states that "[a]ny asteroid resources obtained in outer space are the property of the entity that obtained such resources, which shall be entitled to all property rights thereto, consistent with applicable provisions of Federal law and existing international obligations."<sup>52</sup>

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<sup>52</sup>H.R. 2262.



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## Commercial Space Launch Industry Is Starting to Develop Standards for Human Spaceflight but Faces Challenges

The commercial launch industry has begun developing human spaceflight standards and, as of June 2015, had developed two voluntary standards—one on the storage, use, and handling of liquid propellants and the other on hazardous materials notification.<sup>53</sup> This effort is being led by the Commercial Spaceflight Federation, an industry association established to promote the development of commercial human spaceflight, among other objectives. A representative from the Commercial Spaceflight Federation said the association is developing these standards to promote safety. An association representative also said that, unlike NASA’s human spaceflight standards for its commercial crew program that are focused on orbital operations using vehicles that are similar to those used in the past, the industry standards are intended for use in both orbital and suborbital flight using vehicles with a variety of designs. However, representatives from the association and three companies leading the development of the standards said the process of developing standards for human spaceflight is difficult for several reasons, including (1) that multiple types of technologies are being developed simultaneously, (2) that resources to devote to this effort are lacking, and (3) that FAA is not providing enough direction about its priorities. The association representative said two or three standards would be developed per year, but did not know how many would be prepared in total.

The Commercial Space Launch Amendments Act provides that the Secretary of Transportation “shall encourage, facilitate, and promote the continuous improvement of the safety of launch vehicles designed to carry humans.”<sup>54</sup> FAA officials said they interact with stakeholders through the Commercial Space Transportation Advisory Committee, FAA’s annual Commercial Space Transportation Conference, FAA’s Commercial Space Transportation Center of Excellence,<sup>55</sup> industry

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<sup>53</sup>The hazardous material notification pertains to operators conducting potentially hazardous tests of commercial spaceflight vehicles, rocket engines, hazardous materials, pressure vessels, or other items at commercial multi-user spaceports. A Commercial Spaceflight Federation representative said in June 2015 that two additional standards were under development.

<sup>54</sup>51 U.S.C. § 50903(b)(1). The Secretary of Transportation delegated this authority to FAA.

<sup>55</sup>The Commercial Space Transportation Center of Excellence is a partnership of academia, industry, and government established to address challenges in commercial space transportation.

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workshops, and meetings with license and permit holders and applicants regarding industry-led efforts to develop industry standards. As stated earlier, FAA also developed a set of recommended practices<sup>56</sup> in 2014 on human spaceflight occupants' safety. This document, which FAA prepared based on NASA's requirements and guidance for its commercial crew program, provides 89 recommended practices regarding human spaceflight on suborbital and orbital launch and reentry vehicles in the categories of design, manufacturing, and operations that are primarily performance-based.<sup>57</sup> Specific topics include medical limits for spaceflight participants, human protection, and flightworthiness. However, Commercial Spaceflight Federation representatives said they would like FAA to provide more information about which practices within the document are agency priorities. When we asked FAA officials about this topic, they said that industry is in the best position to identify its priorities. Agency officials also said that an industry standards committee has not yet been formed on which FAA could participate. The bills passed by the Senate in August 2015 and the House of Representatives in May 2015 would require the Secretary of Transportation, in consultation with the commercial space launch industry, to report to Congress every 2 years on the progress of developing voluntary consensus standards starting in 2016.<sup>58</sup>

The Chairman of the Commercial Space Transportation Advisory Committee cited the development of industry consensus standards for the regulation of the light sport aircraft industry as a possible approach that the commercial space launch industry could follow. According to an FAA official who participated in developing standards for the light sport aircraft industry, FAA worked with the industry to develop standards within a year and shared its views about which standards the agency favored. FAA later incorporated these standards by reference into their regulations which made them enforceable. However, the FAA official acknowledged that FAA found through its airworthiness certification process that many manufacturers were not in compliance with the standards. This official also said that the light sport aircraft industry knew the direction it wanted

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<sup>56</sup>FAA, *Recommended Practices for Human Space Flight Occupant Safety Version 1.0* (Washington, D.C.: Aug. 27, 2014).

<sup>57</sup>By performance-based, FAA indicated the recommended practices are safety objectives to be achieved, leaving the design or operational solution up to the designer or operator.

<sup>58</sup>S. 1297 and H.R. 2262.

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to go with the standards, which facilitated the process. Another FAA official noted that the effort was conducted under a FAA rulemaking process, and that once the standards were developed, the agency had to accept them. The official said that this process differed from the situation that the Office of Commercial Space Transportation faces because it cannot proceed with rulemaking regarding commercial spaceflight. Furthermore, another FAA official said that a disadvantage of industry consensus standards is the possibility that one entity could attempt to dominate the process to favor a particular design. A representative from one commercial launch company said that it may be impossible to develop consensus standards because of the number of different vehicles that are being developed and that his company withdrew from the process because there were too many diverse opinions. Commercial Spaceflight Federation representatives said the standards must be approved by three-fourths of the members who vote. Representatives from two companies that are involved in developing the standards said that the standards could become enforceable if insurance companies required adherence to them.

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## FAA Has Not Provided Detailed Information in its Budget Submissions Justifying its Requests

During 6 of the 10 years from fiscal years 2005 to 2014, FAA generally based its budget submissions for the Office of Commercial Space Transportation on the number of launches that it was projecting for the following year.<sup>59</sup> However, as shown in table 1, the actual number of launches during those years was much lower than what FAA projected. (The table shows the actual number of launches in both fiscal and calendar years because the projections in the budget submissions were not always clear regarding whether they pertained to fiscal or calendar years.) Furthermore, while the capability of transporting crew to the ISS is expected in fiscal year 2018, continued budget uncertainty for the commercial crew program could put that date in jeopardy and it is unclear whether those vehicles currently in development under the commercial crew program will be ready in time. This is because NASA has received \$1.13 billion less than it requested for the commercial crew program in fiscal years 2011 through 2015.

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<sup>59</sup>In its budget submissions for 4 years between fiscal years 2005 and 2014 (2005, 2006, 2007, and 2012), FAA did not project the number of launches for the following year.

**Table 1: FAA’s Projected Number of Commercial Space Launches and the Actual Number of Launches from 2005 through 2016**

Year	Projected number of launches in budget submissions	Actual number of licensed and permitted launches during the fiscal year	Actual number of licensed and permitted launches during the calendar year
2016	Over 30 launches and reentries	N/A	N/A
2015	At least 51 <sup>a</sup>	9 (through May 2015) <sup>b</sup>	6 (through May 2015) <sup>c</sup>
2014	More than 40 launches and reentries	19 <sup>b</sup>	18 <sup>c</sup>
2013	More than 40 launches and reentries	18 <sup>b</sup>	15 <sup>c</sup>
2012	Not specified <sup>d</sup>	3 <sup>b</sup>	9 <sup>c</sup>
2011	10 to 20 reusable launch vehicle launches and 4 expendable launch vehicle launches	5 <sup>b</sup>	3
2010	25 to 40 or higher reusable launch vehicle launches; the number of expendable launch vehicle launches is expected to increase	4	4 <sup>c</sup>
2009	25 to 55 or higher reusable launch vehicle launches or higher and 11 expendable launch vehicle launches	9	5 <sup>c</sup>
2008	36	16	16
2007	Not specified <sup>e</sup>	14	13
2006	Not specified <sup>e</sup>	7	7
2005	Not specified <sup>e</sup>	6	5

Source: FAA budget submissions and launch data. Includes both permitted and licensed launches. | GAO-15-706

Note: For 2009, 2010, 2011, and 2015, FAA’s budget submissions specified that the projections were for fiscal years. For the other years, FAA’s projections did not specify whether they were for fiscal years or calendar years. The actual number of launches that occurred is shown above for both fiscal years and calendar years.

<sup>a</sup>In its fiscal year 2016 budget submission, FAA revised its projection regarding the number of launches for fiscal year 2015 from at least 51 to a range of from 20 to 30. FAA officials said that the two launch mishaps that occurred in October 2014 lowered the number of projected launches.

<sup>b</sup>Excludes four licensed reentries during fiscal year 2015, one in fiscal year 2014, two in fiscal year 2013, one in fiscal year 2012, and one in fiscal year 2011, which were not included in the projections. FAA plans to include reentries in its launch projections starting in fiscal year 2016.

<sup>c</sup>Excludes two licensed reentries in calendar year 2015, three in calendar year 2014, one in calendar year 2013, two in calendar year 2012, and one in calendar year 2010, which were not included in the projections.

<sup>d</sup>For fiscal year 2012, FAA estimated that it would handle six license and permit applications, but the number of launches was not specified.

<sup>e</sup>In its budget submissions for these years, FAA projected other workload metrics such as the number of launch inspections, not the number of launches.

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For fiscal year 2016, FAA requested 13 more full-time equivalent staff to handle launches in 2016—a 16 percent increase. In its budget submission, FAA indicated that this level of increase was needed to keep pace with the rapid growth of the U.S. commercial space transportation industry and the growing need to ensure the safe integration of space and air traffic. According to OMB guidance on budget preparation,<sup>60</sup> if agencies are requesting “significant changes” in full-time equivalent positions, they are to “[p]rovide justification for changes in relationship to projected workload...” In addition, the guidance indicates that agencies should discuss alternative implementation strategies considered. However, FAA’s justification did not provide a detailed analysis of the staffing changes requested and is based on the number of projected launches. FAA’s budget submission also did not consider alternative approaches such as paying additional overtime, rather than hiring additional staff. We asked the Office of Commercial Space Transportation to provide data on staff overtime incurred during the last 5 fiscal years; the data showed a decreasing trend and represented less than 1 percent of the office’s budget. In fiscal year 2014, for example, the Office of Commercial Space Transportation expended about \$23,000 in overtime and compensatory time out of its \$16.3 million budget,<sup>61</sup> a decrease of about 42 percent from fiscal year 2010, when it expended about \$40,000 in overtime and compensatory time.

FAA officials said that more detailed information was not provided in their budget submissions because the agency lacked certain workload metrics regarding its commercial space launch oversight activities, but that the fiscal year 2016 budget request was developed on the basis of a workload analysis. The officials also said that although other metrics existed besides the number of launches, they were not consistently used in the budget submissions. The Office of Commercial Space Transportation does not track the amount of time spent on various activities such as pre-application consultations. As of January 2015, for example, FAA indicated that it had initiated pre-application consultations on 46 different projects and was participating in an active dialogue regarding 30. A FAA official noted that the agency often consults with

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<sup>60</sup>OMB Circular No A-11, *Preparation, Submission, and Execution of the Budget* (Washington, D.C.: November 2014).

<sup>61</sup>Officials from the Office of Commercial Space Transportation said that the office maintains data on overtime and compensatory time together and could not be broken out.

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companies that never carry out their plans. FAA officials said that they tried to implement a time tracking system a few years ago, but that it was unsuccessful because the system did not segregate the different working codes into meaningful categories and the data were not accurately inputted. The officials said that the office began developing a labor analysis methodology during fiscal year 2014 and is continuing these efforts. According to these officials, FAA plans to incorporate these metrics in its future budget submissions for the Office of Commercial Space Transportation.

FAA officials said they have started to improve their launch projection methods by reviewing companies' proprietary launch data. In contrast, FAA officials said in the past they relied on projections conducted by consulting firms. Although FAA is taking these steps, it is unknown whether they will result in more accurate launch projections. FAA officials also said that overtime was not an accurate reflection of the workload for the Office of Commercial Space Transportation, in part, because transferring some staff from headquarters to the field in 2012 reduced the amount of overtime needed for travel. Rather, they said that a variety of metrics should be considered, such as the increased number of inspections (discussed earlier); pre-application consultations; and authorizations, which FAA provides to companies authorizing them to conduct one or more launches. FAA officials provided data indicating that the number of authorizations increased from 2 in fiscal year 2006 to 11 in fiscal year 2014. During this time, the number of full-time equivalent positions for the Office of Commercial Space Transportation increased from 59 in fiscal year 2006 to 77 in fiscal year 2014, and 79 are authorized for fiscal year 2015. They also said that the office is considering implementing a new time recordkeeping system starting in fiscal year 2016 to supplement the ongoing development of additional workload metrics. While these efforts may help FAA better estimate its future workload, because FAA has not provided Congress with detailed information on its projected workload and alternative strategies for addressing this workload, Congress lacks information that would be helpful in making decisions about the resources needed for the agency's commercial space launch activities.

Nonetheless, FAA officials and representatives at three of the nine commercial space launch companies that we interviewed said they did not believe that the Office of Commercial Space Transportation had

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sufficient resources.<sup>62</sup> FAA officials said, for example, that because of insufficient resources, the agency is unable to monitor all activities that are subject to inspection. According to FAA, in fiscal year 2014, it did not conduct 23, or about 10 percent, of its safety inspections. An FAA official said that one of the skipped inspections was a simulation for SpaceShipTwo, but that it had no impact on safety.<sup>63</sup> FAA indicated that inspections are prioritized, skipping those which—although they would provide an increased level of safety—may involve systems or operators where a higher confidence level or trust exists or a recent inspection in a certain area may suffice for a longer period of time until the next opportunity arises. The Chairman of the Commercial Space Transportation Advisory Committee explained that due to a lack of resources for the Office of Commercial Space Transportation, the industry fears that the FAA will be forced to prioritize licensing for NASA and government mission launches over private sector launches, resulting in substantial delays for commercial innovation and activities.

FAA officials also noted that the effect of Office of Commercial Space Transportation's lack of resources was reflected in the results of the agency's 2014 employee survey.<sup>64</sup> According to the survey, about 42 percent of FAA respondents agency-wide said they have sufficient resources, compared with about 23 percent of respondents from the Office of Commercial Space Transportation. The survey also indicated that about 60 percent of FAA respondents agency-wide said their workload was reasonable, compared with 42 percent of respondents from the Office of Commercial Space Transportation.

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<sup>62</sup>Of the six other companies we interviewed, representatives from three said they believed that FAA has sufficient resources to handle its commercial space launch oversight responsibilities and representatives from three other companies did not provide an opinion.

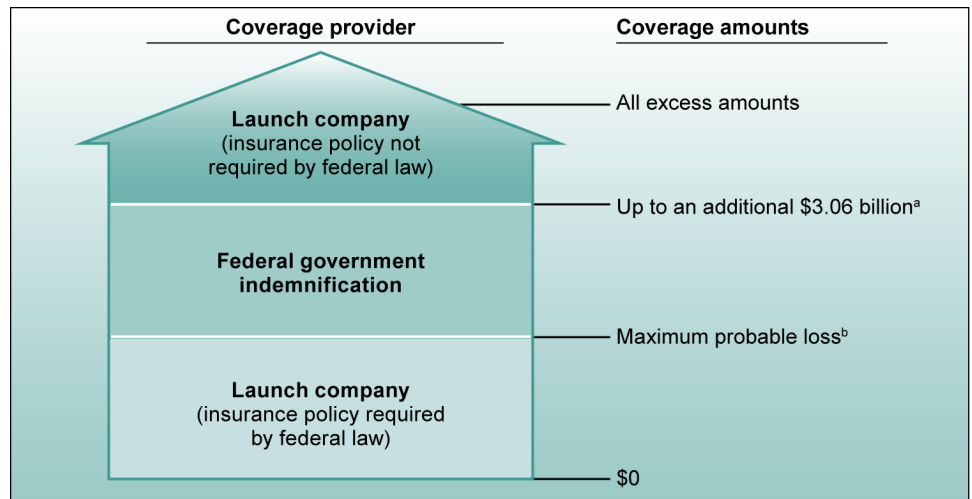
<sup>63</sup>Scaled Composites could not meet with us because of the ongoing investigation of the SpaceShipTwo accident. According to FAA, none of the skipped inspections involved the October 2014 Orbital Sciences launch mishap.

<sup>64</sup>This survey, known as the Federal Employee Viewpoint Survey, is a tool administered by the Office of Personnel Management that measures employees' perceptions of whether, and to what extent, conditions characterizing successful organizations are present in their agencies. According to FAA, the survey response rates were 43.9 percent for FAA agency-wide and 87 percent for the Office of Commercial Space Transportation. FAA indicated that a sample of 42.7 percent of all FAA employees and 100 percent of employees from the Office of Commercial Space Transportation were surveyed.

## Some Industry Changes Could Increase the Government's Exposure but Could Be Mitigated

While the federal government provides a process for the conditional payment of third-party claims i.e., indemnification, to cover claims for damage to people or property as a result of a launch accident, the government has not had any claims as of June 2015. As noted earlier, FAA calculates the maximum probable loss to estimate the losses likely to occur from a potential launch mishap to determine the amount of third-party losses against which launch companies must insure. Launch companies purchase third-party liability insurance up to the maximum probable loss, which is capped at a maximum of \$500 million or the maximum liability insurance available on the world market at reasonable cost, if less. The federal government, subject to the availability of appropriations, then provides indemnification for losses over the maximum probable loss up to \$1.5 billion adjusted for post-1988 inflation, which is about \$3.06 billion in 2015. Figure 7 illustrates the three tiers of coverage.

**Figure 7: Third-Party Liability Insurance Regime for FAA-Licensed Launches**



Source: GAO analysis. | GAO-15-706

<sup>a</sup>\$3.06 billion is the \$1.5 billion authorized in law adjusted for inflation to 2015 dollars using the Consumer Price Index (CPI-U).

<sup>b</sup>The amount of insurance required based upon the FAA's determination of the maximum probable loss will not exceed the lesser of \$500 million or the maximum third-party liability insurance available on the world market at a reasonable cost, as determined by FAA.

The federal government has not paid any third-party liability claims as none of the 246 FAA licensed launches and reentries from 1989, when launches were first indemnified, through May 2015 have resulted in losses which would invoke indemnification. This includes the recent two



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launch mishaps involving Scaled Composites' SpaceShipTwo and Orbital Sciences' Antares, both of which occurred in October 2014.<sup>65</sup> The SpaceShipTwo accident occurred under a FAA experimental permit that was issued to Scaled Composites; the federal government does not indemnify permitted activities. The Antares mishap, a FAA licensed launch, did not result in third-party losses over the maximum probable loss which FAA calculated as \$56 million.

As we have previously reported, industry changes could increase the government's exposure to third-party liability, but the amount of increase could be mitigated as long as the maximum probable loss methodology is reasonable and maximum probable loss calculation is accurate. Increases in the number of prospective launches and reentries would increase the number of times the government is exposed to potential claims. In addition, changes in the types of launches and reentries could increase the government's exposure but the increase could be mitigated if the maximum probable loss calculation accurately takes them into account.<sup>66</sup>

First, the number of launches and reentries covered by federal indemnification is forecasted to increase, and the federal government's potential exposure to third-party liability claims would increase with the added volume. NASA expects to procure 42 launches from launch companies to carry cargo and crew to the ISS from fiscal years 2015 through 2020. The space tourism industry may also increase the number of launches and reentries covered by federal indemnification, although the timing of these launches and reentries is uncertain. In general, by increasing the volume of launches and reentries, the probability of a catastrophe occurring is also increased. A catastrophic accident could result in third-party losses over the maximum probable loss, which would invoke federal indemnification.

Second, forecasted types of launches and reentries include newly developed launch vehicles that have a shorter launch history than more "legacy" launch vehicles. For example, Virgin Galactic's SpaceShipTwo, XCOR's Aerospace's Lynx, and Blue Origin's New Shepard vehicle are

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<sup>65</sup>On June 29, 2015, an FAA official said that no damage had been reported from the June 28, 2015, SpaceX Falcon 9 launch mishap.

<sup>66</sup>[GAO-12-899](#).

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new vehicles. However, increased flights of a launch vehicle could make a vehicle more reliable.<sup>67</sup> For a vehicle to be certified to fly NASA's highest priority science missions, NASA requires at least three successful flights (two of which must be consecutive) of the same vehicle configuration, among other factors. However, an insurance company representative with whom we spoke stated that even launch vehicles with a proven launch history can have accidents particularly if the vehicle has been modified. To license launches of launch vehicles and determine the maximum probable loss, FAA reviews the launch vehicle, flight path, and the potential casualties and fatalities that could result from varying types of launch failures at different points along the path. In addition, although many forecasted launches are anticipated to take place at federal ranges, including Cape Canaveral Air Force Station and Kennedy Space Center where range safety oversight is provided in addition to that of FAA, some forecasted launches and reentries may occur from licensed launch sites that are not located on a federal range and one launch site is collocated at a commercial airport. Thus, according to FAA, the maximum probable loss could be higher for such launches.

According to FAA, industry changes that include space tourism flights may not increase the federal government's potential exposure because the government provides indemnification only for property damage, and injury and death of the public and does not indemnify those involved in a launch, including crew and spaceflight participants onboard a vehicle.<sup>68</sup> Instead, these individuals are required to sign cross waivers stating that they will not bring claims against the federal government in the event of a mishap.<sup>69</sup> Thus, FAA does not consider whether the launch is carrying crew or spaceflight participants when determining the maximum probable loss.

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<sup>67</sup>GAO, *NASA: Medium Launch Transition Strategy Leverages Ongoing Investments but Is Not Without Risk*, [GAO-11-107](#) (Washington, D.C.: Nov. 22, 2010).

<sup>68</sup>FAA has made a legal determination that NASA astronauts who will fly to the ISS on commercial space launches need not sign the statutory waiver of claims against the U.S. Government, which is the employer of the astronauts, in order to avoid conflicts with federal employment law. H.R. 2262 and S. 1297 have provisions making clear that NASA astronauts should not be considered "space flight participants."

<sup>69</sup>51 U.S.C. § 50914(b).

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As we have previously reported, although some industry changes may alter the government's exposure, an accurate maximum probable loss calculation will mitigate the effects to some extent.<sup>70</sup> If the maximum probable loss calculation is accurate, the estimated losses will adjust for the risk profile of each license, such that the likelihood the government would indemnify a third-party remains the same regardless of the industry change. Thus, whether the launch vehicle is newly developed or manned, an accurate maximum probable loss calculation would adjust for the increased (or decreased) potential damage associated with that vehicle. For example, if the maximum probable loss for an unmanned launch over an unpopulated area is \$35 million, it could be \$45 million for the same launch over a populated area and the government would indemnify from the maximum probable loss up to an additional \$3.06 billion in 2015 for losses. In this example, the higher maximum probable loss accounts for the higher expected damages over a populated area, and the estimated likelihood that the launch company's gross liability would exceed the maximum probable loss (triggering government indemnity) would remain the same. However, the amount the government would pay if the launch company's gross liability does exceed the maximum probable loss may change with these industry changes—and could be higher or lower—depending on the circumstances. For example, a launch from a licensed launch site with a flight path over a populated area could affect the severity of a potential accident and thus the amount by which third-party claims exceed the maximum probable loss. These effects notwithstanding, if the industry changes would result in losses that exceed \$500 million or the amount of the insurance that launch companies could purchase at a reasonable cost, the federal government's exposure may increase by the amount of the shortfall. However, according to FAA data on commercial launches and reentries, the average maximum probable loss for launches—most of which are from federal, coastal launch sites—was about \$99 million and ranged from \$23 million to \$267 million as of January 2012.

In July 2012, we recommended that FAA review whether its risk methodology should be updated due to advances in risk modeling of potential catastrophic events since the maximum probable loss methodology was first established in the 1980s.<sup>71</sup> FAA uses an “overlay

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<sup>70</sup>GAO-12-899.

<sup>71</sup>GAO-12-899.

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method” that estimates a debris field and potential impacts on nearby populated areas. On the other hand, insurance companies use “catastrophe modeling” that generates a distribution of potential losses and simulated probability of different losses using computer simulations. We recommended that FAA review its maximum probable loss methodology and FAA is addressing this open recommendation. For further information, see Appendix I.

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## Conclusions

The commercial space launch industry has experienced considerable change over the last decade. Several developments, such as NASA’s commercial cargo and crew programs, continuing efforts to begin space tourism operations, and the launching of small satellites, may increase FAA’s workload for licensing and permitting launches. However, currently there is not enough information to know the level of resources that FAA needs for its commercial space launch oversight activities. Over the last decade, FAA has generally based its budget submissions on the projected number of launches, but launches are not the only indicators of its commercial space launch activity workload. FAA is hindered by the lack of data on how much time its staff spend on related responsibilities such as consulting with companies before they submit their license or permit applications. Because FAA has not provided this type of detailed information in its budget submissions, Congress lacks information that would be helpful in making decisions about the resources needed for the agency’s commercial space launch activities.

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## Recommendation

To provide Congress with more information about the resources requested to address developments in the commercial space launch industry, in justifying requested changes, we recommend that the Secretary of Transportation direct the FAA Administrator to provide more detailed information in its budget submissions for the Office of Commercial Space Transportation regarding its workload.

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## Agency Comments and Our Evaluation

We requested comments on a draft of this report from DOT, NASA, and DOD. In its written comments, DOT said that upon preliminary review, FAA agreed with the recommendation, but DOT also had concerns about how some issues were presented. (This response is summarized below and reprinted in app. III). DOT stated it was concerned that the report did not adequately convey the dramatic growth in commercial space transportation activity and innovation underway, which will affect the workload of FAA’s Office of Commercial Space Transportation. DOT said the report focuses on the licensing of NASA-sponsored commercial programs and on delays in the suborbital space tourism industry. It also

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said that the report does not give sufficient attention to the emerging market for the deployment of small satellites, which the department said is a significant activity for the industry and FAA. For example, DOT said that FAA currently has 54 projects in “pre-application coordination” for possible authorization, 81 percent of which is unrelated to NASA programs or space tourism.

In the report, we focused on FAA’s increasing workload related to licensing and permitting launches such as for NASA’s commercial and cargo programs, in part, because the agency reported in its *Annual Compendium for Commercial Space Transportation: 2014* that launches in the next 10 years are predominantly commercial launches to the ISS, i.e., NASA programs. Further, according to a forecast for 2014 through 2023 in FAA’s *Annual Compendium for Commercial Space Transportation: 2014*, the number of small satellites drops off toward the end of the forecast period, but the number of launches remains relatively steady during this time period as NASA expects to begin its commercial crew program. In response to FAA’s comments, we added more information to the report about the agency’s workload relating to small satellites, including its pre-application coordination activities. However, because the Office of Commercial Space Transportation does not record the amount of time its staff spends on various activities, we could not confirm the extent to which the number of commercial space launch projects in “pre-application coordination” that is unrelated to NASA or the space tourism industry reflects the office’s overall workload.

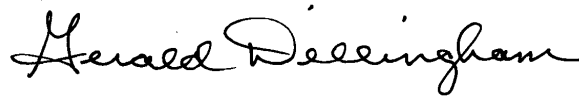
DOT also provided technical comments, which we incorporated as appropriate. NASA only provided technical comments, which we incorporated as appropriate. DOD did not have any comments.

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As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to appropriate congressional committees, the Administrator of the Federal Aviation Administration, the Administrator of the National Aeronautics and Space Administration, and the Secretary of Defense. In addition, this report will be available at no charge at <http://www.gao.gov>

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.

Sincerely yours,

A handwritten signature in black ink that reads "Gerald Dillingham". The signature is written in a cursive style with a large initial "G" and "D".

Gerald L. Dillingham, Ph.D.  
Director, Physical Infrastructure Issues

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# Appendix I: FAA is Taking Steps to Address GAO Recommendation on FAA's Risk Methodology

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In July 2012, we recommended that the Federal Aviation Administration (FAA) review its risk methodology including (1) assessing the reasonableness of the assumptions FAA uses to determine the maximum probable loss and (2) considering the use of external experts to adjust the methodology as appropriate considering the costs.<sup>1</sup> FAA concurred with the recommendation and in response, intends to reassess one of the main assumptions that it uses to determine the maximum probable loss—the cost of casualty value—which represents the value of a lost life or injury due to a catastrophic launch incident. Specifically, FAA would like to contract for a study on whether the \$3 million figure it currently uses should be raised. According to FAA, the Department of Transportation (DOT) uses \$9.2 million for the value of a statistical life, a figure that is based on people's willingness to pay for safety. However, FAA told us that in the case of commercial space launches, there could be data based on liability determined through the judicial process, such as in the case of a wrongful death suit that would provide a more appropriate figure for required third-party liability insurance. A study would look at these factors and assess what would be the figure that best captures the cost of casualty as a result of a commercial space launch accident. In addition, FAA has contracted with ACTA Inc., a company that has provided flight risk and safety hazard analyses of space launches for the U.S. Air Force and the National Aeronautics and Space Administration, to review FAA's maximum probable loss methodology. ACTA is assessing whether FAA could use a risk profile method that looks at a variety of scenarios and probabilities of launch mishaps using software simulations. According to FAA, this approach would allow the agency to run multiple scenarios of potential rocket failures, ways in which the launch vehicle could break apart, and various impacts on the ground. ACTA plans to conclude this review and report to FAA in December 2015.

FAA told us that the agency is also looking at catastrophic risk models and thresholds of risk and would like to develop a risk profile method that would then be reviewed by an external party. Most launch companies and an insurance company that provides third-party liability insurance for commercial launches with whom we spoke said that FAA's maximum probable loss methodology is reasonable and does not need improvement. However, as the maximum probable loss establishes the point at which the federal government is liable for third-party claims

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<sup>1</sup>[GAO-12-899](#).

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subject to the availability of appropriations, we continue to believe that a review of whether the methodology could be improved is warranted, especially given changes in the types and number of forecasted increases in commercial launches.



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# Appendix II: Objective, Scope, and Methodology

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Our objective was to review the extent to which the Federal Aviation Administration (FAA) is prepared to address changes that have occurred in the commercial space launch industry over the last decade and potential changes in the future. Specifically, we examined (1) how the competitive landscape has changed for the U.S. commercial space launch industry over the last decade, (2) challenges that FAA faces in licensing and regulating commercial space launches, (3) the status of developing industry standards for human spaceflight, (4) how FAA has projected its commercial space launch licensing workload for future fiscal years when submitting budget requests to Congress and how changes in the number and types of launches might affect its budget needs in future years, and (5) how changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for commercial launches.

First, to study the competitive landscape regarding the commercial space launch industry, we reviewed FAA trend data, such as the number of orbital launches conducted by U.S. and foreign companies and orbital launch revenues generated during the last 10 years. We also interviewed FAA officials, industry stakeholders, and experts about the factors that have affected the U.S. commercial space launch industry during the last decade. We chose these companies and industry organizations by reviewing FAA reports on the commercial space launch industry and other literature. We interviewed representatives from the majority of U.S. commercial space launch companies identified in FAA's 2014 annual report on commercial space transportation.<sup>1</sup> Of the nine companies we interviewed, three conducted licensed launches in 2014. The experts that we interviewed were selected from academia and private industry based on their knowledge of FAA's oversight of the commercial space launch industry. Their views are not generalizable. Table 2 lists the organizations and experts that we interviewed.

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<sup>1</sup>One company, Scaled Composites, could not meet with us because of the ongoing investigation of the SpaceShipTwo accident and another company did not respond to our interview requests.

**Table 2: List of Organizations and Experts Interviewed**

Industry category	Organization/expert interviewed
Launch sites	Mojave Air and Space Port, Mojave, CA Mid-Atlantic Regional Spaceport, Wallops Island, VA
Industry association	Commercial Spaceflight Federation
Industry advisory group	Commercial Space Transportation Advisory Committee
Launch companies	Blue Origin Boeing Masten Space Systems Orbital ATK SpaceX United Launch Alliance Virgin Galactic Vulcan Aerospace XCOR Aerospace
Insurance company	XL Catlin
Experts	Dr. Henry Hertzfeld, Research Professor of Space Policy and International Affairs, Space Policy Institute, George Washington University Scott Hubbard, Director, Stanford Center of Excellence for Commercial Space Transportation, Stanford University Patti Grace Smith, Aerospace Consultant; former Associate Administrator, Office of Commercial Space Transportation, FAA

Source: GAO | GAO-15-706

To identify the challenges that FAA faces in licensing and regulating commercial space launches and how it is addressing them, we asked FAA officials, industry stakeholders, and experts for their views on how developments in the industry affect FAA’s oversight responsibilities. We also reviewed data on FAA’s licensing, permitting, and safety inspection workload during the last decade; program guidance; legal requirements and restrictions; business plans; and related documentation.

Regarding the status of developing industry standards for human spaceflight, we interviewed representatives from three companies who are involved in developing the standards as well as the Commercial Spaceflight Foundation, which is leading the effort. We also reviewed FAA’s legal responsibilities to promote human spaceflight safety. In addition, to compare how standards were developed for another emerging aviation industry, we interviewed an FAA official who participated in developing standards for the light sport aircraft industry.

To evaluate how FAA estimates its commercial space launch licensing workload for future fiscal years when submitting budget requests to Congress and how the changing market might affect its budget needs in future years, we discussed with FAA officials how the agency prepares its launch projections and its commercial space launch oversight workload. In addition, we examined FAA's budget submissions for its Office of Commercial Space Transportation from fiscal year 2005 through fiscal 2016 to determine the extent to which FAA's launch projections were used as the bases for its budget submissions. We also compared (1) FAA's fiscal year 2016 budget submission for the Office of Commercial Space Transportation against the Office of Management and Budget's guidance on budget formulation and (2) the number of launches that FAA projected during the last 10 fiscal years with the actual number of launches that occurred. In addition, we discussed the workload metrics that the Office of Commercial Space Transportation collects and analyzed the office's overtime and compensatory expenditures during the last 5 years. FAA provided information about the steps that it took to ensure the completeness and reliability of the data on the number of launches that the agency licensed and permitted and inspections that it conducted, as well as the data on overtime and compensatory expenditures. Based on our review of this information, we determined the data were sufficiently reliable for our purposes.

To study how changes in the number and types of commercial space launches could affect the government's overall liability and indemnification for commercial launches, we reviewed prior GAO reports and testimonies and discussed the factors affecting the government's overall potential liability and indemnification for commercial launches with FAA officials, industry representatives, and an insurance company representative.<sup>2</sup> We also discussed with FAA officials the status of our 2012 recommendation that the agency review its risk methodology regarding maximum probable loss.

Moreover, we visited launch facilities in Mojave, CA, and Wallops Island, VA, to review how FAA carries out its launch safety activities. We chose to visit the Mojave Air and Space Port because it is an FAA-licensed launch site where a number of companies are conducting space launch

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<sup>2</sup>For our 2012 review of liability issues regarding commercial space launches ([GAO-12-899](#)), we interviewed four insurance companies. In this follow up work, we interviewed one of those four companies.

and development activities for both suborbital and orbital operations and because it was the site of the SpaceShipTwo test flight accident in October 2014. In addition, we visited the Mid-Atlantic Regional Spaceport at NASA Wallops Flight Facility in Wallops Island, VA, because it is an FAA-licensed launch site located on a federal range and was the site of Orbital Sciences' launch mishap in October 2014.

We also interviewed officials from the National Aeronautics and Space Administration regarding its commercial crew and cargo programs and related issues, the National Transportation Safety Board about the status of its investigation of the SpaceShipTwo accident, and the U.S. Air Force regarding its launch safety oversight at federal ranges and interaction with FAA.

We conducted this performance audit from January 2015 to August 2015 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 objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective.

# 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

**AUG 05 2015**

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

Mr. Dillingham,

The Federal Aviation Administration's (FAA) Office of Commercial Space Transportation (AST) lacks the resources it needs to keep pace with the rapidly growing demand for its products and services, which are directly focused on both public safety and the international competitiveness of the U.S. commercial space transportation industry.

The Agency is concerned that the draft report does not adequately convey the dramatic growth in commercial space transportation activity and innovation currently underway. The report focuses primarily upon the licensing of NASA-sponsored commercial programs and on delays in suborbital space tourism. While it does discuss conventional satellites, it gives only passing mention to the emerging market for the deployment of numerous low-cost small satellites. This is a significant activity for both the industry and the FAA. For example, the FAA currently has 54 distinct projects in "pre-application coordination" for possible FAA authorization. Pre-application coordination, which is required under the commercial space regulatory framework, represents a heavy workload for AST, and it is a crucial step in the licensing process. Of the 54 projects in some stage of pre-application coordination, approximately 13% represent possible authorizations for NASA-related commercial programs and 6% represent space tourism. The other 81% involve a wide range of potential applications, such as: large commercial satellite deployments (7%); non-conventional satellite deployment, including small satellites and the use of hybrid launch vehicles (20%); research & development (22%); launch sites (both commercial and private use) (22%); and Safety Approvals of supporting products and processes (9%)<sup>1</sup>.

While the GAO is correct that the FAA did not include detailed metrics in the FY 2016 Operations budget request that was submitted to Congress, that request was compiled using AST's baseline labor analysis model, the development and results of which were shared with GAO during the audit. The Agency also shared the development status and rationale for ongoing refinements of AST's labor analysis tools. Several workload metrics are noteworthy. For example, compared to a 2006 baseline (which was chosen as a high activity baseline year), in 2014 AST's workload for:

- New authorizations (licenses, permits, safety approvals) increased 450% (11 vs 27);
- Safety inspections increased 726% (223 vs 27);

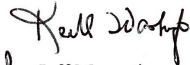
<sup>1</sup> Note that the component percentages do not add up to 100% due to the effects of rounding error.

- Launch and reentry operations increased 214% (22 vs 7); and
- In spite of these huge increases, overall AST staffing was up only 32% (75 vs 57 End of Year staff).

Upon preliminary review of the recommendation, the FAA concurs and will provide more detailed budget briefings to Congressional appropriations and authorizing committees to justify the additional resources required to keep pace with the rapid growth of the commercial space industry. The Department will provide a detailed response to the recommendation within 60 days of the GAO report issuance.

We appreciate this opportunity to offer additional perspective on the GAO draft report. Please contact Patrick D. Nemons, Deputy Director of Audit Relations, at (202) 366-4986 with any questions or if you would like to obtain additional details about these comments.

Sincerely,



*J* Jeff Marootian  
Assistant Secretary for Administration

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# Appendix IV: GAO Contact and Staff Acknowledgments

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## GAO Contact

Gerald Dillingham, (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov)

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## Staff Acknowledgments

In addition to the contact named above, Catherine Colwell (Assistant Director), Namita Bhatia Sabharwal, Melissa Bodeau, Kevin Egan, Bob Homan, David Hooper, Maureen Luna-Long, SaraAnn Moessbauer, Shelby Oakley, Jack Sheehan, Joe Silvestri, and Kristin Van Wychen made key contributions to this report.

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