



Testimony
Before the Subcommittee on Aviation,
Committee on Transportation and
Infrastructure, House of Representatives

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COMMERCIAL SPACE

Industry Developments and FAA Challenges

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

GAO Highlights

Highlights of [GAO-16-765T](#), a testimony before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, 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; however, to allow space tourism to develop, the act prohibited FAA from regulating crew and spaceflight participant safety before 2012—a moratorium that was extended to 2023. The U.S. Commercial Space Launch Competitiveness Act, enacted in November 2015, addressed other aspects of the commercial space launch industry.

This testimony summarizes and updates findings from GAO's 2015 report, specifically industry developments and FAA challenges, including FAA's launch licensing workload and budget. For its 2015 report, GAO reviewed FAA's guidance 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 spaceports where two 2014 launch mishaps occurred. To update this information GAO reviewed FAA information on the industry and FAA's budget request.

What GAO Recommends

In 2015, GAO recommended that FAA, in its budget submissions, provide more detailed information about the Office of Commercial Space Transportation's workload. FAA agreed with the recommendation. GAO is not making new recommendations in this testimony.

View [GAO-16-765T](#). For more information, contact Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov

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COMMERCIAL SPACE

Industry Developments and FAA Challenges

What GAO Found

In 2015, GAO reported that during the last decade, U.S. commercial space launch 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 2015, U.S. companies conducted eight orbital launches, compared with none in 2011. In addition, in 2015, U.S. companies conducted more orbital launches than companies in Russia, which conducted five, or Europe, which conducted six.

In 2015, GAO reported that the Federal Aviation Administration (FAA)—which is responsible for protecting the public with respect to commercial space launches, including licensing and permitting launches—faces challenges. According to FAA officials and industry stakeholders, FAA faces an increasing workload licensing and permitting launches for transporting cargo, and in the future, crew for NASA's commercial space programs, space tourism, and potentially launching small satellites. FAA also faces the challenges of whether and when to regulate the safety of crew and spaceflight participants—in 2015 Congress extended the moratorium to 2023—and overseeing new types of vehicles and technologies. (See figure for commercial space launch vehicles.) Challenges also include updating FAA's method to calculate maximum probable loss—the amount above which the federal government indemnifies the industry for catastrophic loss.

Virgin Galactic's SpaceShipTwo and SpaceX's Falcon 9



Source: Virgin Galactic. | GAO-16-765T

GAO reported in 2015 that FAA's budget requests for its commercial space launch activities generally were based on the number of projected launches, but that in recent years the actual number of launches was much lower than FAA's projections. GAO also reported that, according to FAA officials, more detailed information was not provided in FAA's budget submissions because the agency lacked information on its workload overseeing commercial space launch activities. In addition, GAO reported that the Office of Commercial Space Transportation did not track the amount of time spent on various activities. FAA has taken steps to implement GAO's recommendation that it provide more detailed information in its budget submissions regarding commercial space transportation activities. In its 2017 budget submission, FAA provided workload indices regarding authorizations under which companies conduct one or more launches; on-site inspections; licensing of spaceports; and staffing levels since 2006.

Chairman LoBiondo, Ranking Member Larsen, and Members of the Subcommittee,

Thank you for the opportunity to testify today on the commercial space launch industry. The U.S. commercial space launch industry, which the Federal Aviation Administration (FAA) reports had estimated revenues of \$617 million in 2015, has experienced considerable change since the enactment of the Commercial Space Launch Amendments Act of 2004 (“the act”).¹ 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. As part of its safety oversight responsibilities, FAA licenses and permits launches as well as licenses launch sites. To allow the space tourism industry to develop, the act prohibited FAA from regulating the safety of crew and “spaceflight participants”² before 2012, except in limited circumstances—a moratorium that was extended to October 1, 2023 in the Commercial Space Launch Competitiveness Act enacted in November 2015.³ In addition, in recent years, FAA has been licensing an increasing number of commercial space launches, 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). 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 the space tourism industry.⁴ These challenges included FAA’s ability to determine the specific circumstances under which it would regulate the

¹Pub. L. No. 108-492, 118 Stat. 3974 (2004).

²Federal law currently defines a “space flight participant” as “an individual, who is not crew or a government astronaut, carried within a launch vehicle or reentry vehicle”. 51 U.S.C. § 50902 (20).

³U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 111, 129 Stat. 704, 709 (2015). FAA is required to report to Congress on metrics that could indicate FAA’s and the industry’s readiness to transition to a safety framework that may include regulating crew, government astronauts, and spaceflight participant safety by August 2016 and every 30 months thereafter.

⁴GAO, *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).

safety of crew and spaceflight participants and estimating its future resource needs to license and permit launch activities.

My testimony today focuses on (1) developments in the commercial space launch industry and (2) challenges FAA faces in overseeing and promoting the industry. This statement is primarily based on our August 2015 report⁵ on commercial space issues.⁶ For the 2015 report, we reviewed FAA's guidance 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 spaceports where two 2014 launch mishaps occurred. Additional information on the scope and methodology can be found in our August 2015 report. We updated information for this statement in June 2016 primarily by reviewing FAA information on the industry, FAA's budget request, and contacting FAA officials.

We conducted the work on which this statement is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The commercial space launch industry continues to develop and evolve, with changes in technology and facilities. Historically, commercial space launches carried payloads, generally satellites, into orbit using expendable launch vehicles that did not return to earth.⁷ Figure 1 shows

⁵GAO, *Federal Aviation Administration: Commercial Space Launch Industry Developments Present Multiple Challenges*, [GAO-15-706](#) (Washington, D.C.: Aug. 25, 2015).

⁶We also reviewed previous GAO work including GAO, *Commercial Space Launches: FAA Should Update How it Assesses Federal Liability Risk*, [GAO-12-899](#) (Washington, D.C.: July 2012) and GAO, *Commercial Space Transportation: Industry Trends, Government Challenges and International Competitiveness Issues*, [GAO-12-836T](#) (Washington, D.C.: June 20, 2012).

⁷An expendable launch vehicle is a single-use vehicle that is used to launch a payload into space.

examples of expendable launch vehicles. However, launch companies are testing reusable elements of expendable launch vehicles. For example, after launch, SpaceX has recovered four Falcon 9 first stages—three on a barge located at sea and one on land, according to FAA. United Launch Alliance is also developing capabilities to reuse the first stage of its Vulcan launch vehicle. Since the Space Shuttle fleet was retired in 2011, NASA has procured commercial cargo transportation services to the International Space Station from commercial providers such as SpaceX and Orbital ATK on these types of vehicles.

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).
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In addition, the commercial space launch industry is further changing technology with the emergence of suborbital reusable launch vehicles⁸ that are capable of being launched into space more than once and could be used for space tourism. Several companies such as Virgin Galactic, Blue Origin, and XCOR are in the process of developing and testing manned, reusable launch vehicles for commercial space tourism. For example, according to Blue Origin it has launched, recovered, and re-flown the same booster four times. Companies like Virgin Galactic and Stratolaunch Systems are also developing vehicles that will have the capability to launch small satellites into orbit. See figure 2.

⁸According 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.

Figure 2: Reusable Launch Vehicles Under Development



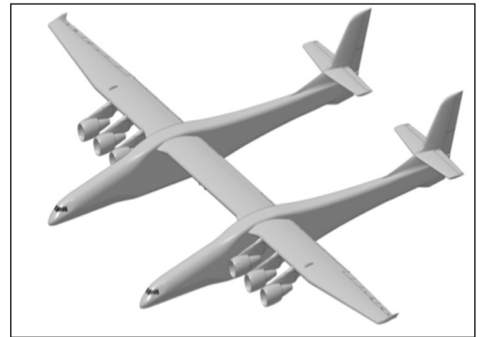
Virgin Galactic's SpaceShipTwo



XCOR's Lynx



Blue Origin's New Shepard

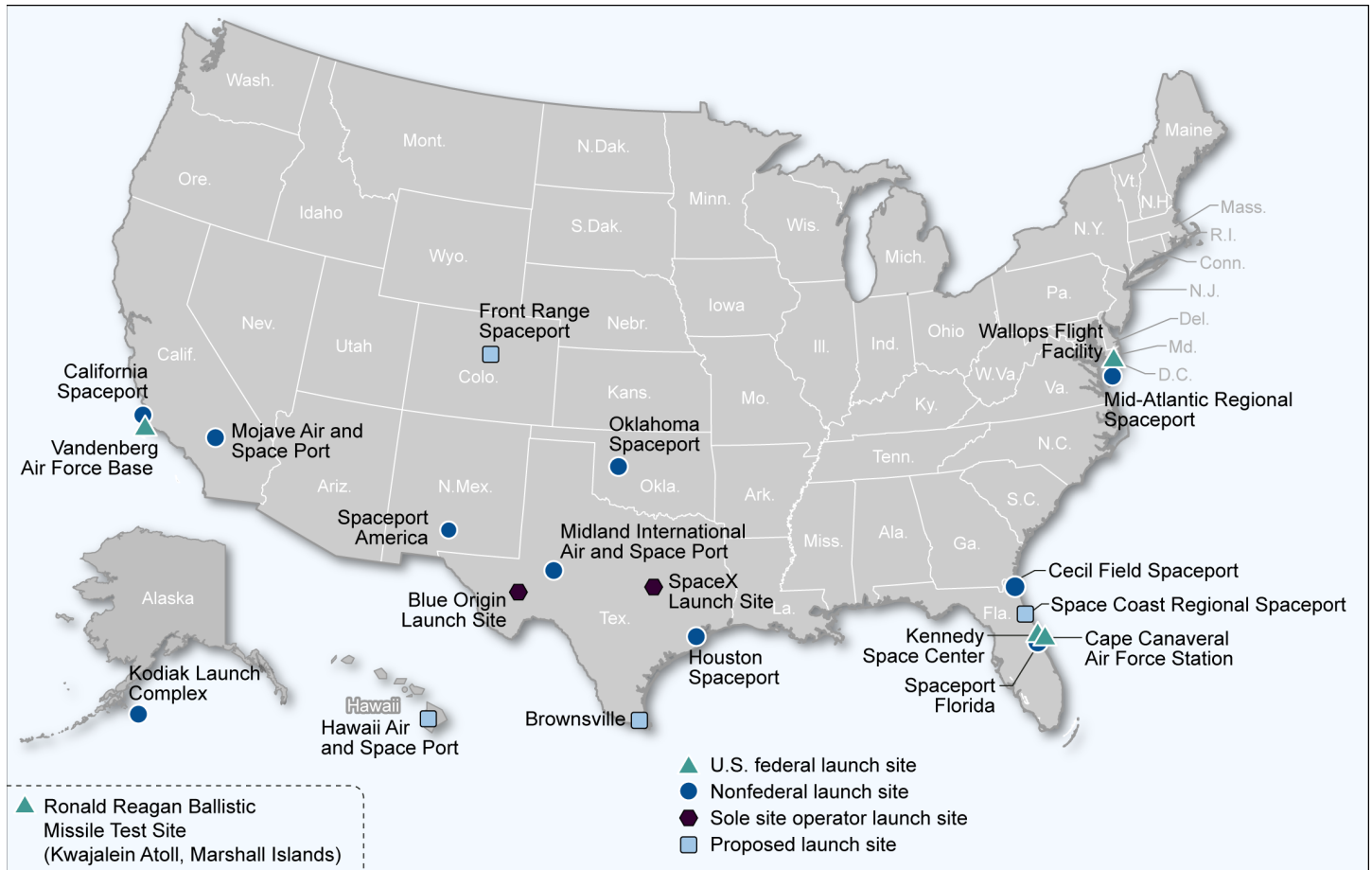


Stratolaunch aircraft

Sources: Virgin Galactic, XCOR, Blue Origin, and Vulcan Aerospace (for Stratolaunch). Reprinted with permission. | GAO-16-765T

Further, private companies and states are developing commercial spaceports—sites used for commercial space launches to support the expected growth in the launch industry. See figure 3.

Figure 3: Commercial Space Launch Sites and Proposed Sites as of June 2016



Sources: FAA and Map Resources. | GAO-16-765T

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

FAA's primary means of authorizing space launch activities is through its licensing process which includes: licensing launch and reentry vehicle operations, reviewing applications for experimental permits, reviewing safety approvals, and conducting safety inspections and oversight of licensed and permitted activities, among other activities. For fiscal year 2016 for the Office of Commercial Space Transportation, FAA's budget request was \$18.1 million and 92 full-time equivalent positions. Congress provided \$17.8 million for commercial space activities for fiscal year 2016.

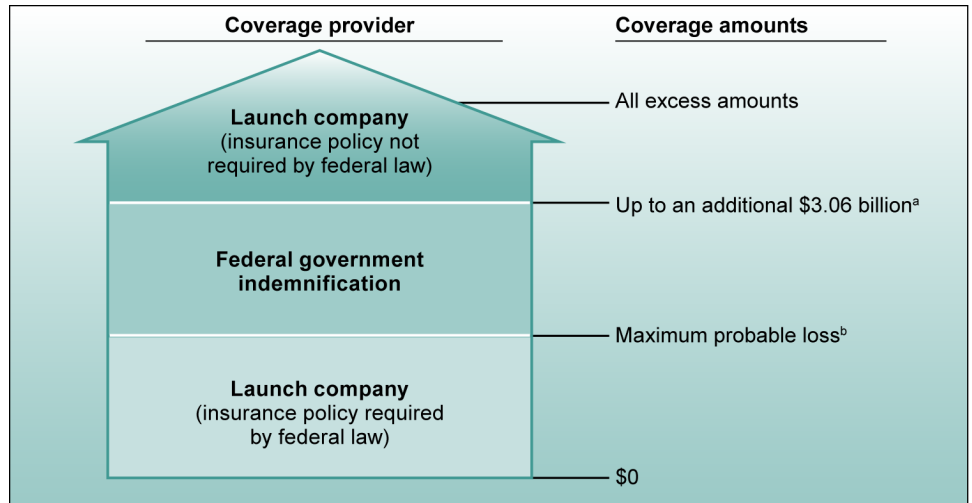
The federal government is authorized to provide catastrophic loss protection in the event of a launch accident for all FAA-licensed commercial launches through the Commercial Space Launch Amendments Act as amended.⁹ Thus, subject to congressional appropriations, the U.S. government may pay third-party liability claims for injury, damage, or loss that result from a commercial launch-related accident in excess of the required “maximum probable loss,” an amount which is calculated by FAA and is capped at \$500 million per launch.¹⁰ The federal government, subject to the availability of appropriations, is then liable for claims over the maximum probable loss up to \$1.5 billion which when adjusted for post-1988 inflation is about \$3.06 billion in 2015 dollars.¹¹ Launch companies are responsible for third-party liability claims up to the maximum probable loss and over \$3.06 billion. Figure 4 illustrates this regime. FAA’s risk methodology to calculate the maximum probable loss uses an “overlay” method that entails 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. There has not been a commercial launch-related accident that has invoked indemnification and thus the federal government has not paid any third-party liability claims to date.

⁹51 U.S.C. § 50915.

¹⁰The launch company must purchase insurance to cover any damage up to the estimated maximum probable loss.

¹¹51 U.S.C. § 50915(a)(1)(B) 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.

Figure 4: Third-Party Liability Insurance Regime for FAA-Licensed Launches



Source: GAO analysis. | GAO-16-765T

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

^bThe 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.

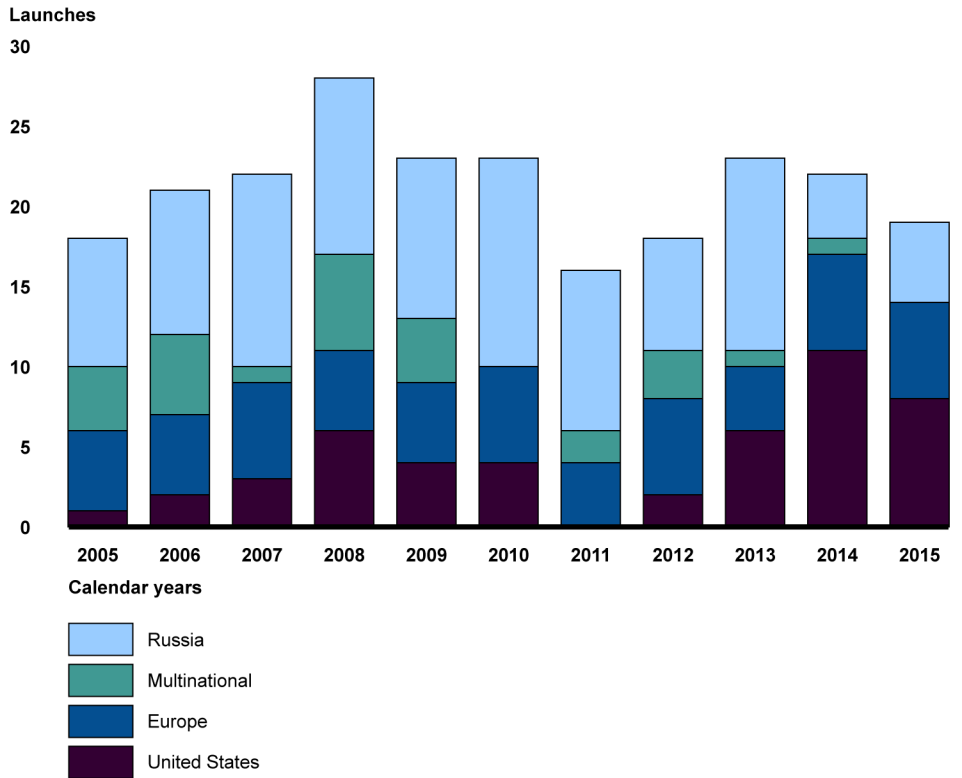
The U.S. Commercial Space Launch Industry Has Expanded in Recent Years

As we reported in our 2015 report, during the last decade, U.S. companies conducted fewer orbital commercial launches in total than companies in Russia or Europe, which are among the main foreign competitors.¹² However, in recent years such as 2014 and 2015, U.S. companies have conducted an increasing number of orbital commercial launches. As shown in figure 4, the number of orbital launches conducted by U.S. companies varied over the last 11 years. For example, recently the number of launches increased from zero in 2011 to eight in 2015.¹³ In 2015, U.S. companies conducted more orbital launches than companies in Russia, which conducted five, or Europe, which conducted six.

¹²FAA 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 2015, U.S. companies conducted a total of 47 orbital launches, compared with 101 conducted by companies in Russia and 58 conducted by companies in Europe. From October 2006 when the first experimental permit was approved to April 2016 there have been 42 experimental permits granted.

¹³According to FAA, the decrease in the number of launches in 2015 was due to launch failures such as SpaceX's Falcon 9 carrying a Dragon cargo capsule to the ISS.

Figure 5: U.S. and Foreign Orbital Commercial Space Launches, 2005 through 2015



Source: FAA. | GAO-16-765T

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 multinational consortium Sea Launch.

In 2015 we found that a number of factors are responsible for the recent expansion of the U.S. commercial space launch industry. First, increase in demand through 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. For example, in 2015, SpaceX conducted three cargo resupply missions for NASA.¹⁴ NASA also procured eight launches from Orbital ATK in 2008

¹⁴A fourth cargo resupply mission to the ISS ended in failure on June 28, 2015.

that were scheduled to occur between 2014 and 2016 with one launch taking place in 2015, one launch taking place in 2016, and another scheduled for July 2016.¹⁵ In addition, in January 2016, NASA announced its selections for companies to conduct Commercial Resupply Services (CRS2) to the ISS. SpaceX and Orbital ATK were selected again, and Sierra Nevada Corporation was added as a new participant. According to NASA, these awards require a minimum of six missions to the ISS from each participant between 2019 and 2024. In addition to fulfilling government contracts, these companies also conduct launches for other customers, including international customers.

Second, according to representatives from two commercial space launch companies, including SpaceX, and an advisory group and an expert whom we interviewed for our 2015 report, the growth in the U.S. commercial space launch industry is largely due to SpaceX because it is 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. Some companies are seeking ways to further reduce costs. For example, Blue Origin is developing new main engine elements for United Launch Alliance's expendable launch vehicle. Representatives from one company and an industry association and an expert told us that reusable stages may further 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.¹⁶

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 launch vehicles to carry spaceflight participants on suborbital flights and to place small satellites into orbit.

¹⁵United Launch Alliance carried Orbital ATK's Cygnus capsule with supplies to the ISS in December 2015 and March 2016 after Orbital ATK's mishap at the Mid-Atlantic Regional Spaceport damaged the launch pad. Orbital ATK plans to launch from the repaired launch pad in July 2016.

¹⁶GAO, *Commercial Space Transportation: Industry Trends, Government Challenges, and International Competitiveness Issues*, [GAO-12-836T](#) (Washington, D.C.: June 20, 2012).

FAA Faces Multiple Challenges Regarding Developments in the Commercial Space Launch Industry and Requested Additional Resources to Address Some Challenges

Challenges

In our 2015 report, 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: (1) determining whether and when to regulate the safety of crew and spaceflight participants and (2) handling an increased workload relating to licensing and permitting launches and launch sites. In addition, in our 2015 report, we noted that changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for launches.¹⁷

- **Determining whether and when to regulate the safety of crew and spaceflight participants:** In 2014, FAA released a set of recommended practices 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.¹⁸ In 2015, we reported that FAA officials said that the agency did not have

¹⁷Stakeholders identified two other challenges not discussed in our testimony—creating a safety reporting system and responding to launch companies' emerging business plans. For more information, see [GAO-15-706](#).

¹⁸FAA, *Recommended Practices for Human Space Flight Occupant Safety Version 1.0* (Washington, D.C.: Aug. 27, 2014).

plans to issue regulations regarding the safety of crew and spaceflight participants but was looking to industry to develop industry consensus standards detailing validation and verification criteria that are needed to implement the agency's recommended practices. As part of the U.S. Commercial Space Launch Competitiveness Act, Congress required FAA in consultation with an industry advisory group—the Commercial Space Transportation Advisory Committee—to submit two reports to Congress on this topic.¹⁹ The first report is on metrics that could indicate FAA's and the industry's readiness to transition to a safety framework that may include regulating crew, government astronaut and spaceflight participant safety and is due by August 2016. The second report is on the industry's progress in developing voluntary industry consensus standards and is required to be submitted by December 31, 2016 and periodically afterwards until December 31, 2021.

- **Increased workload relating to licensing and permitting launches and launch sites:**
 - Licensing more launches: In fiscal year 2015, FAA licensed and permitted 14 launches and re-entries, up from seven in fiscal year 2006 and compared with an average of about 11 launches and re-entries during each fiscal year from 2006 to 2015. We found a large part of this increase was due to launches for NASA's commercial cargo program. In the future, FAA also will need to license launches for NASA's commercial crew program and potentially launches of companies placing small satellites in orbit.
 - Conducting more inspections: In fiscal year 2015, FAA conducted 216 commercial launch inspections, up from 27 in fiscal year 2006 and compared with an average of 90 inspections during each fiscal year from 2006 to 2015. 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 launch companies' 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.

¹⁹Pub. L. No. 114 -90, § 111, 129 Stat. 704, 709.

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- 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.²⁰ 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 as of August 2015 have involved flight termination systems that were human-operated.
 - Licensing more and complex launch sites: Although launch sites traditionally have been located in coastal areas at federal launch facilities, in 2014 FAA licensed an inland launch site that is co-located with a commercial airport in Midland, Texas. In addition, FAA is licensing more nonfederal launch sites. As of June 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.

Also, in our 2015 report we noted that changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for launches for several reasons. 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. In general, by increasing the volume of launches and reentries, the probability of a catastrophic accident 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 "legacy" launch vehicles. For example, Virgin Galactic's SpaceShipTwo, XCOR's Aerospace's Lynx, and Blue Origin's New Shepard are new vehicles. However, increased flights of a launch vehicle could also make a vehicle more reliable. We have previously reported that although some industry

²⁰The 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.

changes may alter the government's exposure, an accurate maximum probable loss calculation will mitigate the effects to some extent.²¹ If the maximum probable loss calculation is accurate, the estimated losses will adjust for the risk profile of each license, in such a way that the likelihood the government would indemnify a third-party remains the same regardless of the industry change. However, in July 2012, we reported that FAA's risk methodology—which was first established in the 1980s—could be updated given advances in catastrophe modeling.²² We recommended that FAA review its maximum probable loss methodology. Congress mandated that FAA review the methodology and report back to the Congress by May 2016. FAA officials told us that in June 2016 that they have drafted a report which is currently under agency review.

FAA Request for Resources

In 2015 we found that FAA's budget requests for its commercial space launch activities generally were based on the number of projected launches, but that in recent years the actual number of launches was much lower than FAA's projections. For example, during 6 of the 10 years from fiscal years 2005 to 2014, FAA generally based its budget submissions on the number of launches that it was projecting for the following year; none of those projections was realized in the actual number of licensed and permitted launches. FAA officials said at that time that although other metrics existed besides the number of projected launches, they were not consistently used in the agency's budget submissions. In addition, other activities, such as time spent on pre-application license consultations, were not included in the metrics used in preparing the budget requests. According to FAA officials, more detailed information was not provided in their budget submissions because the agency lacked certain workload metrics regarding its commercial space launch oversight activities. We also found that the Office of Commercial Space Transportation did not track the amount of time spent on the office's various activities. However, the officials indicated that they were continuing to develop a labor analysis methodology that began in fiscal year 2014 and that the office was considering implementing a new time recordkeeping system in 2016 to supplement the development of additional workload metrics.

²¹GAO, *Commercial Space Launches: FAA Should Update How It Assesses Federal Liability Risk*, [GAO-12-899](#) (Washington, D.C.: July 2012).

²²[GAO-12-899](#)

To provide Congress with more information about the resources requested to address developments in the commercial space launch industry, we recommended that FAA provide more detailed information in its budget submissions about its workload. FAA agreed with the recommendation, but DOT also had some concerns about how issues were presented. FAA has taken steps to implement our recommendation. In the 2017 budget submission, FAA provided workload indices based on the number of authorizations which the agency uses to authorize companies to conduct one or more launches, the number of licenses and permits, the number of on-site inspections as part of licensing launch sites, and staffing levels since fiscal year 2006. We will continue to monitor FAA's progress toward implementing this recommendation.

Chairman LoBiondo, Ranking Member Larsen and Members of the Subcommittee, this concludes my prepared statement. I would be pleased to answer any questions at this time.

GAO Contact and Staff Acknowledgments

For further information on this testimony, please contact Gerald. L. Dillingham, Ph.D., at (202) 512-2834 or dillinghamg@gao.gov. In addition, contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Individuals making key contributions to this testimony include: Catherine Colwell, Bob Homan, Dave Hooper, Maureen Luna-Long, Stephanie Purcell, Namita Bhatia Sabharwal, and Travis Schwartz.

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