

**GAO**

Report to the Ranking Democratic  
Member, Committee on Transportation  
and Infrastructure, House of  
Representatives

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October 2006

# COMMERCIAL SPACE LAUNCHES

## FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry



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# Highlights

Highlights of [GAO-07-16](#), a report to the Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives

## Why GAO Did This Study

In 2004, the successful launches of SpaceShipOne raised the possibility of an emerging U.S. commercial space tourism industry that would make human space travel available to the public. The Federal Aviation Administration (FAA), which has responsibility for safety and industry promotion, licenses operations of commercial space launches and launch sites. To allow the industry to grow, Congress prohibited FAA from regulating crew and passenger safety before 2012, except in response to high-risk events. GAO evaluated FAA's (1) safety oversight of commercial space launches, (2) response to emerging issues, and (3) challenges in regulating and promoting space tourism and responding to competitive issues affecting the industry. GAO reviewed FAA's applicable safety oversight processes and interviewed federal and industry officials.

## What GAO Recommends

If DOT's commissioned report on dual safety and promotion roles does not fully address the potential for a conflict of interest, GAO suggests that Congress revisit FAA's promotional role and decide whether it should be eliminated. GAO recommends that FAA assess its future safety oversight resource needs and identify the circumstances that would trigger passenger safety regulation before 2012. Relevant federal agencies reviewed the draft and DOT agreed with the recommendations.

[www.gao.gov/cgi-bin/getrpt?GAO-07-16](http://www.gao.gov/cgi-bin/getrpt?GAO-07-16).

To view the full product, including the scope and methodology, click on the link above. For more information, contact Gerald L. Dillingham at (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov).

## COMMERCIAL SPACE LAUNCHES

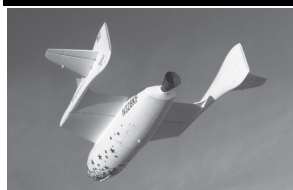
# FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry

## What GAO Found

Several measures indicate that FAA has provided a reasonable level of safety oversight for commercial launches. For example, none of the 179 commercial launches that FAA licensed over the past 17 years resulted in fatalities, serious injuries, or significant property damage. However, FAA shared safety oversight with the Department of Defense (DOD) for most of these launches because they took place at federal launch sites operated by DOD. In addition, FAA's licensing activities incorporate a system safety process, which GAO recognizes as effective in identifying and mitigating risks. GAO's analysis of FAA records indicates that the agency is appropriately applying management controls in its licensing activities, thereby helping to ensure that the licensees meet FAA's safety requirements.

In response to emerging issues in the commercial space launch industry, such as the potential development of space tourism, FAA has developed safety regulations and training for agency employees. The industry has raised concerns about the costs of complying with regulations and about the flexibility of the regulations to accommodate launch differences. However, FAA believes it has minimized compliance costs by basing its regulations on common safety standards and has allowed for flexibility by taking a case-by-case approach to licensing and by providing waivers in certain circumstances.

FAA faces several challenges and competitive issues in regulating and promoting space tourism. For example, FAA expects to need more experienced staff for safety oversight as new technologies for space tourism evolve, but has not estimated its future resource needs. Other challenges for FAA include determining the specific circumstances under which it would regulate space flight crew and passenger safety before 2012 and balancing its responsibilities for safety and promotion to avoid conflicts. Recognizing the potential conflict in the oversight of commercial space launches, Congress required the Department of Transportation (DOT) to commission a report by December 2008 on several issues, including whether the promotion of human space flight should be separate from the regulation of such activity. In addition, U.S. commercial space launch industry representatives said that they face competitive issues concerning high launch costs and export controls that can affect their ability to sell services overseas. The federal government has provided support to the industry to help lower launch costs.



Source: Scaled Composites. SpaceShipOne

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## Abbreviations

DARPA	Defense Advanced Research Projects Agency
DHS	Department of Homeland Security
DOD	Department of Defense
DOT	Department of Transportation
FAA	Federal Aviation Administration
MPL	maximum probable loss
NASA	National Aeronautics and Space Administration
NSC	National Security Council
OSTP	Office of Science and Technology Policy
TSA	Transportation Security Administration
USTR	Office of the U.S. Trade Representative

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United States Government Accountability Office  
Washington, DC 20548

October 20, 2006

The Honorable James L. Oberstar  
Ranking Democratic Member  
Committee on Transportation and Infrastructure  
House of Representatives

Dear Mr. Oberstar:

In 2004, the successful launches of SpaceShipOne raised the possibility of an emerging commercial space tourism industry that would make human space travel available to the public for the first time. Previously, human space travel in the United States was limited to the National Aeronautics and Space Administration's (NASA) flights. SpaceShipOne is a reusable launch vehicle<sup>1</sup> that resembles an airplane. It was launched from an airplane into space, where it traveled nearly 70 miles above the earth (an altitude known as suborbital space), and returned to the original launch site. Designed to carry two crew members and one passenger, SpaceShipOne is the first commercial reusable launch vehicle licensed by the Federal Aviation Administration (FAA). Several companies in addition to SpaceShipOne's designer, Scaled Composites, LLC, are developing reusable launch vehicles for commercial space tourism and plan to start operations within the next few years. Historically, commercial space launches carried payloads, generally satellites, into orbit using expendable launch vehicles<sup>2</sup> that did not return to earth.

In 2004, the U.S. commercial space launch industry accounted for \$1.7 billion in economic impact, according to FAA.<sup>3</sup> At that time, the industry consisted of a few FAA-licensed launch companies that operated primarily from Department of the Air Force launch sites. Currently, the industry appears to be expanding—more firms are applying to FAA for launch

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<sup>1</sup>A reusable launch vehicle is one that is capable of being launched into space more than once.

<sup>2</sup>An expendable launch vehicle, which looks like a rocket, is an unmanned, single-use vehicle that is usually used to launch a payload into space.

<sup>3</sup>FAA defines "economic impact" as increases in revenues, earnings, and jobs that affect the national economy and occur as a result of the demand for commercial space launch products and services.

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licenses, and several commercial spaceports are being planned.<sup>4</sup> One space tourism company, Virgin Galactic, which intends to start operations in 2009 and to initially charge \$200,000 per passenger, plans to carry 3,000 passengers over the subsequent 5 years on space flights, with 100 individuals having already paid the full fare. In addition, the U.S. commercial space launch industry faces strong competition from international companies, primarily from Russia and Europe, offering satellite launches on expendable launch vehicles. Russia is also the only nation that has commercially launched humans into space, with four individuals having paid an estimated \$20 million each for orbital space flights.

The federal government regulates and supports the commercial space launch industry to varying degrees. In 1984, the Commercial Space Launch Act gave the Department of Transportation (DOT) the authority to license and monitor the safety of commercial space launches and to promote the industry. In 2004, the Commercial Space Launch Amendments Act gave FAA the specific responsibility of overseeing the safety of space tourism, but the act prohibits FAA from regulating crew and passenger safety before 2012, except in response to high-risk incidents, serious injuries, or fatalities. The Department of Defense (DOD), through the Air Force, provides infrastructure, operations support, and safety oversight for government and commercial launches at its launch sites. The Department of Commerce (Commerce) is also responsible for promoting the commercial space industry.

This report discusses the federal role in commercial space launches and the government's response to emerging industry trends—both domestically and internationally. In this review, we addressed the following questions:

- How well does FAA oversee the safety of commercial space launches?
- To what extent is FAA responding to key emerging issues in the commercial space launch industry?
- What challenges does FAA face in regulating and promoting the commercial space launch industry?

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<sup>4</sup>A spaceport is a site that is used for launching spacecraft.

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- What are the key competitive issues affecting the U.S. commercial space launch industry, and to what extent are the industry and government responding to them?

To determine how well FAA is overseeing the safety of commercial space launches, we reviewed the agency's safety oversight processes, including the documentation of its licensing and safety monitoring processes, internal guidance and policies, applicable regulations, and memoranda of agreement with other federal agencies. We also reviewed FAA's use of system safety procedures<sup>5</sup> and interviewed industry experts and FAA officials. Because FAA relies on the Air Force to conduct safety oversight at the Air Force's two primary launch sites in Florida and California, we reviewed Air Force launch safety requirements and interviewed FAA and Air Force officials about their respective responsibilities and interaction. In addition, we examined FAA's application of certain management controls in its licensing and monitoring processes using our guidelines for management controls at federal agencies, such as documentation and timeliness of the review process and communication and consultation with relevant federal agencies.<sup>6</sup> To determine the extent to which FAA is responding to key emerging issues in the commercial space launch industry, such as space tourism, we identified these issues through literature reviews and assessed the extent of FAA's response through interviews with federal government officials and industry representatives. These industry representatives were from associations that represent the commercial space launch industry and from entities that had received launch or launch-site licenses from FAA or were consulting with FAA about receiving such licenses as of September 2005. We also interviewed these officials and representatives to identify the challenges FAA faces in regulating and promoting the commercial space launch industry. To determine the key competitive issues affecting the U.S. commercial space launch industry and the extent to which the industry and the federal government are responding to them, we conducted a literature review that included applicable laws affecting industry competitiveness and interviewed agency officials, industry representatives, and industry

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<sup>5</sup>System safety is the application of engineering and management principles, criteria, and techniques to optimize safety by the identification of safety-related risks and then the control or elimination of these risks by design and procedures, on the basis of acceptable system safety precedents.

<sup>6</sup>GAO, *Internal Control Management and Evaluation Tool*, GAO-01-1008G (Washington, D.C.: Aug. 1, 2001); and *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1 (Washington, D.C.: November 1999).



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experts to obtain their views. We conducted our review from August 2005 through October 2006 in accordance with generally accepted government auditing standards. Appendix I contains additional information about our objective, scope, and methodology.

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## Results in Brief

Several measures indicate that FAA has provided a reasonable level of safety oversight for expendable launch vehicles, including the industry's launch safety record and FAA's safety licensing process and use of management controls in its license application reviews. FAA has licensed 179 commercial launches over the past 17 years that have resulted in no fatalities, serious injuries, or significant property damage. However, the Air Force's oversight for launches from its launch sites has contributed to this achievement. From March 1989 to August 2006, FAA exercised sole safety oversight for 27 of the 179 commercial launches. Of the remaining 152 launches, other entities, primarily the Air Force, provided on-site safety oversight of launches from their launch sites. In addition, FAA's licensing activities use a system safety process, which we recognize as an effective evaluative method of identifying and mitigating risks. Furthermore, our analysis of FAA records indicated that the agency is appropriately applying management controls, such as timely reviews and verification of data, in its licensing of commercial launches and launch sites, thereby helping to ensure that the licensees satisfy FAA's safety requirements.

FAA is responding to emerging issues in the U.S. commercial space launch industry, such as the development of space tourism at spaceports, by issuing safety regulations and has developed training for agency employees to use in overseeing the safety of these launches. However, some industry representatives expressed concern about (1) the costs of complying with both FAA's regulations and the Air Force's existing requirements at federal launch sites and (2) the flexibility the regulations would afford to accommodate special launch circumstances. According to FAA, it has minimized the costs of compliance by basing its regulations on common safety standards that it shares with the Air Force, and it has allowed for flexibility by taking a case-by-case approach to licensing and by providing waivers in certain circumstances.

FAA faces several challenges in regulating and promoting an emerging sector of the U.S. commercial space launch industry—space tourism from spaceports—that could affect its safety oversight of the evolving industry. First, FAA faces the challenge of providing a sufficient number of personnel with the experience and training needed to evaluate and

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oversee the safety of an uncertain but potentially escalating number of space tourism launches. FAA's experience with such launches is limited because just five have taken place and all have used the same launch vehicle—SpaceShipOne. At the same time, a wide variety of launch vehicles and technologies are being designed, and FAA is expecting its workload to increase. FAA has not estimated the level of resources needed to oversee this developing sector of the industry and has indicated that it will not do so until the industry further develops. Second, FAA faces the challenge of ensuring that its regulations for operations of launch vehicles and launch sites are suitable not only for operations at federal launch sites but also for spaceports. FAA's regulations are based on common safety standards developed by FAA and the Air Force, primarily on the basis of the Air Force's range safety requirements for expendable launch vehicle operations from federal launch sites. Third, FAA faces the challenge of determining the circumstances under which it would regulate the safety of crew and space flight participants before 2012. Congress prohibited FAA from regulating crew and space flight participant safety before 2012, except in response to high-risk incidents, serious injuries, or fatalities, to allow the industry to grow and innovate; therefore, FAA has not developed criteria for those circumstances. Finally, FAA faces the challenge of balancing its responsibilities for safety and promotion and distinguishing its promotion role from that of Commerce, which is also mandated to promote the commercial space industry. According to some experts, FAA's safety oversight and promotional responsibilities do not conflict because its promotional activities are centered on providing a safe industry. However, according to other experts, FAA's dual role may create a potential conflict of interest as space tourism develops, particularly in FAA's determination of whether or when to regulate crew and flight participant safety. Recognizing the potential conflict in the oversight of commercial space launches, Congress required DOT to commission an independent study by December 2008 on whether the promotion of human space flight should be separate from the regulation of such activity. In addition, some of FAA's promotional activities, such as publishing economic impact studies on the industry, have the potential of overlapping with those of Commerce.

The U.S. commercial space launch industry faces key competitive issues concerning high launch costs and U.S. export controls. Space launches incur high costs for launch vehicle development and for launch facility operations and maintenance. The government has helped to lower these costs by investing in the design and development of vehicles for its use, making its launch infrastructure available for commercial launches when space is available, and providing business opportunities to companies for

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launches of national defense and scientific payloads. The government also provides indemnification<sup>7</sup> for commercial launches and has attempted to reduce costs to the industry by streamlining the licensing of commercial launches through FAA's and the Air Force's development of common safety standards and acceptance of each other's waivers of specific licensing requirements. In addition, industry representatives that we interviewed said that they would like fewer items to be regulated by export controls or a streamlining of the process for obtaining authorization to export these items to improve the U.S. industry's competitive position. Export controls are in place to ensure that sales and leases of controlled U.S. technologies are consistent with U.S. national security and foreign policy interests. Although we have not examined the issue of which specific items should be subject to export controls, we have examined the export control system and have recommended ways to improve its overall efficiency.<sup>8</sup>

We suggest that, if DOT's 2008 report on the dual safety and promotion roles does not fully address the potential for a conflict of interest, Congress consider revisiting FAA's promotional role and decide whether to eliminate it to alleviate a potential conflict of interest. For FAA to be prepared for a potential increase in space tourism launches, we are recommending that FAA plan for the level of resources and expertise needed to assume its additional responsibilities for overseeing the safety of reusable launch vehicle operations at spaceports. In addition, we are recommending that FAA develop and issue guidance on the circumstances under which it would regulate crew and flight participant safety before 2012. Furthermore, to distinguish between FAA's and Commerce's promotional responsibilities, we are recommending that FAA develop a memorandum of understanding with Commerce. We provided a draft of this report to the Departments of Transportation, Defense, Commerce, State, and Homeland Security (DHS); NASA; the White House Office of

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<sup>7</sup>"Indemnification" is catastrophic loss protection in the event of a launch accident. Subject to congressional appropriations, the U.S. government may pay successful third-party liability claims in excess of required "maximum probable loss" (MPL)-based insurance up to \$1.5 billion above the amount of the MPL-based insurance. MPL-based insurance is launch insurance that the commercial space launch provider is required to obtain as part of its license.

<sup>8</sup>GAO, *Defense Trade: Arms Export Controls Vulnerabilities and Inefficiencies in the Post-9/11 Security Environment*, GAO-05-468R (Washington, D.C.: Apr. 7, 2005); and *Export Controls: Reengineering Business Processes Can Improve Efficiency of State Department License Reviews*, GAO-02-203 (Washington, D.C.: Dec. 31, 2001).

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Science and Technology Policy; and the Office of the U.S. Trade Representative. State, Defense, and DHS had no comments and the other agencies provided technical comments, and generally agreed with the facts presented in the report. They provided technical corrections and clarifications, which we incorporated as appropriate. DOT and Commerce agreed with the report's recommendations.

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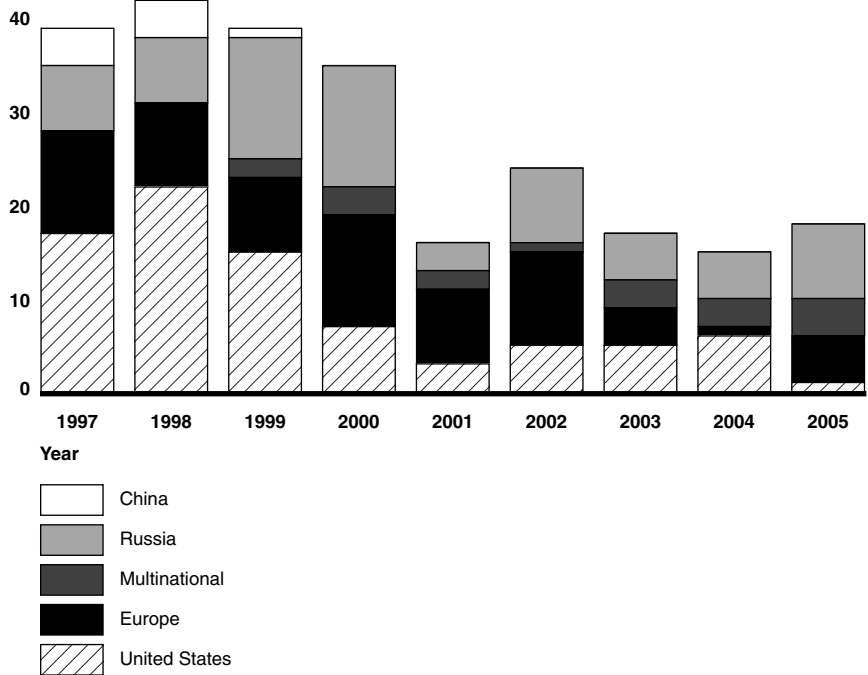
## Background

There are three main types of space launches—national security, civil, and commercial. National security launches are by DOD for defense purposes, and civil launches are by NASA for scientific and exploratory purposes. Many commercial launches are internationally competed and carry payloads, such as satellites, that generate revenue. In 1984, the Commercial Space Launch Act required the Secretary of Transportation to “encourage, facilitate, and promote commercial space launches by the private sector.” At that time, 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 January 1986, the U.S. government transferred responsibilities for commercial payload launches to the private sector. Space launches by private sector companies grew as U.S. commercial launch companies responded to the increase in global demand for commercial satellite launch services in the mid-1990s. Nonetheless, following a downturn at the beginning of this century in the business of the commercial space launch industry’s primary commercial customer, the telecommunications services industry, the demand for commercial space launches has generally declined. As shown in figure 1, the total number of U.S. and worldwide commercial orbital launches has declined from a peak of 41 launches in 1998.

**Figure 1: Worldwide Commercial Orbital Launches, 1997-2005**

Number of commercial orbital launches

50



Source: GAO analysis of FAA data.









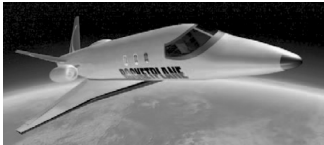

Note: These launches used expendable launch vehicles, which are designed to be launched once, to deliver satellites into orbit. Launches are grouped by the country in which the primary vehicle is manufactured. Exceptions to this are launches by Sea Launch Company, LLC, which is designated as multinational and launches from international waters. Sea Launch, whose partners include Boeing Commercial Space Company of the United States, S.P. Korolev Rocket and Space Corporation Energia of Russia, Kvaerner of Norway, and SKO Yuzhnoye/PO Yuzhmash of Ukraine, is required to have an FAA license because Boeing, a U.S. company, has a controlling interest in the company.

The U.S. commercial space launch industry, comprising a few launch companies, has historically used federal sites to launch satellites using expendable vehicles, which are designed to be launched once. According to FAA, the launch vehicle manufacturing and services sector of the commercial space industry had \$1.7 billion in economic impact on the U.S. economy for 2004, with the greatest economic impacts to enabling

industry sectors such as satellite manufacturing and services.<sup>9</sup> (See app. II for more information on the industry and its economic impact.)

The commercial space launch industry is changing with the emergence of suborbital reusable launch vehicles that enable space tourism from state-sponsored or private launch sites, known as spaceports. (See fig. 2 for examples of expendable and reusable launch vehicles.)

**Figure 2: Examples of Expendable and Reusable Launch Vehicles**

Expendable Launch Vehicles			Reusable Launch Vehicles		
					
Zenit 3SL	Atlas V	Delta IV	Neptune	SpaceShipOne	Falcon I
					
QuickReach	Pegasus		Rocketplane XP	Xerus	

Source: FAA.

Note: Falcon I is partially reusable because its first stage is designed to be recovered and reused.

The prospect for commercial space tourism materialized in 2004 when SpaceShipOne, developed by Scaled Composites, flew to space twice,

<sup>9</sup>Other sectors of the commercial space industry include satellite services and ground equipment manufacturing.

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achieving a peak altitude of about 70 miles to win the Ansari X Prize.<sup>10</sup> Several entrepreneurial launch companies are planning to start taking paying passengers, also known as space flight participants, on suborbital flights within the next few years. Virgin Galactic intends to enter commercial suborbital space flight service around 2009, launching from a spaceport in New Mexico, and according to the company, plans to carry 3,000 passengers over the subsequent 5 years, with 100 individuals having already paid the full fare of \$200,000. In addition, 4 individuals have already paid an estimated \$20 million each for space flights to the International Space Station on a Russian vehicle that launches from Kazakhstan. According to a Futron Corporation market study on space tourism, the orbital and suborbital space tourism market could attract up to 15,000 passengers and generate revenues in excess of \$1 billion per year by 2021, with suborbital space tourism likely generating the most demand.<sup>11</sup> Several other companies in the United States and elsewhere, including former Ansari X Prize competitors, continue to develop their vehicles for space tourism. For example, Russia is developing a reusable launch vehicle, Cosmopolis 21, for space tourism flights.

Spaceports are being developed to accommodate anticipated commercial space tourism flights and are expanding the nation's launch capacity. As of August 2006, the United States had five federal launch sites, six spaceports with an FAA launch site operator's license, and an additional eight spaceports have been proposed (see fig. 3). Although their individual capabilities and level of infrastructure development vary, these facilities may house launch pads and runways as well as the buildings, equipment, and fuels needed to prepare vehicles and payloads before launch. The spaceports are operated by state or local governments and authorities and by private entities. These spaceports also face competition from abroad. Space Adventures, a U.S.-based space tourism broker, in partnership with other investors, plans to develop a \$115 million spaceport near Changi

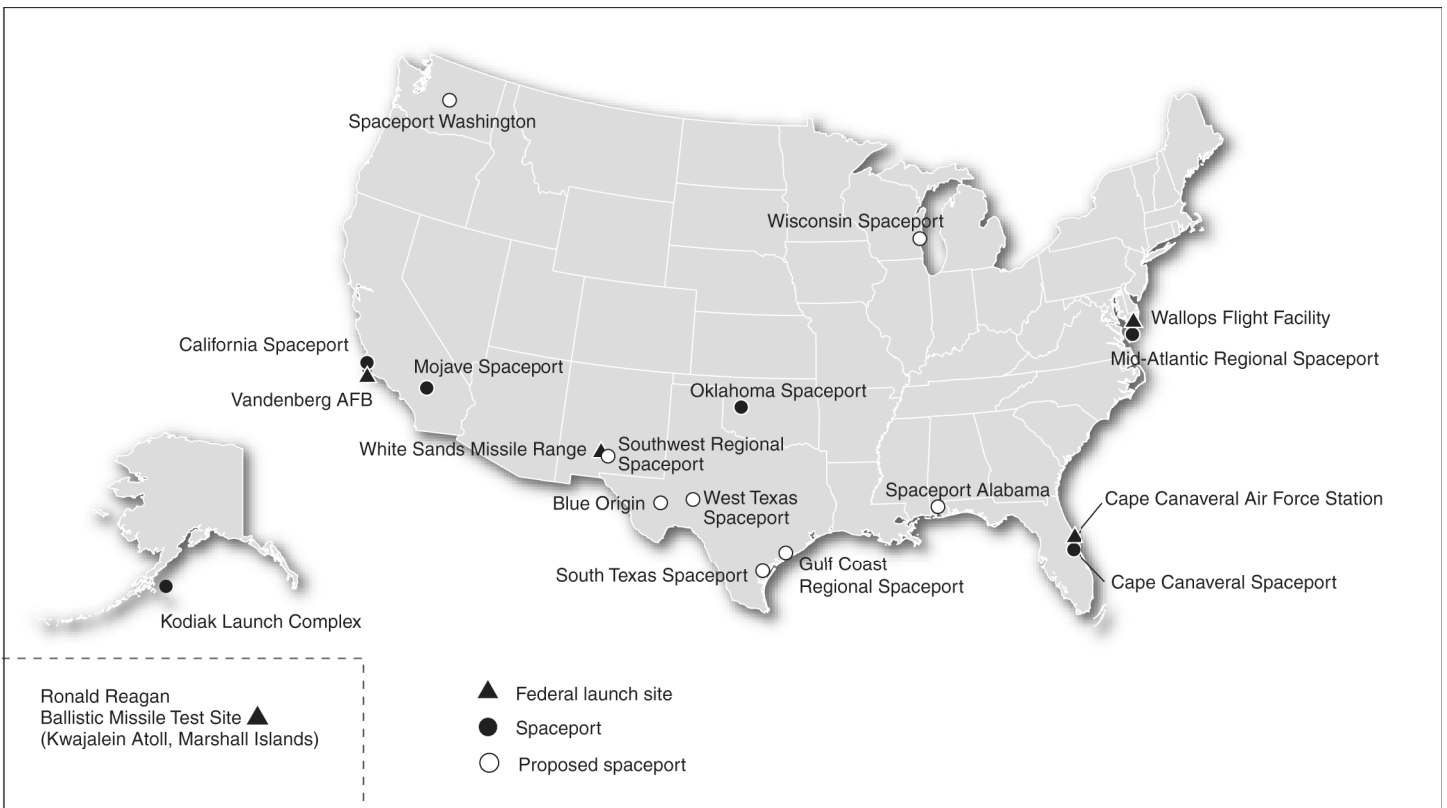
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<sup>10</sup>The X PRIZE Foundation was established in 1995 to award \$10 million to the first team to launch a suborbital, reusable launch vehicle capable of carrying three people to an altitude of 70 miles, return safely to earth, and repeat the exercise within 2 weeks using the same vehicle. Twenty-seven teams from seven countries competed.

<sup>11</sup>Futron Corporation, *Space Tourism Market Study: Orbital Space Travel and Destinations with Suborbital Space Travel* (Bethesda, Md.: October 2002). Revenue information is based on a survey of 450 individuals with annual incomes of at least \$250,000 or a net worth of at least \$1 million, who were questioned about their interest in taking a space flight.

Airport in Singapore and a \$265 million spaceport in Ras Al-Khaimah near Dubai in the United Arab Emirates.

**Figure 3: Federal Launch Sites and Existing and Proposed Spaceports in the United States, as of August 2006**



Sources: FAA and GAO.

## Federal Agencies' Roles and Responsibilities in the Commercial Space Launch Industry

Several federal agencies regulate and support the commercial space launch industry. FAA oversees the safety of all commercial launches—both expendable and reusable launch vehicles from federal launch sites and spaceports—through its licensing, compliance monitoring, and safety inspection activities.<sup>12</sup> FAA licenses launches to ensure the health and

<sup>12</sup>FAA issues four types of licenses: a launch license (for expendable launch vehicles), a reusable launch vehicle mission license, a reentry license, and a launch or reentry site operator license. The first three types of licenses are issued to the operator of a launch vehicle, and the fourth is issued to the operator of a spaceport. Licenses for vehicle operations are granted for one launch or reentry, a series of launches or reentries, or a period of time.



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safety of the public and the safety of property. The agency licenses all commercial launches that take place in the United States. In addition, it licenses all overseas launches by U.S. citizens or companies. FAA generally does not license launches by the U.S. government, nor does it license the operation of federal launch sites.<sup>13</sup> In issuing launch and launch-site operator licenses, FAA does not certify the launch vehicle as safe; in contrast, FAA's Office of Aviation Safety provides initial certification of aircraft and periodically inspects an aircraft and certifies it as safe to fly. FAA can also issue experimental permits for launches of reusable vehicles conducted for research and development, for demonstrations of compliance with licensing requirements, or for crew training before obtaining a license. During commercial launches, FAA aerospace engineers are on-site to monitor licensees' compliance with license and permit requirements. For 179 commercial launches conducted between March 1989 and August 2006, FAA has issued licenses for 63 launch vehicles and six spaceports. In addition, FAA has issued one experimental permit for a suborbital reusable vehicle. (See app. III for more information about FAA's launch licensing process.) Furthermore, FAA is responsible for promoting the industry, which the agency said it accomplishes by sponsoring an annual industry forecast conference, publishing industry studies, and conducting outreach to potential launch companies. FAA also consults with industry through its advisory committee, the Commercial Space Transportation Advisory Committee, which provides advice and recommendations to the FAA Administrator. This advisory committee has working groups comprising industry representatives who consult on reusable launch vehicle development and launch operations and support, among other commercial space subjects.

Other federal agencies support the commercial space launch industry to varying degrees. DOD provides guidance and safety oversight for government and commercial launches at federal launch sites. The Air Force also operates the government's two primary commercial launch sites—Cape Canaveral Air Force Station in Florida and Vandenberg Air Force Base in California—and provides infrastructure and operations support. In addition, the Department of the Army operates a launch site at the White Sands Missile Range in New Mexico and at the Ronald Reagan Ballistic Missile Test Site in the Marshall Islands. Commercial launches at federal launch sites occur when “excess capacity” is available and the

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<sup>13</sup>FAA does license launches for the U.S. government if the launch has been procured commercially.

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launch company reimburses DOD for the direct use of government services.<sup>14</sup> Three U.S. companies—Boeing, Lockheed Martin, and Orbital Sciences—have been the primary commercial users of DOD launch facilities. In support of its mission to have assured access to space, DOD also has supported the industry through investments in the design and development of small, medium, and heavy lift launch vehicles, which have been used for both government and commercial launches.<sup>15</sup>

Under the Technology Administration Act of 1998, Commerce is to serve as an advocate for the commercial space industry. Its Office of Space Commercialization, established in 1988 within the Office of the Secretary of Commerce and now located within the National Oceanic and Atmospheric Administration, is responsible for promoting commercial investment in the industry by, among many activities, collecting and disseminating information on space markets; conducting workshops on commercial space opportunities; promoting space-related exports; and seeking the removal of legal, policy, and institutional impediments to space activities. Commerce's International Trade Administration also promotes the commercial space industry in matters concerning international trade through such activities as trade events, advocacy programs, and the development of policies to further U.S. industry competitiveness. In addition, Commerce regulates export of space technologies that are considered dual-use items—that is, items with military and civilian uses—and is a customer of satellite launches.

NASA's support for the commercial space launch industry includes (1) providing infrastructure and range support from its Wallops Flight Facility in Virginia and radar support for commercial launches from DOD launch sites<sup>16</sup> and (2) encouraging private sector investment in NASA launches and other activities. Since the 1985 National Aeronautics and Space Administration Authorization Act, Congress has required NASA to “seek and encourage, to the maximum extent possible, the fullest commercial use of space.” In January 2004, the President announced the

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<sup>14</sup>Reimbursable services include the direct use of DOD facilities, security personnel, and radar support.

<sup>15</sup>Launch vehicles are defined by the weight of the payload that the vehicle can carry to orbit.

<sup>16</sup>NASA provides tracking and telemetry support for commercial launches out of the Wallops Flight Facility in Virginia, Kennedy Space Center in Florida, Kodiak Launch Complex in Alaska, and Vandenberg Air Force Base in California.

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Vision for U.S. Space Exploration, which directed NASA to pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low-Earth orbit.<sup>17</sup> Congress supported this direction in the NASA Authorization Act of 2005 by requiring NASA to develop a commercialization plan that (1) identifies opportunities for the private sector to participate in NASA missions and activities in space and (2) emphasizes the use of advancements made by the private sector in developing launch vehicles.<sup>18</sup> One such opportunity is NASA's Commercial Orbital Transportation Services demonstration program, for which NASA solicited proposals from private industry in March 2006 to demonstrate cargo and crew space transportation to low-Earth orbit and awarded two contracts in August 2006.









Other federal agencies support commercial launches in various ways. DHS's Transportation Security Administration (TSA) is responsible for security policy, compliance, and related issues for commercial space transportation. TSA also is responsible for establishing national standards for transportation and infrastructure security for commercial space transportation. The Department of State ensures that domestic space policies support U.S. foreign policy objectives and international commitments. State also regulates the export of space technology and represents the United States on the United Nations Committee on the Peaceful Uses of Outer Space. The White House Office of Science and Technology Policy (OSTP) and the National Security Council (NSC) develop and manage commercial space launch policymaking by mediating among federal agencies and reporting to the President on space policy issues, among other duties. The Office of the U.S. Trade Representative (USTR) negotiates and monitors commercial space launch industry trade agreements as needed. (See fig. 4 for a summary of federal agencies' roles and responsibilities.)

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<sup>17</sup>Low-Earth orbit is an orbit around the Earth broadly defined as between 124 and 726 miles above the Earth's surface.

<sup>18</sup>National Aeronautics and Space Administration Authorization Act of 2005, Pub. L. No. 109-155 (Dec. 30, 2005).

**Figure 4: Federal Agencies' Roles and Responsibilities in the Commercial Space Launch Industry**

Agency	Description of Roles and Responsibilities
<b>Commerce</b> 	<ul style="list-style-type: none"> <li>• Promotes commercial investment in the industry and sales of U.S. goods and services internationally</li> <li>• Develops policies to improve the international competitiveness of the U.S. industry and advocates for the U.S. industry in international competitions</li> <li>• Is a customer for satellite and launch services</li> </ul>
<b>DHS</b> 	<ul style="list-style-type: none"> <li>• Responsible for security at spaceports</li> </ul>
<b>DOD</b> 	<ul style="list-style-type: none"> <li>• Provides infrastructure, operations support, and safety oversight at federal launch sites</li> <li>• Provides investment in launch vehicle design and development</li> <li>• Is a customer for satellite services and launches</li> </ul>
<b>FAA</b> 	<ul style="list-style-type: none"> <li>• Issues and monitors licenses for launches and reentries and for launch and reentry sites for the safety of the public and protection of property</li> <li>• Determines financial responsibility, including insurance requirements</li> <li>• Promotes the industry</li> </ul>
<b>NASA</b> 	<ul style="list-style-type: none"> <li>• Provides infrastructure and range support at its launch site at the Wallops Flight Facility</li> <li>• Provides tracking and telemetry support for commercial launches from NASA and DOD launch sites</li> <li>• Provides technical expertise to commercial launch companies on a cost-reimbursable or mutually beneficial basis</li> <li>• Leases rocket propulsion test facilities to commercial space launch companies</li> <li>• Provides business opportunities through prize competitions</li> <li>• Is a customer for launches</li> </ul>
<b>OSTP NSC</b> 	<ul style="list-style-type: none"> <li>• Develops and manages commercial space launch policymaking among federal agencies</li> </ul>
<b>State</b> 	<ul style="list-style-type: none"> <li>• Ensures that U.S. space policies are in accordance with U.S. foreign policy objectives and international commitments</li> <li>• Regulates export of space technology</li> </ul>
<b>USTR</b> 	<ul style="list-style-type: none"> <li>• Negotiates and monitors commercial space launch industry trade agreements</li> </ul>

Source: GAO analysis of agency information.

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## FAA Has Met Its Safety Performance Goal While Using a System Safety Process and Management Controls

FAA has met its safety performance goal of no fatalities, serious injuries, or significant property damage to the public; however, the Air Force's oversight of its launch sites has contributed to this achievement. FAA's oversight of launches includes the use of a system safety process in its licensing and monitoring process and incorporation of management controls, which we have reported to be effective means of providing safety oversight and program management.

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## FAA Has Met Its Safety Performance Goal of No Fatalities or Substantial Property Damage

FAA has met its annual performance goal to have no fatalities, serious injuries, or significant property damage to the public during licensed space launches and reentries since establishing this goal in 2003. Moreover, according to FAA, none of the 179 commercial launches that occurred between March 1989 and August 2006 resulted in casualties or substantial property damage. Of these 179 launches, FAA had joint oversight responsibility with other federal agencies for 152 (about 85 percent) and sole responsibility for 27 (about 15 percent) that included sea launches and the launches of SpaceShipOne from Mojave Spaceport. FAA shared responsibility with the Air Force for 132 launches at Air Force launch sites and with NASA, the Army, or foreign governments for 20 launches at NASA's Wallops Flight Facility in Virginia, the Army's White Sands Missile Range in New Mexico, and other facilities. Thus, the majority of commercial space launches during this period took place at Air Force launch sites where the Air Force had primary responsibility for safety oversight. We discuss later in this report the challenges that FAA faces in the future in assuming sole responsibility for launch safety oversight at spaceports.

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## FAA's Licensing Process Incorporates System Safety

FAA incorporates a system safety process in its oversight of commercial launches by requiring the launch company to use system safety in the development and operation of its vehicle and in applying system safety methodologies to calculate the risk posed by a launch. As we have reported, a system safety process is an effective evaluative method of identifying and mitigating risks.<sup>19</sup> Specifically, system safety relies on the application of technical and managerial skills to identify, analyze, and

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<sup>19</sup>GAO, *Aviation Safety: System Safety Approach Needs Further Integration into FAA's Oversight of Airlines*, GAO-05-726 (Washington, D.C.: Sept. 28, 2005).

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control hazards and risks. An objective of a system safety process is to identify hazard trends to spot and correct problems at their root cause before an incident occurs.

During the licensing process, the launch company is responsible for system safety by demonstrating that it has assessed all hazards and risks posed by its launch operations and has proposed how to mitigate them. The assessment is focused on safety critical systems, such as a vehicle's main structure, propulsion system, and flight safety systems, whose performance or reliability can affect public safety and the safety of property. Through the development of a system safety program plan, the launch company applicant demonstrates that the proposed vehicle design and operations satisfy regulatory requirements, and that the system is capable of performing safely during all flight phases, including launch and reentry. The plan provides a description of the strategy by which recognized and accepted safety standards and requirements, including organizational responsibilities, resources, methods of accomplishment, milestones, and levels of effort, are to be tailored and integrated with other system engineering functions. FAA consults with an applicant early in its launch vehicle development to help the applicant understand what must be included in the system safety program plan. In addition, FAA reviews the final system safety program plan as part of its safety review of the license application.<sup>20</sup>

Another way in which FAA incorporates system safety in its oversight of commercial launches is by conducting a risk analysis for each launch. FAA calculates, for each launch, the expected average number of casualties (deaths or serious injuries) to the public from debris hazards in the proposed flight path. This risk level—no more than 30 per million for the public and no more than 1 per million for an individual—is consistent with the launch standards used at federal launch sites. According to FAA, the risk to the public from commercial launches should not exceed “normal background risk”—that is, no greater risk than is voluntarily accepted in the course of normal day-to-day activities. For licensing launch-site operations, FAA performs a similar safety review that includes a risk analysis, which considers the site's proximity to populated areas and a review of security planned at the facility. The risk analysis is both site-specific and vehicle-specific, and FAA reviews the results on a case-by-

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<sup>20</sup>FAA's review of the license can also include a policy review, a payload review, a financial responsibility determination, and an environmental determination.

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case basis because of differences between launch sites and vehicle designs.

An expert on system safety confirmed our assessment that FAA has appropriately applied a system safety process to its launch license activities. In particular, the expert said that FAA has identified all of the safety systems that are critical to commercial space launches, made the proper assumptions of risk, and used proper validation methodologies. He also noted that FAA has used a higher factor of safety for commercial space launches than is commonly used in other industries, which is appropriate given that the space launch industry has a high-risk profile. However, the expert said that FAA should update its system safety handbook as the space tourism sector matures to incorporate different launch methods, such as launches from land, sea, and air, which may have different safety implications.

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## FAA Has Applied Management Controls in Its Licensing Process

FAA is applying relevant management controls in its licensing process. Management controls that we reviewed include the documentation of the review and approval of licenses, compliance with timely review requirements, communication with other federal agencies, and reliability and verification of data. According to our review of the 19 applications for launch and launch-site licenses that were active as of January 2006, FAA is applying these management controls.<sup>21</sup> FAA accurately documented the review and approval process and completed its reviews of license applications within 180 days, as required by the Commercial Space Launch Act. However, FAA starts counting the 180 days after deciding that an application is sufficiently complete. Our analysis showed that FAA communicated and consulted on an as-needed basis with other federal agencies that are members of an interagency advisory group on expendable launch vehicles, as required by an executive order<sup>22</sup> that designates DOT as lead agency within the federal government for commercial space launches. This communication includes coordinating with other federal agencies during the licensing process. Representatives

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<sup>21</sup>Even though the document had expired, we also reviewed the application for Scaled Composites' SpaceShipOne, which at that time was the only licensed reusable launch vehicle that had flown.

<sup>22</sup>Executive Order 12465, *Commercial Expendable Launch Vehicle Activities* (Feb. 24, 1984). The members of this advisory group include DOD, State, Commerce, the Federal Communications Commission, and NASA.

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from the majority of agencies serving on the group told us that FAA had periodically contacted them during its review of license applications. For example, agency representatives told us that FAA had checked with DOD on whether certain launches would negatively affect national security, and with State on whether launches were consistent with international treaties. In addition, our analysis showed that FAA verified the information in the applications for accuracy.

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## FAA Has Developed Regulations and Training to Respond to Emerging Issues

In response to changes in the commercial space launch industry, including the emerging issues of anticipated growth in space tourism, FAA issued regulations in 2000 for the licensing of launch and reentry of reusable launch vehicles. The regulations for reusable launch vehicles require launch operators to obtain a safety approval from FAA in order to receive a license.<sup>23</sup> In August 2006, FAA issued regulations that include safety requirements that applicants must meet to obtain a license for operations of expendable launch vehicles.<sup>24</sup> The 2006 regulations cover license requirements for any launch of a commercial expendable launch vehicle from any launch site, whether a federal launch site or a spaceport. However, some industry experts raised questions about the appropriateness of the regulations for operations at spaceports and also expressed concern about both existing and potential future safety requirements for reusable launch vehicles, which can vary widely in design and operation. In addition, FAA has developed training for its aerospace engineers to help prepare them to assume safety oversight responsibility at spaceports.

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## FAA Has Developed Safety Regulations for Launch Vehicles and Launch Sites

FAA's regulations for operations of launch vehicles and launch sites are based on common safety standards, which were developed jointly by FAA and the Air Force to harmonize the respective agencies' safety practices. (See app. IV for a timeline and list of FAA's commercial space launch rulemaking and guidance.) These safety standards cover vehicle design and operations and criteria for acceptable risks for launch and launch-site

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<sup>23</sup>Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing Regulations, Final Rule, 14 C.F.R. Parts 400, 401, 404, 405, 406, 413, 415, 431, 433, and 435; 65 Fed. Reg. 56618 (September 19, 2000).

<sup>24</sup>Licensing and Safety Requirements for Launch, Final Rule (to amend 14 C.F.R. Parts 413, 415, and 417); 71 Fed. Reg. 50508 (August 25, 2006).



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operations, such as the siting of hazardous materials.<sup>25</sup> The regulations build on those common standards with the goal of promoting consistent, streamlined safety reviews of launch operations.

However, concerns have been raised regarding the suitability of the 2006 regulations, which are based on the experience of expendable launch vehicles at federal launch sites, for launches at spaceports. Some industry experts that we interviewed noted that differences in spaceports from which vehicles are or will be launched raise questions about the appropriateness of the regulations. Additionally, while the 2006 regulations only apply to expendable launch vehicles, industry experts expressed concern about safety regulation of reusable launch vehicles, given the difference in the design of vehicles and the methods for launching them. FAA stated that it addresses these concerns by (1) making license determinations on a case-by-case basis using common performance standards and (2) providing waivers in special circumstances. Performance standards require launch companies to meet certain performance thresholds—a risk level, calculated by an expected casualty analysis, of no more than 30 per million for the public and 1 per million for an individual—while allowing these companies to develop their own specific launch vehicle design. FAA said that it uses performance standards to encourage innovation in vehicle design, rather than being prescriptive on how the vehicle should be designed. FAA said that its ability to issue waivers of license requirements for special circumstances allows it to assess the unique characteristics of a launch and its impact on safety. FAA, for example, granted a waiver at Mojave Spaceport that allowed for the storage and handling of liquid propellants closer to the runway—which would be used for a horizontal launch, such as SpaceShipOne—than would have been allowed for a vertical launch. Later in this report, we discuss the challenges that FAA faces in ensuring that its regulations are suitable for the emerging space tourism sector.

In addition, industry officials and one expert with whom we spoke raised concerns about the costs that expendable launch vehicle companies would incur to comply with the proposed regulations, because they believe that FAA's safety requirements at federal launch sites will be in addition to the Air Force's requirements. However, according to FAA, it has minimized these companies' costs by ensuring that its safety standards are the same

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<sup>25</sup>Under the regulations, the launch company has responsibility for flight and ground safety at spaceports.

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as the Air Force's, and that waivers issued by FAA or the Air Force are accepted by both agencies. FAA officials also noted that they have the authority to implement an option that they said could potentially reduce costs for both launch companies and the agency—namely, to issue a safety approval that is separate from a licensing determination. For example, they said that FAA could approve a component of a vehicle, such as a flight termination system, which could then be used for multiple licenses.<sup>26</sup> This approval could reduce uncertainty and costs for the vehicle manufacturer and save FAA the cost of evaluating the component for each license. As of August 2006, FAA had not made any such approvals.

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## FAA Has Developed Training to Respond to Space Tourism

FAA has developed training for its aerospace engineers that focuses on oversight duties and technical areas. According to FAA, the oversight training addresses evaluations of license and permit applications; safety inspections of launch, reentry, and site operations; and mishap investigations of launch and reentry vehicles. Technical training addresses system safety, flight safety analyses, and flight safety systems. The training is either provided in-house or obtained from commercially available sources and other government agencies. In addition, to help its aerospace engineers develop expertise that will be applicable to reusable launch vehicles, employees from FAA's Office of Commercial Space Transportation who are pilots and familiar with aircraft certification systems share their expertise with other staff. FAA also has sent its aerospace engineers to NASA and Air Force courses on launch and space flight operations, which include procedures for the launch and recovery of vehicles; FAA courses on avionics and aircraft operations, which are relevant because reusable launch vehicles have aircraft characteristics; and National Transportation Safety Board courses on aviation accident investigation, which includes procedures that would be useful in the event of a launch incident. While this training will help FAA to respond to current emerging issues, it will be important for FAA to keep abreast of industry changes and train their aerospace engineers accordingly.

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<sup>26</sup>A safety approval would allow the use of an approved launch vehicle, a safety system, a process, a service, or personnel, without requiring reexamination of fitness for a particular launch or reentry proposal subject to FAA licensing. Any safety system or service integral to launch or reentry operations is a possible candidate for a safety approval, as well as the entire vehicle and personnel who perform key safety functions.

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## FAA Faces Challenges in Fulfilling Its Responsibilities for Regulating the Emerging Space Tourism Sector

FAA faces multiple challenges in responding to the emergence of the space tourism sector. Those challenges include obtaining the expertise and resources needed to provide safety oversight of the sector, ensuring that its various regulations are suitable for the different launches and launch sites it licenses, determining the circumstances under which it would regulate passengers and crew, and ensuring that its industry promotion responsibilities do not conflict with its safety oversight responsibilities.

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## FAA Faces Human Resources and Workload Challenges in Addressing Its Responsibilities for Licensing Reusable Vehicles

If the space tourism industry develops as rapidly as some industry representatives suggest, FAA's responsibility for licensing reusable launch vehicles will greatly expand. However, FAA's experience in this area is limited because its launch safety oversight has focused primarily on unmanned orbital launches. From 1989 to 2005, FAA issued two reusable launch vehicle licenses that were mission-specific<sup>27</sup> and conducted compliance monitoring and safety inspections for five reusable launch vehicle missions. Although FAA gained some experience and expertise from these missions, some industry representatives and experts with whom we spoke questioned whether FAA is prepared for its expanded role and raised concerns about whether FAA has sufficient experience and expertise. Experts also indicated that FAA must stay ahead of the development of the reusable launch vehicle industry to fulfill its safety oversight responsibilities, because many companies are developing space hardware for the first time and are producing different designs that have not been tested. For example, a safety incident<sup>28</sup> occurred during a SpaceShipOne flight when the vehicle deviated from the launch trajectory and flew over a populated area. FAA evaluated this incident and required Scaled Composites, the developer of SpaceShipOne, to take corrective measures to continue its licensed flights. During its next flight, SpaceShipOne unexpectedly rolled 29 times, which FAA did not classify as

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<sup>27</sup>Launch vehicle licenses are granted for either specific missions or for all missions over a fixed period.

<sup>28</sup>FAA defines an incident as an unplanned event occurring during the flight of a launch vehicle involving a malfunction of a flight safety system or safety-critical system or a failure of the licensee's safety organization, design, or operations.

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an incident.<sup>29</sup> In addition, retaining staff expertise may also be a challenge, given federal funding constraints and competition within the industry for qualified aerospace engineers. We have reported on the challenges the aerospace industry faces in attracting, training, and retaining new workers with the engineering, science, and technical capabilities it needs, given recent trends in the decline of the future supply of such workers.<sup>30</sup> In FAA's case, two of the five aerospace engineers who worked on the licensing and monitoring of SpaceShipOne flights are no longer with the agency. However, FAA said that it has since filled these positions.

To help evaluate the safety of reusable vehicle launches, FAA's Office of Commercial Space Transportation has obtained expertise from outside firms and other FAA offices. For example, FAA contracted with a consulting firm to verify the expected casualty analysis involving SpaceShipOne's flights. In addition, because of certain similarities between reusable launch vehicles and aircraft, the Office of Commercial Space Transportation has consulted with FAA's Office of Aviation Safety. Both of these FAA offices, for example, worked on SpaceShipOne's license application and had a documented agreement that described how the offices would work together. However, according to Scaled Composites, confusion existed during the licensing process regarding the respective authorities of the FAA offices. For instance, Scaled Composites was required to have two authorizations—one for its vehicle and one for its launch operations. Initial vehicle flight tests to demonstrate “proof of concept” were conducted by the Office of Aviation Safety. Once Scaled Composites was ready to conduct launch operations, the Office of Aviation Safety transferred the vehicle review to the Office of Commercial Space Transportation, which reviewed the launch for licensing. According to an Office of Aviation Safety inspector, communication between the two offices, especially during the transfer stage of the review of SpaceShipOne, was not clear. In addition, an FAA engineer stated that distinctions between the two offices' respective authorities had to be made so that there was no overlap and disagreement between the offices. Since the licensing of SpaceShipOne, the Commercial Space Launch Amendments

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<sup>29</sup>FAA did not classify the unexpected rolls as a launch incident because the agency was listening to the transmission during the roll and concluded that the pilot was in command and control of the vehicle and the potential impact point of the vehicle was over an unpopulated area.

<sup>30</sup>GAO, *U.S. Aerospace Industry: Progress in Implementing Aerospace Commission Recommendations and Remaining Challenges*, GAO-06-920 (Washington, D.C.: Sept. 13, 2006).

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Act of 2004 clarified responsibility by stating that only one license would be required by DOT to approve commercial space launches, and this responsibility has been designated to the Office of Commercial Space Transportation. However, the two offices still need to coordinate on license reviews for operations of hybrid vehicles having both aircraft and rocket-like characteristics, according to officials in both offices. Nonetheless, no formal process exists between the two offices that outlines when and under what circumstances the offices should consult. While the documented agreement between the offices described how they would authorize flights of SpaceShipOne, this document is specific to those flights and is not generic for future reusable launch vehicle licenses.

FAA's safety oversight of the commercial space launch industry may be further challenged, in part, because of the expected increase in workload demands facing agency staff. FAA is anticipating a substantial increase in the number of permit and launch applications that could be submitted for reusable launch vehicle and launch-site operations in the near future, but FAA has not quantified the magnitude of applications. For example, FAA's annual industry forecast does not include projected reusable vehicle launches. FAA said that its anticipated increase in applications is based on preapplication consultations that FAA has conducted with reusable launch vehicle companies and spaceports. In addition, an FAA official noted that companies with existing reusable launch vehicle licenses are likely to apply for additional permits or licenses for the new vehicles they are developing. Furthermore, launch companies participating in NASA's Lunar Lander Challenge and Commercial Orbital Transportation Services demonstration program and Commerce's Geostationary Operational Environmental Satellite Program are required to obtain commercial launch permits or licenses from FAA.<sup>31</sup> FAA initially plans to be present for every licensed launch of a reusable vehicle. If FAA carries out this plan, its staff workload would increase, since the proposed spaceports for space tourism flights are located throughout the country and space tourism companies are planning frequent launches. FAA has not determined the

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<sup>31</sup>The objective of NASA's Lunar Lander Challenge, conducted under the auspice of the agency's Centennial Challenges Program, is to accelerate technology developments supporting the commercial creation of a vehicle capable of ferrying cargo or humans back and forth between lunar orbit and the surface of the moon. An objective of the Commercial Orbital Transportation Services demonstration program is to develop a transportation system that can carry cargo and eventually crew to the International Space Station. The purpose of the Geostationary Operational Environmental Satellite Program, which is a joint effort of NASA and the National Oceanic and Atmospheric Administration, is to help meteorologists observe and predict local severe weather events.

level of resources needed to meet this expected increase in responsibilities involving reusable launch vehicles. Agency officials said that they monitor the industry to assess how its development could impact resource requirements and will not make a budget request for additional resources until the workload has grown to justify the request. However, the agency has not conducted scenarios of different workload projections on the basis of increased space tourism launches.

### FAA Faces the Challenge of Ensuring That Its Various Regulations Are Suitable for Launches

FAA faces the challenge of ensuring that its 2006 regulations on licensing and safety requirements for launch, which are based on the Air Force's safety requirements for expendable launch vehicle operations at federal launch sites, will be suitable not only for operations at federal launch sites, but also for operations at spaceports. As we previously mentioned, industry representatives and experts are concerned that the safety regulations for reusable launch vehicles may not be suitable for space tourism flights because of differences in vehicle types and launch operations. Table 1 contains a comparison of some of the differences between expendable and reusable launch vehicles.

**Table 1: Comparison of Expendable and Reusable Launch Vehicles for Commercial Launches**

Expendable launch vehicle	Reusable launch vehicle
Vehicle not reused	All or part of vehicle reused
Flight may be terminated by destroying the vehicle	Flight may be terminated by landing the vehicle
Generally not piloted and not designed to carry passengers	Piloted or unpiloted and most are designed to carry passengers
Generally launched vertically or in the air	May be launched vertically, horizontally, or in the air
May be used for either orbital or suborbital flights	May be used for either orbital or suborbital flights
Proven safety records	Generally unproven safety records
Typically launched over unpopulated ocean areas	May be launched over partially populated areas
Primarily launched by established launch companies, such as Boeing, Lockheed Martin, and Orbital Sciences Corporation, at federal launch sites	Will be launched primarily by new launch companies at spaceports
Currently subject to Air Force and FAA safety requirements	Subject to FAA licensing regulations, which require safety approvals
Generally use liquid and solid rocket fuels	Generally use liquid rocket fuels
Not required to withstand the heat of reentry	Required to withstand the heat of reentry

Source: GAO analysis of comments from the Air Force, FAA, aerospace representatives, and experts.

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Three of the six operators of licensed spaceports and six of the eight operators of spaceports in the licensing process told us they did not believe that FAA's regulations should apply to the new spaceports. Five of these spaceport officials said that since reusable vehicles can be launched differently from expendable vehicles and can return to earth, the reusable vehicles present different safety implications.






In addition, concerns about the suitability of the safety regulations were raised by experts we interviewed and by comments filed in the public docket for these regulations. While it was noted that the regulations were appropriate to spaceports if the vehicles launching from them are using exotic or dangerous fuels, concerns were raised that the rules may be too stringent for the currently proposed and operating reusable launch vehicles. Although the safety regulations applicable to expendable launch vehicles are separate from the safety approvals required to obtain a reusable launch vehicle license, some experts are concerned about similarities in the safety rules. For example, two experts noted that the expected casualty analysis<sup>32</sup> that is the same for launches of expendable and reusable vehicles might be too high for reusable vehicles, given the vehicles' different safety implications. Experts also said that safety regulations should be customized for each spaceport to address the different safety issues raised by different orbital trajectories and the differences in the way that vehicles launch and return to Earth—whether vertically or horizontally. (See fig. 5 for examples of vertical federal launch sites and spaceports.) To address these concerns, experts have noted that it will be important to measure and track safety information and use it to determine if the regulations should be revised. For example, an expert noted that FAA should identify and track safety indicators for launch companies and spaceports and, as the industry matures, conduct trend analyses with the objective of eliminating negative situations representative in the trends. Another expert noted that any safety performance measure should account for different launch and trajectory tracks, such as over land or over water. Yet another expert noted that FAA's proposed regulations for experimental permits allow FAA to collect statistical data that could then be applied to develop safety standards criteria. FAA says that it collects data on anomalies and failures of safety-critical systems, which will allow it to analyze safety trends and determine potential precursors to accidents. However, the agency has not conducted

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<sup>32</sup>Acceptable Reusable Launch Vehicle Mission Risk, 14 C.F.R. 431.35; Flight Safety, 14 C.F.R. 417.107 (b).

trend analyses of that information. Other industry experts noted that the regulations should be revisited when the space tourism sector has further developed. Meanwhile, the Commercial Space Launch Amendments Act of 2004 requires DOT to commission an independent report to be issued to Congress and completed by December 2008. This report is to analyze whether expendable and reusable vehicles should be regulated differently from each other, and whether either of the vehicles should be regulated differently if carrying passengers. This report could provide FAA with information to address industry concerns about the suitability of its regulations to space tourism.

**Figure 5: Examples of Vertical Federal Launch Sites and Horizontal Spaceports**

Federal Launch Sites	Spaceports
 <p data-bbox="131 1360 358 1388">Vandenberg Air Force Base</p>  <p data-bbox="542 1360 708 1434">Delta IV launch pad Cape Canaveral Air Force Station</p>	 <p data-bbox="1024 1396 1179 1423">Mojave Spaceport</p>
 <p data-bbox="241 1745 516 1793">Atlas V launch pad Cape Canaveral Air Force Station</p>	 <p data-bbox="959 1745 1133 1772">Oklahoma Spaceport</p>

Sources: GAO and FAA.



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## FAA Faces the Challenge of Determining the Circumstances under Which It Would Regulate Crew and Flight Participant Safety on Space Tourism Flights before 2012

The Commercial Space Launch Amendments Act of 2004 requires that a phased approach be used in regulating commercial human space flight, and that regulatory standards evolve as the industry matures. The act prohibits FAA from regulating crew and space flight participant safety before 2012, except in response to incidents that either pose a high risk or result in serious or fatal injury. However, the act maintains FAA's authority over protecting the uninvolved public, and FAA stated that it has the authority to regulate crew and passenger safety to the extent that the public would be affected. According to FAA, it is only prohibited from issuing regulations that apply solely to crew and passenger safety, and any situation that implicates the public would allow FAA to regulate. FAA asserts that it has the authority to protect the crew because they are part of the flight safety system that protects the general public. FAA's proposed regulations for human space flight<sup>33</sup> would establish requirements for crew qualifications and training and space flight participant training and informed consent. Although these proposed regulations address passenger and crew behavior, FAA believes that the regulations are within its authority because they are intended to protect the public—not space flight participants. For example, the proposed regulations would require an operator to train each space flight participant before the flight on how to respond to emergency situations, including loss of cabin pressure, fire, smoke, and emergency egress. The proposed training requirement is aimed at protecting public safety, because if a space flight participant did not receive this training, he or she might interfere with the crew's ability to protect public safety.

The proposed regulations are not aimed solely at crew and passenger safety and, as a result, there have been instances in which FAA has not stepped in and imposed additional regulations or requirements for safety reasons because the public was not implicated. For example, Scaled Composites' SpaceShipOne rolled 29 times, and, according to FAA, it did not impose additional requirements because the flight was over a unpopulated area, and because FAA concluded that the pilot was in control of the vehicle. FAA monitored and reviewed the corrective actions taken by Scaled Composites prior to its next flight. Additionally, FAA has not developed specific criteria regarding when an incident would qualify as contributing to "an unplanned event or series of events...that pose a

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<sup>33</sup>Human Space Flight Requirements for Crew and Space Flight Participants; Proposed Rule to amend 14 C.F.R. parts 401, 431, 435, 440, 450, and 460; and 70 Fed. Reg. 77262.

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high risk of causing a serious or fatal injury” that would trigger FAA’s authority to issue regulations specific to crew and passenger safety.

Experts and industry representatives that we interviewed expressed different opinions about whether FAA should regulate crew and flight participant safety and, if so, when. Some industry representatives and experts we interviewed agreed that the Commercial Space Launch Amendments Act of 2004 provides the industry with the flexibility needed to innovate and grow. However, other experts said that there is too much flexibility in the act. One of these experts noted that FAA should publish the criteria that would cause it to regulate crew and flight participant safety before 2012. Another expert said that FAA’s having the discretion to decide when it would regulate crew and flight participant safety creates uncertainty for the industry, noting that without published criteria, the industry does not know how FAA would react to an incident involving a space tourism company, which could seriously hurt the industry. The designer of a reusable launch vehicle told us that FAA should regulate crew and flight participant safety for commercial space flight because he believes that space tourism needs to be as safe as commercial aviation.

Meanwhile, a trade association made up of space tourism companies and spaceports—called the Personal Spaceflight Federation—plans to commission standards for vehicles and their operation, including space flight participant safety, as the space tourism industry develops.<sup>34</sup> The federation believes that ensuring the highest-possible level of safety for the industry and sharing best practices will be essential to promote the safety and growth of the industry. The federation intends to commission an independent standards organization, such as the American Society for Testing and Materials, to develop accredited industry standards for voluntary testing and approval, much as Underwriters Laboratories, an independent organization that tests electrical devices, has done. According to an expert, while companies do not have to submit their products to Underwriters Laboratories for testing, market acceptance is low and liability exposure is high without the Underwriters Laboratories’ stamp of approval. The expert believes that a similar approach will work for space flight participants, who are more likely to choose to fly on a launch vehicle

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<sup>34</sup>Personal Spaceflight Federation members include AirLaunch, LLC; Armadillo Aerospace; Bigelow Aerospace; New Mexico Spaceport Authority; Mojave Spaceport; Oklahoma Spaceport; Rocketplane Kistler; Scaled Composites; SpaceDev; SpaceX; Space Adventures; Virgin Galactic; XCOR Aerospace; and X PRIZE Foundation.

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that has been approved according to industry standards than on one that has not been approved.

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### FAA's Dual Role of Promotion and Safety May Pose a Challenge

FAA faces the potential challenge of overseeing the safety of commercial space launches while promoting the industry as the space tourism sector develops. According to our analysis, FAA's current promotional activities have not conflicted with its safety regulatory role; however, industry experts have noted that potential challenges may arise as the space tourism sector develops. FAA is mandated to regulate the commercial space transportation industry to protect public safety and property while encouraging, facilitating, and promoting commercial space launches. According to FAA, its promotional activities include sponsoring an annual industry conference, sponsoring Commercial Space Transportation Advisory Committee meetings and work groups, presenting space-related topics at various aerospace professional association conferences, creating forums at which industry elements network, publishing economic impact studies and launch forecast reports, and conducting outreach to potential license applicants. These are all activities that experts say, and we agree, do not conflict with FAA's safety oversight responsibilities. According to some experts, FAA's promotional activities have not conflicted with the agency's role as a safety regulator because the activities do not involve advocacy for the industry, nor do they increase demand in the industry. Furthermore, experts noted that some of these activities promote FAA's safety role. For example, outreach to potential license applicants is a means of ensuring that new launch companies know about and adhere to federal safety regulations. Experts also noted that industry conferences are a means by which FAA can have a dialogue with industry to ascertain new industry trends and issues. FAA also has provided an estimated \$200,000 for Mojave Spaceport to complete its environmental impact study, which FAA deems a promotional activity. According to its statutory responsibility, FAA can take action to facilitate private sector involvement in spaceport infrastructure.

However, as the commercial space launch industry matures, there is a greater risk that FAA's role as both the regulator and a promoter of the industry may pose a conflict of interest. Experts told us, and we agree, that as the commercial space launch industry evolves, it may be necessary to separate FAA's regulatory and promotional activities. For example, one expert indicated that with the emergence of space tourism, FAA's dual role could pose a potential conflict of interest between creating an enabling business environment and not compromising safety with regard to the agency's determining when and if it would regulate crew and passenger



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safety on space launches. Other experts cited Congress's removal of FAA's promotional responsibilities for commercial aviation in 1996 as evidence of the importance of maintaining FAA's focus on safety oversight. In response to the ValuJet accident of May 11, 1996, the DOT Secretary asked Congress to restrict FAA's mandate to safety, eliminating its role in promoting the airline industry. According to the conference report that accompanied the legislative change, Congress withdrew FAA's promotional role in commercial aviation to address public perceptions that might exist that the promotion of air commerce by FAA could create a conflict with its safety regulatory mandate. Congress also has withdrawn promotional responsibilities from other transportation entities. In 1961, the Federal Maritime Board was dissolved and its promotion and safety responsibilities were transferred to Commerce and the Federal Maritime Commission, respectively. In proposing the legislative change, the President stated that this change was made to eliminate the intermingling of regulatory and promotional functions that had diluted responsibility and led to serious inadequacies, particularly in the administration of regulatory functions. Recognizing the potential conflict in the oversight of commercial space launches, Congress required DOT to report by December 2008, among other things, on whether the federal government should separate the promotion of human space flight from the regulation of such activity.

Furthermore, FAA's promotional role has the potential to overlap with that of Commerce's role—given the broad definition of FAA's statutory promotional responsibilities, the more detailed definition of Commerce's promotional responsibilities, and the efforts of Commerce to fully staff its Office of Space Commercialization. Commerce's International Trade Administration, which is responsible for promoting U.S. exports and competitiveness of U.S. companies in foreign markets, has remained fully staffed and provides assistance to the U.S. commercial space industry. However, the Office of Space Commercialization within NOAA did not have a permanent director from 1999 through January 2006 and had been staffed with one permanent employee who had been charged with work related to satellite services. In February 2006, a new director was appointed, and, as of June 2006, the office has been fully staffed. The Office of Space Commercialization is currently developing a strategic plan that is to be completed by the end of 2006. Some of FAA's promotional activities, such as publishing economic impact studies on the industry, have been undertaken due to past understaffing at Commerce, according to an FAA official. FAA has not revisited which promotional activities it should continue to undertake in light of these new developments at

Commerce. (Fig. 6 describes FAA’s and Commerce’s statutory promotional responsibilities.)

**Figure 6: FAA’s and Department of Commerce’s Statutory Promotional Responsibilities**

Agency	Statutory Promotional Responsibilities
<p><b>Commerce</b></p> 	<ul style="list-style-type: none"> <li>• Promote commercial provider investment in space activities by collecting, analyzing, and disseminating information on space markets and conducting workshops and seminars to increase awareness of commercial space opportunities.</li> <li>• Assist U.S. commercial providers in their efforts to conduct business with the U.S. government.</li> <li>• Act as an industry advocate within the executive branch to ensure that the federal government meets space-related requirements to the fullest extent feasible using commercially available space goods and services.</li> <li>• Ensure that the U.S. government does not compete with U.S. commercial providers in the provision of space hardware and services otherwise available from U.S. commercial providers.</li> <li>• Promote the export of space-related goods and services.</li> <li>• Participate in the development of U.S. policies and in negotiations with foreign countries to ensure free and fair trade internationally in the area of space commerce.</li> <li>• Seek the removal of legal, policy, and institutional impediments to space commerce.</li> </ul>
<p><b>FAA</b></p> 	<ul style="list-style-type: none"> <li>• Encourage, facilitate, and promote commercial space launches and reentries by the private sector, including those involving passengers.</li> <li>• Take actions to facilitate private sector involvement in commercial space transportation activity and to promote public-private partnerships involving the U.S. government, state governments, and the private sector to build, expand, modernize, or operate a space launch and reentry infrastructure.</li> </ul>

Source: GAO analysis of statutory authorities.

## To Help Address Key Competitive Issues Facing the Industry, the U.S. Government Has Played an Important Role

The U.S. commercial space launch industry faces key competitive issues concerning high launch costs and export controls. Space launches incur high costs for launch vehicle development and for launch facility operations and maintenance. The U.S. government has responded by providing support, such as launch contracts, the use of its launch facilities, and launch vehicle development infrastructure.

Some foreign competitors have historically offered lower launch prices than U.S. launch providers. During the rise of the commercial launch industry in Russia, Ukraine, and China in the 1980s and 1990s, bilateral

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agreements between these countries and the United States (1) limited the number of launches in those countries of commercial satellites containing U.S. licensed components and (2) imposed pricing restrictions. According to a Commerce official, the United States entered into these agreements because foreign countries were nonmarket economies and there was the potential to employ nonmarket-based practices or offer prices substantially below international market value. According to an USTR official, which negotiated these agreements, the agreements required the countries to price their commercial launch services “on a par” with Western companies, which allowed the nonmarket economies to evolve their industries while competing on a fair basis. These foreign governments were required to sign the agreements with the United States as a condition of launching U.S. satellites or of launching any satellites containing U.S. licensed parts. According to an USTR official, these agreements were intended to be transitional to allow time for U.S. competitors to adjust to the entry of new launch companies from nonmarket economies. The bilateral agreement with Ukraine was terminated in 2000, while agreements with Russia and China were allowed to expire in 2000 and 2001, respectively, because of the changing dynamics in the marketplace—including, for example, the emergence of international partnerships in the expendable launch vehicle industry.

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### U.S. Industry Formed International Partnerships in Response to Foreign Price Competition

The creation of international partnerships in the commercial space launch industry could allow expendable launch vehicle companies to offer commercial launches at lower prices. International Launch Services, formed in 1995, is an international partnership of Lockheed Martin and a Russian launch company that markets launches of the U.S. Atlas vehicle from Cape Canaveral and the Russian Proton vehicle from Baikonur in Kazakhstan. According to representatives from International Launch Services, between 1995 and 2005, the company contracted for 48 commercial launches from Cape Canaveral and Baikonur. Sea Launch, formed in 1995, is an international partnership between the Boeing Commercial Space Company and companies from Ukraine, Russia, and Norway that launches from a sea platform near the equator. Between 1999 and 2005, Sea Launch conducted 18 launches on a Ukrainian launch vehicle. Sea Launch has also partnered with Russia’s Space International Services to form Land Launch, which will offer launches on the same Ukrainian vehicle from Baikonur beginning in 2007.

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U.S. Government Supports the Industry through Launch Vehicle Development Contracts, Access to Infrastructure, Industry Competitions, and Indemnification

The United States, like foreign governments, supports its commercial launch industry in several ways. The U.S. government encourages federal agencies to acquire space transportation from U.S. commercial launch companies. Some of these companies have also received DOD funds to develop new launch vehicles that are intended to provide low-cost access to space for government purposes. Once developed, these vehicles could also be used for commercial purposes. For example, DOD's Evolved Expendable Launch Vehicle Program, a government-industry partnership whose objective is to lower the cost of medium-to-heavy lift vehicle launches, has led to the development of Lockheed Martin's Atlas V vehicle and Boeing's Delta IV vehicle. DOD has provided \$1.4 billion to the program as of fiscal year 2006, with an additional investment of \$4.6 billion provided by Lockheed Martin and Boeing. With the objective of reducing U.S. government launch costs, Lockheed Martin and Boeing have proposed a joint venture of their vehicle programs, called the United Launch Alliance, for which DOD gave conditional approval in January 2006 and for which the Federal Trade Commission gave conditional clearance in October 2006. In addition, DOD has funded small vehicle development.<sup>35</sup> For example, SpaceX, which has received DOD funding, has developed and is testing its Falcon I vehicle that will carry a small government payload and will launch from the Army's Ronald Reagan Ballistic Missile Test Site on Kwajalein Atoll in the Marshall Islands.<sup>36</sup> SpaceX then plans on launching a small commercial payload to low-Earth orbit from Kwajalein at an estimated cost of under \$7 million (in 2006 dollars).<sup>37</sup> This cost is in contrast to launch prices for small payloads averaging \$15 million, according to a report on space transportation costs.<sup>38</sup> Furthermore, whereas international competitors launch prices for medium-to-heavy

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<sup>35</sup>The Defense Advanced Research Projects Agency and Air Force's Falcon program provides funding with the goal of developing a low-cost small launch vehicle that will place small satellites into low-Earth orbit and provide a low-cost means of launching suborbital hypersonic technology vehicles.

<sup>36</sup>On March 25, 2006, Falcon I failed on its maiden launch. The failure is thought to have been due to a fuel leak.

<sup>37</sup>These costs are for launch vehicle development and do not include launch costs.

<sup>38</sup>Futron Corporation, *Space Transportation Costs: Trends in Price Per Pound to Orbit 1990-2000*, (Bethesda, Md.: Sept. 6, 2002). Estimated average launch prices are in 2000 dollars and are based on published data. Launch prices vary according to factors that include the weight of the payload and its intended orbit. Estimated average launch prices for small vehicles exclude the Russian Navy Shtil vehicle.

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payloads to geosynchronous transfer orbit<sup>39</sup> average \$56 million for medium and \$87.5 million for heavy payloads,<sup>40</sup> SpaceX plans to launch medium payloads on its Falcon 9 vehicle from \$27 million and heavy payloads from \$78 million. SpaceX said that it has reduced launch costs in a number of ways, including the simplification of vehicle design akin to Russian vehicles. Another example of new lower-cost vehicles that have been developed with DOD support is AirLaunch, LLC, which has developed a small lift vehicle that launches from the air from a military cargo aircraft and is intended to put a small payload into orbit for less than \$5 million.<sup>41</sup> A representative from AirLaunch said that it plans to use this technology in partnership with t/Space to develop a vehicle that will compete in NASA's Commercial Orbital Transportation Services demonstration program.<sup>42</sup>

The U.S. government also supports the industry by making infrastructure and support staff available at its launch sites. Air Force launch pads leased by launch companies may be used for government or commercial launches. The commercial launch company pays the Air Force the direct costs associated with its use of facilities and services for a commercial launch.<sup>43</sup> The Air Force is not reimbursed for indirect costs such as infrastructure improvements or base support that involves the use of Air Force active-duty personnel.<sup>44</sup> NASA provides launch vehicle development facilities, including rocket propulsion test stands, wind tunnels, and thermal vacuum chambers to vehicle developers. Other types of

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<sup>39</sup>Geosynchronous transfer orbit is the orbit used to transfer a payload from an initial low-Earth orbit to the final orbit. It is used to calculate costs because most launch vehicles place geostationary orbit-bound payloads in an intermediate transfer orbit from which the spacecraft maneuvers into geosynchronous orbit.

<sup>40</sup>Estimated average launch prices for large vehicles are from Futron (2002) and exclude NASA's space shuttle.

<sup>41</sup>Costs are for launch vehicle development only.

<sup>42</sup>In August 2006, NASA selected SpaceX and Rocketplane Kistler as finalists in the demonstration program.

<sup>43</sup>Launch companies expressed several concerns about the charges they have received from the Air Force. For example, some commercial launchers said that bills have not provided sufficient detail about the charges incurred, have not always been accurate, and have arrived years after services were rendered.

<sup>44</sup>A limited number of Air Force active-duty personnel may be used to support commercial space launches. The commercial customer could pay for extra civilian contractor positions but not for extra active-duty positions.



government support include prize competitions and indemnification. (See table 2.)

**Table 2: Examples of Federal Support to the Commercial Space Launch Industry**

Type of federal support	Example
Launch vehicle design and development	DOD's Evolved Expendable Launch Vehicle Program's objective is to lower the cost of launches and has led to the development of the medium-to-heavy lift Atlas V and Delta IV vehicles. DOD's Defense Advanced Research Projects Agency (DARPA) and Air Force Falcon Program's goal is to develop a low-cost small launch vehicle that can be rapidly deployed. NASA's Commercial Orbital Transportation Services demonstration program will provide \$500 million through 2009 to one or more developers who demonstrate and successfully launch a vehicle that can deliver cargo and crew to the International Space Station.
Infrastructure and support personnel	DOD facilities at Cape Canaveral, Vandenberg, and White Sands and NASA facilities at Wallops Island provide some infrastructure and personnel support. NASA also provides launch vehicle development facilities, such as rocket propulsion test stands, wind tunnels, and thermal vacuum chambers.
Prize competitions	NASA's Lunar Lander Challenge is designed to accelerate technology developments supporting the commercial creation of a vehicle capable of ferrying cargo or humans back and forth between lunar orbit and the surface of the moon. DARPA's Vertical Rocket Challenge is designed to accelerate technology developments supporting the commercial creation of vehicles capable of performing vertical takeoffs and vertical landings under rocket power. The combined prize money that could be awarded to one or more developers for these challenges is \$3 million.
Indemnification	The U.S. government may pay third-party liability claims in excess of required launch insurance, up to \$1.5 billion above the amount of the insurance. This catastrophic loss protection in the event of a commercial launch incident is known as indemnification. <sup>a</sup>

Source: GAO analysis of agency data.

<sup>a</sup>FAA has commissioned a study, which is expected to be published in the fall of 2006, that will propose alternatives to indemnification.

Demonstration programs, such as NASA's Commercial Orbital Transportation Services, have received positive feedback from launch vehicle developers, according to a NASA official. In addition, the official said that the agency's prize competitions, such as the Lunar Lander Challenge competition, have inspired many new launch vehicle companies to design vehicles using different launch approaches that could be used for human space flight. According to a launch company, the Commercial Orbital Transportation Services demonstration program allows for solicitations that encourage innovation and investment in the space industry by specifying an objective, such as carrying payloads to the International Space Station, rather than detailed requirements for a particular aircraft type.

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## States Are Offering Economic Incentives to Develop Spaceports for Space Tourism

States are offering economic incentives to develop spaceports to attract space tourism and provide economic benefits to localities. The New Mexico legislature approved \$100 million in February 2006 for construction of the Southwest Regional Spaceport in Upham, New Mexico. The spaceport is expected to be completed in 2008 or 2009, with three vertical launch pads; two runways; and service facilities for fuel service, payload processing, launch control, and mission control. Currently, the Southwest Regional Spaceport has 5 signed customers,<sup>45</sup> including Virgin Galactic, which plans to launch its initial commercial space flights from the spaceport and expects to fly 3,000 passengers within five years after commercial launches begin. According to an official from the Oklahoma spaceport, Oklahoma provides approximately \$500,000 annually to the spaceport for operations, and the state paid for the environmental impact statement and the safety analysis needed to apply for an FAA license. Existing infrastructure includes a 13,500-foot runway capable of accommodating the Space Shuttle, maintenance and repair hangars, and a rail spur. Furthermore, the Oklahoma spaceport has offered incentives valued at over \$128 million over 10 years to attract space companies. Rocketplane Kistler, which has developed a reusable vehicle, plans to launch from the Oklahoma spaceport starting in mid-2007.<sup>46</sup>

The Florida Space Authority, a state agency, has an arrangement with the Cape Canaveral Air Force Station to use a launch pad for expendable vehicle launches when excess capacity exists. The Florida Space Authority has invested over \$500 million in new space industry infrastructure development, including upgrades to the launch pad, a new space operations support complex, and a reusable launch vehicle support complex. Lockheed Martin's Athena and Atlas vehicles and Boeing's Delta vehicle launch from the spaceport. Although a launch site primarily for vertical launches, the Florida Space Authority is also considering the development of a commercial spaceport at a Florida airport to accommodate horizontally launched space tourism flights. The Mid-Atlantic Regional Spaceport, colocated at NASA's Wallops Flight Facility, owns two launch pads for expendable vehicle launches and has access to

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<sup>45</sup>Other customers include the X PRIZE Cup, Rocket Racing League, Starchaser Industries, and UP Aerospace.

<sup>46</sup>The Rocketplane Kistler vehicle is built on a Lear jet fuselage and launches horizontally. The company plans on flying passengers at \$200,000 per passenger. In 2006, Rocketplane Kistler signed a marketing agreement with Incredible Adventures to sell suborbital tourist flights.

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three runways. The spaceport receives half of its funding from Virginia and Maryland, with the remainder coming from revenue from operations. According to the spaceport's executive director, the spaceport will compete for Commercial Orbital Transportation Services demonstration program launches. The Mojave Spaceport in Mojave, California, is owned and operated by the East Kern Airport District and consists of three runways with associated taxiways and other support facilities. With an FAA Airport Improvement Program grant of \$7.5 million, one of these runways will be extended to allow for the reentry of horizontally landing reusable vehicles.<sup>47</sup> The spaceport also received FAA financial support to conduct its environmental assessment. Scaled Composites, XCOR Aerospace, and Interorbital Systems—companies that plan to enter the space tourism business—are tenants at the airport.<sup>48</sup> Officials from spaceports told us the competition among the spaceports is positive. One licensed spaceport official mentioned that because each spaceport will attract a market unique to its launch capability; this competition will help the overall industry to grow.

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## Industry Raised Concerns about Export Controls

Industry representatives that we interviewed identified export licensing requirements under the International Traffic in Arms Regulations as a competitive issue facing the U.S. space launch industry. The regulations establish controls to ensure that arms exports are consistent with national security and foreign policy interests. Launch vehicles are included on State's munitions list that is part of these regulations because these vehicles can deliver chemical, biological, and nuclear weapons. In the 1990s, U.S. space technology was divulged to a foreign country, which led to improvements of the reliability of its ballistic missiles that could be used against the United States. Industry representatives said that they would like fewer items to be regulated or a streamlined process for obtaining authorization to export launch vehicles. While we have not examined the issue of which specific items should be subject to export

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<sup>47</sup>FAA's Airport Improvement Program allocates grants to airports that are part of the National Plan of Integrated Airport Systems. Mojave Spaceport is classified as a general aviation airport and, thus, is eligible to apply for and receive Airport Improvement Program grants.

<sup>48</sup>XCOR is developing the Xerus vehicle, which could be used for space tourism as well as the launching of small satellites to orbit. Interorbital Systems is designing the Neptune launch vehicle, which would launch from the surface of the ocean.

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controls, we have examined the export control system and have recommended ways to improve its overall efficiency.<sup>49</sup>

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## Conclusions

As the commercial space launch industry expands to include the transportation of humans as well as satellites and other payloads into space and the use of inland as well as coastal launch sites, FAA's safety oversight responsibilities will grow. To carry out these responsibilities and address the serious safety implications of the industry's expansion for people both on the ground and in the launch vehicles, FAA will need sufficient expertise, either in-house or available from an impartial source, to evaluate a range of highly complex launch technologies. Such expertise may be difficult for FAA to obtain and maintain, given federal funding constraints and competition from the industry for qualified aerospace engineers. While FAA's decision not to request additional safety oversight resources until the space tourism industry materializes is prudent in light of the industry's uncertain pace of development, FAA also needs to be prepared to provide competent safety oversight if and when its workload increases in order to continue to provide timely license approvals and monitoring.

Experience has not yet shown whether FAA's regulations will be appropriate for the space tourism industry, given the differences in the operations of launch vehicles and the launch sites used to transport humans and payloads into space. FAA's plan to address these differences through case-by-case evaluations of individual launch license applications is reasonable for an emerging industry with a wide variety of products. A DOT commissioned report to be issued to Congress and completed by December 2008, which will analyze whether expendable and reusable launch vehicles should be regulated differently from each other, could provide FAA with information about the suitability of its regulations to space tourism.

FAA is prohibited from regulating crew and passenger safety before 2012, except in response to incidents that either pose a high risk or result in serious or fatal injury. FAA has interpreted this limited authority to allow it to regulate crew safety in certain circumstances and has been proactive in proposing regulations concerning emergency training for crews and passengers. However, FAA has not developed safety indicators by which it

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<sup>49</sup>GAO-05-468R and GAO-02-203.

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would monitor the developing space tourism sector and determine when to step in and regulate human space flight.

Because FAA is a regulatory agency, it is important that its statutory responsibility to promote the commercial space launch industry not interfere with its safety oversight of the industry. We have no evidence that FAA's promotional activities have conflicted thus far with its safety regulatory role, but conflicts could occur as the industry matures. For example, such conflicts may have occurred or appeared to occur when FAA was responsible for promoting as well as regulating the airline industry. Recognizing the potential conflict in the oversight of commercial space launches, Congress required DOT to report by December 2008 on whether the federal government should separate the promotion of human space flight from the regulation of such activity. Furthermore, Commerce now has the staff resources to promote the commercial space industry, possibly eliminating the need for FAA to play a promotional role.

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## Matter for Congressional Consideration

If DOT's 2008 commissioned report on the dual safety and promotion roles does not fully address the potential for a conflict of interest, Congress should revisit the granting of FAA's dual mandate for safety and promotion and decide whether the elimination of FAA's promotional role is necessary to alleviate the potential conflict.

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## Recommendations for Executive Action

To prepare for a possible major expansion in its safety oversight responsibilities resulting from the emergence of the space tourism industry and spaceports, we recommend that the Secretary of Transportation direct the FAA Administrator to implement the following three recommendations:

- As part of its strategic planning effort, FAA needs to assess the level of expertise and resources that will be needed to oversee the safety of the space tourism industry and the new spaceports under various scenarios and timetables. In addition, the Office of Commercial Space Transportation should develop a formal process for consulting with the Office of Aviation Safety about licensing reusable launch vehicles. The process should include the criteria under which the consultation takes place.
- To allow the agency to be proactive about safety, rather than responding only after a fatality or serious incident occurs, FAA should identify and continually monitor space tourism industry safety indicators that might

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trigger the need to regulate crew and flight participant safety before 2012. As part of this effort, FAA should develop and issue guidance on the circumstances under which it would regulate crew and flight participant safety before 2012.

- As long as FAA has a promotional role, it should work with the Department of Commerce to develop a memorandum of understanding that clearly delineates the two agencies' respective promotional roles in line with their statutory obligations and larger agency missions. This memorandum of understanding should reflect Commerce's role as an advocate of the industry, with the objective of increasing U.S. competitiveness and FAA's focus on providing a safe environment in which the emerging space tourism sector could operate.

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## Agency Comments and Our Evaluation

We provided a draft of the report to Commerce, DHS, DOD, DOT, NASA, OSTP, State, and USTR. Commerce and NASA provided written comments (see apps. V and VI). State, DOD, and DHS had no comments. The four agencies that provided comments generally agreed with the findings presented in the report and FAA (within DOT) and Commerce agreed with the report's recommendations. FAA, Commerce, OSTP, and USTR provided technical corrections, which we incorporated as appropriate.

In response to the draft report's discussion of resource challenges, FAA stated that it monitors commercial space launch developments to assess the impact on agency resources, and that it will request additional resources when they can be justified through the annual budget process. We agreed that FAA assesses resource requirements annually and added this information to the report; however, we have not seen evidence that it does so on a longer-term, strategic basis. In response to the draft report's discussion of the suitability of FAA's expendable launch vehicle regulations for reusable launch vehicles, FAA explained that the regulation is not intended to apply to reusable vehicles. We agreed with this comment and revised the draft to indicate the specific reusable launch vehicle regulation to which we were referring. Commerce agreed with our recommendation concerning the need for a memorandum of understanding between it and DOT that clearly delineates the two agencies' respective promotional roles. In addition, Commerce pointed out that the draft report did not reflect the industry advocacy role played by its International Trade Administration. We agreed and added that information to the report. OSTP stated that the report should include more discussion of competition challenges facing the industry. Although we agree that such challenges are important and addressed some competitive issues, such as

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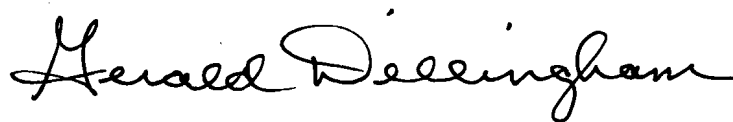
foreign price competition, a larger study of these issues was beyond the scope of the report. Finally, NASA noted that the draft report did not reflect the infrastructure support, such as wind tunnels and rocket propulsion test stands, that it provides to the commercial space launch industry. We agreed that this information should be included and modified the text accordingly.

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As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution of this report until 5 days after the date of this letter. At that time, we will send copies of this report to interested congressional committees, the Secretary of Transportation, the Administrator of FAA, the Secretary of Defense, the Secretary of Commerce, the Secretary of State, the Administrator of the National Aeronautics and Space Administration, the Secretary of Homeland Security, the Assistant Secretary of Homeland Security for the Transportation Security Administration, the Director of the White House Office of Science and Technology Policy, and the Assistant U.S. Trade Representative for Policy Coordination. We will also make copies available to others upon request. In addition, the report will be available at no cost on GAO's Web site at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me on (202) 512-2834 or at [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 major contributions to this report are listed in appendix VII.

Sincerely yours,



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

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# Appendix I: Objective, Scope, and Methodology

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Our objective was to assess the federal role regarding commercial space launches and the government's response to emerging industry trends both—domestically and internationally. To accomplish this, we addressed the following questions: (1) how well does the Federal Aviation Administration (FAA) oversee the safety of commercial space launches? (2) To what extent is FAA responding to key emerging issues in the commercial space launch industry? (3) What challenges does FAA face in regulating and promoting the commercial space launch industry? and (4) What are the key competitive issues affecting the U.S. commercial space launch industry, and to what extent are the industry and government responding to them?

For background information on the commercial space launch industry, we reviewed reports prepared by the Congressional Research Service, FAA, the Department of Commerce (Commerce), and other sources to determine the composition of the industry and its role in the economy. We also obtained data on historical commercial launch activity worldwide, including the number of commercial space launches conducted, by country, from 1997 through 2005; the types of vehicles used; and the types of payloads launched. We did not independently verify this information because it was used for background purposes only. In addition, we identified the commercial launch infrastructure in the United States and observed the commercial launch facilities at Cape Canaveral Air Force Station and Vandenberg Air Force Base, which are the two main federal launch facilities. We also determined the roles and responsibilities of various federal agencies involved in commercial space launch activities by reviewing their respective statutory authorities and interviewing agency officials. These included officials from FAA, Commerce, the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of State, the Department of Homeland Security, the Office of the United States Trade Representative, and the Office of Science and Technology Policy.

To determine how well FAA has overseen the safety of commercial space launches to date and to what extent it is responding to key emerging issues in the commercial space launch industry, we reviewed FAA's safety oversight processes, identified key emerging issues in the commercial space launch industry, and reviewed FAA's response to those issues. We reviewed FAA's safety oversight process by interviewing agency officials about their safety oversight activities and reviewed documentation on FAA's licensing and safety monitoring processes, including internal guidance and policies, applicable regulations, and memorandums of agreement with other federal agencies. Because FAA shares responsibility



with the Department of the Air Force to conduct safety oversight at the Air Force's launch sites, we interviewed FAA and Air Force officials at Cape Canaveral Air Force Station and Vandenberg Air Force Base about their interaction and respective responsibilities, and reviewed Air Force launch safety requirements. We also interviewed representatives from eight commercial space launch companies that had received launch licenses from FAA and six launch companies that were consulting with FAA about obtaining licenses as of September 2005 about FAA's licensing process. We also interviewed an official heading a working group on reusable launch vehicles from the Commercial Space Transportation Advisory Committee, which is an industry group that provides advice to FAA on commercial launch issues. This official is also a key principal of the Personal Spaceflight Federation, which is an industry group. When we found that some companies were offering to sell tickets for flights into space, we also interviewed two firms that were selling such tickets or were planning to sell them about their services and related safety issues. In addition, because security is a component of safety, we interviewed officials from the Transportation Security Administration about its future role in securing new spaceports.

To further assess how well FAA has overseen the safety of commercial space launches and because FAA conducts its safety oversight largely through its licensing process, we reviewed its application files for the licenses that were in effect in January 2006, which consisted of 13 launch licenses and five launch-site licenses. In addition, although its license was no longer in effect at the time of our review, we reviewed the application file for Scaled Composites' launch of SpaceShipOne because the company had received the first license from FAA for a reusable vehicle. We reviewed these application files to determine the types of FAA safety issues that the agency examined and how it conducted those examinations. Because we were evaluating the management of a government program, we examined (1) how FAA applied certain management controls in its license approval process using our guidelines for management controls at federal agencies and (2) whether FAA met the 180-day review criteria established by the 1984 Commercial Space Launch Act.<sup>1</sup> The management controls included documentation of the review process, effective communication, reliability and verification of data,

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<sup>1</sup>GAO, *Internal Control Management and Evaluation Tool*, GAO-01-1008G (Washington, D.C.: August 2001); *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1 (Washington, D.C.: November 1999); and the Commercial Space Launch Act, Pub. L. No. 98-575 (Oct. 30, 1984).

supervisory review, and documentation of the approval process, which we determined from consulting *Standards for Internal Control in the Federal Government* for the elements needed for effective management of the licensing approval process. Furthermore, we assessed the extent to which FAA interacted with other federal agencies participating in an interagency advisory group on expendable vehicles, which was part of the application review process in some cases, by interviewing the interagency group members about their interaction with FAA on commercial launch issues. In addition, we reviewed FAA's safety monitoring process by examining its most recent compliance-monitoring reports that corresponded to the licenses that were in effect as of January 2006,<sup>2</sup> as well as enforcement actions taken against commercial launch companies for noncompliance with safety issues. Moreover, to obtain an independent perspective on how well FAA has conducted launch safety oversight and responded to key emerging issues, we interviewed 11 experts from academia and industry that we selected with the assistance of the National Academy of Sciences. (See table 3 for a list of these experts.)

**Table 3: Experts Providing Input on GAO's Review**

<b>Expert</b>	<b>Organization</b>
Robert Crippen, President, retired	Thiokol Propulsion Group
Donald Cromer, Lt. General and President, retired	United States Air Force and Hughes Space and Communications Company
Henry Hertzfeld, JD, Ph.D., Research Professor	The Space Policy Institute, Elliot School of International Affairs, George Washington University
Michael S. Kelly, Vice President, Operations	X PRIZE Cup
Christopher Kunstadter, Vice President	XL Insurance
Molly Macauley, Ph.D., Senior Fellow	Resources for the Future, Inc.
James A. M. Muncy, Principal	PoliSpace
Elon Musk, CEO and CTO	SpaceX
Eligar Sadeh, Ph.D., Assistant Professor of Space Studies	School of Aerospace Sciences, Department of Space Studies, University of North Dakota
J.R. Thompson, Vice Chairman, President and Chief Operating Officer	Orbital Sciences Corporation

Source: GAO.

Note: One expert asked to remain anonymous.

<sup>2</sup>In some cases, launch activity had not yet occurred after the licenses were issued; therefore, monitoring reports had not yet been prepared.

We identified key emerging issues through literature reviews and interviews with agency officials and industry representatives, including associations representing the commercial space launch industry and entities that had received launch or launch-site licenses from FAA or were consulting with FAA about receiving such licenses as of September 2005. To assess the extent to which FAA has responded to emerging issues in the commercial space launch industry, we interviewed federal government officials, including FAA officials and representatives from federal launch sites and FAA-licensed and proposed spaceports, launch companies, industry experts, and trade associations to obtain their views. See table 4 for a list of the organizations that we interviewed.

**Table 4: List of Organizations That GAO Interviewed**

<b>Industry category</b>	<b>Organization interviewed</b>
Federal launch sites <sup>a</sup>	Cape Canaveral Air Force Station Ronald Reagan Ballistic Missile Test Site Vandenberg Air Force Base
Industry associations	Aerospace Industry Association American Institute of Aeronautics and Astronautics Satellite Industry Association Space Frontier Foundation Space Transportation Association
Launch companies	Arianespace Armadillo Aerospace ATK Thiokol, Inc. Blue Origin, LLC Boeing Launch Services Boeing Launch Services, Cape Canaveral Air Force Station Interorbital Systems Kistler Aerospace <sup>b</sup> Lockheed Martin Corporation, Cape Canaveral Air Force Station Rocketplane Limited, LLC <sup>b</sup> Scaled Composites, LLC Sea Launch Company, LLC SpaceX Sprague Astronautics, Inc. XCOR Aerospace

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

<b>Industry category</b>	<b>Organization interviewed</b>
Spaceports	Alaska Aerospace Development Authority California Spaceport, Spaceport Systems International Florida Space Authority Mid-Atlantic Regional Spaceport Mojave Spaceport Oklahoma Space Industry Development Agency
Spaceports (proposed)	Blue Origin, LLC Nevada Test Site Development Corporation <sup>c</sup> New Mexico Office for Space Commercialization Office of the Governor, Aerospace and Aviation/Gulf Coast Regional Spaceport, Texas Office of the Governor, Aerospace and Aviation/South Texas Spaceport Office of the Governor, Aerospace and Aviation/West Texas Spaceport Spaceport Alabama Spaceport Washington Wisconsin Spaceport
Space tourism operators	Space Adventures Virgin Galactic
Miscellaneous	Aerospace Corporation California Space Authority RAND Corporation

Source: GAO.

<sup>a</sup>We did not interview two federal launch sites—White Sands Missile Range and Wallops Flight Facility—because they have had no commercial launches since 2000.

<sup>b</sup>In February 2006, Rocketplane and Kistler Aerospace joined to form Rocketplane Kistler.

<sup>c</sup>As of March 2006, the Nevada Test Site Development Corporation told us that it was no longer considering developing a spaceport.

We also reviewed the proposed and issued regulations relating to commercial space launches and comments published in the Federal Register on those regulations to assess how the agency had responded to the emerging issues.

To determine the challenges that FAA faces in responding to emerging issues in the commercial space launch industry, we interviewed FAA officials, industry representatives, industry experts, and trade associations to obtain their views on how FAA would need to respond and the level of expertise and resources that would be required. This included considering the challenges that FAA may face in complying with requirements contained in both proposed regulations and under existing law to provide

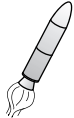



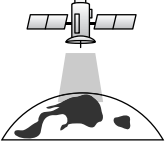

safety oversight over a new industry sector involving reusable launch vehicles.

To determine the key competitive issues affecting the U.S commercial space launch industry and the extent to which the industry and federal government are responding to them, we conducted a literature review that included applicable laws affecting industry competitiveness and interviewed FAA officials, industry representatives, industry experts, and trade associations to obtain their views. This included interviewing officials from the Office of the U.S. Trade Representative about the U.S. government's past use of bilateral treaties with foreign governments regarding the commercial space market and from the Commercial Space Transportation Advisory Committee, which is an industry group that provides advice to FAA on commercial launch issues, about industry concerns regarding insurance and liability matters. We also interviewed U.S. commercial space launch companies, including U.S. partners in international partnerships. In addition, to obtain the perspective of a foreign commercial launch company on international competitive issues, we interviewed an official from Arianespace, which is a French commercial space launch company. To obtain the perspective of a domestic commercial launch company, we interviewed SpaceX. We also reviewed regulations affecting the competitiveness of the commercial space launch industry, such as the International Traffic in Arms Regulations, and reports on competitive issues prepared by the Congressional Research Service, FAA, Commerce, Futron, and others. We attempted to compare the extent to which countries were providing financial assistance to their commercial space launch industries, but we were unable to obtain transparent and quantifiable data. We conducted our review from August 2005 through October 2006 in accordance with generally accepted government auditing standards.

# Appendix II: Economic Impact of the Commercial Space Industry

The commercial space transportation industry as a whole represents a significant sector of the U.S. economy. The industry consists of the commercial launch industry as well as the industries that commercial space enables, such as satellite manufacturing and services, ground equipment manufacturing, remote sensing, distribution industries, and launch vehicle manufacturing and services (see fig. 7).

**Figure 7: Commercial Space-Related Industries**

Industry Sector	Description
<b>Launch vehicle manufacturing and services</b> 	Includes the construction of U.S. commercial launch vehicles and the provision of U.S. commercial launch services.
<b>Satellite manufacturing</b> 	Includes the sale of all commercial satellites constructed by U.S. satellite manufacturers.
<b>Ground equipment manufacturing</b> 	Includes satellite-related hardware, such as gateways and satellite control stations; mobile uplink equipment; very small aperture (VSAT) terminals; and consumer electronics used with satellite services, such as direct broadcast satellite dishes, telephone booths, and handheld telephones.
<b>Satellite services</b> 	Includes both end-user services and transponder leasing. End-user services include satellite telephony, VSAT services, satellite data services, and direct-to-home television. Satellite data services include mobile data services, such as asset tracking and high-speed internet services. Transponder leasing includes services offered by companies that operate satellites and lease or sell satellite transponder capacity on a full-time or occasional-use basis.
<b>Remote sensing</b> 	Includes the provision of raw satellite data and satellite imagery services. It does not account for sales by firms that digitally process imagery and combine it with additional information to create maps, databases, or other value-added products.
<b>Distribution industries</b> 	Represent wholesale and retail trade margins and transit costs incurred as components are moved to manufacturing sites. Distribution industries are considered an additional enabled industry of commercial space transportation because truck, air, and rail transportation services are required to move parts to the manufacturing sites and to move launch vehicles and satellites to launch sites.

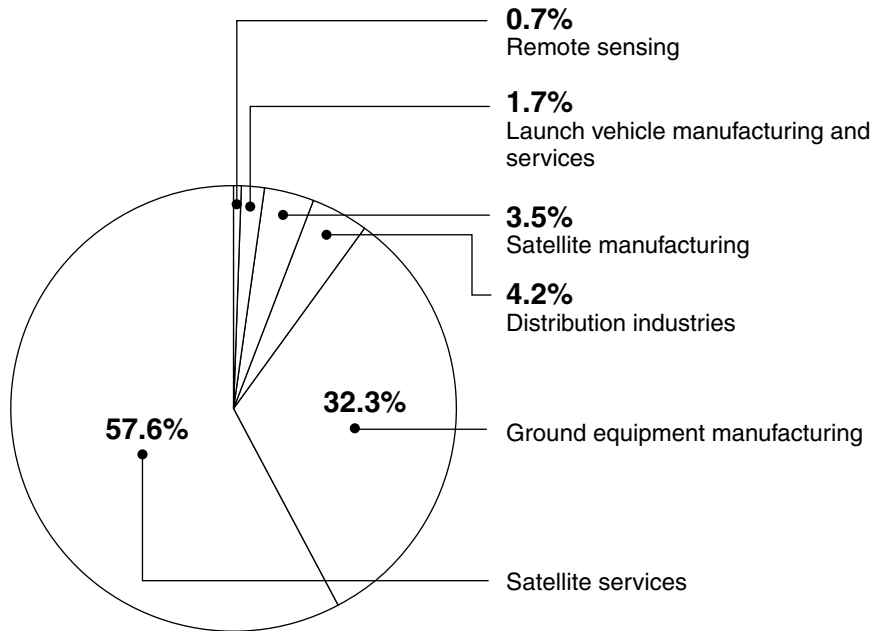
Source: FAA.

According to FAA, the commercial space transportation and enabled industries were responsible for approximately 550,000 total jobs and \$98 billion in economic activity<sup>1</sup> in the United States in 2004, with the satellite services industry, such as direct-to-home television services, having the largest economic activity impact (see fig. 8). Of this, launch vehicle manufacturing and services had \$1.7 billion in economic impact.

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<sup>1</sup>Each measure of economic impact comprises three components—direct impacts, indirect impacts, and induced impacts. Direct impacts are the expenditures on inputs and labor involved in the provision of any final goods or services relating to the industries analyzed; indirect impacts involve the purchases made by and labor supplied by the industries that provide inputs to the launch and enabled industries; and induced impacts are the successive rounds of increased household spending that result from the direct and indirect impacts (e.g., a launch vehicle engineer’s increased spending on household goods and services).

**Figure 8: Distribution of Economic Activity Impacts Resulting from Commercial Space Transportation and Enabled Industries, 2004**



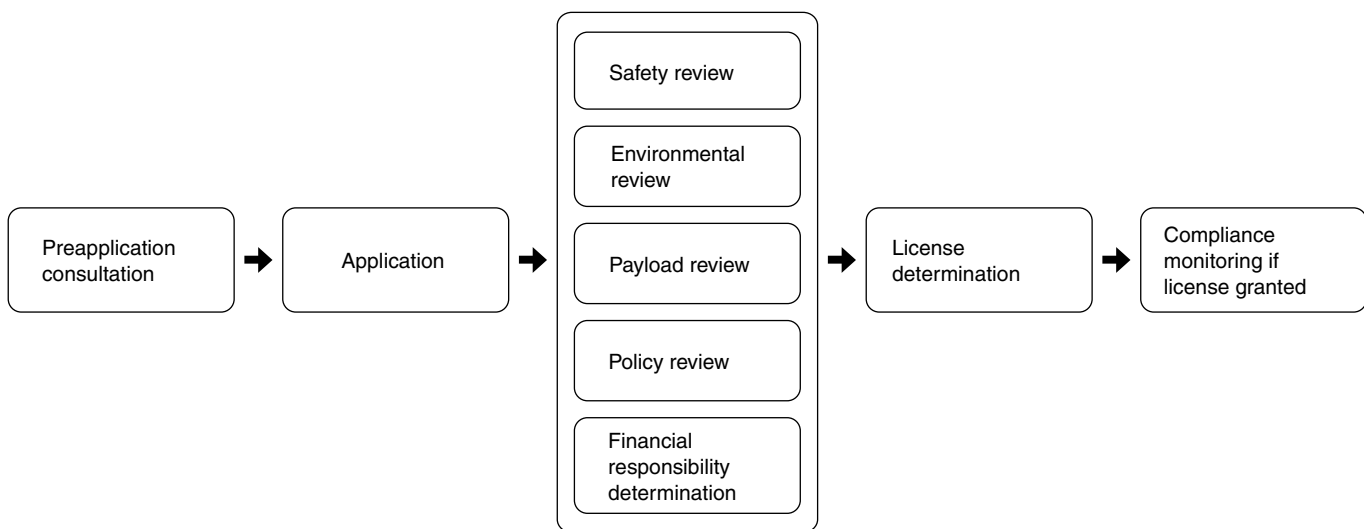
Source: GAO analysis of FAA data.



# Appendix III: FAA's Launch and Reentry Licensing Process

FAA evaluates applications for launch licenses by reviewing the safety, environmental, payload, and policy implications of a launch and determining the launch company's insurance liability or financial responsibility. Figure 9 illustrates this process.

**Figure 9: FAA's Launch Licensing Process**



Source: GAO presentation of FAA information.

FAA's safety review includes an analysis of the reliability and functions of the vehicle, an assessment of the risk and hazards it poses to public property and individuals, and a review of the launch company's policies and practices to demonstrate that the operations "pose no unacceptable threat to the public."<sup>1</sup> FAA conducts environmental reviews to fulfill its obligations under the National Environmental Policy Act,<sup>2</sup> and FAA

<sup>1</sup>FAA's safety review of a license includes the review of data provided by the license applicant on the proposed flight path of the launch vehicle and a determination of its potential risk to the noninvolved public and property. Federal launch sites conduct their own risk analysis, which FAA reviews.

<sup>2</sup>The issuance of a license is considered to be a major federal action defined under the National Environment Policy Act, 42 U.S.C. 4332. Therefore, a license applicant must comply with requirements stated in the National Environment Policy Act, the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environment Policy Act, 40 C.F.R. parts 1500-1508, and the FAA's Procedures for Considering Environmental Impacts, FAA Order 1050.1D.

ensures that proposed commercial space transportation activities present “no unacceptable danger to the natural environment.” In addition, FAA reviews a proposed payload to determine whether its launch or reentry would jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States. During the policy review, FAA consults with other federal agencies to determine whether the launch license presents any issues affecting U.S. national security, foreign policy, or international obligations. FAA also determines the amount of liability insurance<sup>3</sup> required to compensate third-parties for activities carried out under a license, up to a maximum of \$500 million or the maximum liability insurance available on the world market at a reasonable cost as determined by FAA.<sup>4</sup> FAA also sets insurance requirements for U.S. government range property on the basis of its determination of the maximum probable loss that would result from licensed launch or reentry activities, not to exceed the lesser of \$100 million or the maximum available on the world market at reasonable cost.

FAA's launch-site safety requirements are similar to those for launches of vehicles. FAA reviews a launch-site's application for environmental, policy, operations, and safety considerations that include the location of the spaceport and its siting of explosives. Applicants also are required to address how they will control public access to their sites, which would include the use of security personnel, surveillance systems, physical barriers, or other means approved during the licensing process.

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<sup>3</sup>Under the 2004 Commercial Space Launch Amendments Act, license holders must provide liability insurance to cover their licensed activities. The calculation of the amount of insurance required is based on a maximum probable loss determination, which is an assessment of the maximum monetary losses likely to be incurred by government and third-party personnel and property in the event of a mishap.

<sup>4</sup>This liability insurance is separate from indemnification that FAA provides for commercial launches.

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# Appendix IV: Timeline and List of FAA Commercial Space Launch Rulemaking and Guidance

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August 25, 2006	Licensing and Safety Requirements for Launch; <i>Final Rule</i> (to amend 14 C.F.R. parts 413, 415, 417). 71 Fed. Reg. 50508.
March 31, 2006	Experimental Permits for Reusable Suborbital Rockets; <i>Notice of Proposed Rulemaking</i> (to amend 14 C.F.R. parts 401, 404, 405, 406, 413, 420, 431, 437). 71 Fed. Reg. 16251.
December 29, 2005	Human Space Flight Requirements for Crew and Space Flight Participants; <i>Proposed Rule</i> (to amend 14 C.F.R. parts 401, 431, 435, 440, 450, 460). 70 Fed. Reg. 77262.
July 20, 2005	Reusable Launch and Reentry Vehicle System Safety Process, AC 431.35-2A; <i>Advisory Circular</i> .
June 1, 2005	Safety Approvals; <i>Proposed Rule</i> (to amend 14 C.F.R. part 414). 70 Fed. Reg. 32912.
May 19, 2005	Miscellaneous Changes to Commercial Space Transportation Regulations; <i>Proposed Rule</i> (to amend 14 C.F.R. parts 401, 404, 413, 415, 420). 70 Fed. Reg. 29164.
March 1, 2005	Licensing and Safety Requirements for Launch; <i>Availability of Draft Regulatory Language and Notice of Public Meeting</i> (to amend 14 C.F.R. parts 415, 417). 70 Fed. Reg. 9885.
October 20, 2003	Commercial Space Transportation; Suborbital Rocket Launch; <i>Notice and Request for Comments</i> . 68 Fed. Reg. 59977.
August 15, 2002	Licensing Test Flight Reusable Vehicle Missions, AC 431.35-3; <i>Advisory Circular</i> .
July 30, 2002	Licensing and Safety Requirements for Launch; <i>Proposed Rule</i> (to amend 14 C.F.R. parts 413, 415, 417). 67 Fed. Reg. 49456. (This is a supplemental <i>Notice of Proposed Rulemaking</i> to the October 25, 2000, Proposed Rule.)
January 10, 2001	Civil Penalty Actions in Commercial Space Transportation; <i>Final Rule</i> (14 C.F.R. parts 405, 406). 66 Fed. Reg. 2176.
October 25, 2000	Licensing and Safety Requirements for Launch; <i>Proposed Rule</i> (to amend 14 C.F.R. parts 413, 415, 417). 65 Fed. Reg. 63921.
October 19, 2000	Licensing and Safety Requirements for Operation of a Launch Site; <i>Final Rule</i> (14 C.F.R. parts 401, 417, 420). 65 Fed. Reg. 62812.

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**Appendix IV: Timeline and List of FAA  
Commercial Space Launch Rulemaking and  
Guidance**

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September 19, 2000	Commercial Space Transportation Reusable Vehicle and Reentry Licensing Regulations; <i>Final Rule</i> (14 C.F.R. parts 400-435). 65 Fed. Reg. 56618.
September 19, 2000	Financial Responsibility Requirements for Licensed Reentry Activities; <i>Final Rule</i> (14 C.F.R. part 450). 65 Fed. Reg. 56670.
August 30, 2000	Expected Casualty Calculations for Commercial Space Launch and Reentry Missions, AC 431.35-1; <i>Advisory Circular</i> .
December 30, 1999	Small-Scale Rockets; <i>Notice of Public Meeting</i> (to solicit comments on possible FAA regulation of small-scale rocket launches). 64 Fed. Reg. 73597.
August 16, 1999	License Application Procedures, AC 413-1; <i>Advisory Circular</i> .
April 21, 1999	Commercial Space Transportation Licensing Regulations; <i>Final Rule</i> (14 CFR parts 401, 411, 413, 415, 417). 64 Fed. Reg. 19586.
November 3, 1998	Part 440 Insurance Conditions, AC 440-1; <i>Advisory Circular</i> .
August 26, 1998	Commercial Space Transportation Financial Responsibility Requirements for Licensed Launch Activities; <i>Final Rule</i> (14 C.F.R. part 440). 63 Fed. Reg. 45592.
April 4, 1988	Commercial Space Transportation Licensing Regulations; <i>Final Rule</i> (14 C.F.R. Ch. III). 53 Fed. Reg. 11004.

# Appendix V: Comments from the Department of Commerce



**THE DEPUTY SECRETARY OF COMMERCE**  
Washington, D.C. 20230

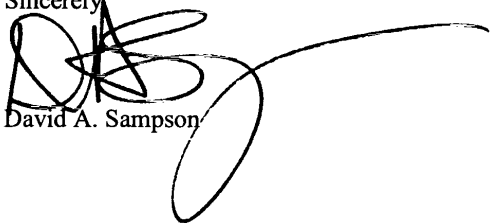
September 19, 2006

Mr. Gerald Dillingham  
Director, Physical Infrastructure  
U.S. Government Accountability Office  
441 G Street, NW  
Washington, D.C. 20548

Dear Mr. Dillingham:

Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled *Commercial Space Launches: FAA Needs Better Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry* (GAO-07-16). I enclose the Department of Commerce's comments from two of our agencies, National Oceanic and Atmospheric Administration and International Trade Administration, to the draft report.

Sincerely,

  
David A. Sampson

Enclosure

**U.S. Department of Commerce  
National Oceanic and Atmospheric Administration (NOAA)  
Comments on the Draft GAO Report Entitled  
“Commercial Space Launches: FAA Needs Better Planning and Monitoring to  
Oversee the Safety of the Emerging Space Tourism Industry”  
(GAO-07-16/October 2006)**

**General Comments**

None.

**NOAA Response to GAO Recommendations**

The draft GAO report states, “To prepare for a possible major expansion in its safety oversight responsibilities resulting from the emergence of the space tourism industry and spaceports, we recommend that the Secretary of Transportation direct the FAA Administrator to implement the following three recommendations:

Recommendations 1 and 2 are not related to the Department of Commerce.

**Recommendation 3:** “As long as FAA has a promotional role, it should work with the Department of Commerce to develop a memorandum of understanding which clearly delineates the two agencies’ respective promotional roles in line with their statutory obligations and larger agency missions. This memorandum of understanding would reflect Commerce’s role as an advocate of the industry with the objective of increasing U.S. competitiveness and FAA’s focus on providing a safe environment in which the emerging space tourism sector could operate.”

**NOAA Response:** NOAA supports the recommendation to develop a memorandum of understanding defining the roles of FAA and the Department of Commerce in promoting the commercial space industry.

**U.S. Department of Commerce  
International Trade Administration (ITA)  
Comments on the Draft GAO Report Entitled  
“Commercial Space Launches: FAA Needs Better Planning and Monitoring to  
Oversee the Safety of the Emerging Space Tourism Industry”  
(GAO-07-16/October 2006)**

**General Comments**

The GAO report fairly addresses the role and responsibilities of the FAA’s Office of Commercial Space Transportation, but failed to accurately represent the industry promotion, advocacy, and forecasting roles and responsibilities of the Commerce Department’s International Trade Administration.

Throughout the report, the GAO failed to include the statutory responsibilities of the International Trade Administration, which is the lead U.S. Government agency for industry and trade promotion and competitiveness. For instance, the 1974 Trade Act outlines the responsibilities assigned to the International Trade Administration to coordinate all issues concerning international trade and commercial policy, trade promotion, and trade competitiveness. ITA hosts an entire team of analysts who promote all sectors of U.S. industry, including the commercial space transportation industry, through trade events, advocacy programs, and the development of policies that promote overall industry competitiveness. These responsibilities should be incorporated into the text and figures in this report in order to accurately reflect the potential areas of overlap between the FAA and the Department of Commerce on industry promotion issues.

**ITA Response to GAO Recommendations**

**Executive Recommendation 1:** “As part of its strategic planning effort, FAA needs to assess the level of expertise and resources that will be needed to oversee the safety of the space tourism industry and the new spaceports under various scenarios and timetables. In addition, the Office of Commercial Space Transportation should develop a formal process for consulting with the Office of Aviation Safety about licensing reusable launch vehicles. The process should include the criteria under which the consultation takes place.”

**ITA Response:** ITA has no comment on this recommendation.

**Executive Recommendation 2:** “In order to allow the agency to be proactive about safety, rather than responding only after an incident or possibly serious incident occurs, FAA should identify and continually monitor space tourism industry safety indicators that might trigger the need to regulate crew and flight participant safety before 2012. As part of this effort, FAA should develop and issue guidance on the circumstances under which it would regulate crew and flight participant safety before 2012.”

**ITA Response:** ITA has no comment on this recommendation.

**Executive Recommendation 3:** “As long as FAA has a promotional role, it should work with the Department of Commerce to develop a memorandum of understanding that clearly delineates the two agencies’ respective promotional roles in line with their statutory obligations and larger agency missions. This memorandum of understanding would reflect Commerce’s role as an advocate of the industry with the objective of increasing U.S. competitiveness and FAA’s focus on providing a safe environment in which the emerging space tourism sector could operate.”

**ITA Response:** ITA supports the GAO’s recommendation to establish clear promotional responsibilities between the FAA and Department of Commerce. Due to ITA’s lead responsibility for industry and trade promotion within the Department, ITA strongly recommends that the proposed MOU be negotiated with all interested DOC bureaus, and not only NOAA’s Office of Space Commercialization.



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# Appendix VI: Comments from the National Aeronautics and Space Administration

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National Aeronautics and  
Space Administration  
**Headquarters**  
Washington, DC 20546-0001



October 3, 2006

Space Operations Mission Directorate

Mr. Allen Li  
Director  
Acquisition and Sourcing Management  
United States Government Accountability Office  
Washington, DC 20548

Dear Mr. Li:

The Commercial Space Launch Industry is of vital importance to NASA and the Vision for Space Exploration. Overall the report captures the current role and challenges of the Federal Aviation Administration, and the federal sector in general, in support of the Commercial Space Launch Industry. Thank you for the opportunity to comment on the Draft Government Accountability Office (GAO) report entitled, "Commercial Space Launches: FAA Needs Better Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry" (GAO-07-17).

The only additional point I would like to make is that it is important to note the role of NASA in support of the Commercial Space Launch Industry which goes well beyond the use of launch facilities. NASA provides support during the launch vehicle design and development phases by allowing the commercial sector the use of launch vehicle development infrastructure. The capital investment that would be required from the commercial sector to duplicate these development facilities would be prohibitive. These development facilities include such items as rocket propulsion test stands, wind tunnels, and thermal vacuum chambers.

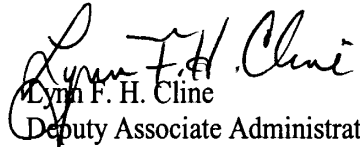
I recommend the following changes:

Pg. 32, paragraph 1, last sentence, should read, "The U.S. government has responded by providing support such as launch contracts, use of launch facilities and launch vehicle development infrastructure. The capital investment that would be required from the commercial sector to duplicate the development facilities would be prohibitive. The development facilities include rocket propulsion test stands, wind tunnels, and thermal vacuum chambers."

Pg. 36, Table 2. “Examples of Federal Support to the Commercial Space Launch Industry”, under, “Infrastructure and support personnel” in the examples column please add this sentence: “Also, development facilities such as, the rocket propulsion test stands, wind tunnels and thermal vacuum chambers.”

Again, we appreciate the opportunity to provide our comments to the report.

Sincerely,

  
Lynn F. H. Cline  
Deputy Associate Administrator  
for Space Operations

---

# Appendix VII: GAO Contact and Staff Acknowledgments

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## GAO Contact

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

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## Staff Acknowledgments

In addition to the contact named above, Teresa Spisak (Assistant Director), Maureen Luna-Long, Bob Homan, Ashley Alley, Elizabeth Eisenstadt, Jim Geibel, Dave Hooper, Rosa Leung, Sara Ann Moessbauer, Josh Ormond, and Sandra Sokol made key contributions to this report.

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U.S. Government Accountability Office, 441 G Street NW, Room 7149  
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