United States Government Accountability Office

GAO

Report to Congressional Committees

July 2012

COMMERCIAL SPACE LAUNCHES

FAA Should Update How It Assesses Federal Liability Risk

GAO-12-899

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GAO Accountability * Integrity * Reliability

Highlights

Highlights of GAO-12-899, a report to congressional committees

Why GAO Did This Study

A catastrophic commercial launch accident could result in injuries or property damage to the uninvolved public, or "third parties." In anticipation of such an event, a launch company must purchase a fixed amount of insurance for each launch and reentry, per calculation by FAA; the federal government is potentially liable for claims above that amount up to an additional $1.5 billion, adjusted for inflation and subject to congressional appropriations. As of 2012, the inflation-adjusted amount is about $2.7 billion. CSLAA provides for this payment, called indemnification. The indemnification provision, unless reauthorized, expires this year.

GAO was asked to address, among other things, (1) the U.S. government's indemnification policy compared to policies of other countries, (2) the federal government's potential costs for indemnification, (3) the ability and willingness of the insurance market to provide additional coverage, and (4) the effects of ending indemnification on the competitiveness of U.S. launch companies. GAO reviewed FAA data and documents and relevant literature and conducted interviews with officials from FAA and the National Aeronautics and Space Administration, insurers, brokers, launch companies, launch customers, risk modelers, and experts.

What GAO Recommends

GAO recommends that FAA periodically review and update as appropriate its methodology for calculating launch providers' insurance requirements. The Department of Transportation provided technical clarifications, which GAO incorporated.

View GAO-12-899. For more information, contact Alicia Puente Cackley at (202) 512-8678 or cackleya@gao.gov or Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov

What GAO Found

According to studies, the United States provides less commercial space launch indemnification for third party losses than China, France, and Russia. These countries put no limit on the amount of government indemnification coverage, which in the United States is limited by the Commercial Space Launch Act Amendments of 1988 (CSLAA). Governments' commitments to pay have never been tested because there has not been a third party claim that exceeded a private launch company's insurance.

The potential cost to the federal government of indemnifying third party losses is currently unclear because it depends in part on the method used by the Federal Aviation Administration (FAA) to calculate the amount of insurance that launch companies must purchase, a calculation that may not be sound. FAA has used the same method since 1988 and has not updated crucial components, such as the cost of a casualty. Estimating probable losses from a rare catastrophic event is difficult, and insurance industry officials and risk modeling experts said that FAA's method is outdated. FAA, however, has not had outside experts or risk modelers review the appropriateness of its method. An inaccurate calculation that understates the amount of insurance a launch provider must obtain would increase the likelihood of costs to the federal government; a calculation that overstates the amount of insurance needed would raise the cost of insurance for the launch provider. FAA officials said that their method was reasonable and conservative, but they agreed that a review could be beneficial and that involving outside experts might be helpful. Overall, they said use of more sophisticated methodologies would have to be balanced with the additional costs to both FAA and the launch companies that would result from generating and analyzing additional data.

The insurance market is generally willing and able to provide up to $500 million per launch as coverage for third party liability, according to industry representatives. Because the amount of insurance FAA requires launch providers to obtain averages about $99 million per launch, and coverage available through CSLAA is about $2.7 billion above that, insurers could provide some of the coverage currently available through CSLAA. However, the amount and price of insurance that could be provided could change quickly if a large loss were to occur, according to insurance industry representatives.

The effects on global competition from the United States eliminating CSLAA indemnification are unknown. However, launch companies and customers GAO contacted believe that ending federal indemnification could lead to higher launch prices for U.S.-based launch companies, making them less price competitive than foreign launch companies. Although the cost of third party liability insurance for launch companies has been about 1 percent of the dollar amount of coverage they purchased, how much this cost might increase in the absence of federal coverage is not clear. Launch customers said that price and vehicle reliability were key factors in their choice of a launch company. Launch companies reported that additional costs would be passed along to customers, but whether this increase alone would be sufficient reason for a launch customer to choose a foreign company over a U.S. company is unclear.

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Abbreviations

CSLAA	Commercial Space Launch Act Amendments of 1988
FAA	Federal Aviation Administration
ISS	International Space Station
NASA	National Aeronautics and Space Administration

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

July 30, 2012

The Honorable John D. Rockefeller IV
Chairman
The Honorable Kay Bailey Hutchison
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

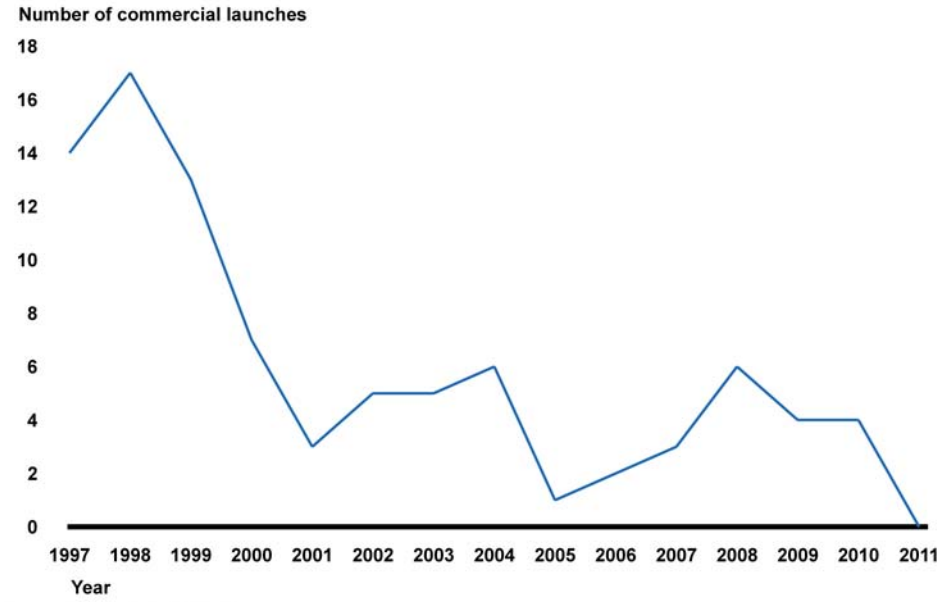
The Honorable Ralph M. Hall
Chairman
The Honorable Eddie Bernice Johnson
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

The Commercial Space Launch Act Amendments of 1988 (CSLAA)[1] made the federal government responsible, subject to an appropriation provided by Congress, for a portion of third party liability claims that arise from a catastrophic launch-related incident that results in injury or damage to uninvolved people or property, or "third parties."[2] This indemnification provision will expire at the end of 2012. The goal was to provide a competitive environment for the U.S. commercial space launch industry by providing, among other things, government indemnity while still minimizing the cost to taxpayers. As figure 1 shows, the number of U.S. commercial launches, which are licensed by the Federal Aviation Administration (FAA), reached a peak of 17 in 1998.

[1]Pub. L. No. 100-657, 102 Stat. 3903 (1988).

[2]51 U.S.C. § 50915.

Figure 1: Annual Number of Commercial U.S. Space Launches, 1997 to 2011



Source: GAO analysis of FAA data.

Although the number of U.S. commercial space launches has fallen in recent years, it is reasonable to expect an increase in the years ahead. The National Aeronautics and Space Administration (NASA) plans to begin procuring commercial cargo transportation services to the International Space Station (ISS) in 2012 and intends to procure commercial manned launches to carry its astronauts to the ISS beginning in 2017.[3] A number of companies are developing new launch vehicles that could provide these orbital services. Other companies are developing suborbital vehicles that could carry passengers for space tourism flights.

[3]All commercial missions for NASA thus far have been demonstration missions conducted under Space Act agreements, which involve NASA providing significant funds to private industry partners to stimulate the development of large-scale commercial space transportation capabilities. NASA has procured transportation services to the ISS to begin later in 2012 through traditional contractual arrangements. For more information on Space Act agreements, see GAO, *Key Controls NASA Employs to Guide Use and Management of Funded Space Act Agreements Are Generally Sufficient, but Some Could Be Strengthened and Clarified,* GAO-12-230R (Washington, D.C.: Nov. 17, 2011).

In this context, you asked us to address the following objectives:

- how the current U.S. commercial space launch indemnification policy compares to other countries' policies;
- the federal government's potential costs under CSLAA;
- the extent to which the insurance market is able and willing to provide third party liability insurance at levels currently provided by CSLAA;
- the implications of commercial manned launches for the current federal indemnification policy, including the gaps, if any, that exist in that policy and the potential financial risks those gaps pose; and
- what is known about the direct and indirect effects that ending indemnification would have on the competitiveness of U.S. commercial launch companies.

For this work, we reviewed launch data from FAA and performed a literature search. We also reviewed documents from and conducted interviews with insurance brokers and underwriters who provide commercial launch companies with coverage for third party liability, experts in commercial space launch liability issues and risk management, representatives from launch companies and customers, and officials from FAA and NASA. We also reviewed past GAO work.[4] Additional information on our methodology is provided in appendix I.

We conducted this performance audit from November 2011 to July 2012 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[4]GAO, *Commercial Space Launch Act: Preliminary Information on Issues to Consider for Reauthorization*, GAO-12-767T (Washington, D.C.: June 6, 2012) and *Commercial Space Transportation: Industry Trends, Government Challenges, and International Competitiveness Issues*, GAO-12-836T (Washington, D.C.: June 20, 2012).

Background

U.S. Indemnification Policy

CSLAA established the current U.S. policy to provide federal payment, subject to appropriation—known as indemnification—for a portion of claims by third parties for injury, damage, or loss that result from a commercial launch-related incident. All FAA-licensed commercial launches and reentries by U.S. companies, whether unmanned or manned and from the United States or overseas, are covered by federal indemnification for third party damages that result from the launch or reentry.[5] Launches and reentries by foreign entities are also licensed by the FAA if they take place from or into the United States and are covered by federal indemnification. Parties involved in launches and reentries—for example, passengers and crew—are not eligible for indemnification coverage.[6]

U.S. indemnification policy has a three-tier approach for sharing liability between the government and the private sector to cover third party claims:

- The first tier of coverage is the responsibility of the launch company and is handled under an insurance policy purchased by the launch company. As part of FAA's process for issuing a license for a commercial launch or reentry, the agency determines the amount of third party liability insurance a launch company is required to purchase so the launch company can compensate third parties for any claims for damages that occur as a result of activities carried out under the license. FAA calculates the insurance amount to reflect the maximum probable loss that is likely to occur because of an accident that results in third party damages, including deaths and injuries on

[5]51 U.S.C. § 50914(a)(1)(A).

[6]A crew includes any employee who performs activities directly relating to the launch, reentry, or other operation relating to the vehicle that carries human beings. 51 U.S.C. § 50902(2). A passenger—also called a spaceflight participant—is an individual who is not crew, carried aboard a launch vehicle or reentry vehicle. 51 U.S.C. § 50902(17).

the ground and damage to property from spacecraft debris.[7] FAA uses a statistical approach to estimate expected losses based on estimated probabilities that a catastrophic incident could occur and the estimated costs of a catastrophic incident given the details of the specific launch. This first tier of required insurance coverage is capped at a maximum of $500 million for third party damages.[8]

- The second tier of coverage is provided by the U.S. government, and covers any third party claims in excess of the specific first tier amount up to a limit of $1.5 billion adjusted for post-1988 inflation; in 2012, the inflation-adjusted amount was approximately $2.7 billion.[9] For the federal government to be liable for these claims, Congress would need to appropriate funds. This second tier of coverage will expire in December 2012 unless Congress reauthorizes it.[10] (The other two tiers have no expiration date.)

- The third tier of coverage is for third party claims in excess of the second tier—that is, the federal coverage of $1.5 billion above the first tier, adjusted for inflation. Like the first tier, this third tier is the responsibility of the launch company, which may seek insurance above the required first tier amount for this coverage. Unlike the first tier, no insurance is required under federal law.

Another component of U.S. indemnification policy for commercial space launches and reentries is cross waivers. They provide that each party involved in a launch (such as the launch company, the spacecraft manufacturer, and the customer) agrees not to bring claims against the other parties and assumes financial responsibility for damage to its own

[7]FAA makes this determination for each space launch by reviewing the specific circumstances of the launch, including the planned launch vehicle, launch site, payload, flight path, and the potential casualties and fatalities that could result from varying types of launch failures at different points along that path. FAA estimates the total cost of estimated casualties from a launch failure and uses this information as the basis for determining property damage. 51 U.S.C. § 50914(c).

[8]51 U.S.C. § 50914(a)(3)(A)(i).

[9]51 U.S.C. § 50915(a)(1).

[10]51 U.S.C. § 50915(f).

property or loss or injury sustained by its own employees.[11] Cross waivers also do not have an expiration date.

According to FAA, no FAA-licensed commercial space launch since 1989 has resulted in casualties or substantial property damage to third parties. Orbital launches have taken place over the ocean from launch sites not located near densely populated urban areas. In the event of a third party claim that exceeded the launch provider's first-tier coverage, FAA would be involved in any negotiations, according to FAA officials, and the Secretary of Transportation must approve any settlement.[12]

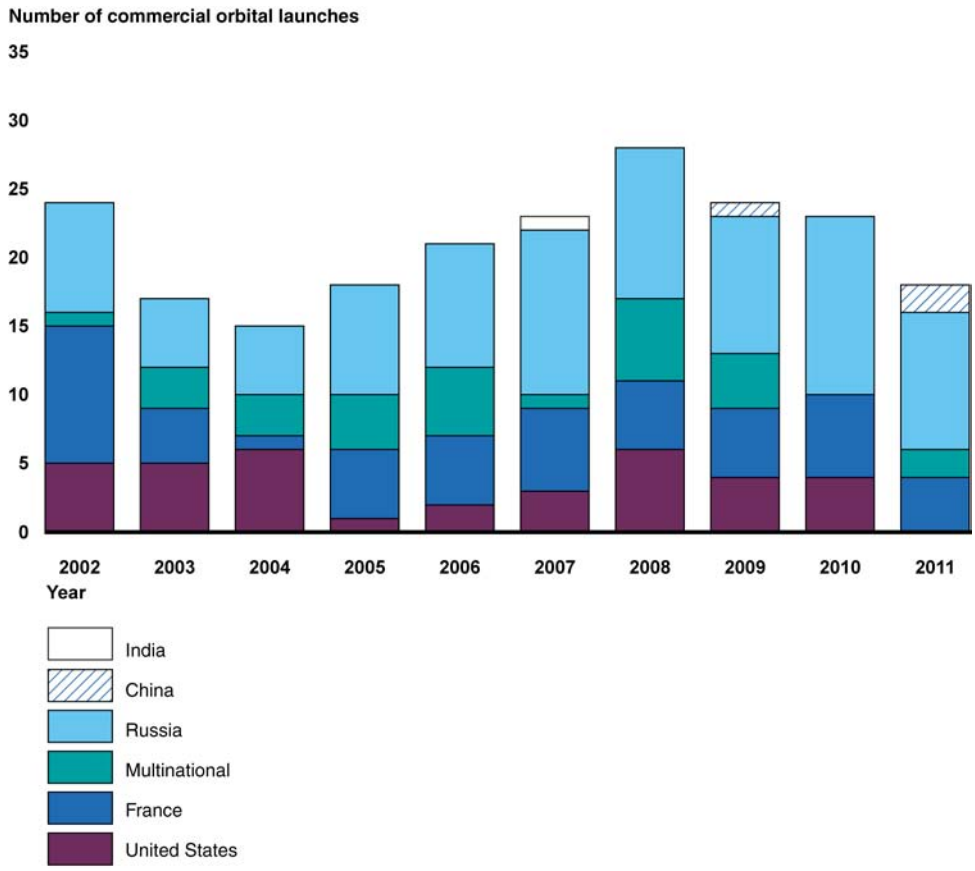
Global Commercial Space Launch Industry

From 2002 through 2011, U.S. companies conducted approximately 17 percent of commercial space launches worldwide, while Russia conducted 43 percent and France's launch company conducted 24 percent. Figure 2 shows the trend in number of commercial space launches over the last 10 years.

[11]51 U.S.C. § 50914(a)(4).

[12]51 U.S.C. § 50915(b)(3).

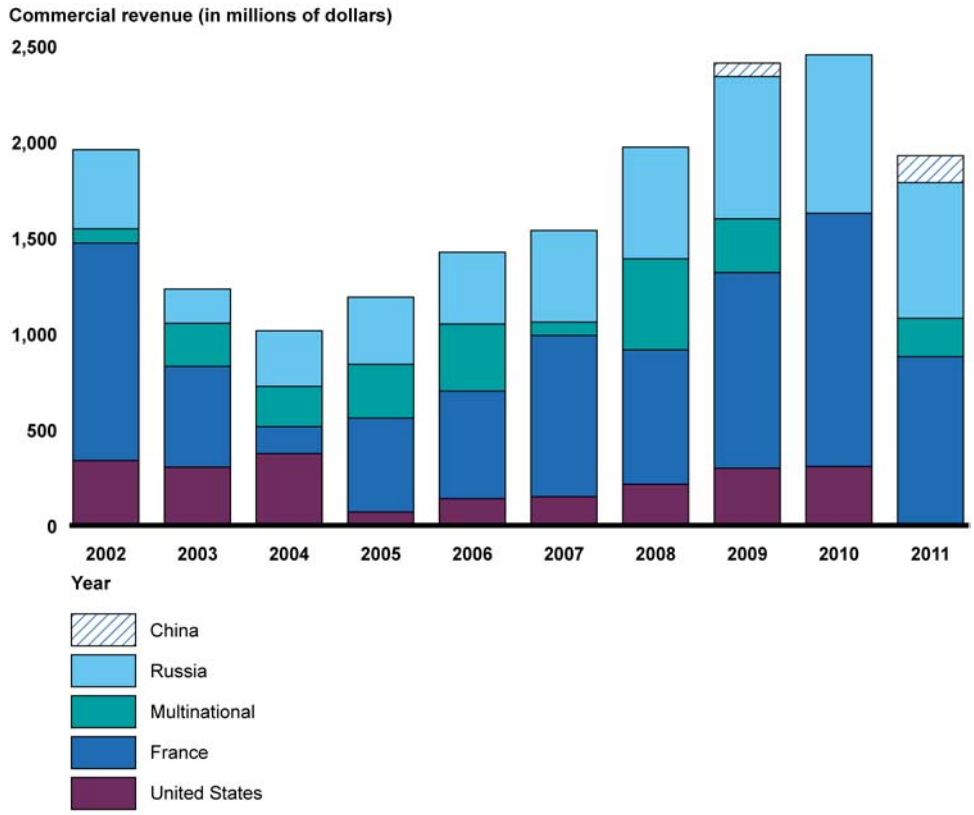
Figure 2: Number of Commercial Space Launches Worldwide, 2002 to 2011



Source: GAO analysis of FAA data.
Note: The multinational launches were conducted by Sea Launch, which is a multinational consortium that launches from a modified oil-drilling platform at sea and is licensed by FAA because one of its principals is a U.S company.

Over the past several years, Russian and French launches have generated the most revenues, followed by U.S. launches. Moreover, in 8 of the last 10 years, U.S. commercial launch companies generated less revenue than launches in either Russia or France. U.S. companies generated no commercial launch revenue in 2011 because they conducted no launches. (See fig. 3.)

Figure 3: Commercial Space Launch Revenues Worldwide, 2002 to 2011



Source: GAO analysis of FAA data.

Note: India is not included in this figure because it earned a small amount of revenue—$11 million in 2007—the only year it had a commercial launch.

The United States Provides Less Liability Coverage than Foreign Competitors Because of a Cap on Government Indemnification

The United States provides less total third party liability coverage than China, France, or Russia—the primary countries that have conducted commercial space launches in the last 5 years—according to published reports.[13] These countries each have an indemnification regime in which the government states that it will assume a greater share of the risk compared to that of the United States because each country has a two-tiered system with no limit on the amount of government indemnification. By comparison, the United States caps government indemnification at $1.5 billion adjusted for inflation beyond the first-tier insurance amount. However, U.S. government coverage, in some cases, begins at a lower level than that of the other countries because U.S. coverage begins above the estimated maximum probable loss, which averaged about $99 million for active FAA launch and reentry licenses as of January 2012 and ranged from about $23 million to $267 million. The level at which government coverage begins for the other three countries ranged from $79 million to $300 million.

China, France, and Russia have a first tier of insurance coverage that a commercial launch company must obtain, similar to the United States. The second tier of government indemnification varies for these countries:

- The Chinese government provides indemnification for third party claims over $100 million.
- The French government provides indemnification for third party claims over 60 million euros (about $75 million in foreign exchange conversion as of May 2012).
- The Russian government provides indemnification for third party claims over $80 million for the smaller Start launch vehicles and $300 million for the larger Soyuz and Proton vehicles.[14]

For all these countries, their commitments to pay have never been tested. Globally, there has never been a third party claim for damages from a

[13]In addition, India conducted one commercial space launch during this period, but we found conflicting information on the Indian government's indemnification coverage, and therefore, we are not including it in this discussion.

[14]The source for all the government amounts is The Aerospace Corporation, *Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation* (El Segundo, Calif.: August 2006) or FAA, *Liability Risk-Sharing Regime for U.S. Commercial Space Transportation: Study and Analysis* (Washington, D.C.: April 2002).

commercial space launch failure that reached second-tier government coverage.

Potential Cost of Indemnification by the Federal Government Depends on a Variety of Factors

Catastrophic Events and Congressional Appropriations

The federal government's potential costs under CSLAA depend on (1) the occurrence of a catastrophic launch failure with third party claims that exceed the first tier of coverage and (2) Congress appropriating funds to cover the government's liability under the second tier of coverage. FAA officials stated that no FAA-licensed commercial space launches or reentries have resulted in casualties or substantial property damage to third parties. As a result, FAA believes that it is highly unlikely that there will be any costs to the federal government under CSLAA. In the event that a catastrophic failure did occur, FAA's maximum probable loss calculation is intended to estimate the maximum losses likely to occur from a commercial space launch or reentry and determine the amount of third party losses against which launch companies must protect. In calculating maximum probable loss, FAA aims to include estimates of losses from events having greater than a 1 in 10 million chance of occurring, meaning that losses are very unlikely to exceed launch companies' private insurance and become potential costs for the government under CSLAA.

Under CSLAA, if a rare catastrophic event were to occur whose losses exceeded private insurance coverage, the government would be responsible for paying claims that exceeded FAA's maximum probable loss only if Congress provided appropriations for this purpose. Under CSLAA, the federal government does not incur a legal liability unless an

appropriation is made for this purpose.[15] Accordingly, an obligation would not be recorded in the federal budget unless and until such an appropriation is made. While an obligation is not incurred or recorded for potential CSLAA losses until an appropriation is provided, some insurance companies told us that they expect the government to pay losses that become eligible for coverage under CSLAA.

Maximum Probable Loss Soundness

While it is very difficult to assess catastrophic failures that have low probabilities but potentially high losses, FAA's use of an appropriate process for determining the maximum probable loss is important because the maximum probable loss sets the point at which losses become potential costs to the government under CSLAA. Several issues raise questions about the soundness of FAA's maximum probable loss methodology:

- FAA uses a figure of $3 million when estimating the cost of a single potential casualty—that includes either injury or death—which FAA officials said has not been updated since they began using it in 1988. Two insurers, as well as representatives of two companies that specialize in estimating damages from catastrophic events (modeling companies), said that this figure is likely understated. Because this number has not been adjusted for inflation or updated in other ways, it may not adequately represent the current cost of injury or death caused by commercial space launch failures. Having a reasonable casualty estimate can affect FAA's maximum probable loss calculation and could affect the potential cost to the government from third party claims.

- FAA's methodology for determining potential property damage from a commercial space launch starts with the total cost of casualties and adds a flat 50 percent to that cost as the estimate of property damage, rather than specifically analyzing the number and value of properties that could be affected in the event of a launch failure. One insurer and two risk modelers said that FAA's approach is unusual and generally not used to estimate potential losses from catastrophic events. For

[15]CSLAA requires the Secretary of Transportation to provide for the payment of specific types of successful third party claims to the extent provided in advance in an appropriation law or to the extent additional legislative authority is enacted providing for paying for claims in a compensation plan submitted to Congress by the President. 51 U.S.C. § 50915 (a)(1).

example, officials from both modeling companies noted that the more common approach is to model the property losses first and derive the casualty estimates from the estimated property losses. For example, if a property loss scenario involves the collapse of a building, that scenario would have a different casualty expectation than a scenario that did not involve such a collapse. One modeler stated that FAA's method might significantly understate the number of potential casualties, noting that an event that has a less than 1 in 10 million chance of occurring is likely to involve significantly more casualties than predicted under FAA's approach. Moreover, a 2007 FAA review conducted with outside consultants said that this approach is not recommended because of observed instances where casualties were low yet forecasted property losses were very large.[16]

- More broadly, FAA's method does not incorporate what is known in the insurance industry as "catastrophe modeling." One modeler told us that catastrophe modeling has matured over the last 25 years—as a result of better data, more scientific research, and advances in computing—and has become standard practice in the insurance and reinsurance industries.[17] Catastrophe models consist of two components: a computer program that mathematically simulates the type of event being insured against and a highly detailed database of properties that could potentially be exposed to loss. Tens of thousands or more computer simulations are generated to create a distribution of potential losses and the simulated probability of different levels of loss.[18] In contrast, FAA's method involves estimating a single loss scenario.

FAA officials told us that they have considered the possibility of using a catastrophe model. However, they expressed concern about whether the more sophisticated approach would be more accurate, given the great uncertainty about the assumptions, such as the probability and size of

[16]For more information on FAA's methodology, see J.D. Collins, C.P. Brinkman, and C.L. Carbon, ACTA Inc., and FAA, *Determination of Maximum Probable Loss* (2007).

[17]Reinsurance is essentially insurance for insurers—that is, insurance companies buy coverage for all or a part of a policy's liability from other insurers in order to offset exposure.

[18]The probability distribution of losses is typically presented in what is known as an exceedance probability curve, which shows the probability of losses exceeding various levels.

potential damages that must be made with any model. Also, industry experts told us that a significant cost factor in catastrophe modeling is creating and maintaining a detailed database of exposed properties. One expert told us that for FAA to do such modeling, it would need to purchase a property exposure database, which could cost hundreds of thousands of dollars. Experts also disagreed about how feasible it would be to mathematically model the potential damages associated with space launches. One expert thought such modeling would not be credible because the necessary knowledge of the factors that can influence a space launch is not at the same level as the more developed research for modeling hurricanes, for example. Another expert thought that it would be possible to develop credible space launch simulation models. Another expert stated that such models have not been developed to date because of the government-provided indemnity coverage; this expert believed that if such coverage were the responsibility of the private sector, the necessary models might be developed.

FAA officials also said that they believe the maximum probable loss methodology is reasonable and produces conservative results for several reasons. First, FAA officials described a 2002 study on aviation casualty costs to support its use of a $3 million casualty figure in its methodology. Use of a casualty estimate that is based on 2002 data, however, still raises questions about whether this figure is outdated, which could result in underestimating the cost of casualties. Second, to support basing the potential cost of property damage on the potential cost of casualties, FAA officials said that they have conducted internal analyses using alternative methodologies—including some that assessed property values in the vicinity of launches—and compared them to their current methodology. In each case, officials said that the current methodology produced higher, or more conservative, maximum probable losses. We were unable to review or verify these analyses, however, because FAA officials said that these analyses were done informally and were not documented.

FAA officials acknowledged that updating the $3 million casualty figure and conducting analyses of potential property damage (rather than using a casualty cost adjustment factor of 50 percent) might produce more precise estimates of maximum probable losses. However, they said that because the probabilities assigned to such losses are still rough estimates, whether taking these actions would increase the accuracy of their maximum probable loss calculations is uncertain. Overall, they said, use of more sophisticated methodologies would have to be balanced with the additional costs to both FAA and the launch companies that would result from requiring and analyzing additional data. For example, a new

methodology might require either FAA or the launch company to gather current property information, and might necessitate that FAA construct a statistical model for analyzing potential losses.

The same officials noted that they periodically evaluate their current maximum probable loss methodology, but acknowledged that they have not used outside experts or risk modelers for this purpose. They agreed that such a review could be beneficial, and that involvement of outside experts might be helpful for improving their maximum probable loss methodology. FAA's 2007 review of potential alternatives identified a number of criteria for a sound maximum probable loss methodology that could be useful in such a review. These included, among other things, that the process use a valid risk analysis, be logical and lead to a rational conclusion, and avoid being overly conservative or under conservative. A sound maximum probable loss calculation can be beneficial to both the government and launch companies because it can help ensure that the government is not exposed to greater costs than intended (such as might occur through an understated maximum probable loss) and help ensure that launch companies are not required to purchase more insurance coverage than necessary (such as might occur through an overstated maximum probable loss).

Private Market Generally Offers $500 Million in Coverage per Launch

Private Capacity

Some insurers and brokers suggested that the maximum amount of private sector third party liability coverage the industry is currently willing to provide is generally around $500 million per launch. This amount, or capacity, is determined by the amount of their own capital that individual insurers are willing to risk by selling this type of coverage. According to some insurers and brokers with whom we spoke, commercial space launch third party liability coverage is a specialized market involving a relatively small number of insurers that each assume a portion of the risk for each launch. One broker said that no launch company thus far has pursued private sector insurance protection above $500 million. Two insurers said that there might be slightly more coverage available beyond $500 million, and one said that up to $1 billion per launch in liability coverage might be possible in the private insurance market.

The cost to launch companies for purchasing third party liability insurance, according to some brokers and one insurer, is approximately 1 percent or less of the total coverage amount. According to FAA data on commercial launches, the average maximum probable loss is about $99 million. As a result, in the absence of CSLAA indemnification, insurers could still provide some of the coverage currently available through the government under CSLAA. For example, if the maximum probable loss for a launch is $100 million and the insurance industry is willing to offer up to $500 million in coverage, the private market could potentially provide $400 million in additional coverage.

According to some insurers, brokers, and insurance experts with whom we spoke, there are a number of reasons why private sector insurers are generally unwilling to offer more third party liability coverage than $500 million per launch.

- First, these brokers and insurers said that worldwide capacity for third party liability coverage is generally limited to $500 million per launch, which some considered a significant amount of coverage and a challenging amount to put together—particularly given that the number of insurers in the space launch market is relatively small.

- Second, according to these same officials, insurers are unwilling to expose their capital above certain amounts for coverage that at least currently brings in small amounts of premium relative to the potential payouts for losses. For example, they said that losses from a catastrophic launch accident could exceed many years of third party liability policy premiums and jeopardize insurers' solvency.

- Third, according to some insurers and brokers with whom we spoke, to have sufficient capital to pay for losses above $500 million per launch would require insurers to charge policy premiums that would likely be unaffordable for space launch companies.

Changes to Market Capacity

The current amount of private market capacity could change due to loss events and changing market conditions, according to some insurance industry participants. Some insurers and brokers said that a launch failure could affect the level and cost of coverage offered, and that a launch failure with significant losses could quickly raise insurance prices and reduce capacity, potentially below levels required by FAA's maximum probable loss calculation. However, one risk expert suggested that a space launch failure would likely cause liability insurance rates to rise and that this might encourage insurers and capital to enter the space launch

market and cause liability insurance capacity to increase. According to FAA, insurers have paid no claims for U.S. commercial launches to date, but they have paid some relatively small third party claims for U.S. military and NASA launch failures. For example, according to an insurance broker, a U.S. Air Force launch failure in 2006 resulted in property damage of approximately $30 million. According to NASA, the Space Shuttle Columbia accident in 2003 resulted in property damage of approximately $1.2 million. Two brokers said that given the low number of launches and low probability of catastrophic events, total worldwide premiums for space liability coverage are approximately $25 million annually, amounts insurers believe are adequate to cover expected losses. However, if a large loss occurs, according to two insurers, they would likely increase their estimates of the potential losses associated with all launches.

Under CSLAA, launch companies must purchase coverage to meet FAA's maximum probable loss amount or purchase the maximum amount of coverage available in the world market at reasonable cost, as determined by FAA. The potential cost to the government could increase if losses caused insurance prices to rise and insurance amounts available at reasonable cost to decrease. Some insurers and brokers also said that the amount of insurance the private market is willing to sell for third party liability coverage for space launches can also be affected by changes in other insurance markets. For example, large losses in aviation insurance or in reinsurance markets could decrease the amount of capital insurers would be willing to commit to launch events because losses in the other markets would decrease the total pools of capital available.

Alternatives for Addressing Space Launch Risk

Because launch failures and changing market conditions could change the amounts of coverage available in the private market, we identified other possible ways of managing catastrophic risk. While we have not conducted specific work to analyze the feasibility of alternative approaches for providing coverage currently available through CSLAA, FAA and others have looked at possible alternatives to CSLAA indemnification and we have examined different methods for addressing the risk of catastrophic losses associated with natural disasters and acts

of terrorism.[19] These events, like space launch failures, have a low probability of occurrence but potentially high losses. Some methods involve the private sector, including going beyond the traditional insurance industry, in providing coverage, and include the use of catastrophe bonds or tax incentives to insurers to develop catastrophe surplus funds. Other methods aid those at risk in setting aside funds to cover their own and possibly others' losses, such as through self-insurance or risk pools.[20] Still other methods, such as those used for flood and terrorism insurance, involve the government in either providing subsidized coverage or acting as a backstop to private insurers.[21]

Use of any such alternatives could be complex and would require a systematic consideration of their feasibility and appropriateness for third party liability insurance for space launches. For example, according to a broker and a risk expert, a lack of loss experience complicates possible ways of addressing commercial space launch third party liability risk, and according to another risk expert, any alternative approaches for managing this risk would need to consider key factors, including the

- number of commercial space launch companies and insurers and annual launches among which to spread risk and other associated costs;
- lack of launch and loss experience and its impact on predicting and measuring risk, particularly for catastrophic losses; and
- potential cost to private insurers, launch companies and their customers, and the federal government.

[19]See FAA, *Liability and Risk-Sharing Regime for U.S. Commercial Space Transportation: Study and Analysis* and Aerospace Corporation, *Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation*. See also GAO, *Catastrophe Insurance Risks: The Role of Risk-Linked Securities and Factors Affecting Their Use*, GAO-02-941 (Washington, D.C.: Sept. 24, 2002); *Catastrophe Insurance Risks: The Role of Risk-Linked Securities*, GAO-03-195T (Washington, D.C.: Oct. 8, 2002); and *Natural Disasters: Public Policy Options for Changing the Federal Role in Natural Catastrophe Insurance*, GAO-08-7 (Washington, D.C.: Nov. 26, 2007).

[20]See GAO, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk*, GAO-03-1033 (Washington, D.C.: Sept. 24, 2003). Self-insurance occurs when an entity assumes the risk for its losses and can involve the formation of an insurance company solely for that purpose. Risk pooling occurs when two or more entities agree to set aside funds to help pay for the others' losses.

[21]See GAO, *Flood Insurance: FEMA's Rate-Setting Process Warrants Attention*, GAO-09-12 (Washington, D.C.: Oct. 31, 2008) and *Terrorism Insurance: Status of Efforts by Policyholders to Obtain Coverage*, GAO-08-1057 (Washington, D.C.: Sept. 15, 2008).

As such, alternatives could potentially require a significant amount of time to implement.

Forecasted Increase in Manned Launches and Reentries Could Increase Potential Federal Government Costs; Current Coverage Has a Gap

Issues and Implications for Commercial Manned Launches and Reentries

The planned increase in manned commercial launches and reentries raises a number of issues that have implications for the federal government's indemnification policy for third party liability, according to insurance officials and experts with whom we spoke. NASA expects to begin procuring manned commercial launches to transport astronauts to the ISS in 2017. In addition, private companies are also developing space launch vehicles that could carry passengers for space tourism flights.

First, the number of launches and reentries covered by federal indemnification will increase with NASA's planned manned launches, which will be FAA-licensed commercial launches and reentries.[22] NASA expects to procure from private launch companies 2 manned launches per year to the ISS from 2017 to 2020. In addition, a space tourism industry may also increase the number of launches and reentries covered by federal indemnification, but the timing of these launches and reentries

[22]NASA-contracted launches for NASA's science missions are not currently covered by CSLAA; rather, NASA requires its launch contractors to obtain insurance coverage for third party losses. The amount of the insurance required by NASA is the maximum amount available in the commercial marketplace at reasonable cost, but does not exceed $500 million for each launch. The facts and circumstances for claims in excess of this amount would be forwarded by NASA to the Congress for its consideration. 51 U.S.C. § 20113 (m) (2). NASA-contracted launches for the Commercial Resupply Services to the ISS will be licensed by the FAA under CSLAA, and will be covered by CSLAA indemnification.

is uncertain. Virgin Galactic plans to conduct suborbital, manned launches and reentries. Virgin Galactic forecasts launches starting in 2014 and, according to the company, 500 individuals have made deposits for the $200,000 fare. However, Virgin Galactic has not yet applied to FAA for a launch license and its planned schedule for flights has experienced delays in the past.

According to insurance company officials with whom we spoke, the potential volume of manned launches and reentries for NASA and for space tourism could increase the overall amount of insurance coverage needed by launch companies, which could raise insurance costs, including those for third party liability.[23] By increasing the volume of launches and reentries, the probability of a catastrophe occurring is also increased and any accident that occurs could also increase future insurance costs, according to insurance company officials with whom we spoke. A catastrophic accident could also result in third party losses over the maximum probable loss, which would invoke federal indemnification.

Second, because newly developed manned launch vehicles have less launch history they are viewed by the insurance industry as more risky than "legacy" launch vehicles. Insurance company officials told us that launch vehicles such as United Launch Alliance's Atlas V, which launches satellites and may be used for future manned missions, is seen as less risky than new launch vehicles, such as SpaceX's Falcon 9, which could also be used for manned missions. As of May 2012, Atlas V has had over two dozen launches with a 100 percent launch success rate; Falcon 9 has had 3 successful launches and 2 successful reentries. According to insurance company officials with whom we spoke, they expect to charge higher insurance premiums for newly developed launch vehicles than legacy launch vehicles given their different risk profiles. Insurance company officials' opinions varied as to when a launch vehicle is deemed reliable—from 5 to 10 successful launches. They also told us that whether vehicles are manned is secondary to the launch vehicle's history and the launch's trajectory—over water or land—in determining risk and the price and amount of third party liability coverage.

[23]Launch providers obtain insurance in addition to that for third party liability, including coverage of assets, such as the launch vehicle.

Third, having people on board a space vehicle raises issues of informed consent and cross waivers, which could affect third party liability and the potential cost to the federal government. CSLAA requires passengers and crew on spaceflights to be informed by the launch company of the risks involved and to sign a reciprocal waiver of claims (also called a cross waiver) with the federal government—which means that if an accident occurs the party agrees not to seek claims against the federal government, which would have licensed the launch. CSLAA also requires cross waivers among involved parties in a launch except for spaceflight passengers. Two key issues dealing with cross waivers include the heirs of spaceflight passengers and crew and limits on liability for involved parties.

- The heirs of spaceflight passengers and crew, which are considered third parties to a launch and part of the general public as they are not involved in a launch, are not covered by the informed consent and cross waiver of claims, according to two insurance companies and one legal expert. Although an insurance company said that it would be difficult for heirs to seek damages in case of an accident, the legal expert said that the informed consent requirement does not address future litigation issues. Officials from two insurance companies and one expert told us that they expect spaceflight passengers to be high-income individuals, which could result in large insurance claims by heirs of the passengers, as determination of the amount of claims is based on an individual's expected earning capacity over his or her lifetime.

- According to two insurance companies and two legal experts, requiring cross waivers among the crew, the launch company, and other involved parties may not minimize potential third party claims as they would not place limitations on liability. An insurance company and a legal expert stated that, without a limitation on liability, insurance premiums for third party and other launch insurance coverage could increase as the same small number of insurance companies insures passengers, crew, launch vehicles, as well as third parties to a launch. According to FAA, putting a limitation on spaceflight passenger liability could foster the development of the commercial space launch industry through lower costs for insurance and liability exposure. Liability exposure and the related litigation impose costs on industries and the limitation on liability shifts the risk to spaceflight passengers, who have been informed of the launch risks. If limitations on liability were set by federal legislation, it could conflict with state law because at least five states currently have their

own space liability and indemnity laws limiting liability.[24] Launch and insurance companies believe that a limit or cap on passenger liability could decrease uncertainty and consequently decrease the price of insurance, according to an FAA task force report.[25]

As previously discussed, the potential cost to the government depends on the accuracy of the maximum probable loss calculation, which assesses a launch's risk. If the calculation is understated, then the government's exposure to liability is higher. Thus, whether the launch vehicle is newly developed or manned, the effect on the government's potential cost for third party claims is still based on how accurately the maximum probable loss calculation assesses launch risks. FAA officials told us that they intend to use the same maximum probable loss assessment method for manned launches and reentries as they currently do with unmanned launches.

Gap in Federal Indemnification

Officials from the insurance industry and space launch companies and an expert told us that a gap in federal indemnification is the lack of coverage of on-orbit activities—that is, activities not related to launch or reentry, such as docking with the ISS and relocating a satellite from one orbit to another orbit—but they did not agree on the need to close this gap. FAA licenses commercial launches and reentries, but does not license on-orbit activities. Federal indemnification only applies to FAA-licensed space activities. NASA's commercial manned launches to the ISS will involve on-orbit activities, including docking with the ISS, will be subject to the cross waivers of liability required by agreements with participating countries. This cross waiver is not applicable when CSLAA is applicable, such as during a licensed launch or reentry, and it does not address liability for damage to non-ISS parties such as other orbiting spacecraft. Claims between NASA and the launch company are not affected by the ISS cross waiver and are historically addressed as a contractual agreement. In addition, Virgin Galactic operations will only have suborbital launches and reentries and no on-orbit activities that require regulation. Therefore, according to officials from two launch companies, they do not believe that on-orbit activities need to be regulated by FAA or that federal indemnification coverage should be provided. However, one

[24]Those states are Colorado, Florida, New Mexico, Texas, and Virginia.

[25]FAA, *FAA's Response to NASA on the Insurance Task for Commercial Crew* (Washington, D.C.: Apr. 30, 2012).

insurer noted that other proposed manned launches—such as an on-orbit "hotel" that is in development—will not be NASA related and therefore will not be covered by any regulatory regime. An expert noted that such a proposal for an on-orbit hotel remains an open question regarding regulation and liability exposure. In addition, the expert noted that federal oversight of on-orbit activities may be needed to provide consistency and coordination among agencies that have on-orbit jurisdiction. He pointed out that the Federal Communications Commission and the National Oceanic and Atmospheric Administration have jurisdiction over their satellites and NASA has jurisdiction over the ISS. Thus, according to the expert, there should be one U.S. agency that coordinates regulatory authority over on-orbit activities. If such authority were granted to one agency, then that agency may need to establish memorandums of understanding with other agencies involved in on-orbit activities.

FAA may seek statutory authority over on-orbit activities, according to senior agency officials. They further explained that they are not seeking on-orbit authority for satellite or spectrum usage. An insurer told us that having FAA in charge from launch to reentry would help ensure that there were no gaps in coverage. According to this insurer, this would help bring stability to the insurance market in the event of an accident as involved parties would be clear on which party is liable for which activities. However, having FAA license on-orbit activities would increase the potential costs to the federal government for third party claims. If FAA obtains authority to license on-orbit activities then the potential costs to the government may increase as its exposure to risk increases.

Effects Unknown from Ending Indemnification, but Could Decrease U.S. Competitiveness

The actual effects that eliminating CSLAA indemnification would have on the competitiveness of U.S. commercial launch companies are unknown. For example, we do not know how insurance premiums or other costs might change as well as the availability of coverage. In addition, we do not know whether or to what extent launch customers might choose foreign launch companies over U.S. companies. Furthermore, it is difficult to separate out the effects of withdrawing indemnification on the overall competitiveness of the U.S. commercial space launch industry. Many factors affect the industry's competitiveness, including other U.S. government support, such as research and development funds, government launch contracts, and use of its launch facilities, in addition to the third party indemnification.

While the actual effects on competition of eliminating CSLAA indemnification are unknown, several launch companies and customers

with whom we spoke said that in the absence of CSLAA indemnification, increased risk and higher costs would directly affect launch companies and indirectly affect their customers and suppliers. The same participants said that two key factors—launch price and launch vehicle reliability—generally determine the competitiveness of launch companies. According to two launch customers, launch prices for similar missions can vary dramatically across countries. For example, two customers said that a similar launch might cost about $40 million to $60 million with a Chinese launch company, about $80 million to $100 million with a French launch company, and approximately $120 million with a U.S. launch company. However, another U.S. launch company told us that it is developing a vehicle for a similar launch for which it intends to charge about $50 million. Other considerations also would be involved in selecting a launch company, according to launch customers with whom we spoke. For example, some said that export restrictions for U.S. customers could add to their costs or prevent them from using certain launch companies. One launch customer also said that it considers the costs of transporting the satellite to the launch site as well as other specific aspects of a given launch.

Launch company officials said that the lack of government indemnification would decrease their global competitiveness by increasing launch costs. Launch company officials said their costs would increase as a result of their likely purchase of greater levels of insurance to protect against the increased potential for third party losses, as the launch companies themselves would be responsible for all potential third party claims, not just those up to the maximum probable loss amount. As previously discussed, whether the private insurance market has the capacity to provide coverage at levels currently provided by the government, or at what price they might sell such coverage, is uncertain. Some launch company officials said that their costs may also increase if their suppliers decided to charge more for their products or services as a result of being at greater risk from a lack of CSLAA indemnification. That is, to compensate for their greater exposure to potential third party claims, some suppliers might determine that they need to charge more for their products to cover the increased risks they are now assuming. Some launch companies told us that they would likely pass additional costs on to their customers by increasing launch prices. Two launch customers told us that in turn, they would pass on additional costs to their customers. Several also told us that they might increase the amount of their own third party liability insurance, another cost they might pass on to their customers. Two said they might be more likely to choose a foreign provider if the price of U.S. launches rose.

According to launch companies and customers we spoke with, ending CSLAA indemnification would also decrease the competitiveness of U.S. launch companies because launch customers would be exposed to more risk than if they used launch companies in countries with government indemnification. For example, officials from several launch companies and customers said that if some aspect of the launch payload is determined to have contributed to a launch failure, they could be exposed to claims for damages from third parties. Launch customers are currently protected from such claims through the CSLAA indemnification program. Several launch customers with whom we spoke said that without CSLAA indemnification they might be more likely to use a launch company in a country where the government provides third party indemnification.

According to launch companies with whom we spoke, ending CSLAA indemnification could also have other negative effects. For example, some said that the increased potential for significant financial loss for third party claims could cause launch companies, customers, or suppliers to reassess whether the benefits of staying in the launch business outweigh the risks. If some companies decided it was no longer worthwhile to be involved in the launch business, it could result in lost jobs and industrial capacity. Lastly, one industry participant pointed out that some suppliers, such as those that build propulsion systems, have to maintain significant amounts of manufacturing capacity whether they build one product or many. If there are fewer launches, the cost of maintaining that capacity will be spread among these fewer launches, resulting in a higher price for each launch. To the extent that the federal government is a customer that relies on private launch companies for its space launch needs, it too could face potentially higher launch costs.

Conclusions

Although the number of commercial launches by U.S. companies has generally declined since 2008, commercial space is a dynamic industry with newly developing space vehicles and missions. With the termination of the shuttle program, NASA plans to procure cargo delivery to the ISS from private launch companies in 2012 and intends to use private companies to carry astronauts to the ISS starting in 2017. In addition, private launch companies have been developing launch vehicles that will eventually carry passengers as part of an emerging space tourism industry. Both of these developments would increase the number and type of flights eligible for third party liability indemnification under CSLAA. As the industry changes and grows, periodically assessing federal liability indemnification policy to ensure that it protects both launch companies and the federal government will be important. This assessment would be

affected by the amount of coverage the insurance industry is willing to provide for space launches. This amount depends on a number of factors including the number of launches and reentries and insurers' ability to evaluate the underlying risks. To the extent private insurance capacity might increase, it could reduce the need for indemnification under CSLAA. It is also possible, however, that certain events, such as a launch failure with large losses, could reduce insurance industry capacity for this type of coverage. Review of potential alternative means for addressing the financial risks associated with space launches, while beyond the scope of this work, would also be an important part of any periodic assessment of CSLAA indemnification.

Several factors raise questions about FAA's methodology for determining the maximum probable loss for a commercial space launch or reentry, which determines the amount of insurance coverage launch companies must buy and the amount above which government indemnification begins. Although FAA believes its approach is conservative, we believe that the maximum probable loss methodology needs to be updated. For example, FAA uses a dollar amount for estimating space launch losses from casualties and fatalities that the insurance industry says is outdated. Moreover, FAA has not had outside experts and risk modelers review its methodology. In addition, FAA uses this estimate of losses from casualties and fatalities as the basis for estimating potential property damage, an approach that could underestimate property losses. We agree with FAA that the benefits of developing and implementing a potentially more comprehensive maximum probable loss methodology need to be balanced against the possible increased costs to the agency and launch companies. However, the importance of a sound calculation suggests that a review of the current methodology would be a worthwhile effort. An inaccurate maximum probable loss value could increase the cost to launch companies by requiring them to purchase more coverage than is necessary, or result in greater federal government exposure to expenditures.

Recommendation for Executive Action

To better ensure the accuracy of FAA's determination of the amount of insurance coverage required for an FAA commercial space launch license, we recommend that the Secretary of Transportation direct the Associate Administrator for Commercial Space Transportation to review and periodically reassess FAA's maximum probable loss methodology—including assessing the reasonableness of the assumptions used. For these reviews, the Associate Administrator should consider using external

experts such as risk modelers, document the outcomes, and adjust the methodology, as appropriate, considering the costs.

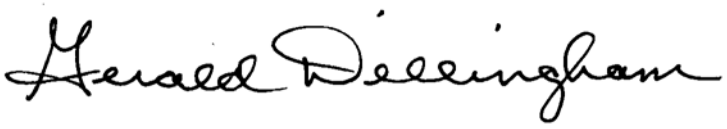
Agency Comments

We provided a draft of this report to the Department of Transportation and NASA for their review and comment. The Department of Transportation provided technical clarifications, which we incorporated as appropriate. NASA had no comments.

We are sending copies of this report to interested congressional committees, the Secretary of the Department of Transportation, and the Administrator of the National Aeronautics and Space Administration. In addition, this report will be available at no charge on GAO's Web site at http://www.gao.gov.

If you or your staff have any questions or would like to discuss this work, please contact Alicia Puente Cackley at (202) 512-8678 or cackleya@gao.gov or Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Individuals making key contributions to this report are listed in appendix II.

Alicia Puente Cackley
Director, Financial Markets and Community Investment



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Appendix I: Objectives, Scope, and Methodology

Our objective was to assess the Commercial Space Launch Act Amendments of 1988 (CSLAA) indemnification policy. To accomplish this, we addressed the following: (1) how the current U.S. commercial space launch indemnification policy compares to other countries' policies; (2) the federal government's potential costs under CSLAA; (3) the extent to which the insurance market is able and willing to provide third party liability insurance at levels currently provided by CSLAA; (4) the implications of commercial manned launches for the current federal indemnification policy, including the gaps, if any, that exist in that policy and the potential financial risks those gaps pose; and (5) what is known about the direct and indirect effects that ending indemnification would have on the competitiveness of U.S. commercial launch companies.

To determine how the current U.S. commercial space launch indemnification policy compares to policies in other countries, we conducted a literature review and selected four countries for comparison—China, France, India, and Russia—because they are the only countries other than the United States that have conducted commercial space launches in the last 5 years. Our source for the amounts of government indemnification provided by these countries is a 2006 Aerospace Corporation report and a 2002 Federal Aviation Administration (FAA) report.[1] To the extent possible, we verified information from the literature review through discussions with officials from FAA, insurance companies, launch companies, and experts. We did not find sufficiently reliable information about India to report on its government indemnification.

To determine the federal government's potential costs under CSLAA, we reviewed CSLAA, our past work on the budget treatment of insurance programs, and FAA's maximum probable loss calculation. We also interviewed FAA officials and experts in risk modeling. To determine the extent to which the insurance market is able and willing to provide third party liability insurance at levels currently provided by CSLAA, we reviewed CSLAA to determine the amount of coverage the act provides commercial launch companies; reviewed relevant industry reports; and interviewed officials from FAA, insurance companies, and brokerage

[1]The Aerospace Corporation, *Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation* (El Segundo, Calif.: August 2006) and Federal Aviation Administration, *Liability Risk-Sharing Regime for U.S. Commercial Space Transportation: Study and Analysis* (Washington, D.C.: April 2002).

companies. We also interviewed launch company officials to determine the additional coverage they might seek absent CSLAA indemnification. To determine a range of paid claims, we reviewed data from the National Aeronautics and Space Administration (NASA) on third party claims that have been paid as the result of the Space Shuttle Columbia accident and from an insurance official on third party claims paid as a result of a U.S. Air Force launch accident. Based on our discussions with NASA officials and an insurance broker involved in the U.S. Air Force claims, we found the data sufficiently reliable for our purposes.

To determine issues and implications of commercial manned launches for the current federal indemnification policy, including the gaps, if any, that exist in that policy and the potential financial risks those gaps pose, we interviewed officials from FAA, NASA, insurance companies, brokerage companies, and launch companies; and experts. To determine what is known about the effects of ending indemnification on the competitiveness of U.S. commercial launch companies, we conducted interviews with officials from launch companies, launch customers, and industry associations, and experts. We also obtained information from FAA on launches and revenues from 2002 through 2011. As the information was used for background, we did not assess the reliability of the data.

We selected launch companies, insurance companies, brokerage companies, and launch customers for interviews that had conducted or participated in commercial launches in the past 5 years. In addition, we selected launch companies that are competing to conduct commercial launches as part of NASA's Commercial Crew Development program or plan to conduct launches and reentries for space tourism. We also selected launch customers to include U.S. companies and foreign companies and those that had used both U.S. and foreign launch companies. We selected experts to interview to provide a variety of expertise, including space liability, risk modeling, and space law issues. Table 1 lists the organizations and agencies whose officials we interviewed as well as the experts we interviewed.

Table 1: Organizations, Agencies, and Experts Interviewed

Category	Organization, agency, or individual
Brokerage company	AON
	Marsh USA
	Willis Inspace
Insurance company[a]	Chartis Europe Limited
	Global Aerospace
	XL Insurance
Launch company	The Boeing Company
	Orbital Sciences Corporation
	Sierra Nevada Corporation Space Systems
	Space Exploration Technologies Corp (SpaceX)
Launch customer[a]	Digital Globe
	GeoEye
Risk modeling company	AIR Worldwide
	Risk Management Solutions
Industry association	The American Academy of Actuaries
	Aerospace Industries Association[b]
	Satellite Industry Association
Federal agency	FAA
	NASA
Expert	Henry R. Hertzfeld, Research Professor, Elliott School of International Affairs, Space Policy Institute and Adjunct Professor of Law, The George Washington University
	Howard Kunreuther, James G. Dinan Professor of Decision Sciences & Public Policy, Co-Director Risk Management and Decision Processes Center, Wharton School, University of Pennsylvania
	Rosanna Sattler, Partner, Posternak, Blankstein, and Lund LLP

Source: GAO.

[a]An additional insurance company and launch customer were interviewed but did not wish to be identified.

[b]Aerospace Industries Association convened a panel that included the launch companies Lockheed Martin, Virgin Galactic, and ATK.

We conducted this performance audit from November 2011 to July 2012 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: GAO Contacts and Staff Acknowledgments

GAO Contacts

Alicia Puente Cackley at (202) 512-8678 or cackleya@gao.gov and Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov

Staff Acknowledgments

In addition to the contacts named above, Teresa Spisak and Patrick Ward (Assistant Directors), Maureen Luna-Long, James Geibel, Carol Henn, David Hooper, Shelby Oakley, Susan Offutt, Amy Rosewarne, Steve Ruszczyk, Melvin Thomas, and Frank Todisco made key contributions to this report.