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Liability Risk-Sharing Regime For U.S. Commercial Space Transportation:

Study and Analysis

U.S. Department of Transportation

Federal Aviation Administration

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Executive Summary

Executive Summary

This report presents the results of a study and analysis of seven issues related to liability risk-sharing for commercial space transportation, as directed by Congress in the Commercial Space Transportation Competitiveness Act of 2000 (Public Law 106-405). It includes public views and recommendations in addition to those of interested federal agencies, as directed by Congress.

The Commercial Space Transportation Competitiveness Act of 2000, Public Law 106-405, referred to in this report as the Space Competitiveness Act, directs the Secretary of Transportation to submit a study and analysis of seven key issues regarding the liability risk-sharing regime for U.S. commercial space transportation. The issues are delineated as follows:

(1) analyze the adequacy, propriety, and effectiveness of, and the need for, the current liability risk-sharing regime in the United States for commercial space transportation;

(2) examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities;

(3) examine the appropriateness of deeming all space transportation activities to be "ultrahazardous activities" for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous activities or not;

(4) examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties;

(5) examine the appropriateness, as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime towards the approach of the airline liability regime;

(6) examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations; and

(7) recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.

As required by Congress, this report contains analyses, views and recommendations of interested federal agencies, as well as views and recommendations of the public, on the seven specific areas of study and analysis identified in the legislation.

Current U.S. Liability Risk-Sharing Regime Under 49 U.S.C. Subtitle IX, Chapter 701, (popularly known as the CSLA)

The U.S. liability risk-sharing regime for commercial space transportation is comprised of three tiers:

Tier I: **Maximum Probable Loss (MPL)-Based Financial Responsibility Requirements**

- Launch or reentry licensee obtains insurance to cover claims of third parties, including Government personnel, for injury, loss or damage, against launch or reentry participants. Participants include the licensee, its customer, and the U.S. Government and its agencies, and the contractors and subcontractors of each of them.
- Launch or reentry licensee obtains insurance covering damage to U.S. Government range property.
- The Federal Aviation Administration (FAA) sets insurance requirements based upon the FAA's determination of the MPL that would result from licensed launch or reentry activities, within statutory ceilings, not to exceed the lesser of:
  - $500 million for third-party liability, or the maximum available on the world market at reasonable cost.
  - $100 million for U.S. Government range property, or the maximum available on the world market at reasonable cost.
- Participants enter into no fault, no subrogation reciprocal or cross-waivers of claims under which each participant accepts its own risk of property damage or loss and agrees to be responsible for injury, damage or loss suffered by its employees, except that claims of Government personnel are covered claims under the licensee's liability insurance coverage.

Tier II: **Catastrophic Loss Protection (Government Payment of Excess Claims, Known as "Indemnification")**

- Subject to appropriations, the U.S. Government may pay successful third-party liability claims in excess of required MPL-based insurance, up to $1.5 billion (as adjusted for post-1988 inflation) above the amount of MPL-based insurance.
- U.S. Government waives claims for property damage above required property insurance.

Tier III: **Above MPL-Based Insurance plus Indemnification**

- By regulation, financial responsibility remains with the licensee, or legally liable party.

Exceptions

- The government does not indemnify a party's willful misconduct.
- The government may pay claims from the first dollar of loss in the event of an insurance policy exclusion that is determined to be "usual."

This executive summary is organized in three parts. The first part reports the views and recommendations of the interested public. Public views were obtained through a public meeting conducted at the Federal Aviation Administration (FAA), virtual public meetings conducted on the Internet, and solicitation of comments to a public docket. The second part provides the views and recommendations of the Commercial Space Transportation Advisory Committee[1] (COMSTAC). COMSTAC submitted a report for inclusion in the study at its October 2001 meeting. The third part provides a summary of report findings, federal agency views and recommendations.

[1] COMSTAC is a committee of non-government, broad-based industry representatives which provides information and advice to FAA and the Department of Transportation.

PUBLIC VIEWS AND RECOMMENDATIONS

Public views and recommendations were elicited using several methods: (1) a public meeting conducted on April 25, 2001, at the FAA in Washington, D.C.; (2) the public docket, open for comments; and (3) two Internet public meetings, held from April 27, 2001 through May 11, 2001, and from September 4, 2001 until September 28, 2001, respectively. Most attendees at the April 25 meeting represented the space transportation industry. The basic themes advocated during the public meetings were:

1. The best way to support the U.S. launch industry is to have stability in the insurance and indemnification regime. The expiration date or "sunset provision" is exploited by foreign competitors, who have no monetary caps or expiration date, nor are they subject to appropriation concerns. A change in the extant liability risk-sharing regime could raise the risk profile of new launch operators and have the following potential effects: deter private investment or increase capital costs as a result of higher perceived risk; shift customers to foreign launch operators; discourage contractor participation leading to increased development costs; and expose the launch operator to greater potential liability. These effects, in turn, could lead to higher operational costs for government and commercial launch operations.

2. The current U.S. liability risk-sharing and indemnification regime should either be retained in its existing form without any changes, or retained with improvements, such as elimination of any sunset provision, to support the competitiveness of the U.S. industry. Foreign launch services providers offer similar or better indemnification in a tight market with small profit margins.

3. The only changes that should be considered in order to ensure continued growth and competitiveness of the U.S. launch industry are those that would improve the existing risk allocation regime, e.g., elimination of the sunset provision or a 10-year extension. Modifications to indemnification, such as establishment of trust funds or use of tax credits (to offset cost of additional insurance), would undermine U.S. industry competitiveness.

4. The need for Congress to appropriate funds for the $1.5-billion indemnification is a disadvantageous provision in the current U.S. regime in comparison to foreign competitors' regimes.

5. Some state laws limit liability for hazardous activities that are not part of a licensed space launch or reentry. Because these activities are not covered by the statutory liability risk-sharing regime, use of commercial spaceports may be hindered.

6. The commercial space transportation industry, including both reusable launch vehicle (RLV) and expendable launch vehicle (ELV) operators, cannot be compared to the commercial airline industry, and the commercial space liability regime will likely not evolve into that used by airlines.

COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE (COMSTAC) RISK MANAGEMENT WORKING GROUP VIEWS AND RECOMMENDATIONS

The FAA tasked COMSTAC to provide a report presenting the range of views on the issues identified for study in the Space Competitiveness Act. COMSTAC adopted a report prepared by its Risk Management Working Group on the seven issues of the Space Competitiveness Act. The report stated that the main objective of the 1988 amendments to the Commercial Space Launch Act (CSLA), which established the current risk allocation regime, was to ensure the competitiveness of the emerging U.S. commercial launch industry—a need that continues under current market conditions. With regard to the various issues of the Space Competitiveness Act, the report stated that:

1. The current regime enables U.S. commercial launch services providers to compete globally, ensures financial responsibility and security for industry and government, protects the national security of the United States and encourages innovation.

2. The risk allocation provided by the current regime is comparable to, albeit less favorable than, that provided by government-supported foreign launch services providers.

3. It is neither necessary nor appropriate to deem all space transportation activities as ultrahazardous.

4. The current regime enables the U.S. Government to meet its obligation under international law with minimal risk to the U.S. taxpayer.

5. There are similarities between the operation of aircraft and conceptual RLVs. Despite the similarities, there are fundamental differences between the operation of civil aircraft and RLVs. Though the application of an aviation-style insurance regime may be possible in the future as RLV flight rates reach sustained higher levels, removal of the current indemnification regime at this time would severely disrupt the formation of the RLV industry.

6. Current users of the spaceports (i.e., licensed launch operators) find application of the existing statutory scheme to licensed launch site and reentry site operators to be adequate and appropriate. However, one launch site operator believes that the FAA's current interpretation of the CSLA risk allocation scheme, which precludes the possibility of U.S. Government indemnification for launch and/or reentry site operators, even though they are licensed by the FAA, is wrong. This operator would like the FAA to extend the full benefits of the CSLA risk allocation regime to all spaceports, including establishing a requisite amount of insurance and the promise to pay claims in excess of such insurance, subject to appropriations.

7. COMSTAC recommended that the CSLA be amended to either (a) delete the "sunset provision," the preferred option, or (b) extend application of the indemnification provision for no less than a 10-year period.

SUMMARY OF FINDINGS

The Federal Aviation Administration of the Department of Transportation (DOT), in cooperation with interested federal agencies, has performed a study and analysis of seven issues specifically identified in the Space Competitiveness Act, and provides the following summary of findings:

Issue 1 — Adequacy, Propriety, Effectiveness, and Need for the Current Liability Risk-Sharing Regime

The current liability risk-sharing regime for commercial space transportation is judged to be **adequate** based on historical acceptability of statutory risk allocation, including risk-based insurance requirements; support of U.S. obligations under relevant treaties; and the ability of the U.S. launch industry to compete for a share of the commercial space launch market.

The current liability risk-sharing regime for commercial space transportation is deemed to be **appropriate** due to the inherently high risk of space transportation. This is predicated on national security, defense, commercial, and civil interests, including benefits derived from economies of scale; considerable precedent for government subsidy and support of other industries such as commercial nuclear power, commercial aviation, and semiconductors; and impacts on launch safety and international competitiveness of U.S. industry.

Effectiveness of the current liability risk-sharing regime has been demonstrated by the following facts. No U.S. commercial launch events have challenged the regime. Cross-waivers of claims among launch participants have encouraged greater insurance industry participation in launch coverage. The U.S. launch ranges continue to demonstrate the highest safety record in the world. Coverage for third parties while protecting government interests from excessive risk has been achieved. Available insurance capacity has increased from the inception of this regime (excluding the yet unknown future impact of the terrorist attack of September 11, 2001, on available capacity).

The **need** for U.S. Government involvement in liability risk-sharing with the commercial space transportation industry was assessed in terms of the following factors: historical evolution and maturity metrics of the U.S. commercial space transportation industry; available insurance capacity history and fluctuations; insurance premium history and volatility; and international competitiveness. The assessment yields the following findings. Since the inception of the current U.S. liability risk-sharing regime, the commercial space transportation industry has, under certain metrics, reached maturity for ELVs, while available insurance capacity has increased and premiums have decreased during the time period of 1988 to 2001. Potential changes in the worldwide insurance industry (i.e., possibly smaller capacity and rising premiums) stemming from the events of September 11, 2001, may also dictate a continuing need for a liability risk-sharing regime. The current liability risk-sharing regime has existed for all licensed commercial space launches. Although foreign competitors use risk-sharing regimes providing similar or greater government indemnification, a variety of factors influence competitiveness. It is therefore impossible to quantify the need for the current regime for reasons of competitiveness except to note that the current regime places U.S. industry on a near-level playing field with foreign competitors. Removal of this consideration may have destabilizing effects on competitiveness in an increasingly competitive international market, particularly given that, over the next decade, launch vehicle supply is predicted to exceed demand for launch services in the commercial space launch market.

Issue 2 — Liability Risk-Sharing Regimes in Other Countries with Space Transportation Capabilities

Major competitors of the United States in commercial space transportation (Arianespace, China, and Russia) offer risk-sharing regimes in which the government assumes a greater share of the risk compared to that of the United States by using a two-tier system including unlimited government indemnification, although some manage it contractually. Countries with emerging competitive commercial space launch capability (Australia, Brazil, India, and Japan) have also adopted two-tier risk-sharing regimes featuring unlimited government indemnification provisions. The current U.S. liability risk-sharing regime is nearly comparable to that of current foreign competitors and emerging competitors with the significant exceptions that the United States: (1) uses a more complicated three-tier system, as opposed to two tiers, with a defined limit on government obligations to cover excess claims ("indemnification"); (2) uses a more complex risk-based method to determine primary insurance coverage requirements; (3) has an expiration date (i.e., sunset provision); and (4) has limited government indemnification subject to appropriations.

Issue 3 — Ultrahazardous Activity and Appropriate Legal Standards

Certain hazardous activities, such as commercial nuclear power, chemical industry pollution, and civil aviation in high-risk regions benefit from U.S. Government liability risk sharing. To date, space transportation activities have not been classified as ultrahazardous under federal law and have not been subject to strict liability standards, whereas activities such as nuclear power generation, explosives manufacturing, and transport of dangerous chemicals are treated under a strict liability standard under state laws without a legislatively conferred "ultrahazardous activity" classification. A federal declaration that commercial space transportation is an "ultrahazardous activity" would likely cause legal complications in claims litigation and settlement and negatively affect insurance market capacity and conditions resulting in higher premiums and reinsurer withdrawal from the market, without affecting the ultimate outcome of managing space launch accident liability claims. Regardless of whether a strict liability or fault-based liability standard applies, societal and political incentives are expected to ensure quick settlement and victim compensation in the event of a launch accident.

Issue 4 — Effects of Outer Space Treaties on Government Launch Liability

Two international treaties, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") of 1967 and the 1972 Convention on International Liability for Damage Caused by Space Objects ("Liability Convention"), are particularly relevant to the domestic space transportation liability risk-sharing regime. Under the Outer Space Treaty, Article VI, the United States bears international responsibility for national activities in outer space. Under the Outer Space Treaty, Article VII, each State Party that launches or procures the launching of an object into outer space, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its persons for damage on the Earth, in air or in outer space. Under the Liability Convention, the U.S. Government accepts liability, either absolute or fault-based, depending upon where damage occurs, when it is a launching State. The current liability risk-sharing regime assigns financial responsibility for the most probable third-party damages arising from U.S.-based FAA-licensed launches and those conducted by U.S. commercial entities to the launch licensee whose insurance protects the interests of the U.S. Government as an additional insured. Accordingly, under the existing liability risk-sharing regime, the government is afforded financial protection in meeting certain of its international treaty obligations, up to the amount of maximum probable loss, at no cost to the government (or U.S. taxpayer).

Issue 5 — Propriety of Applying an Airline Liability Regime to Commercial Reusable Launch Vehicles

RLVs are designed to return to Earth from outer space or Earth orbit, substantially intact and, like aircraft, to be used in subsequent flights. RLV development began in the 1970s with the space Shuttle and has been supported at various times by the Air Force, National Aeronautics and Space Administration (NASA), and private industry. After decades of development and billions of dollars of investment, a commercially viable RLV has yet to develop. Routine RLV operation similar to that of commercial airlines may be decades away.

RLV hazards are, in some ways, similar to those of ELVs during liftoff because of the nature of their propellants, and are also similar to those of airlines in that a crash could occur during the liftoff or reentry and landing phases. Depending upon the actual design of a vehicle, RLV hazards may be greater than those of airlines in terms of the vehicle mass, propellant masses and propellant properties. Under domestic law, RLV mission operators and certificated air carriers are required to obtain a minimum amount of insurance, and there are no limits on liability. The major difference between RLV and airline legal regimes is applicability of the CSLA risk-sharing program to RLV missions, including indemnification. Major airlines, prior to September 11, 2001, have typically obtained between $1 billion and $2 billion in insurance at reasonable rates to protect their assets from accident liabilities. Government-industry liability risk-sharing consistent with the current regime is regarded as desirable to enable RLV developers to manage risk in a manner comparable to that relied upon by ELV operators. The experimental nature of commercial RLV design concepts – coupled with realistic expectations that RLV operations will not be as frequent, reliable, or routine as that of airlines for decades – suggests that it is premature to offer recommendations on transitioning the liability regime applicable to RLVs to that of airlines.

Issue 6 — Commercial Spaceport Operations

Currently, there are four licensed launch sites (popularly referred to as spaceports) in the United States. Three commercial spaceports (i.e., Florida, California, and Virginia) are co-located with federal launch facilities and are within the purview of federal range safety oversight. Alaska's Kodiak Launch Complex is not located on a federal facility. Other states have announced plans or expressed interest in developing commercial spaceports, with principal emphasis on their use to support RLVs. The statutory liability risk-sharing regime covers commercial spaceports during licensed launch or reentry activities. Non-launch-related activities, such as rocket motor balancing, are not covered by the liability risk-sharing regime. None of the states operating licensed spaceports or considering spaceports have the legal authority to indemnify non-launch activities, thereby making them reluctant to offer their sites for potentially hazardous services other than licensed launch or reentry, unless their customer accepts liability risk. Government risk-sharing in launch liability protects launch participants, including commercial spaceports, in the event of a catastrophic launch vehicle or reentry vehicle accident, and protects certain interests of the U.S. Government arising under international law. Education, business development, and related opportunities for commercial spaceports are recognized, but are not federally supported through indemnification. Commercially available insurance can be obtained by spaceports for such activities. Spaceports have identified no activity performed at their sites that warrants federal risk-sharing due to unmanageable risk or for competitiveness purposes. No changes to the current liability risk-sharing regime as it relates to commercial spaceport activities are recommended.

Issue 7 — Recommended Appropriate Modifications

Ten possible options were analyzed and measured in terms of their capability to fulfill one or more of five different purposes or objectives. Two additional modifications – maintaining the current liability risk-sharing regime but offering unlimited or "limitless" indemnification and offering a more unconditional government indemnification, such as that provided under Public Law 85-804 and Executive Order 10789 authority (discussed in Chapter 5 of this report) – satisfy four of the objectives; however, these options would potentially increase the financial obligations of the U.S. Government and were not considered economically viable. The two options were therefore not analyzed in detail and are not included in the following assessment.

Certain options or modifications were found to bolster a given purpose, while others were either neutral or detracted from that specific purpose. For each of the five objectives identified for analysis, the modifications that definitively bolster specific purposes or objectives are delineated on the following page. It should be noted that no single recommended modification fulfills all five objectives.

To maintain adequate space launch third-party liability insurance capacity including catastrophic risk protection, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish tax subsidies (with or without government indemnification)

To support the international competitiveness of the U.S. commercial space transportation industry, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish trust funds (with or without government indemnification)
- Require industry to self-insure (with or without government indemnification)
- Require industry to establish captive insurance (with or without government indemnification)
- Require industry to establish catastrophe bonds (with or without government indemnification)

To maintain the framework of the current regime, which is familiar to launch customers and contractors, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Require higher MPL-based insurance (Tier 1) with current government indemnification
- Maintain current MPL-based insurance requirements (Tier 1) with only $1 billion of government indemnification but eliminate the sunset provision

To maintain a viable and robust U.S. commercial space transportation industry, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish tax subsidies (with or without government indemnification)

To establish full cost internalization by launch participants, one of the following could be done:

- Maintain current MPL-based insurance requirements (Tier 1) but eliminate government indemnification
- Eliminate MPL-based insurance requirements (Tier 1) and eliminate government indemnification

Chapter 1

Introduction

Chapter 1
Introduction

Chapter 1 presents the purpose of this report; background regarding U.S. commercial space transportation risk allocation from 1984 to the present; the current U.S. commercial launch liability risk-sharing regime; and the organization of this report.

1.1 Purpose of Study

Congress directed the Secretary of Transportation to study and analyze the existing liability risk-sharing regime for U.S. commercial space transportation. This study provides a framework for understanding the role liability risk-sharing, as directed by 49 U.S.C. Chapter 701 (popularly known as the Commercial Space Launch Act, or CSLA), has played in enabling development of the commercial space launch industry and in securing its viability and international competitiveness.

First enacted in 1988, statutory provisions for allocating risk among public and private participants in launch activities were intended to relieve private industry of the risk of potentially catastrophic liability associated with launching satellites into space and to place U.S. industry on a more equal footing with foreign launchers offering government-sponsored services and financial protections to customers and suppliers. The most prominent feature of the regime provided a mechanism, popularly known as "indemnification," for payment by the government of excess liability claims against launch participants.

Indemnification under the CSLA was initially enacted for a five-year term, thereby assuring Congress and the Administration an opportunity to revisit the need for an extension based upon launch and insurance industry developments and related market conditions. In 1993, a six-year extension of liability risk-sharing and indemnification was enacted with little or no controversy; however, public debate over the need to continue further government indemnification of commercial launch activities beyond 1999 proved a temporary stumbling block to passage of a second multiyear extension. A one-year extension was enacted in 1999 to retain the status quo while Congress considered longer-term legislation. In October 2000, the Commercial Space Transportation Competitiveness Act of 2000 (referred to in this report as the "Space Competitiveness Act," or "SCA") was enacted, assuring maintenance of the liability risk-sharing status quo through 2004, but directing an assessment of the need to continue it thereafter.

The Space Competitiveness Act, Public Law 106-405, mandated the conduct of a multifaceted study of liability risk-sharing under the CSLA. In continuing the existing regime through 2004, Congress found that the extension would be beneficial to the international competitiveness of the U.S. space transportation industry. Congress determined that the need exists to maintain the Nation's economic well-being and national security through a robust space transportation industry. However, Congress also found that space transportation may evolve into airplane-style operations, given the much-heralded development of reusable launch vehicle (RLV) technology for commercial use, and that this eventuality, along with other considerations, warranted examination of appropriate risk-sharing for commercial space transportation beyond 2004.

Current U.S. Liability Risk-Sharing Regime Under 49 U.S.C. Subtitle IX, Chapter 701, (popularly known as the CSLA)

The U.S. liability risk-sharing regime for commercial space transportation is comprised of three tiers:

Tier I: **Maximum Probable Loss (MPL)-Based Financial Responsibility Requirements**

- Launch or reentry licensee obtains insurance to cover claims of third parties, including Government personnel, for injury, loss or damage, against launch or reentry participants. Participants include the licensee, its customer, and the U.S. Government and its agencies, and the contractors and subcontractors of each of them.
- Launch or reentry licensee obtains insurance covering damage to U.S. Government range property.
- The Federal Aviation Administration (FAA) sets insurance requirements based upon the FAA's determination of the MPL that would result from licensed launch or reentry activities, within statutory ceilings, not to exceed the lesser of:
  - $500 million for third-party liability, or the maximum available on the world market at reasonable cost.
  - $100 million for U.S. Government range property, or the maximum available on the world market at reasonable cost.
- Participants enter into no fault, no subrogation reciprocal or cross-waivers of claims under which each participant accepts its own risk of property damage or loss and agrees to be responsible for injury, damage or loss suffered by its employees, except that claims of Government personnel are covered claims under the licensee's liability insurance coverage.

Tier II: **Catastrophic Loss Protection (Government Payment of Excess Claims, Known as "Indemnification")**

- Subject to appropriations, the U.S. Government may pay successful third-party liability claims in excess of required MPL-based insurance, up to $1.5 billion (as adjusted for post-1988 inflation) above the amount of MPL-based insurance.
- U.S. Government waives claims for property damage above required property insurance.

Tier III: **Above MPL-Based Insurance plus Indemnification**

- By regulation, financial responsibility remains with the licensee, or legally liable party.

Exceptions

- The government does not indemnify a party's willful misconduct.
- The government may pay claims from the first dollar of loss in the event of an insurance policy exclusion that is determined to be "usual."

In light of these circumstances and the lack of a sufficiently developed record regarding the need to continue the liability risk-sharing regime of the CSLA, Congress directed the Department of Transportation (DOT) to provide the factual, policy, and legal foundations upon which the Federal Government and the private sector could assess its propriety and effectiveness. Then, if deemed necessary, the Federal Government and private sector may use the information developed through the study to consider a modified or replacement regime.

The elements of this report, directed by Congress for study under the Space Competitiveness Act, are delineated below.

1) "analyze the adequacy, propriety, and effectiveness of, and the need for, the current liability risk-sharing regime in the United States for commercial space transportation;

2) examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities;

3) examine the appropriateness of deeming all space transportation activities to be "ultrahazardous activities" for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous activities or not;

4) examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties;

5) examine the appropriateness, as commercial RLVs enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime towards the approach of the airline liability regime;

6) examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations; and

7) recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications."

In addition, Congress directed that the report "…shall contain sections expressing the views and recommendations of: (1) interested federal agencies including—(A) the Office of the Associate Administrator for Commercial Space Transportation, Federal Aviation Administration; (B) the National Aeronautics and Space Administration; (C) the Department of Defense; and (D) the Office of Space Commercialization, Department of Commerce; and (2) the public…."

1.2 Background of U.S. Commercial Space Transportation Risk Allocation

1.2.1 Pre-1988 Liability Risk Management for Commercial Space Transportation

The Commercial Space Launch Act of 1984, Public Law 98-575, focused on liability considerations for the U.S. Government arising out of commercial launches. It addressed launch liability concerns of the U.S. Government by requiring that a launch licensee obtain liability insurance in an amount considered necessary by DOT, considering the international obligations of the United States (49 U.S.C. App. 2615). DOT would prescribe the appropriate amount of insurance after consulting with the Attorney General and other appropriate agencies; however, the CSLA provided no further direction by which DOT would determine the amount of insurance deemed appropriate to address the potential liability of the United States. (International obligations assumed by the United States under treaties concerning launch liability are addressed in detail in Chapter 6 of this report.)

In addition, DOT was given discretion to determine appropriate measures, including requirements for liability insurance and hold harmless agreements, to protect the United States and its agencies and personnel from liability, loss, or injury as a result of a launch or operation of a launch site involving government facilities or personnel (49 U.S.C. App. 2614).

In enacting these requirements, Congress acknowledged treaty-based liability assumed by the U.S. Government and granted to DOT licensing authority commensurate with international responsibilities assumed by the United States under treaty [S. Rpt. No. 98-656, 98th Cong., 2nd Sess. at 14 (1984)]. For international claims, the U.S. Government could require contribution from the licensed launch operators to cover any treaty-based liability of the U.S. Government. Although DOT would prescribe insurance requirements, commercial launch operators remained potentially liable for all third-party damages resulting from commercial launches, without bound. Effectively, this arrangement left the licensed launch operator potentially liable for the maximum *possible* loss that could result from a licensed launch.

Executive Order 12465, signed by President Reagan in February 1984, in combination with passage of the CSLA subsequently that year, created the legal and policy framework for commercialization of the U.S. launch industry and placed responsibility for safety regulation with DOT. Although the CSLA enacted a legal framework for licensing of commercial launches, commercialization of the U.S. launch industry proceeded slowly. Issuance in 1986 of National Security Directive 254 following the *Challenger* accident of that year created a more favorable climate for launch commercialization by prohibiting launch of a commercial or foreign payload on the Shuttle.

The year 1988 proved to be a significant turning point in commercialization of the U.S. space launch industry. Administration space policy evolved to acknowledge the significance of private sector launches. The National Space Policy issued by President Reagan on February 11, 1988, recognized a distinct commercial space sector that would exist alongside military and civilian government sectors to maintain U.S. space leadership. The Reagan Administration also announced a 15-point Commercial Space Initiative (CSI 1988), reinforcing promotion of a robust commercial launch industry by, among other things, establishing risk allocation between the government and private sector for use of government launch ranges in the conduct of commercial launches. The Commercial Space Initiative called for a waiver by the U.S. Government in the event of property damage at the federal ranges in excess of DOT-required insurance. It also provided for a U.S. Government waiver of claims when loss or injury was the result of government willful misconduct or recklessness. Passage of the CSLA Amendments of 1988, Public Law 100-657 (1988 Amendments), codified into law the government's property waiver policy and the existing financial responsibility and liability risk-sharing regime.

Although national space policy was evolving to facilitate commercialization of a U.S. launch industry, no launch licenses had been issued as of November 1988, when the existing liability risk-sharing regime was enacted.

1.2.2 1988 Congressional Hearings

1.2.2.1 Bases for the 1988 Commercial Space Launch Act Amendments

For space launch services to become a viable commercial industry, federal policy needed to be established making government-owned launch infrastructure at the federal ranges, including facilities and services, available to support the new commercial industry. Federal ranges remained the primary source of critical launch infrastructure, and agreements with the cognizant range authorities were necessary to allow a commercial entity access to the ranges for purposes of launching private satellites. In response, the Air Force developed a "model use agreement" that provided the terms and conditions for commercial use of national range assets. (*See* the U.S. Air Force Model Expendable Launch Vehicle Commercialization Agreement, January 1988, (Revision), referred to herein as "Air Force Agreement.")

Nevertheless, progress was slow in developing a commercial launch industry and gaining market share in internationally competed launch services. Congress held hearings over a two-year period, 1987 and 1988, regarding obstacles to space launch commercialization and means of facilitating commercialization. U.S. industry representatives testified to the difficulties of attempting to act as a private commercial industry in the face of government-backed foreign competition and enormous liability risk that previously had been managed by the U.S. Government as part of launch services procurement.

Accordingly, a primary focus of congressional concern at the 1988 hearings was appropriate risk allocation for commercial launches. At the hearings, the point repeatedly made by industry and Congress was that launch services had, for years, been strictly a governmental function. The government typically would self-insure its own property and assume its launch liability risk and that of its contractors (i.e., launch vehicle operators). Under authority provided in Public Law 85-804, the Air Force agreed to indemnify contractors providing launch services, and the National Aeronautics and Space Administration (NASA) provided indemnification to its contractors under Section 308 of the Space Act of 1958, as amended. An insurance market that would address liability and risk to range property and assets existed, but was of limited capacity. To the extent insurance was available, it was costly and inadequate to cover the liability exposure of launch operators and their contractors and customers.

Representatives of large and small launch operators testified that they were forced either to "bet the company" with each launch or decide not to accept the risk and stay out of the commercial launch business. To further aggravate matters, the newly established commercial launch industry was competing against foreign suppliers of launch services, such as Arianespace, and the Soviet and Chinese launch systems, whose governments subsidized launch operations and accepted liability risk on behalf of their launch providers.

Further compounding the commercial launch industry's insurance and risk management difficulties was imposition by the Air Force under its "model use agreement" of third-party liability on the launch operator. Under the Air Force Agreement, the user, or commercial launch provider, was required to fully assume third-party liability arising out of use of Air Force ranges, to the extent of the maximum available insurance, except in the event of intentional misconduct by the government or its contractors. That agreement required the user to indemnify and hold harmless the government, its contractors, and associated personnel from any third-party liability arising out of activities under the Air Force Agreement. Moreover, under the terms of the Air Force Agreement, the United States reserved "the right to pursue claims or bring appropriate legal action against the user or any other responsible party for its damage or for liability incurred under U.S. or international law or agreement" (Air Force Agreement, Article IV.c.6). Hence, commercial launch providers were ultimately responsible for covering the maximum possible liability that could arise out of their launch activities, whether insurance was available to cover the risk or not. The Air Force Agreement was later modified to provide that, to the extent insurance was not sufficient to cover all third-party claims, questions of liability between the parties and responsibility for paying claims would be left for resolution according to applicable U.S. law.

Legislation was introduced in the House and Senate to address a more equitable means of allocating risk between the public and private sectors. Hearings were conducted on February 16 and 17, 1988, before the Subcommittee on Space Science and Applications of the House Committee on Science, Space, and Technology on H.R. 3765, predecessor legislation to the 1988 Amendments. At the hearing, launch industry representatives testified to a number of difficulties impeding space launch commercialization, including concerns over appropriate risk allocation for launch services and the inability of the insurance market to respond. Industry representatives testified to the need for a risk allocation scheme, based in law, that would relieve the commercial launch industry of the risk of potentially catastrophic liability associated with launch vehicles, or from "betting the company" with each launch. Industry representatives further raised as an obstacle to commercialization their inability to manage liability risks in a satisfactory way due to lack of insurance capacity. Lack of government support for the commercial launch industry's potential liability was also cited as an impediment to the U.S. industry's ability to compete effectively against foreign launch services providers whose governments offered indemnification to launch customers and other participants. At that time, the commercial launch services market was dominated by the European Space Agency-backed Arianespace, which had gained the dominant share of the commercial satellite launch business in the two-year Shuttle stand-down following the 1986 *Challenger* accident and the lack of an alternative U.S. launch vehicle supply. Demand for launch services was relatively small, and the small market that existed was dominated by Arianespace launch vehicles.

The commercial launch industry advocated an allocation of launch risk between private launchers and the government as a means of alleviating, to varying degrees, obstacles to the launch industry's ability to become internationally competitive and viable. Government/industry risk-sharing would allow U.S. launch operators to compete against foreign suppliers that offer government-backed indemnification, modeled in large part on the precedent established by NASA in launching commercial payloads on the Shuttle, according to industry testimony. Under the NASA Program, NASA would require payload owners to provide the maximum liability insurance available at a reasonable premium and would indemnify users of Shuttle services in the event of excess liability. Typically, $500 million was required for a single payload launched on the Shuttle and, where multiple payloads were launched, payload owners would contribute toward $750 million in coverage. Under authority of the Space Act of 1958, as amended, Section 308, NASA could indemnify payload owners in the event of excess liability claims. As part of the arrangement, payload owners were required to enter into cross-waivers of claims against NASA and other payload owners under which each participant in a Shuttle launch would agree to absorb its own property damage. The cross-waiver scheme relieved participants from the need to buy liability insurance to protect against claims for damage to another's property, thereby relieving further drain on the limited supply of insurance for space launch.

Provisions of the legislation were actively debated at the hearings. Some representatives of the insurance community were concerned that limiting liability insurance requirements to $500 million, regardless of availability of more insurance at reasonable cost, would prevent the insurance market from developing, place greater burden on the U.S. taxpayer, and provide a disincentive to launch operators to buy more insurance even if it were available on reasonable price terms.

One witness testified that indemnification had no bearing on international competitiveness but, rather, must be regarded in a larger context; that is, as part of a package of government support foreign governments provide to their launch systems. He forecast that, in the long term, international competition with support of foreign governments would cause U.S. expendable launch vehicles (ELVs) to become noncompetitive, and this in turn would "necessitate the need for U.S. Government involvement in the form of subsidization or a change in the private-public sector infrastructure for the provision of commercial ELV launch services." [1]

At the hearings, launch and satellite industry representatives testified that a comprehensive risk allocation program limiting the amount of insurance that launch operators would be required to purchase would relieve the strain on the liability insurance market for space launch and allow capacity to grow and

[1] Testimony of Joel Greenberg, President, Princeton Synergetics, Inc., H.R. Rep. No. 114, 100th Cong., 2d Sess. at 95 (1988).

eventually respond to market demand. A public/private partnership for equitable sharing of launch risk would benefit the U.S. Government while relieving launch providers of their concern that they would risk their companies on each launch, a concern that could lead launch providers to decline to offer commercial launch services, according to industry statements.

In its submission to the record, the American Institute of Aeronautics and Astronautics (AIAA) identified the need for a commercially-tolerable approach to allocation of launch liability risks. It suggested that a risk allocation program prescribing a level of reasonably available commercial insurance based upon an assessment of risk factors would facilitate and encourage a U.S. commercial space transportation industry, when coupled with an excess of insurance protection assumed or contained by the U.S. Government, either through indemnity, a cap on liability, or a combination of government-provided insurance of last resort and indemnity or a cap on liability for excess claims above the amount of insured risk. (*See* "U.S. Commercial Space Transportation Risk Allocation Insurance, an AIAA Position Paper," January 1988.)

The Administration did not support the risk allocation scheme proposed in H.R. 3765, however. Instead, the Administration stated that it would propose a cap on non-economic damages, consistent with tort reform, as a means of relieving the launch industry's concern over unbounded risk, and would recommend an insurance pool in place of government indemnification. Critics of the Administration's proposal pointed out that insurance pooling would not work for an industry with very few participants (launch operators) and so few launch events per year (20 to 30 internationally competed commercial launches predicted as the annual rate for the following 10-year period). House Subcommittee Chairman Bill Nelson of Florida responded to Administration testimony by stating that tort reform was not within the jurisdiction of the Committee on Science, Space, and Technology and was too controversial to successfully address immediate concerns over launch liability.

Shortly thereafter, the Senate held hearings on H.R. 4399, the successor legislation to H.R. 3765, introduced in the Senate as S. 2395. A hearing on "Commercial Expendable Launch Vehicle Liability" was conducted before the Subcommittee on Science, Technology, and Space, chaired by Senator Donald W. Riegle, Jr., of the Committee on Commerce, Science, and Transportation, which was chaired by the Honorable Ernest F. Hollings. Chairman Hollings's opening statement expressed deep concern about foreign competition, but noted a number of issues requiring resolution. The Chairman stated that he had "serious reservations" about the proposed risk allocation measures in the bill, noting concern over the national interest in supporting a commercial launch industry and the propriety of indemnification for the launch industry as distinct from other U.S. industries. He asked whether the wrong issue was under debate and if the issue should be "whether or not the United States should be trying to promote a commercial RLV industry when the rest of the world is promoting government-subsidized launch vehicle industries…," referring to the French Ariane, Russian Proton, Chinese Long March, and Japanese H-II launch vehicle systems [S. Hrg. 100-750, 100th Cong., 2d Sess. (1988)].

Once again, the Administration testified against the bill, while the Senate Subcommittee on Science, Technology, and Space stressed the need to retain U.S. industry leadership in space transportation and pointed out the uniqueness of the commercial launch industry in terms of risk and risk management.

The launch industry testified that it had entered the commercial launch arena with the expectation that the government would follow the precedent established by NASA on risk management in terms of an insurance cap and cross-waivers limiting liability risk exposure. An insurance brokerage concern, Alexander & Alexander, testified to the difficulties of covering launch liability through private insurance for several reasons. Space insurance losses were substantial in the late 1980s, and that affected the willingness of underwriters to accept liability risk for launches. The volatility of the market made it difficult to price insurance. And, most importantly, the law of large numbers and the ability to spread risk that is critical to the provision of insurance did not apply to launches because there were so few events.

1.2.2.2 State of the Insurance Market

Following the Senate hearings on H.R. 4399, the Congressional Research Service issued a report entitled *Insurance and the U.S. Commercial Space Industry*, submitted June 20, 1988, updating its 1985 report. The report was prepared for the Senate Committee on Commerce, Science, and Transportation, chaired by Senator Hollings. The report echoed a number of themes reflected in the Senate hearings, including inapplicability of the law of large numbers and inability to adequately spread risk; the volatility of the insurance market and, hence, premiums; and the potential for government liability and responsibility in the event of an accident due to its involvement in launch activities.

The report considered a number of options, including risk pooling, such as that used for the nuclear power industry, and a combination of tiered insurance with a government insurance fund to cover excess liability. The former option was viewed as undesirable because there were too few launch services providers to fund the pool. Merely adding subcontractors to the pool could increase launch costs, making the companies less competitive internationally. The latter option would require further study, but still had the disadvantage of increasing launch prices and making the U.S. industry less competitive against foreign launchers.

The report concluded by stating that the issue before Congress was not whether the government should support the commercial launch industry, citing government involvement in launch operations on a number of fronts, including the provision of launch property and services, but rather, how much government involvement would be appropriate. The report did not answer that question, noting that it must be considered as part of larger policy questions.

1.2.2.3 1988 Amendments to the Commercial Space Launch Act

The 1988 amendments to the CSLA, enacted November 15, 1988, Public Law 100-657, formed the basis of the three-tiered comprehensive risk allocation regime currently in effect. That regime, as currently implemented by the FAA in regulations, is described in greater detail below. The amendments retained the notion of risk-based insurance based upon a determination by DOT of the maximum probable loss (MPL) to third parties and government property presented by a proposed launch. Over the objection of some insurance industry members, required third-party liability insurance was capped at the lesser of $500 million or the maximum available on the world market at reasonable cost. Government property insurance requirements would be based upon a determination of MPL and limited to the lesser of $100 million or the maximum available on the world market at reasonable cost. A requirement for reciprocal waivers of claims among all launch participants, including the government, was added to the CSLA. Above the required amount of insurance, the 1988 amendments to the CSLA provided for payment by the government of excess claims. However, unlike other statutory indemnification schemes, the CSLA provides a mechanism by which Congress may appropriate funds to cover excess liability, up to a statutorily established ceiling, in response to a compensation plan prepared by DOT and submitted by the President.

1.2.3 History of Extensions

The 1988 Amendments, as enacted, provided a brief 5-year life span for the newly developed commercial launch liability risk allocation regime. In response to Administration objections to indemnification, a

5-year sunset provision (a compromise from an initial 10-year proposal) was added, making it available only for launches conducted pursuant to an application submitted to DOT by the end of 1993. Thus, under the 1988 Amendments, claims arising out of a launch conducted pursuant to a license for which an application had been submitted to and accepted by DOT by the end of December 1993, would be eligible for indemnification.

In November 1992, the 5-year sunset provision was extended from December 1993 through 1999, by Section 503 of the NASA Authorization Act for Fiscal Year 1993, Public Law 102-588.

In April 1999, with the next sunset date of December 1999 on the horizon, the House Subcommittee on Space and Aeronautics of the Committee on Science conducted hearings to address, among other things, U.S. commercial space launch competitiveness and bases to extend further space launch indemnification under the CSLA. Inability to report a bill out of conference committee led to a one-year extension of the sunset provision from December 31, 1999, to December 31, 2000, enacted by Section 433 of H.R. 2684, the Departments of Veterans Affairs and Housing and Urban Development and Independent Agencies Appropriations Act, 2000. The following year, the Commercial Space Transportation Competitiveness Act of 2000 was enacted, providing a multiyear extension of the indemnification sunset provision through December 2004 and directing DOT to study questions associated with appropriate risk allocation for commercial space transportation and possible modifications to the existing risk-sharing program.

1.3 Current Liability Risk-Sharing Regime

In 1998, the FAA issued final rules, codified at 14 CFR 440, implementing the statutory three-tiered liability risk-sharing regime for licensed launches set forth in the CSLA, as amended in 1988. (*See* 63 FR 45592-45625, issued August 26, 1998.) On September 19, 2000, the FAA issued comparable requirements, codified at 14 CFR 450, for licensed reentries, including reentry of an RLV, although an application had not yet been submitted seeking a license to conduct a reentry. (*See* 65 FR 56670-56705.)

Under the CSLA and as reflected in 14 CFR 440, the first tier or most probable risk of loss is covered by insurance obtained by a launch licensee. The licensee is directed by the FAA to obtain the lesser of up to $500 million of insurance or other demonstration of financial responsibility, as determined by the FAA, or the maximum liability insurance available on the world market at reasonable cost if the FAA-established amount is not otherwise available. The amount of insurance prescribed by the FAA is based upon its determination of the maximum probable loss, or MPL, for covered third-party claims for bodily injury or property damage resulting from licensed activities in connection with any particular launch or reentry. Covered third-party claims are those of persons or entities not participating in the licensed activity, except that claims by government and government contractor employees are also covered third-party claims. Claims of employees of other launch participants are not covered third-party claims and are the responsibility of their employer, as explained below. Insurance obtained by the licensee must cover as additional insureds the licensee, its customer, the United States and its agencies, and the contractors and subcontractors of each of them, involved in launch services.

Government range property must be covered by insurance or other demonstration of financial responsibility up to the lesser of $100 million or the maximum available on the world market at reasonable cost. The amount of insurance prescribed by the FAA is based upon its determination of the MPL for covered property resulting from licensed activities in connection with any particular launch or reentry. Covered property includes all property owned, leased, or occupied by, or within the care, custody, or control of, the United States, its agencies, contractors, and subcontractors, involved in licensed launch or reentry activities at a federal launch range. For purposes of allocating risk, government property located off the federal launch range is regarded as other third-party property and must be covered by the licensee's liability insurance. The government waives any claims it may have for damage or loss to government range property above the required amount of insurance for that property.

MPL is defined in 14 CFR 440 to mean the greatest dollar amount of loss for bodily injury or property damage that is reasonably expected to result from licensed launch activities. The regulations establish probability thresholds on the order of 1 in 10 million that losses to third parties (other than government personnel) will exceed the required amount of liability insurance and on the order of 1 in 100,000 that losses to government property on a federal launch range will exceed the required amount of property insurance. The difference in thresholds reflects the government's acceptance of greater risk in supporting launch activities than that accepted by the uninvolved public.

In the rulemaking proposal for launch financial responsibility, issued July 25, 1996 (*see* 61 FR 38992-39021), the FAA explained in significant detail its methodology and assumptions used to determine MPL and associated financial responsibility requirements for licensed launches and to assess and allocate launch risk among launch participants. The analyses are specific to the type or model of launch vehicle and launch site, taking into account property and population at and surrounding a particular launch site. The FAA uses conservative assumptions in its analyses in estimating the number of casualties in the event of a launch accident and the percent of loss to infrastructure at a launch site. The FAA assigns a value of $3 million per fatality and does not consider consequential damages, such as loss of use or lost profits.

Launch participants are required to enter into no fault, no subrogation reciprocal waivers of claims under which each party to the agreement agrees to accept the risk of damage or loss to its property and agrees to waive and release claims against the other parties to the agreement for property damage or loss. Launch participants must also agree to assume financial responsibility for covering claims of their employees against other launch participants for injury, damage, or loss. Under 14 CFR 440, the FAA requires that launch or reentry licensees execute reciprocal waiver of claims agreements with their customers and the U.S. Government under which each party passes on the responsibility of the waiver of claims agreement to its contractors and subcontractors by requiring that they enter into like agreements.

Reciprocal waivers of claims are a critical element of risk management because they relieve each participant in a launch from liability to the other participants and from the threat of costly litigation in the event their activity or property causes damage or injury to property or employees of the other launch participants. The only exception from the waiver of claims agreement is in the event of a party's willful misconduct. Launch participants may insure or self-insure their own property, such as the launch vehicle or spacecraft, but, by virtue of the reciprocal waivers, do not require liability insurance to protect themselves from claims of other launch participants. And, because the licensee's liability insurance must cover all launch participants as additional insureds, launch participants do not need to obtain separate liability coverage for claims that result directly from the licensed launch. In this manner, component suppliers, such as rocket motor and other parts manufacturers, who might otherwise be reluctant to participate in licensed activity, are covered for liability exposure resulting from a licensed launch. By avoiding the need for multiple insurance coverage for claims arising out of the same launch event, and by minimizing the risk of interparty litigation, launch costs are contained and insurance capacity is assured.

Above the amount of liability insurance the FAA prescribes in a license order, the CSLA payment of excess claim provisions, or indemnification, provides a mechanism for Congress to appropriate funds to pay successful covered claims of third parties against launch participants up to a statutorily established ceiling of $1.5 billion[2], subject to post-1988 inflation. This amount represents the second tier of the three-tiered risk allocation regime. The CSLA prescribes detailed procedures for congressional consideration and approval of legislative authority providing for claims payment in response to a compensation plan prepared by DOT and submitted to Congress by the President.

Above the combined amount of required insurance plus appropriated indemnification, the third and last tier of risk, responsibility for covering claims belongs to the legally liable party. By regulation, the FAA does not relieve the licensee of the government's responsibility, including that arising under international law, for satisfying claims in excess of the combined amount of insurance plus indemnification, the third risk tier, unless the licensee has no legal liability for the claim.

Payment of excess claims under the CSLA also extends to third-party liability, where insurance is not available to cover a successful claim because of an insurance policy exclusion determined usual for the type of insurance involved. Under 14 CFR 440, the FAA does not make an advance determination that an exclusion is usual, but places responsibility upon the licensee for obtaining insurance, if it is commercially available at reasonable cost. For the FAA to support a claim for indemnification under those circumstances, the FAA requires a certification of the licensee, at the time of submission of evidence of compliance with the license, that insurance covering the excluded risk is not commercially available at reasonable cost. Where coverage is not available because of a usual insurance exclusion, government indemnification applies from the first dollar of loss.

1.4 Organization of This Report

This report consists of 12 chapters and 6 appendices, which have been designed to fully respond to the requirements set forth in the Space Competitiveness Act. Chapter 1 presents the history, basis, and an explanation of the current liability risk-sharing regime in the United States for commercial space transportation. Chapter 2 presents information sources, limitations, and boundaries for the study and the methodology used in analyses presented in this report. Chapters 3, 4, 5, 6, 7, 8, and 9 each address one of the seven issues or elements specified in the Space Competitiveness Act and mandated by Congress for this study. Chapter 10 presents a summary, findings, and recommended options as a result of the analyses, study, evaluation, and assessments in the previous chapters. Acronyms and a glossary are included in Chapters 11 and 12, respectively. Appendix A summarizes all public comments received through meetings, Internet sites, and submissions to the FAA docket. Federal agency views and recommendations are presented in Appendix B. The Commercial Space Transportation Advisory Committee (COMSTAC) report on the current liability risk-sharing regime is presented in Appendix C. Appendix D describes, as a result of interviews with key insurance brokers and underwriters, the commercial space launch liability insurance market. Appendix E describes the history of U.S. Government support of the commercial aviation, semiconductor, and commercial nuclear power industries, respectively. Appendix F presents the effects of the events of September 11, 2001, on civil aviation liability and the commercial airline insurance industry, and discusses correlating commercial space transportation liability risk-sharing impacts.

[2] The inflation adjusted amount is computed as $2.2 billion in 2001 dollars, but would be subject to further changes in inflation rates and assessed at the appropriate time as needed. Due to fluctuation and variations in inflation rates, the report relies upon the statutory construct of $1.5 billion subject to post-1988 inflation.

1.5 References

CSI (Commercial Space Initiative), 1988, The President's Space Policy and Commercial Space Initiative to Begin the Next Century, February 11.

Department of the Air Force Model Expendable Launch Vehicle Commercialization Agreement, Article IV, January 1988 (Revision).

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Insurance and the U.S. Commercial Space Industry, Congressional Research Service, June 20, 1988.

S. Hrg. 100-750, 100th Cong., 2d Sess. (1988), Hearing before the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation on *Commercial Expendable Launch Vehicle Liability*, May 17.

S. Rep. No. 98-656, 98th Cong., 2nd Sess. at 14 (1984), Report of the Committee on Commerce, Science, and Transportation on Commercial Space Launches.

"U.S. Commercial Space Transportation Risk Allocation Insurance, an AIAA Position Paper," American Institute of Aeronautics and Astronautics position paper submitted to the House Subcommittee on Space Science and Applications, January 1988.

Chapter 2

Scope of Study and Analyses

Chapter 2
Scope of Study and Analyses

Chapter 2 delineates the sources of data used for this report, along with the boundaries and limitations describing its scope. The methodology used in preparing the report is also presented in this chapter.

2.1 Introduction

This chapter provides a description of the sources of information and data, limitations and boundaries, and methodology that were used in developing this report.

2.2 Data and Information Sources

Information provided in this report is based on the following sources:

- Federal Aviation Administration (FAA)/Office of Associate Administrator for Commercial Space Transportation regulations on commercial space transportation
- Congressional hearings on the Commercial Space Launch Act and amendments
- Virtual and in-person public meetings
- Written public comments to the docket [Docket Number FAA-2001-9119]
- Consultation with federal agencies
- Consultation with aviation and launch liability insurance brokers and underwriters
- Consultation with satellite manufacturers who are major commercial launch customers
- Consultation with foreign launch services providers
- International treaties and law
- Law review articles and treatises, as well as a review of potentially relevant case law
- Documentation, reports, and studies (government and private)
- Economic analyses

2.3 Limitations and Boundaries of Study and Analyses

The study and analyses presented in this report were prepared within certain specified and practical limitations and boundaries. Most of these limitations and boundaries were necessitated by the nature and history of the worldwide commercial space transportation and insurance business areas. Until enactment of the Commercial Space Launch Act of 1984 and its subsequent amendments, the 1986 *Challenger* accident, and establishment of the National Space Policy in 1988, as well as commercial space launch agreements executed with Russia, China, and Ukraine in the early 1990s, commercial satellite owners and operators relied primarily on the National Aeronautics and Space Administration (NASA) for most launch services. The commercial space transportation industry is continuously evolving as new launch vehicles are introduced, states consider the development of new commercial spaceports, and other countries are developing space launch capability. The following delineates major limitations and boundaries for this report.

- Although U.S. Government statistical data regarding commercial space launch market conditions have been compiled prior to 1996 (including some data related to government policy, negotiated memoranda of understanding regarding U.S. and foreign launch market conditions and payload markets), the data compiled and published since 1996 are more complete.

- Launch operators, insurance brokers, and insurance underwriters will not divulge proprietary data such as costs, due to the highly competitive nature of this business area.

- This report recognizes the difficulty of considering the impacts of one facet of government support for a commercial industry in isolation, with the understanding that governments provide a range of support in the form of economic enhancement or incentives (such as tax and investment credits), research and development, and infrastructure. This report examines one element, public/private risk sharing, with due regard for difficulties of isolating its effects on international competitiveness.

- Much of the information evaluated in this study, specifically that addressing insurance market capacity and underwriting of launch liability risk, was gathered and evaluated prior to the tragic events of September 11, 2001. Appendix F was prepared following September 11, to assess its effects on insurance, risk allocation, and cost. That situation continues to evolve, and future reexamination of its effects may be appropriate once stability is reintroduced into the insurance market.

- The availability, content, and language translation of foreign laws regarding commercial space launch risk sharing, as well as variations in legal regimes in terms of victim compensation, limits the amount and detail of information that can be obtained in some cases.

- Third-party losses due to commercial space transportation accidents have been limited to several historical events, in China and Kazakhstan, which cannot be extrapolated to other countries' legal systems.

- Reusable launch vehicles (RLVs), with the exception of the Space Shuttle (which is not a true RLV), are still in the conceptual and developmental stage and have not yet been proven viable nor licensed for actual space transportation.

Within the context of the aforementioned limitations and boundaries, this report fully responds to all the issues delineated in the multi-faceted study mandated by the Commercial Space Transportation Competitiveness Act of 2000 (the Space Competitiveness Act).

2.4 Methodology for Acquisition of Information and Public and Federal Agency Views

The FAA conducted extensive research and analysis regarding report elements directed for study by Congress. Results appear in Chapters 3 through 10 of this report. Also, as required by the Space Competitiveness Act, the FAA published a notice of public meeting in the *Commerce Business Daily* and the *Federal Register* (66 FR 15520) on March 19, 2001, announcing a public meeting to be held April 25, 2001, at FAA offices in Washington, D.C. The purpose of the meeting was to address current liability and risk sharing for commercial space launch and reentry activities and to solicit public views and comments. At issue was whether the government should continue to share the risk of liability for commercial launches in the unlikely event of an accident or should consider changes to existing law. Participants included representatives of the commercial launch industry, space insurance brokers, and state-sponsored commercial spaceports. Attendees were encouraged to provide their comments on the Department of Transportation electronic docket website (http://dms.dot.gov). In addition, two virtual public meetings on the Internet were conducted for those unable to travel to Washington, D.C., posing specific questions for public response. The comments and views provided by the public and to the docket are summarized in Appendix A. The first virtual public meeting was conducted from April 27, 2001 to May 11, 2001. The second virtual public meeting, pursuant to notice in the *Federal Register* (66 FR 39545, issued July 31, 2001) was conducted September 4 through 14, 2001, and, due to the events of September 11, was subsequently extended through September 28, 2001.

In addition to soliciting public views, Congress also directed that this report present views of interested federal agencies, including NASA, the Department of Defense, and the Office of Space Commercialization of the Department of Commerce, in addition to the FAA. Other interested agencies involved in the preparation of this report or in research for its development include the Department of Treasury, the Federal Communications Commission (an independent agency), the Nuclear Regulatory Commission, the Department of Justice, and the Department of State.

Agency views and recommendations are provided in Appendix B. The final report of the Commercial Space Transportation Advisory Committee (COMSTAC), prepared in response to a request from the FAA Associate Administrator for Commercial Space Transportation, is presented in Appendix C.

Chapter 3

Analysis of Adequacy, Propriety, Effectiveness, and Need

Chapter 3
Analysis of Adequacy, Propriety, Effectiveness, and Need

Chapter 3 presents the study and analysis of the adequacy, propriety, effectiveness, and need for the current liability risk-sharing regime for U.S. commercial space transportation. This analysis includes such elements as adequacy of coverage; international obligations of the United States; international competitiveness; industry analogues; safety implications; insurance market development, volatility, and fluctuations; limits on inter-party litigation; industry "maturity" metrics; and possible transition factors.

3.1 Introduction

In 1988, the U.S. Congress amended the Commercial Space Launch Act of 1984 (CSLA) to establish public-private risk allocation measures for commercial launches. Provisions include a mechanism for payment by the U.S. Government, generally known as indemnification, of claims of third parties for injury, damage, or loss against space launch operators and participants, including customers and component suppliers, that exceed required amounts of insurance. Provisions also include the government's waiver of property damage claims in excess of required insurance, in addition to risk-based insurance requirements and reciprocal waivers of claims among launch participants, as explained in greater detail in Chapter 1. The risk-sharing and indemnification regime has been extended several times since its enactment in 1988. In the most recent extension of the provision, the Commercial Space Transportation Competitiveness Act of 2000 (the Space Competitiveness Act), Congress directed that the program be evaluated with respect to several key issues that have characterized public debate.

Issue 1 of the Space Competitiveness Act states, "*analyze the adequacy, propriety, and effectiveness of, and the need for, the current liability risk-sharing regime in the United States for commercial space transportation.*" This chapter presents the results of an analysis of adequacy, propriety, and effectiveness of, and need for, the current U.S. Government risk-sharing regime for commercial space transportation.

For purposes of this analysis, the following considerations will be addressed, as appropriate:

- Coverage for third-party/victim compensation
- Coverage for government property
- U.S. launch industry competitiveness
- Protection of the American taxpayer
- International obligations of the United States

It should be noted that it is difficult to assess, in isolation, the effects of liability risk-sharing and indemnification, and its operation, on international competitiveness. The launch business is a complex one, and launch customers decide where and which launch services to use based on many different factors. Indemnification must be considered in the context of these other factors, some of which are discussed in depth in the following analysis.

3.2 Adequacy

3.2.1 Definition and Associated Issues

Assessing the adequacy of the current liability risk-sharing regime focuses largely on the extent to which the provisions have met their stipulated objectives of catastrophic loss protection and facilitating competitiveness of the U.S. launch industry in the international space transportation market. The impacts of the regime on U.S. Government treaty obligations are briefly considered while more elaborate analysis is deferred to Chapter 6. Detailed discussion of international competitiveness is deferred to Section 3.5.6.

3.2.2 Coverage for Third-Party Claims and Government Property Loss/Damage: Adequacy of Risk-Based Financial Responsibility

The CSLA uses a three-tiered approach to liability and risk management[1] for licensed launch activities, as previously explained in Chapter 1. The first tier of risk, which has the greatest likelihood of occurrence, is covered by insurance or other demonstration of financial responsibility that a licensee (launch operator) must demonstrate as a condition of launch authorization. All launch participants, including the U.S. Government, are covered as additional insureds under the licensee's launch liability coverage against claims by a third party for bodily injury or property damage resulting from licensed launch activities. Third parties include individuals not involved in the launch process, as well as government personnel involved in the launch process. Insurance requirements are established by the Federal Aviation Administration (FAA) based on a probabilistic assessment of the risk presented by a specific launch proposal, taking into account the launch vehicle and its capability, vehicle performance (failure probabilities), the payload, launch location, and proximity to populations and other property. Maximum probable loss (MPL) analysis yields, in dollar amount, the greatest potential losses for bodily injury and property damage that could reasonably be expected to result from a launch accident. The probability that liability for third-party claims would exceed the MPL amount is about 1 in 10 million.

The CSLA limits required insurance for third-party claims for bodily injury and property damage to $500 million, or the maximum available at reasonable cost if less than $500 million. Coverage for government range property is determined using MPL methodology and is limited to $100 million or the maximum available at reasonable cost if less than $100 million. The probability that government property damage would exceed the MPL amount is about 1 in 100,000. The difference in risk thresholds used reflects the government's acceptance of greater risk when its launch property is used to directly support a launch campaign, consistent with U.S. national space policy. The current MPL values range up to $261 million for third-party losses resulting from launch vehicle flight and up to about $80 million for U.S. Government property damage. Based on conservative assumptions utilized in performing MPL analyses, the chances of claims exceeding required amounts of financial responsibility, and therefore being eligible for indemnification, are quite small.

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1 For purposes of insurance and risk management, characteristics or considerations that may be used in defining risk include the probability of occurrence of an undesirable event and the potential severity of loss.

3.2.3 Impact on U.S. Government Treaty Obligations

As discussed in further detail in Chapter 6, the United States is a State Party to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty"). Under the Outer Space Treaty, a State Party that launches or procures the launching of an object into outer space and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party or its persons caused by an object launched into outer space. (Outer Space Treaty, Article VII). In addition, the United States is a signatory to the 1972 Convention on International Liability for Damage Caused by Space Objects (Liability Convention). As such, the United States bears absolute liability for damage on the surface of the earth or to aircraft in flight resulting from a launch when the United States is a launching State (Liability Convention, Article II).

By setting insurance requirements on the basis of MPL, as directed by the CSLA, the government is essentially making a risk estimate that its potential liability under the Outer Space Treaty and Liability Convention will be covered by MPL-based insurance requirements. The MPL is structured so that the risk estimate of government indemnification obligations is no greater than 1 in 10 million (a probability of 0.0000001). Put another way, the government might expect to incur a substantial liability obligation under the CSLA at a likelihood more remote than 1 in every 10 million commercial launches. Even if the number of commercial space launches increased exponentially, as some visionaries have predicted, commercial space launches from the United States might occur for hundreds of years without exceeding the estimated MPL, although it cannot be said with certainty that damage of this magnitude will not occur tomorrow. Balancing that risk with the benefit of preserving the competitiveness and viability of the U.S. commercial space launch industry, it would appear the current risk-sharing regime is adequate.

To date, there have been no claims for third-party liability resulting from a U.S.-licensed commercial launch, much less any exceeding required insurance. In fact, the government is aware of no claims of third-party liability having been presented against the required coverage. Coverage required by the CSLA to protect potential governmental liability up to the insured amount is essentially provided at no cost to the government or to U.S. taxpayers, who might be the ultimate cost bearers in the event of a catastrophic accident.

3.2.4 International Competitiveness

States that are parties to the Liability Convention are absolutely liable when they are a launching State for damage caused by its space object on the surface of the Earth or to aircraft in flight. To cover the liability exposure of governments resulting from launches they conduct or procure or that are conducted from their national territory or facilities, governments generally require a launch operator to provide some level of first-tier insurance or demonstration of financial responsibility. This level varies, however. For example, for launches from French Guiana, Arianespace requires insurance, as a condition of a launch contract with its customer, to protect Arianespace and its customer in the event of third-party claims. Additional insureds include the French Government and other parties to the launch. Insurance is required in the amount of 400 million French francs, or approximately $53 million (2001 dollars); Arianespace agrees to protect its customers against all damages above that figure. By way of contrast, the United States calculates the level of MPL for specific launches and requires demonstration of financial responsibility up to that point (or up to $500 million, whichever is less) and provides a mechanism whereby Congress may appropriate up to $1.5 billion (as adjusted for post-1988 inflation) covering excess liability.

In terms of assessing international competitiveness, it is difficult to determine whether and to what extent the risk allocation regime in the United States is "adequate" compared to that of other nations because so many factors influence competitiveness and a customer's selection of launch provider. If adequacy is defined in terms of ability of U.S. launch services providers to compete against international competitors, in the face of more advantageous management of customer liability, it would appear that the current risk-sharing regime is adequate. However, it remains true that other governments offer more comprehensive and advantageous coverage for customers and contractors than that provided under the current regime of the CSLA. To some extent, the existence of the U.S. regime offsets or "neutralizes" the advantages offered by other governmental programs. It is speculative to quantify shifts in international market share that may result from shifting additional financial or liability risk from the government to commercial launch providers and their customers for U.S. licensed launches. However, it is reasonable to anticipate market reactions to increased cost, risk, uncertainty, and liability exposure, particularly under current market conditions of large supply and low demand for launch services.

3.3 Propriety

3.3.1 Definition and Issues

Propriety is interpreted to address whether maintaining the current liability risk-sharing regime appears to be appropriate as a continued role for the government—a fundamental point of public discussion when private markets may exist to satisfactorily fulfill this role. Private markets could be insurance markets, privately established and managed trust funds, or private secondary pools of financial assurance, for instance—options discussed in Chapter 9 of this report.

3.3.2 Appropriateness of Government "Indemnification" of Commercial Space Transportation

Section 3.3.3 and Chapter 5 of this report discuss a variety of precedents cited to support the government's role in commercial space launch indemnification, as well as examples of "dangerous and risky activity" potentially affecting human health and safety for which the government does not indemnify. For example, the U.S. Government does not indemnify industries that may impose environmental, health, or natural resource damages by way of waterborne vessels carrying oil or hazardous substances, offshore facilities used for oil exploration and drilling, underground storage tanks and injection wells, and surface coal mining operations (reclamation).

In many of these cases, financial assurance, or the satisfactory demonstration of ability to meet mandated financial responsibility requirements, is a common component of the assignment of liability under U.S. law governing these activities (Boyd 2001). Private insurance and capital markets, rather than the Federal Government are relied upon for performance bonds and other demonstrations of financial qualification. In most (but not all) cases, however, the government plays a role in setting various insurance limits, much in the way that the FAA/Office of the Associate Administrator for Commercial Space Transportation requires insurance for space transportation launch providers.[2]

In terms of precedent, although not necessarily cost-effectiveness of the investment, the Federal Government has subsidized transportation systems in the United States in an attempt to encourage growth of the commercial sector by reducing financial risks. The United States effectively subsidized the transcontinental rail system through land grants. Government intervention in aviation included federal support for research and development (R&D) of aircraft technology and economic subsidization and

[2] These cases are discussed in detail in "Financial Assurance Rules and Natural Resource Damage Liability: A Working Marriage" (Boyd 2001).

regulation of passenger airlines, including airmail contracts to commercial airlines. However, the U.S. Government has avoided direct intervention in the development and production of commercial aircraft.

3.3.3 Industry Analogues: Comparison to Other Government-Subsidized or -Supported Industries

A challenge in using analogies to support or question the government's role in launch liability risk-sharing is that such precedents may not be fully analogous with commercial space transportation, its current liability risk-sharing regime, and changes in insurance markets and space transportation since the late 1980s. Distinguishing characteristics of commercial space transportation considered important for making relevant analogies include:

- Government support has been justified on the basis of U.S. national interests, including a relationship among commercial, civil, and national security objectives of insured and low-cost access to space.
- Government intervention includes limited assumption of third-party risks.
- Government intervention includes providing facilities and support directly related to safety performance in the form of space launch range and testing facility operation and range safety oversight and responsibility on federal ranges.
- The industry involves potentially high third-party risk.
- Prior to enactment of the CSLA, space transportation was conducted by the government or under government contracts with provision for contractor indemnification in the event of a high consequence accident.
- The industry involves emerging and evolving transportation and technologies.
- The industry competes internationally for a share of the limited demand for launch services against foreign competition, including heavily government-supported foreign competition.
- The industry involves R&D efforts that may justify government support if the benefits from the R&D are nonappropriable—that is, if there are technology spillovers from nonpatentable results, from industrywide learning-by-doing, or industrywide learning about costs.

Several analogous industries within the collective spirit of these characteristics were chosen for review. Other industries receiving direct or indirect government support (agriculture, higher education, etc.) were excluded. Ideally, focus would be on commercial markets, but space transportation overlaps both commercial activity and government-contracted activity.

Chapter 5 of this report discusses the risk and insurance aspects of several other industrial sectors. In general, little precedent is found for a regime that *fully* matches the current liability risk-sharing regime for commercial space transportation.

For example, in the case of nuclear power generation (discussed in greater detail in Section 5.3.2), amendments to the 1957 Price-Anderson Act, which provided government indemnification, have, since 1975, required the industry to evolve a self-funded secondary insurance pool. The primary and secondary insurance capacity is now far greater than that set originally by the Price-Anderson Act. Should the claims exceed the available primary and secondary insurance capacity, the Price-Anderson Act includes a provision for Congress to "…provide full and prompt compensation to the public for all public liability claims resulting from a disaster of such magnitude," which is specified in 42 U.S.C. 2210 Section 170(e).

In the case of chemical industry environmental damages (discussed in greater detail in Section 5.3.3), the U.S. Government specifies financial assurance amounts that must be demonstrated for material-handling facility (including vessels carrying hazardous waste and most onshore and offshore facilities) operator licensing. These liabilities pertain to natural resource and environmental damages. Owners/operators are held financially liable for amounts exceeding these limits. In addition, funds financed by per-unit environmental taxes on facilities are made available to cover damages after all attempts have been made to recover costs from the owner/operator. These include the Superfund (for hazardous materials) and the Oil Spill Liability Trust Fund. Since 1995, the Superfund is no longer funded by the tax, but instead by cost recovery (including penalties and fines), investment income, and appropriations by Congress.

A key principle from federal support of transportation technology is the challenge of "pushing on a string." Federal subsidies to fund mass transit infrastructure, for example, affect the supply of, but not the demand for, mass transit, and the public continues to prefer independent auto travel to mass transit alternatives. Similarly, in the case of space transportation, federal funding of launch R&D may be less effective than finding ways to encourage demand for access to space. In addition, recent study has also suggested that federal support of capital costs for transit development biases localities toward investment in capital-intensive facilities with high operating costs (Li and Wachs 2001). While this principle may not be directly related to indemnification, it does pertain to the larger context of the health of the space transportation industry and, thus indirectly, to federal intervention by way of indemnification or other policies to make it more competitive. The distortion of capital versus operations also illustrates the type of bias that federal involvement can create, perhaps unintentionally, in the launch market. In the case of space launch, an example of this bias may arise in incentives for the private sector to undertake safety-related R&D. (This is mentioned in Section 9.2.2.3 of this report under "Catastrophe Bonds.") The concern is that if commercial launch operators do not fully bear the costs of the safety procedures now in place at federal ranges, the operators may have less incentive to invest scarce R&D money into risk-mitigating designs. If commercial launches bear the full cost of safety, there may be greater incentives to invest in safety-related R&D. Although practical experience within the U.S. commercial launch industry has led to a consistent safety track record, it seems that the government risk-sharing regime's influence on safety innovation has been minimal. (*See* discussion in Section 3.3.4.)

The role of government in supporting R&D, testing, safety regulation, and infrastructure development for the commercial aviation and semiconductor industries in large part underlies these industries' success, especially regarding *supply*. In the case of the commercial aviation industry, many experts claim that Lindbergh's flight across the Atlantic seemed to ignite the *demand* for passenger airlines much more effectively than any government program of the time (Rose 1986). Government efforts in establishing the Air Commerce Act of 1926 and later the Civil Aeronautics Act of 1938, were the cornerstone of Federal Government regulations enacted at the urging of the aviation industry to maintain safety standards and nurture the financially shaky airline industry. The airline industry is also responsible for its success. Even though the government boosted demand for commercial airlines through airmail subsidies, a substantial share of passenger transport was carried by airlines without airmail contracts. Appendix E contains additional information about the development of the commercial aviation industry, as well as the semiconductor industry in light of government support.

Government efforts in bolstering a flagging industry also offer some insights into the difficulty of rationalizing and ensuring successful government industrial support. In 1994, Congress enacted the General Aviation Revitalization Act (GARA) of 1994, Public Law 103-298, in an effort to help the U.S. light aircraft industry by providing a statute of repose for product liability suits related to light aircraft (typically used for training, personal use, and for small businesses). At the time of enactment, domestic production of small piston-driven aircraft had fallen to just 5 percent of the levels of previous decades. The industry cited the potential for huge liability exposure as the result of product liability suits filed against aircraft manufacturers and held that, absent some legislative protection, the industry could vanish altogether. The aircraft industry has generally held up GARA as an unqualified success, citing the creation of 25,000 new jobs and production levels 100 percent higher than pre-enactment levels (GAMA 2001). Detractors of GARA and of limitations on product liability generally have argued that the enactment of the GARA limitations has had little or nothing to do with the resurgence of the light aircraft industry. A consumer advocacy group asserts in a fact sheet that "product liability was not the industry's problem in the first place" (PC 2001). Opponents cite independent economic factors, such as the cyclical nature of the industry, limited demand, and even the manufacture of superior aircraft (making used aircraft attractive alternatives to new planes) as reasons the industry was in decline. Commentors also dispute as "artificial" the figures cited by the industry that liability insurance cost industry from $70,000 to $100,000 per new aircraft sold (Tarry and Truitt 1995) and note that, during several of the supposed years of crisis, aircraft companies such as Beech and Cessna posted record profits, primarily due to their increasing market share in the lucrative small turboprop and jet markets (Anton 1998).

The domestic general aviation industry, enactment of GARA, and the resulting market responses offer limited analogies in considering potential alternative liability regimes for the commercial space transportation industry. First, GARA's statute of repose may offer some consumer protection under the theory that if a plane does not malfunction and crash after 19 years, subsequent failure is not likely to have been caused by some defect in manufacture, but by some other cause (such as negligence). This assumption continues to be hotly debated. The commercial space transportation launch business as currently configured would have a much smaller "window of liability," that is, the potential liability resulting from launch would likely manifest itself within minutes of ignition, or at most days, or, for reusable launch vehicles (RLVs), during reentry. Second, the limitations of GARA seem to be directed toward passengers, whether paying or not, and not toward uninvolved third parties such as victims of ground damages. Were a launch accident to cause injury and damage to uninvolved third parties, they would be able to make the same compelling argument that, as involuntary and innocent participants in the event, they should not be limited in legal options for recovering for their loss.

In the case of the semiconductor industry, the Federal Government enacted Public Law 100-418, the Omnibus Trade and Competitive Act, providing government matching funds for R&D and manufacturing base upgrades to the semiconductor industry, as well as expanding R&D at various research centers among selected universities. Government funds, in conjunction with restructuring and retooling of the manufacturing base, resulted in U.S. semiconductor manufacturing regaining the international market competitiveness lost in 1985.

The complex mix of policy intervention and the role of commercial demand may be seen in the prosperity of the commercial aviation and semiconductor industries. Appendix E of this report offers more extensive discussion of U.S. Government support of these industries. Indemnification, prior to September 11, 2001, was not deemed necessary for commercial aviation because of its relatively high number of aircraft, flights, passenger miles and revenue generating capacity as compared to commercial space transportation.

3.3.4 Launch Safety

The direct impact of the current liability risk-sharing regime on launch safety design and implementation is minimal. Indirectly, strong safety programs at federal launch ranges have helped keep third-party insurance rates from escalating. At the primary launch sites used for commercial launches—Vandenberg

Air Force Base and Cape Canaveral Air Force Station—there are stringent federal launch and range safety procedures that must be followed by government and commercial launch providers. At times, the safety community is even accused of being too intrusive in the design and acceptance of launch vehicles, command destruct systems, fueling activities, and associated operations. There are detailed safety regulations (e.g., Air Force 127-1 series) that establish safety criteria. When taken as a whole, launch safety operations are imposed externally by the safety community and executed internally by commercial launch providers to ensure success rates are competitive. Both underpin future business opportunities and competitiveness.

Launch and range safety activities at federal launch ranges include detailed inspections, certifications, and quality-control oversight of vehicle designs, hardware operations, and launch management. Safety rules are in effect as soon as hardware and personnel arrive at the launch base and remain in force until the launch team departs. Safety accountability is a federal responsibility under the long-standing charge of providing security and public safety during hazardous operations. Commercial spaceports located on federal launch ranges (Spaceport Florida Authority, the California Space Authority, and Virginia Space Flight Center) comply with federal—U.S. Air Force or NASA—safety requirements.

Commercial spaceports not located on federal launch ranges (Alaska and potentially state-owned inland commercial spaceports) may not have to comply with extant federal launch range standards and procedures. However, there will be basic safety requirements established by the FAA for launch vehicle operations (e.g., 14 CFR 417), and responsibility will fall on the site operator to protect public safety by restricting access.

3.3.5 International Competitiveness

As stated earlier, States that are parties to the Liability Convention are absolutely liable when they are a launching State for damage caused by its space object on the surface of the Earth or to aircraft in flight. As to the propriety of the existing domestic liability risk-sharing regime, it would appear the current regime is “proper” in the sense that the basic approach of victim compensation and adherence to treaty obligations is comparable to that of other nations engaged in similar activities, at least in terms of the maximum probable liability exposure.

It does not appear that the differences between the third-party liability regime in the United States and in other nations, by themselves, are having a substantial adverse impact on international competitiveness of the domestic commercial space launch industry. One might argue a compensation regime is improper if its existence is due to excessive or improperly placed costs. Insurance costs for launches are substantial, but the bulk of this expense comes from underwriting the payload and not on potential third-party liability. The levels of financial responsibility required by the FAA reflect the monetary value that juries and courts in tort claim cases tend to place on human life, as well as larger numbers of people and higher valuation of property exposed to risk for launches from U.S. territory. While some MPL calculations may be higher than those of comparable launches by other countries, many factors may come into play, including, possibly, less willingness by the government (and by extension, the taxpayer) to assume risks that could be borne by the companies engaging in the activity giving rise to the risk. Some developing countries have legal systems that can result in relatively lower financial compensation for victims when launches go awry—the 1995 incident in Xichang, China, which resulted in deaths and injuries to third parties, is one example.

3.4 Effectiveness

3.4.1 Definition and Issues

Assessment of the current liability risk-sharing regime in terms of its effectiveness addresses its role in loss protection and international competitiveness. This section discusses protection against third-party claims, cross-waiver provisions among launch participants that limit litigation, safety implications, and the extent to which the capacity of the insurance market has developed during implementation of the current regime. A more elaborate discussion of international competitiveness, a factor critical to assessment of effectiveness, is deferred to Section 3.5.6, and additional discussion of U.S. market share is presented in Section 3.5.

3.4.2 Protection Against Third-Party Claims and Government Property Damage

Under the CSLA, the FAA establishes risk-based insurance requirements covering potential damage, injury or loss to third parties and government range property. To date, third-party claims and damage to facilities and other range property owned by the government have been insubstantial. The current regime, in combination with range safety oversight and federal regulation, has been effective in affording adequate protection to the public. The FAA is proposing uniform safety standards at nonfederal launch sites, including spaceports, consistent with those at federal launch sites, to minimize the possibility of a catastrophic occurrence in an increasingly commercial realm.

3.4.3 Cross-Waiver of Claims Provisions—Limits on Litigation

Given range safety standards and practices, a party suffering injury resulting from a commercial launch is more likely to be a participant in the launch than an uninvolved third party (an innocent bystander). Claims and litigation among launch participants have occurred in the past, typically where a launch has failed and a valuable payload was destroyed. By requiring cross-waivers of liability claims for commercial launch participants, the CSLA risk allocation mechanisms ensure that the parties most likely to sue one another (the participants or insurers of the participants faced with a substantial claim) will not do so and will assume their own risk of property loss for which asset insurance is available. Cross-waiver provisions are essential to limiting cost and need for additional liability insurance, thereby restricting launch costs. Because launch participants must accept risk and responsibility for their own losses on a no-fault basis, there is an added incentive for each participant to ensure that others participating in a launch campaign adhere rigidly to safety and best practices.

3.4.4 Safety Implications

The current liability risk-sharing regime has been associated with an excellent launch safety record in terms of absence of harm to third parties and extremely little government property damage resulting from a commercial launch. It is difficult to disentangle the contribution of the current regime *per se* and the safety practices at the federal ranges for commercial launch programs. Over the course of the Nation's space program, safety implications have proven to be a key factor in the design, development, and operation of space systems. Due to the toxic nature of booster and payload fuels, hazardous launch processing, and actual launch events, comprehensive safety programs have evolved. Today, government and commercial payload and launch operations at Kennedy Space Center, Cape Canaveral Air Force Station, Vandenberg Air Force Base, and NASA's Goddard Space Flight Center, Wallops Flight Facility, at which Virginia Space Flight Center is located, are the safest in the world. Safety offices and officers are provided by the launch services provider, payload manufacturer, and range operators. Virtually every launch-related event is reviewed and assessed for safety adequacy. Changes in design, techniques, and procedures are made to improve safety. Today's space vehicle fleet safety activities are part of daily operations at the coastal launch ranges.

3.4.5 International Competitiveness

States that are parties to the Liability Convention are absolutely liable when they are a launching State for losses that might be suffered by third parties on the surface of the Earth or to aircraft in flight. If effectiveness is defined broadly as the ability to provide compensation to victims while protecting the interests of the government from excessive liability risk, then the current regime is probably effective. FAA regulations specify that U.S. Government liability includes that accepted by the government under international treaties. It may be impossible to know concretely whether the current regime is truly effective without a significant history of accidents and resulting claims, which, fortunately, are exceedingly rare. In relative terms, required demonstrations of financial responsibility are higher in the United States, in part because of exposure of greater numbers of people and more valuable property to launch risks—all other things being equal, casualty related damages in French Guiana would likely be lower than on the coast of Florida due to the difference in population density. By itself, an effective domestic liability regime does not appear to substantially impact international competitiveness. Put another way, it appears it is possible to have a commercially viable domestic commercial space transportation industry that effectively protects third parties. Because the principal foreign competitors of the U.S. launch industry offer comprehensive liability protection to customers, the U.S. launch liability regime is at least a neutralizing factor although it is not as advantageous as the program offered by Arianespace. While the effects of its absence cannot be predicted, the lack of a regime could be destabilizing in an internationally competitive market experiencing limited launch demand.

3.4.6 Development of Insurance Market Capacity

The amount of financial assurance that launch operators must demonstrate for licensing under the current regime is based upon the determination of MPL; however, it is not to exceed the lesser of $500 million or the maximum liability insurance available on the world market at reasonable cost. All launch licensees to date have chosen to demonstrate financial assurance by the purchase of insurance.

A detailed description of the history of insurance capacity and market volatility is found in Appendix D. In summary, the current insurance market is, in several respects, much more robust than was the case in the 1980s, when the commercial launch industry was emerging. At that time, some prominent launch mishaps (most visibly the *Challenger* tragedy in 1986) and substantial claims—in the hundreds of millions of dollars—made several years unprofitable for the space insurance market. Capacity was also affected by catastrophes unrelated to space launches or aviation, such as large natural disasters (primarily hurricanes) that essentially flooded the insurance market. In short, examination of gains or losses in the industry for specific years yields an incomplete picture, because underwriters will raise rates to recoup losses and insured parties will pay a premium to cover risky activities. Third-party liability insurance is provided by aviation insurers (who provide similar coverage for airlines) and, therefore, tends to operate more independently of the payload insurance market; yet, like other insurance markets, it is subject to general trends.

A 1988 study by the Congressional Research Service for the Committee on Commerce, Science, and Transportation of the U.S. Senate noted the sensitivity, or volatility, of the space insurance market, including liability insurance.[3]

3.5 Need

3.5.1 Definition and Issues

As previously indicated in this study, the U.S. commercial launch industry's safety record has been excellent, so much so that there have been no third-party claims. Congress has requested evaluation of the need for the current liability risk-sharing regime. Areas of evaluation include whether the industry continues to need the level of indemnification offered, how the industry has matured over past decades as a commercial sector, how it is faring in international competition, and whether insurance and capital markets would perform satisfactorily without government indemnification.

Directly related to the need for insurance and catastrophic risk protection is the nature and cost of the extensive safeguards taken to mitigate risk. In the case of expendable launch vehicles (ELVs), these costs are predominantly incurred at launch ranges to protect against third-party and government property damage. Related issues include the costs borne by the government (effectively, U.S. taxpayers) to supply this level of safety at shared costs with launch providers, and who should pay for range upgrades and modernization, currently the focus of an Air Force initiative. As noted in Section 9.4.1 (benefits and costs of third-party liability risk-sharing and indemnification), an undesirable side effect when industry does not pay the full cost of safety is the possibility that industry may under-invest in safety or safety innovation. Range-related issues are outside the scope of this study, but it is crucial to note that space launch liability insurance and the safety record to date cannot be divorced from range operating provisions. While funding R&D for future new commercial spaceports, reentry vehicles, and launch vehicles themselves is not an FAA objective, achieving an equivalent level of safety for these facilities and vehicles *is an* FAA objective and is an important consideration in addressing the future of the commercial space industry.

Also related to the discussion of need for the existing liability risk-sharing regime is its importance in assuring a stable component supplier base by covering liability of all suppliers of component parts and services related to launch operators. Without such comprehensive coverage, contractors may withdraw from participation in space launch rather than risk corporate assets on potential liability.

3.5.2 Commercial Space Transportation Industry Evolution

Another need-related argument made on behalf of the current regime pertains to the maturity of the industry. In general terms, an "infant industry" argument is a popular claim for government support and protection of an industry. It asserts that industries could grow to optimum size under such protection because they benefit from large-scale operations. Once this size is attained, the support can be removed, leaving behind a viable and competitive industry.

Theoretically this is a valid argument, but there are difficulties with its practical application. First, the argument can be misused by declining industries or obsolete technologies that attempt to protect their

[3] Prior to September 11, 2001, the liability insurance market appeared to have evolved significantly since 1988, in terms of capacity and willingness to underwrite launch liability risk. Appendix F assesses the effects of the September 11 tragedy on the availability and cost of launch liability insurance for the near term.

position in the market. For example, many industry experts and steel users are criticizing American steel producers for recently resurfacing a 40-year-old argument to convince Congress to impose import restrictions on finished steel products (Wayne 2001). Second, once government support has been imposed, it can be difficult to eliminate, regardless of the industry's competitive standing. Finally, even in cases where the infant industry position applies, it is generally more efficient to offer a direct subsidy as a means of helping industry to expand.

The evolution of the U.S. commercial space launch industry, discussed next in this section, suggests an industry rich in experience, knowledge, and voluntary investing in ever-expanding capacity that may exceed demand. The discussion also suggests a natural progression of the formation of partnerships among some entities (such as Sea Launch Limited Partnership) and growth in overall competition, typically signs of a healthy industry.

The brief review below includes a mix of developments that began in the mid- to late 1980s and has continued to shape the commercial space transportation industry:

- The changed role of the Shuttle in U.S. space transportation policy in the aftermath of the 1986 *Challenger* accident
- The relationship between the U.S. Government and commercial launch demand and its effect on commercial launch vehicle production and operation
- The development of international competition and allegations of nonmarket pricing practices among foreign competitors leading to international trade agreements
- Launch infrastructure and modernization
- New vehicle development
- Recent trends toward manifesting multiple payloads by customers
- Reusable launch vehicle development
- Commercial spaceport licensing
- The formation of international joint ventures such as International Launch Services and Sea Launch Limited Partnership
- The effect of such joint ventures in giving access to established business relationships with Western markets and leading policymakers to relax quota limits relating to certain foreign vehicle launches

Sources for the review include government reports, reviews by the RAND Corporation and other experts, and information from annual reviews in *Aviation Week and Space Technology (AWST)* and the American Institute of Aeronautics and Astronautics' *Aerospace America*. Specific references are noted in the following discussion.

Mid- to late 1980s

In 1988, the U.S. Office of Technology Assessment (OTA) critically evaluated in a special report the status of the U.S. launch industry (OTA 1988). The OTA pointed out that, in the early 1980s, the direction of U.S. launch policy was to eventually rely solely on the Space Shuttle for access to space.

Despite the CSLA of 1984, which encouraged commercial space transportation, Shuttle-pricing policies favoring commercial payloads had crowded out much of the demand for alternative transportation. The *Challenger* accident led decisionmakers to reconsider including ELVs as part of a resilient national launch strategy. By the late 1980s, a replacement Shuttle orbiter was in production for flight in 1992, and the Air Force had ordered 57 ELVs with a forecasted requirement for an additional 45 ELVs by the end of 1993. The OTA also made the following observations about the status of the industry at that time:

- *Lack of Resiliency in the Ability to Maintain Schedules in the Face of' Failures.* Failures of ELVs and the Shuttle in 1986 called into question the resiliency of existing launch fleets. The OTA report suggested as options the development of new, more reliable vehicles, improvements in the reliability of existing vehicles, reductions in the duration of stand-downs after failures, and the design of payloads to be flight-capable on more than one type of vehicle. The OTA also suggested expanding ground facilities and building additional launch pads.

- *High Launch Costs.* Launch costs in the late 1980s were between $3,000 and $6,000 per pound ($6,600 and $13,200 per kilogram) to low Earth orbit (LEO). The OTA noted that these costs were prohibitively high for civil, military, and commercial space activities, and activities such as a baseline Strategic Defense Initiative kinetic-energy weapon architecture or a human mission to Mars. The OTA also pointed out that the costs of payloads, between $20,000 and $60,000 per pound ($44,000 and $132,000 per kilogram), could prove the ultimate limitation on the use of space to beyond LEO.

- *Shuttle Flight Rate Uncertainties.* The OTA observed that planned Shuttle flight rates could be optimistic, given that the industry had less experience with Shuttle processing than ELV processing.

In addition to these issues, the OTA also noted limits on payload size imposed by the fleet of vehicles and environmental concerns associated with combustion byproducts.

In a study also motivated by the loss of *Challenger* that provided a basis for a decision to build a replacement orbiter, the Congressional Budget Office (CBO) assessed the status of the industry in 1986 (CBO 1986). It noted that, before the *Challenger* accident, launch demand projections from NASA, the U.S. Department of Defense (DOD), and Battelle Columbus Laboratories (under contract with NASA) for the period from 1986 to 2000 projected the U.S. launch market to grow rapidly in the late 1980s and peak at 35 Shuttle-equivalent flights[4] annually during the 1990s, when the U.S. space station was to be built. This level of activity would more than quadruple the annual average launch rate from 1970 to 1985. These projections included anticipated demand for commercial payloads (about 25 to 30 percent of total projected payloads), but did not include payload demand for deployment of a space system defense or extensive manufacturing in space. The CBO observed, however, that, "if the historical record is a guide, NASA, DOD, and NASA contractors have consistently overestimated launch demand." The CBO also offered lower and higher projections.

Because the Reagan Administration had proposed commercializing U.S. ELVs, the CBO also addressed whether ELV commercialization "would lead to an internationally competitive industry in the 1990s" (CBO 1986). At that time, the only competition was Arianespace, but the CBO forecast other foreign entrants into the market. Figuring prominently in the CBO launch projections for commercial ELVs were government demand and the moving of commercial satellite launches from the Shuttle to ELVs. Prior to the *Challenger* accident, NASA had positioned the Shuttle to dominate the international market for space transportation by setting a minimum Shuttle price for ELV launches. In the wake of the loss of

[4] A Shuttle-equivalent flight is defined in the report as the transportation of 65,000 pounds (30,000 kilograms) to LEO destination of 28.5 degrees, 160 nautical miles (296 kilometers) above the Earth.

Challenger, the CBO concluded "direct federal acquisition of ELVs from potential private entrants is the most important federal influence on the international competitiveness of U.S. firms, since it would reduce the unit costs of ELVs through procurement of larger numbers," (CBO 1986). The CBO commented:

> The commitment of the DOD to purchase ELVs, the backlog of payloads created by the *Challenger* accident, and only limited foreign competition could characterize an environment through the early 1990s in which U.S. private firms could become internationally competitive and economically efficient. But after that time, the dissolution of the backlog and intensified (and perhaps subsidized) foreign competition could leave U.S. producers at a disadvantage (CBO 1986).

The CBO listed attempts to eliminate subsidies, e.g., through the General Agreement on Tariffs and Trade, or providing government subsidies for operating costs or technology development, as approaches to maintaining U.S. industry international competitiveness. Another development in the 1980s was the creation of the Office of Commercial Space Transportation within the U.S. Department of Transportation (DOT). (Later, the office was moved to the FAA under a delegation of authority from the Secretary of Transportation to the FAA Administrator).

Early 1990s

By the early 1990s, and nearly 10 years after passage of the CSLA in 1984, the number of commercial launches was still small. Between January 1989 and July 1992, there were 19 commercial launches, including 2 failures and 17 successful "commercial-like" launches. These commercial-like launches were defined in a 1993 review of the industry by the National Defense Research Institute of the RAND Corporation for the Under Secretary of Defense for Acquisition (Chow 1993). They included launches by Delta II for the global positioning system (GPS) satellites and by Atlas II for the Defense Satellite Communication System III under the Medium Launch Vehicle-I and II programs, respectively. RAND observed that competition among domestic suppliers for payloads of different sizes was not proving to be fierce, since the providers tended to serve different lift classes. In addition, RAND examined whether differences in reliability between government and commercial launches were statistically significant and thus influencing the market. The report estimated confidence intervals to test for significant differences and found that the ranges overlapped, indicating that there was no statistical confidence that different procurement approaches result in different reliabilities.

The report offered additional observations about the health of the industry at the time, noting that manufacturers of smaller vehicles were concerned about the conversion of surplus strategic missiles into space launch vehicles by U.S. competitors, and that the largest-capacity ELV, Titan IV, had no domestic competition. Arianespace had about 60 percent of the commercial market, and other foreign competition remained small. The report noted that, based on cost and performance information, foreign competitors did not appear to have a cost advantage over U.S. suppliers, although foreign technologies and infrastructures were more modern. Foreign competition, however, continued to be a potentially near-term concern, including competition from, and the possibility of nonmarket pricing by, China and new members of the Commonwealth of Independent States. The report further noted that, while the U.S. launch industry could survive on government demand alone, an advantage of supplying other countries would be deterrence of foreign development of space launch vehicles or ballistic missiles, which would help slow missile proliferation. The report also echoed the concerns of other analysts that the U.S. launch infrastructure, of 1950's vintage, was 40 years old at the time and in need of modernization.

The Office of Space Commerce (later renamed the Office of Space Commercialization) of the U.S. Department of Commerce (DOC), in a report entitled *Space Business Indicators 1992*, expected eight commercial launches by U.S. launch providers and forecast about $500 million in revenue for the launch providers for the coming year (DOC 1992). Launch prices for medium to large payloads ranged from about \$45 to \$100 million or more. The DOC report also noted that, although demand for launches appeared to have leveled off, launch demand forecasts included planned new communications systems using small satellites in LEO and direct broadcast satellite services. Seven DOT-licensed launches were conducted in 1992, including launch of one small Brazilian environmental satellite, a reentry vehicle for microgravity experiments, as well as several small vehicle launches. DOC estimated \$60 million in revenue from these launches and forecast this smaller launch vehicle market as a growing market segment. The report also cited a DOT study predicting a substantial market for recoverable microgravity experiments—up to 18 reentries per year by 1999 and as many as 30 by 2005.

DOC noted that, although the U.S. Government remained the largest consumer of U.S. launch services, declining defense spending had led DOD to reduce its future launch requirements. In the international market, the European Space Agency was developing the Ariane V, and Japan planned to begin operating its new H-II vehicle in 1993. China appeared to be having difficulty winning launch contracts.

A task group report by the Vice President's Space Policy Advisory Board in November 1992 sharply criticized the status of the U.S. launch industry (Aldridge et al. 1992). The report noted that, while government launch requirements through 2000 were likely to be met, the current U.S. launch industry had "significant overcapacity" in vehicle production based on future projections of launch demand. The task group reported that international competition based on nonmarket pricing would strain the U.S. industry:

> In light of the industrial overcapacity and the recent entry of very capable space launch vehicles from nonmarket economies into the launch vehicle competition, there is little hope for the United States to be price competitive in this market without major reductions in launch vehicle costs and mutual agreements on pricing guidelines and enforcement provisions.

The group also found that the national launch capability, including the Shuttle and ELVs:

> …is fragile, not as reliable or safe as it could be, more expensive than it need be, and inefficient in its operations. The combination of existing launch vehicle technology and dated operational concepts in launch facilities costs excessive time and money, reduces U.S. competitiveness, and keeps the United States from achieving low-cost access to and the full benefits of space.

Continuing, the group recommended:

- Range modernization (FAA 1999b)[5]
- Cancellation of plans to develop a heavy-lift National Launch System vehicle
- A new initiative, the development of a National Launch System-type vehicle in the 20,000-pound (9,100-kilogram)-to-LEO class as "the key to future commercial competitiveness of U.S. space launch vehicles"
- Development of a single new vehicle, Spacelifter, for medium and heavy lift
- Downsizing of the industry through cost sharing
- A more formal "national" space launch management arrangement headed by an executive-level government appointee reporting directly to either NASA or DOD

[5] In 1993, the Air Force began the Range Standardization and Automation Program to modernize launch ranges by 2006.

Mid-1990s

By 1994, DOD had halted the National Launch System and Spacelifter projects to pursue the Evolved Expendable Launch Vehicle (EELV) Program. The objective of the EELV Program was to modernize the existing fleet rather than invest in new vehicle technology. Among other developments during this period, the most notable were perhaps the formation of several key international joint ventures (Caceres 1998). In 1995, Russia's Khrunichev and Energia joined with Lockheed Martin to form a joint venture, International Launch Services (ILS), which markets the Proton and Atlas vehicles. The partnership was immediately successful in competing with Arianespace for heavy-lift demand. The same year, Russia's Polyot formed the Cosmos-USA joint venture with Assured Space Access to market Cosmos internationally, and Khrunichev and Daimler-Benz Aerospace formed the Eurockot joint venture to supply the Rockot vehicle. Daimler-Benz Aerospace was a shareholder in Loral's Globalstar LEO satellite program, and Khrunichev was an equity partner in Motorola's Iridium. Also in 1995, a team comprised of Boeing, Energia, Yuzhnoye of Ukraine, and Kvaerner of Norway formed Sea Launch Limited Partnership (Sea Launch) to launch the Zenit III from ocean platforms. Sea Launch garnered orders from Hughes Space and Communications and Space Systems/Loral for at least 15 Sea Launch missions through 2002. In 1996, Aerospatiale, TsSKB-Progress, the Russian Space Agency, and Arianespace formed Starsem to market Cyclone and Soyuz vehicles commercially. The partnership gave Arianespace a medium-lift capability to compete in the low- and medium-Earth-orbit market.

Japan's H-II launch vehicle, introduced in 1994, continued on shaky financial ground. Some observers noted that, “at $180 million per launch, the vehicle is not commercially viable” (Caceres 1998). Similarly, Japan's J-I and M-V vehicles were also deemed expensive and even less commercially competitive.

Late 1990s and 2000

As the year 2000 approached, the early series of the Atlas, Delta, Titan, Proton, Cosmos, and Soyuz vehicles had been active since the 1960s. Ariane, Long March, and Ukraine's Cyclone had been operating since the 1970s. New vehicles that were then expected in the coming years included Atlas IIAR (later redesignated Atlas III), Delta III, Proton KM, an improved Cosmos, and new RLVs including Kelly Space & Technology's Eclipse Astroliner, Kistler Aerospace Corporation's K-I, and Rotary Rocket's Roton—all planned for test flight in 1999.

AWST's 1999 “Year-in-Review” highlighted launch activity in 1997 and 1998 that centered on multiple small payload launches as deployment of large networked constellations of LEO telecommunication satellites began. There had been at most one commercial LEO payload launched each year from 1993 to 1996. In 1997, LEO launches were 64 percent of the total commercial payloads launched. During 1997 and 1998, 84 Iridium satellites were launched using 11 Boeing Delta IIs (7920), 4 China Great Wall Industry Long March CZ-2C/SDs, and 3 International Launch Services Proton Ks, for an average of 4 to 5 satellites per launch. Loral had planned to use 3 Ukrainian Zenit II vehicles to launch 36 Globalstar satellites, but a failed Zenit mission in September 1998 caused Loral to consider a mix of Delta II (7420) and Starsem Soyuz U vehicles. Orbital Sciences Corporation's (Orbital Sciences) Pegasus had launched 24 Orbcomm satellites on three flights. Meanwhile, with an eye toward this segment of the market, the European Space Agency approved development of FiatAvio's Vega small-lift vehicle.

A trend was apparent toward multiple payloads per launch not only among small spacecraft, but including the piggybacking of large geostationary satellites on powerful new vehicles such as Ariane V, Delta III and IV, Zenit 3SL, and Atlas III.

All of the launch vehicles introduced since the early to middle 1990s had failed at least once, including the Ariane V, Delta III, Long March CZ-3B, EER Systems' Conestoga, Lockheed Martin's Athena, Orbital Sciences' Pegasus XL, and Brazil's VLS. By 1997, the Athena, Long March, and Pegasus programs had successful missions and, in 1998, Ariane V also flew successfully. These programs, however, had incurred millions of dollars in added development costs and delays. *AWST* commented that these losses might force some new launch providers to shut down, reducing competition and maintaining prices. In addition, Arianespace was facing increasing competition from Proton.

The award of the EELV development contract by the Air Force to The Boeing Company (Boeing) and Lockheed Martin Corporation (Lockheed Martin) in 1998 was expected to lead to a 25 to 50 percent savings in DOD launch costs over the next 20 years by replacing Titan IV, Atlas III and Delta II. Initial launch of an EELV was planned for 2002. The EELV Program would also have more potential use by commercial payload customers rather than DOD, although the program would receive about $2 billion in guaranteed government business through 2006. DOD business could enable Atlas and Delta to compete more aggressively with Arianespace and Proton in the commercial market.

During 1996 through 1998, the FAA licensed the California Spaceport Authority, the Spaceport Florida Authority, operation of the Kodiak Launch Complex, and the Virginia Space Flight Center. In its year-end report for 1998, the FAA noted that 1998 was the first time in U.S. space launch history that commercial FAA-licensed launches (including orbital and suborbital) from U.S. ranges exceeded those of U.S. Government payloads, primarily driven by the commercial LEO market. The 100th FAA-licensed launch also occurred that year. The FAA noted that the first 50 of these launches took place from 1989 to 1995, and the second 50 occurred during the next three years (FAA 1999a). During 1999, U.S. commercial vehicles made fewer launches and earned lower revenues than expected. Sea Launch was successful in its first launch, and its second launch represented the first time an FAA-licensed launch was conducted outside U.S. borders entirely without the use of U.S. range assets. Half of 36 commercial orbital launches that year were to LEO (the others were to GSO), but forecasts of future LEO demand decreased markedly because of difficulties in the LEO-based communications market. Also in 1999, two Titan IVs, a Delta III, and an Athena II failed. The Atlas II was delayed in launch activity, as was the first flight of Atlas III, because the Centaur upper stages of both vehicles use the same engine as the Delta III.

In 2000, *Aerospace America* noted in its "Year-in-Review" series the inaugural launch of the Atlas III carrying a Eutelsat communications satellite (Williams 2000). This was the 50th consecutive successful Atlas/Centaur mission and the first U.S.-built vehicle to have a Russian-built engine, the RD-180. The review noted the large number of vehicle R&D programs underway. In May 2000, nine launch providers were slated to help define requirements and safety improvements for a second-generation RLV. In August, four small launch providers received study contracts for concepts for a space station contingency resupply service to augment the Space Shuttle. Thiokol and Boeing entered a teaming arrangement to develop a new system, AirLaunch, for government "launch on demand" capability, and NASA performed wind tunnel tests on a rocket-based, combined-cycle, air-breathing launch vehicle.

Sharply contrasting with these additions to the capacity of the launch market were demand projections that fell well short of matching supply. In its 2000 Commercial Space Transportation Forecasts, the FAA and its Commercial Space Transportation Advisory Committee (COMSTAC) forecast around 40 commercial launches annually through 2010, a forecast that declined close to 20 percent from 1999. *AWST*, in its "Year-in-Review" for 2000, noted that, "with just over 700 [total—commercial and government] satellites forecast to be launched through 2005, it is clear there will be a lack of sufficient business to sustain the 40 to 50 launch vehicle programs that are currently operational or soon plan to be" (Caceres 2000). *AWST* typically forecasts a larger market than many other sources, but even its review was titled "Industry Faces Launch Excess."

3.5.3 Commercial Space Transportation Industry "Maturity" Metrics

Since the first use of the Delta and Atlas vehicles in 1979 and 1980 to launch commercial satellites, over two decades of experience suggest that the U.S. ELV launch industry of the new millennium is "mature," based on several commonly used indicators in studies of industrial organization (Kreinin 1987).

Continued Planned Investment. One of the strongest indicators is the continued large increases in investment in U.S. ELV lift capability since the late 1980s. In 1988, the OTA (OTA 1988) measured total national capability for all U.S. vehicles (defined by OTA as the aggregate lift capability in pounds delivered to a 100-nautical-mile (185-kilometer) circular orbit at 28.5 degrees inclination). The expendable vehicles in OTA's calculations were Scout, Titan II, Delta II (3920), Atlas/Centaur, Titan III, and Titan IV. Not all of these vehicles have since been used for commercial launch, but investment in this capacity nonetheless represents the overall supply of investment dollars for space transportation.

Based on launch rate (defined as sustainable launch rate with current facilities), the total capability for these ELVs was 572,960 pounds (259,895 kilograms); based on production rate (maximum sustainable production with current facilities), it was 703,040 pounds (318,899 kilograms). Using OTA's methodology for 1999 data, with data from Isakowitz et al. (Isakowitz, Hopkins, and Hopkins 1999), launch and flight rate capabilities for all U.S. ELVs available for commercial and government use were 847,642 pounds (384,490 kilograms) and 1,317,404 pounds (597,575 kilograms), 48 and 87 percent larger, respectively, than in 1988. If the capabilities of planned new vehicles during the next five years are added, total capabilities are then 1,953,802 pounds (886,245 kilograms) and 3,072,344 pounds (1,393,615 kilograms), 340 and 430 percent larger, respectively, than in 1988. The ELVs included in the 1999 calculations are Athena I, Athena II, Atlas IIA, Atlas IIAS, Atlas IIIA, Delta II (7320), Delta II (7920), Delta III, Pegasus XL, Taurus, SSLV Taurus, Titan II, and Titan IVB. Planned vehicles include Atlas IIIB, Atlas V400, Atlas V500, Delta IV medium, Delta IV medium plus, and Delta IV heavy.[6] These estimates do not include the capacity of Sea Launch or the ILS-marketed Proton.

In terms of additions to commercial capacity measured by production and launch rates, the 1999 U.S. commercial ELV capability is over twice as large as the total U.S. ELV capability in 1988 (114 versus 50), and commercial launch rate capability is almost 15 percent larger (63 versus 55). In terms of planned additions to commercial capacity, production and launch rates increase capacity even further (55 and 36). The Atlas III series is intended to gradually replace the Atlas II series, however, so *net* additions to capacity are on the order of at least 22 and 32 percent, respectively, for production and launch rates, with data for Atlas V and Delta IV resulting from EELV investment and technology currently unavailable. As of 2000, these new additions to capacity are planned for routine use by 2005.

Continuous Technological Improvement and Innovation. This chapter notes new space transportation vehicles launched recently including Atlas III and Delta III and those planned for 2002 and the coming years. These vehicles all incorporate a moderate amount of improved technologies as well as a small amount of wholly new innovation. This combination of technological change—progressive refinement and moderate innovation rather than a series of significant redefinitions of a technology in attempts to find one that works—is indicative of a mature industry. For instance, the new Atlas III includes new engines and a single-stage booster, but these components have been introduced specifically to continue a trend toward enabling reductions in part counts, number of engines, and staging events to increase reliability and reduce cost. The new RD-180 engine, a joint venture between Pratt & Whitney and NPO Energomash, has higher thrust and specific impulse and incorporates throttling capability. These

[6] The production capability totals may be more comparable in 1988 and 1999 than flight rate capability, as the definition of flight rate in the 1999 data is sometimes expressed as "what the market will bear," rather than sustainable launch rate with current facilities.

improvements have increased the geosynchronous transfer payload capability of the Atlas series 2.5 times from 1990 to 2000, a higher growth rate than at any time in the series' history, but a rate that has, at the same time, permitted the vehicle to maintain reliability and flight rates. The Delta III series has an all-new cryogenic upper stage, and, although the first two maiden flights were unsuccessful, once flight-proven (it has flown successfully), the vehicle will continue the trend toward continuous performance increases in geosynchronous transfer capability.

Some of the newest innovations are forthcoming in RLVs. For example, the Kistler Aerospace Corporation (Kistler) K-I has a very differently designed payload fairing that is a separate element of the launch vehicle and operates not by splitting open and separating from the vehicle during payload deployment, but rather opens by way of an articulated hinge that swings back into place after deployment and latches shut for reentry. Flight avionics are also unique in that stages have their own control systems to be capable of independent flight, and the second stage must be capable of restarting on orbit. The stages are also designed to burn LOX/ethanol propellants, which are nontoxic and easier to maintain than conventional propellants.

As in any industry, the financial success of improvements and innovations can progress in fits and starts, and, in the current introductory years, as is the case for RLVs in particular, the jury is out. Taken together, however, the continuous improvements and adoption of new innovations by the class of traditional vehicles (such as Atlas and Delta) and the frontier technological change pioneered by the RLVs are indicators of a technologically healthy industry. These changes are evidence of ongoing, multiyear R&D programs, a labor force that has talent and resources to pursue design and testing, and production facilities that can be upgraded to permit new throughput.

Entry and Consolidation. The record of continued planned capacity investment during nearly two decades of growth is typically a hallmark of a healthy, mature industry.[7] Another benchmark is the entry (but not necessarily success) of newcomers, including both U.S. and foreign launch providers (Caceres 2000). Finally, industry consolidation (joint U.S. and international partnerships, as in Sea Launch and ILS) frequently takes place as firms mature and identify complementary business opportunities. **Table 3–1** indicates growth in the number of vehicles serving the commercial market and mergers from 1984 to 2000 and explains changes in market shares, as described in Section 3.5.6, a discussion of international competitiveness.

It is important to note that ELVs are single use transportation vehicles, as compared to aircraft, with each launch constituting a unique high-risk event. In addition, the number of ELV launches is very small in comparison to commercial aircraft.

In summary, the U.S. ELV commercial space transportation industry has been assessed to be mature, based upon the criteria applied in this analysis, but still retains an inherent high degree of risk requiring a liability risk-sharing regime.

[7] This is the case even if demand projections appear to fall significantly short of additions to supply (Kreinin 1987).

Table 3–1 Vehicles Flown in Commercial Payload Market 1984-2000

	1984-1988	*1989-1993*	*1994-1998*	*1999-2000*[a]
Geostationary				
U.S.	Atlas Delta, Shuttle	Atlas Delta	Atlas Delta	Atlas Delta
U.S./Multinational				Zenit (Sea Launch)[b]
Foreign	Ariane	Ariane Long March	Proton[c] Ariane Long March	Proton[c] Ariane
Nongeostationary				
U.S.		Pegasus	Athena Delta Pegasus Taurus	Athena Delta Pegasus Taurus
Foreign	Cyclone	Cyclone Start	Proton[c] Dnepr Cosmos Start Zenit Long March	Proton[c] Cosmos Start Soyuz Long March

[a] Excludes Japan’s N-I, H-I, and H-II flights for Japanese commercial communications payloads.
[b] KB Yuzhnoye, RSC Energia, and Boeing.
[c] Lockheed Martin-Khrunichev-Energia (LKE); listed as U.S./Multinational because it is a joint U.S. and foreign partnership that FAA categorizes as “foreign.”

3.5.4 Insurance Industry Available Capacity History—Market Fluctuations

In the mid-1980s, the space insurance market for payloads in particular had been aggravated by a widespread “liability insurance crisis” affecting almost all industries. The widespread crisis affected the entire property/casualty market and was manifested in an increase in liability insurance rates, lack of available coverage in some areas, and the potential for large jury verdicts. In the case of space launches, a long series of losses beginning in 1984, encompassing the *Challenger* tragedy in January 1986 and culminating in failures of the Delta and Ariane vehicles in the spring of 1986, caused insurers to reevaluate the probability of loss and, in turn, to either restrict the availability of insurance coverage, increase premiums substantially, or both. Insurance coverage of more than $100 million per vehicle had been readily available for 5 to 6 percent of insured value until 1984. After that time, insurance coverage fell to $60 million per vehicle and premiums increased to about 30 percent of insured value. The statutory risk allocation provisions enacted in 1988 arose in this context. Although payload and space insurance, in general, are distinct from third-party liability insurance, markets for each kind of insurance are not completely unrelated, and may be equally subject to broader insurance market disruptions.

Since the 1980s, but prior to September 11, 2001, the space insurance market and the insurance market overall have remained healthy in terms of capacity, or the reserve available to cover the maximum loss sustainable in the overall insurance market. A recent article reports that underwriters have lost money for a third year in a row after heavy claims made by satellite owners for in-orbit failures (not launch-related) (Taverna 2001). While these claims affect the total size of the space insurance market and, therefore, the supply of insurance available for launch, the industry also notes that they may alter certain provisions of their in-orbit coverage and, in turn, rebuild capacity in the market. Space insurance covers assets, such as satellites and launch vehicles, however. The health of the liability insurance market must be separately assessed.

Many experts believe the liability insurance industry to be more robust than during the liability crisis of the mid-1980s due to structural and institutional changes and a more global marketplace that enables improved opportunities for pooling to share risk. **Table 3–2**, below, shows that capacity has become significantly larger, on the order of less than $1 billion.[8] Insurance policies are also now routinely traded like mortgages, other financial instruments, and commodities (less attractive policies can be swapped in return for higher premiums). In addition, reinsurance offers insurers numerous opportunities to diversify their portfolios and further hedge their risk. Reinsurance enables underwriters, through a series of commercial arrangements with other underwriters, to dilute the risks they have assumed by spreading them across broad segments of the industry. In the case of space transportation insurance, difficulties of statistical (actuarial) quantification for the current fleet of vehicles have markedly lessened, although some insurers still admit that actuarial calculations remain subjective, and that the industry has an impressive safety record. Moreover, insurers indicated that capacity of about $1 billion of space insurance is available at moderate premiums. In the event of a catastrophic loss in space or in aviation (a conjoint market), this capacity could be oversubscribed. Several contemporaneous launch failures involving payloads worth hundreds of millions of dollars could exhaust the market's capacity. But insurers also agreed that capacity would be rebuilt over time. If the event were independent—a unique occurrence on a vehicle and not endemic to a fleet or the industry as a whole—future insurance would likely still be available for space launch liability. If the event were related to a more widespread cause, then insurance may be difficult to obtain at any reasonable price; but, in this event, an obvious conclusion would be to query whether space launch is advisable and would be attempted at all until the cause of failure were fully understood and rectified.

Whereas only a small and quite limited market existed initially, launch liability insurance is now readily available. However, it is a part of the larger aviation liability market and it remains to be seen how recent events of September 11, 2001, will affect long-term cost and availability of liability insurance. Recent developments affecting insurance market capacity and premiums after September 11 are presented in Appendix F.

Table 3–2 Growth of Total Capacity in the Space Launch Insurance Market

Year	*$ Millions*
1987	150
1990	300-350
1995	550
1996	650
1998	800-1,000
2001	1,000

Sources: FAA 1998, SAIC 2001.

3.5.5 Insurance Premium History and Volatility

In congressional testimony and discussions with the industry on the current liability risk-sharing regime, insurance industry representatives have been careful not to overstate stability in the industry. Like any other market, it is subject to possibly wide fluctuations. But, also like most markets, the industry as a whole recovers fairly soon from large losses. Sometimes the losses induce a change in coverage or in specific geographic regions, but these changes are appropriate responses to new market conditions or behavior on the part of the insured. Information collected from interviews with space launch liability insurance underwriters and brokers is presented in Appendix D.

[8] Following September 11 events, it appears that space insurance capacity has declined to about $815-900 million per launch event.

3.5.6 International Competitiveness

One of the principal rationales for the current liability risk-sharing regime is to enable the U.S. space transportation industry to compete internationally against government supported foreign launch providers with government-backed indemnification. This section offers an overview and examples of the complexities of assessing competition in the international marketplace, including the effects of government policies in the United States and abroad, measurement challenges, and data limitations.

Clearly, the international market for launch services is keenly competitive. During the FAA public meeting in April 2001 (*see* Appendix A), on the current regime and issues presented for study by the SCA, in comments to the public docket, and in the COMSTAC Report (*see* Appendix C), launch operators strongly endorsed the international competitiveness rationale, emphatically agreeing that risk sharing and indemnification are crucial to the industry's ability to compete in international markets. The argument goes as follows: A customer in the market for launch services requires a stable, predictable, transparent risk allocation regime, such as that currently implemented under the CSLA. The existence of and growth in significant foreign competition, in concert with projections of lower demand, have created an excess supply of space launch vehicles in the world market. In this buyer's market, all factors become more important to a payload customer. According to launch operators, the current liability regime allows U.S. launch providers to compete on a more level playing field and to achieve economies of scale to support the civil and national security-related launch demands of the government. Absent the current risk-sharing regime, the operators claim U.S. launch providers would be forced to purchase relatively high levels of coverage that would put them at a cost disadvantage and subject them to capacity fluctuations in the market for insurance. Further, the operators argue that any retreat from government-supported risk-sharing arrangements would create uncertainty and perceptions of greater, perhaps unacceptable, risk for potential customers that understand and accept the existing regime. Change in the status quo would signal concerns among customers that the benefits of liability risk-sharing would no longer be available to them at the time of launch, which may be several years following execution of a launch contract. Faced with unpredictability and customer discomfort, U.S. launch operators claim they could be sorely disadvantaged in competing for limited demand against foreign launch providers with stable risk allocation regimes of indefinite duration (that is, having no sunset provision). Launch services providers have not supported these arguments with market data to substantiate their claims, although one launch services provider stated in its comments to the public docket that it has had to obtain written confirmation from the FAA affirming the terms of applicability of the CSLA indemnification provision to its customer's launch (LM 2002).

A challenge in making this assertion without empirical support in the form of market data is that it does not give policymakers enough information to judge the effects, if any, of indemnification on competitiveness. To some observers, the argument resembles a demand to support the domestic space transportation industry by excluding foreign "imports" in the form of foreign space transportation vehicles simply because they may undersell domestic producers—an argument that goes back many years (Kreinin 1987).[9] Industries often claim that their products, production processes, facilities, and labor are essential—e.g., to national security—and therefore should be preserved by government support. One counter to this claim is made by asking whether the competition is from countries that are allies. If so, an argument for domestic support for national security reasons may be weakened. On the other hand, if the national security argument is true, then the argument may be made that support should be directly provided via the defense budget.

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[9] A short satire from the early nineteenth century offers replies to this argument. In "The Petition of the Candlemakers," complaints against the importation of free sunlight are given in an imaginary petition to the French Chamber of Deputies. The petitioners request a law to close all windows, dormers, skylights, holes, chinks, and fissures through which sunlight may pass in order to guarantee employment in the whale oil industry.

In addition, a distinct but related effect of encouraging competition rather than reducing it is that consumers of services and products often benefit from access to the competitive markets offered by international competition. In this view, a discussion of competitiveness solely from the perspective of the launch industry may be too narrow.[10] The relevant issue for society as a whole is the effect of competition (and indemnification) for payload services on the launch industry *as well as* on consumers. Consumers include everyone who uses telecommunication services and benefits from lower launch prices (including foreign prices subsidized by foreign countries). In other words, even if indemnification *does* influence vehicle choice, observe who benefits from use of indemnification to compete for the market. From this perspective, using indemnification as a tool to attain competitiveness theoretically, at least, costs the citizens of the country practicing this approach and benefits consumers in the rest of the world. Because this point is often lost in public discussion of the current regime, the following example may help emphasize the idea:

Example: Indemnification Beneficiaries. It is often noted in public debate that Arianespace requires less insurance of customers than the United States does in basing insurance requirements on MPL for comparable vehicles. But this does not necessarily disadvantage the United States. One implication may be that the expected third-party loss is less for Arianespace, hence a lower required amount of insurance is appropriate from the point of view of ensuring that third parties are compensated. However, another implication is distribution of the burden of third-party losses if they do occur. In the event of losses, European citizens will, in effect, subsidize all consumers of the services provided by the payloads launched by Arianespace. In the United States, these beneficiaries could include the payload design and construction business and consumers of the services of the payloads.

The underlying concept in this example—the distribution of the costs and benefits of indemnification—shows that, on net, determining the effect of indemnification policies by the United States and other countries is more complicated than ascertaining the effect on launch providers alone. For this reason, indicators of competitiveness in space transportation may misrepresent the complete picture of gains and losses from government policy intervention. However, because no claim has been paid by the U.S. taxpayer, indemnification to date has cost the United States little, but to the extent it sustains international competitiveness for U.S. launch providers, it has yielded benefits for the U.S. economy and consumers.

Measurement Issues. Assessing the need for the current regime to ensure international competitiveness of the U.S. launch industry is difficult for several reasons. The industry has never operated in the absence of government-provided liability provisions [prior to the current regime, NASA could provide liability insurance for third-party claims under Section 308(a) of the Space Act of 1958, as amended and the Department of Defense indemnified its contractors' liability risk under Public Law 85-804]. There are no "before and after" data to compare regimes with and without indemnification.

It is also difficult to compare the market shares of U.S. launch providers with those of other countries or to evaluate the need for indemnification for several reasons:

1. All launch vehicles in the international market receive various forms of government backing (e.g., direct financing, below-cost access to ranges and other facilities, funding of some or all R&D, restrictions that government and sometimes commercial payloads fly on launch vehicles of the same nationality as payload ownership).

2. Companies in different countries operate under different regulatory frameworks in terms of export credits, reflight guarantees, and general business practices.

[10] As noted earlier in this section, the effect of commercial business on achieving economies of scale to service government launch demand, or vice versa, is hard to estimate, but is accepted and endorsed by defense agencies.

3. U.S. Trade Agreement quotas on Russia, China, and Ukraine had limited the number of internationally competed launches they could offer each year and imposed pricing constraints[11].

In short, evaluating competitiveness in this market is tantamount to evaluating the relative effectiveness of the different countries engaged in managing the competition of virtually all aspects of the launch industry, from quantity and price agreements to indemnification regimes.

Even without these complications, there are no watertight definitions of competitiveness or methods to measure it consistently. As a popular economics textbook notes in discussing definition and measurement of market share, "'Market' deserves the same careful handling we would give a stink bomb…. Indeed, the predictive accuracy of one's structural measure may depend more heavily on the proper choice of market definitions than on the proper choice of statistical index" (Kreinin 1987). In fact, the definition of relevant market can make important differences in determining market share. It could be argued that fiber optic networks, which do not involve satellite launches at all, have had a major impact on the space launch industry overall.

Several analytical approaches are taken in an attempt to estimate competitiveness. The results illustrate the difficulty of empirically assessing the influence of indemnification on competition. For both geosynchronous orbit (GSO) and nongeostationary orbit (NGSO) markets, the percentage of all "internationally competed" payloads launched by U.S. space transportation providers and the U.S. share of all internationally competed commercial launches are analyzed. The data for these estimates come from the FAA. "Internationally competed" payloads generally have commercial functions or are commercially operated, but also include government payloads open to international launch services procurement. They do not include dummy payloads or those that are captive to national flag launch service providers, such as U.S. and certain foreign government payloads, or those with some other strong tie to particular launch service providers, such as the commercial group MirCorp-launched Progress re-supply missions on Soyuz. The data include payloads regardless of the success of the launch or the payloads' performance on orbit. Internationally competed launches encompass all of the launches that carry internationally competed payloads.

The number of foreign launches may have been higher in the absence of imposed quotas. It should also be noted that the FAA counts launches on Zenit III SL (Sea Launch) as "multinational" and subject to negotiated quota restrictions. Launches for the ILS-marketed Proton are classified as Russian. In both cases, U.S. launch providers are partners in the ventures.

In addition, summary measures of international market competition for total launches and revenues are also constructed using the "H index." The H index is a commonly used index of market concentration that accounts for both the number of companies as well as their relative size.[12] Each country is treated as a "company" in the calculation of the index (thus, competition *among* U.S. companies is not analyzed). Data compiled from Isakowitz et al., 1999, are used to identify payloads, launches, and revenues by country.

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[11] The Russian agreement was allowed to expire in December 2000 and the Ukraine agreement was terminated in June 2000. The China Agreement expired in December 2001. U.S. Government involvement with international competition in the launch market began in 1984 when a U.S. company filed a Section 301 petition alleging that Arianespace was subsidized by the French Government and that it was dumping launch services in the U.S. market at predatory prices. At the time, the President determined that European practices were not sufficiently different from U.S. practices (then primarily in support of Shuttle commercial activities) to justify action. In 1989, the United States signed a Commercial Launch Services Memorandum of Agreement with China that controlled the latter's entry into the commercial space market and, in 1993, similar provisions were negotiated with Russia, restricting the number of launches per year and the prices of launches to GSO and NGSO.

[12] The H index is named for Orris Herfindahl and Albert Hirschman. It is the sum of the squares of the sizes of firms in a market in which sizes are expressed as a proportion of total market sales, assets, employment, or other measures.

The data show an increasingly competitive market with entry of vehicles from Russia and Ukraine and the beginnings of mergers of complementary business acumen (as in the case of Sea Launch and ILS). On one hand, this increase in competitive activity is probably independent of the liability regime because all launch service providers rely upon some form of risk allocation. Hence, U.S. space transportation launch providers would argue that the ability of U.S. providers to compete is assured by having a liability risk-sharing regime that at least neutralizes the ability of foreign competitors who offer an indemnification regime. On the other hand, it is unclear what effect, if any, changes in the U.S. regime would have.

It is also important to note the relatively small percentage of U.S. launch costs represented by third-party liability insurance premiums at current rates. The premiums are about 0.2 percent of reported launch prices for larger U.S. vehicles and 0.5 percent for smaller vehicles. It is unknown whether, and if so, by how much, the cost of coverage in the absence of indemnification might increase or whether any change would be long- or short-run following the events of September 11, 2001. However, this current market, with an over-supply of launch services, is expected to increase price sensitivity.

Competition in Payloads

Indemnification is one of many factors contributing to overall competitiveness. How does indemnification factor into this analysis? First, performance of U.S. launch providers in capturing payloads was evaluated, since payloads are one measure of the demand side of space transportation. Launch demand has evolved into two somewhat distinct markets during the past decade. The primary market during the 1980s and early 1990s, large spacecraft to be deployed in GSO, remains, but consists largely of launching replacement spacecraft on a fairly routine cycle, rather than adding wholly new capacity. The trend among launch vehicles has been to carry up to four to six LEO payloads on a single launch. The small payload market for NGSO launches has represented new capacity and a unique market, although this market has been subject to significant financial difficulty in the past few years. It is served by a distinct class of launch vehicles (e.g., Pegasus, Athena, Start) competing with several mid-sized vehicles (Delta, Long March, and Proton). Accordingly, it is important to note that competition exists both internationally and domestically—e.g., among Pegasus, Athena, and Delta for small NGSO payloads.

The GSO Commercial Payload Market. **Table 3–3** shows internationally competed payloads launched from 1989 to 2001.[13] Despite the fact that U.S. launch providers flew 63 percent more payloads in 1994-1998 than in the previous five years, U.S. market share has dropped by half over the entire time period reviewed – from 28 percent in the 1989-1993 time frame to 14 percent in the past three years.

[13] It should be noted that while the 1989-1993 and 1994-1998 periods each capture five years, the 1999-2001 period captures only three years. Comparisons among these periods of total numbers of payloads and launch vehicles flown are thus not appropriate here.

Table 3–3 Internationally Competed Payloads (Geostationary Orbit) (1989 – 2001)

Payloads	*1989-1993*		*1994-1998*		*1999-2001*	
	#	Percent	#	Percent	#	Percent
On U.S. vehicles	19	28	31	26	8	14
On foreign vehicles	48	72	85	74	44	77
On multi-national vehicles	0	0	0	0	5	9
Total	67	100	116	100	57	100

The NGSO Commercial Payload Market. **Table 3–4** shows the commercial NGSO payload market since the beginning of significant NGSO demand in the mid-1990s. U.S. vehicles dominated the launch market with a 68 percent market share between 1993 and 1998. That share has declined, however, in the past three years while foreign market share has increased. As shown previously in Table 3–2, the large growth in the number of small vehicles serving this market and the piggybacking of large numbers of small NGSO payloads on existing large vehicles such as Delta and Proton explain much of the competition in this market (Isakowitz, Hopkins, and Hopkins 1999; FAA 2000; FAA 2001).

Table 3–4 Internationally Competed Payloads (Nongeostationary Orbit) (1993 – 2001)

Payloads	*1993-1998*		*1999-2001*	
	#	Percent	#	Percent
On U.S. vehicles	101	68	33	41
On foreign vehicles	48	32	47	58
On multi-national vehicles	0	0	1	1
Total	149	100	81	100

Second, major U.S commercial satellite design and manufacturing companies assessed the importance of risk allocation in selecting a launch provider as follows. The U.S. satellite manufacturing industry is aware of and understands the details of the current liability risk-sharing regimes for commercial space launches both in the United States and at foreign launch sites. Although the industry knows of the maximum probable loss (MPL) calculation by the FAA, the $1.5 billion indemnification for third-party claims is frequently cited as a key aspect of the U.S. liability risk-sharing regime. The industry is also very aware of the cross-waiver provisions and implications for their liability and risk exposure. In evaluating a bid by launch providers to place one or more satellites into orbit, other important criteria are used in selecting a launch provider. They include: price "envelope," launcher reliability, schedule, risks, performance, and other contract terms and conditions.

The price "envelope" of a launch services contract bid includes not only the cost of the launch, but also the cost of all required insurance, shipping satellite(s) to the launch site, support personnel, and operations at the launch site. According to the U.S. commercial satellite design and manufacturing companies, a lower cost bid by one launch provider can be offset by higher costs to move satellite(s), personnel, and equipment to a remote launch site. For example, the additional costs for a U.S. satellite company, attributable to location, the Baikonur Cosmodrome, were estimated to be approximately $1 million more than at Cape Canaveral Air Force Station, Florida. After the costs of the satellite itself and the launch vehicle, insurance costs (i.e., payload insurance, launch vehicle insurance, and launch liability insurance) typically represent the third highest element of the total cost. Most launch contracts are won based on very small differences in price, as weighted by other factors discussed below.

Reliability, another important factor in awarding a launch contract, is defined as the reliability of the specific launch vehicle to deliver the payload to its desired orbit. A lower cost can be offset by lower launch vehicle reliability. Along with price and reliability, the third most mentioned criteria among major U.S. commercial satellite designer/manufacturers for selecting a launch provider is schedule. The client for satellite services establishes a specific schedule in which it expects its satellites to be placed in orbit and become operational so that the system utilizing these satellites can function and start generating revenue. Schedule credibility is a measure of the launch provider's prior record in meeting schedules and is enhanced by offering alternate launch vehicle and launch site provisions for the same satellite(s).

Performance for a launch services contract is not only whether a payload can be placed into a specific orbit location, but also whether one contract can guarantee a longer lifetime for that satellite. The lifetime aspect of a contract is related to how close the satellite can be placed into its exact desired orbit while using minimal fuel from the satellite itself for its initial placement. The more fuel remaining in the satellite correlates directly to a longer lifetime since fuel is periodically used to maintain orbital location due to temporal orbital decay. Contract terms and conditions are another important factor and can include such items as financing, additional liabilities, the presence or absence of cross-waivers, cancellation penalties, and failure-to-perform penalties. In some cases, the customer has a preference for a specific launch provider and this factor becomes an overriding consideration in selecting the winning bid.

In conclusion, the satellite manufacturing industry considers an acceptable liability risk-sharing regime to be a "go no-go" criterion in evaluating launch providers' bids, according to major U.S. satellite manufacturing companies. Within this context, the current U.S. liability risk-sharing regime is considered to be acceptable, albeit inferior, to that of principal foreign competitors (i.e., Arianespace, Russia, and China). Any significant changes in the current U.S. regime, such as eliminating or reducing the amount of government indemnification, would, at a minimum, cause the industry to more closely examine its risk exposure and associated costs in selecting a launch provider. The satellite manufacturing industry supports the current U.S. liability risk-sharing regime without any modification because it is well understood and provides acceptable coverage as compared to international competitors. Any changes affecting indemnification may offer advantages to competitors of U.S. launch providers, which are not expected to modify or discontinue their respective launch liability risk-sharing regimes.

Competition in Launches

Another measure typically used to discuss competitiveness in the launch industry is the number of launches performed by each spacefaring country. This measure is also influenced by the payload trends previously discussed. Note that the number of payloads is not necessarily equal to the number of launches because of multi-manifesting payloads.

GSO Launches. **Table 3–5** indicates shares of the number of GSO launches for U.S. launch providers. The share of U.S. launch providers has declined from 40 to 16 percent since 1989. Isakowitz gives detailed data on launches by country. Europe's share of launches has consistently been at least 40 percent. China and Russia/Ukraine have garnered 10 to 25 percent of the market at various times. It is important to note that China and Russia agreed to quotas and price restrictions during some of this time period, and these restrictions influenced their market shares.

Table 3–5 Launches of Internationally Competed Payloads (Geostationary Orbit) (1989 – 2001)

Launches	***1989-1993***		***1994-1998***		***1999-2001***	
	#	Percent	#	Percent	#	Percent
U.S. vehicles	22	40	31	32	8	16
Foreign vehicles	33	60	66	68	37	74
Multi-national vehicles	0	0	0	0	5	10
Total	55	100	97	100	50	100

NGSO Launches. **Table 3–6** shows shares of launches in the NGSO market. While the United States had 72 percent of the launch market from 1993 to 1998, that share has dropped to 38 percent in the past three years; foreign vehicles' shares have more than doubled between these periods. Russia and Ukraine hold large market shares.

Table 3–6 Launches of Internationally Competed Payloads (Nongeostationary Orbit) (1993 – 2001)

Payloads	***1993-1998***		***1999-2001***	
	#	Percent	#	Percent
U.S. vehicles	28	72	12	38
Foreign vehicles	11	28	19	59
Multi-national vehicles	0	0	1	3
Total	39	100	32	100

Market Concentration Reflected in the H Index

The H index is a common summary statistic of market concentration. The index ranges from 0 to 1; an index close to 0 indicates a fully competitive market; an index approaching 1 indicates a much more concentrated market in which a single entity may dominate; and an index equal to 1 describes a monopoly market. **Table 3–7** shows the index for GSO and NGSO markets based on launches and revenues from 1989 to 2000.[14] The index for the GSO market has fallen significantly during the post-Shuttle era of commercial space transportation. For GSO launches, the index has fallen from 0.45 to 0.33 and for revenues, from 0.57 to 0.34. Based on this measure, the market is increasingly less concentrated, and none of the players has a dominant market share. In the NGSO market, the index has increased slightly for launches and remained close to 0.5 for revenues. While the index is larger for NGSO than for GSO, it is still not as large as it would be in the case of extreme market concentration. From a broad economic assessment of market conditions, this degree of competition in both the GSO and NGSO markets is healthy and not necessarily a sign of an industry where market power is exercised. As noted above, however, numerous policies (including quotas, pricing agreements, export restrictions, and other government influences) play a strong role in this outcome.

[14] The classification of Sea Launch as Multinational and Proton as foreign is maintained, consistent with FAA practice.

Table 3–7 The Herfindahl Index

	1989-1993	*1994-1998*	*1999-2000*
GSO			
Launches	0.45	0.34	0.33
Revenues	0.57	0.40	0.34
NGSO			
Launches	*	0.41	0.46
Revenues	*	0.49	0.47

* Too few launches to estimate index

Conclusions

This analysis of payload, launch, and revenue data to discern trends in different measures of competitiveness is intended to show the extreme difficulty, both conceptually and in practice, of discerning the effects of indemnification policy on the commercial space transportation market. Based on a variety of measures reported here, the market is increasingly competitive and is measured on a conventional index, the H index. No one country dominates the markets for GSO and NGSO.

Several factors could explain the patterns reflected in the data, but in all cases, the effects of indemnification policies are speculative at best. The data neither support nor reject a contribution of indemnification to competitiveness. Factors affecting these patterns may include:

Export Controls. U.S. restrictions on exports of spacecraft technology and component systems to some countries can clearly favor a choice of U.S. vehicles by U.S. payload owners if the spacecraft incorporate new technology not previously licensed for export to these countries. Such a pattern is observable in the data for U.S. payloads launched on U.S. vehicles.

Buy Domestic. Another pattern in more detailed study (not captured in the figures) of the foreign GSO payload data is a high degree of nationalism in the choice of launch vehicle by payload owners in countries with national launch capability. This pattern may or may not reflect nationalism *per se*, but rather a host of factors such as export controls, technology transfer issues, pressure to "buy domestic," proximity to the launch site, ease of doing business, and domestic launch subsidies (most foreign vehicles are government-owned and -operated).

Arianespace Market Share. The data also show that, among countries without indigenous launch capability, most consistently choose Arianespace for GSO launches. Here, because required third-party insurance for Ariane tends to be less than for U.S. vehicles, specific questions concerning the effect of indemnification might be asked, but such questions only further illustrate the challenge of linking indemnification with competitiveness. Arianespace has practiced aggressive marketing and pricing, and the effect of its indemnification policy, compared with the U.S. program, is far from clear.

Managed Competition. This discussion illustrates the difficulty of ascertaining the competitive effects of the current indemnification regime. The launch market to date is the result of interplay among a multitude of complex policy interventions, rendering a relationship between competitiveness and indemnification virtually impossible to discern empirically. It is difficult to predict the effects of reducing government indemnification or increasing the amount of indemnification at any or all tiers of the current regime. The degree of competition and the apparent flexibility of payload owners in choosing among vehicles suggest some of the effects that might result from potential changes in the current regime. Costs related to increases in liability insurance, assuming it is available, could be financed by launch providers rather than passed on to customers through higher launch prices because payload owners appear to be flexible in their choice of launch vehicle. However, it is not clear what effect the opposite policy direction would have—whether increases in government indemnification would result in lower U.S. launch prices and a more competitive U.S. industry. Under the current regime, the price of required insurance is a small percentage of total launch prices. Reducing it would not affect prices very much. Finally, although detailed discussion of alternative options is deferred to Chapter 9 of this report, two additional options are illustrative in light of the competitiveness discussion. These options are: (1) requiring U.S. operators to contribute to a self-insurance secondary pool modeled after the current regime in nuclear power generation, or (2) establishment of a trust fund similar to that used to manage liability for oil spills. Both options would either be financed by launch providers or result in increased launch prices if the costs were passed on to the payload customer, or some combination of both. It is unlikely that much of the cost increase would be passed through to customers because of the current degree of competition in launch vehicles. However, it may also be the case that, given the safety record of the industry, equity in a pool or trust fund could generate income for launch providers (since the equity can be invested).

As the preceding suggests, the global commercial launch industry is currently highly competitive, with low market concentration. No single country dominates the launch business, and consumers (companies seeking launch services) have been increasingly mobile in choosing among service providers. The applicable liability regime is one among many factors launch purchasers take into account when making decisions about which providers, locations, and countries best meet their expected needs.

3.5.7 Possible Transition Factors

Regardless of whether or to what extent the current liability risk-sharing regime for commercial launches may be needed today, there may come a time when the current framework providing government indemnification is no longer needed. The existence or occurrence of certain factors may indicate when a reexamination of the liability regime is appropriate.

The key transition factor is the *ability of the private market to address risk exposure.* This ability primarily involves the long-term capacity of the market; in any given time period, an unusual event could occur to absorb a large amount of capacity (the events of September 11, 2001, in the United States are an obvious example), but the key issue is whether the insurance market can recover capacity within a reasonable adjustment period. In addition, it should be noted that the relevant portion of the insurance market is the subset of the market that serves the space transportation industry for third-party coverage.

The long term is the relevant time period because, in the long term, if launch frequency increases, more firms enter the launch market, and RLVs emerge as commercially viable options, the private sector may become better able to shoulder the entire potential liability. Firms may elect to self-insure for launches, participate in risk pools, or purchase insurance. As the industry becomes more mature, insurers will gain greater experience in assessing related launch risk and insurance pricing. In other words, the standard approach to demonstration of financial assurance (the purchase of conventional space launch insurance) will involve less subjectivity because the spectrum of uncertainty (which plays a substantial role in insurers' price-loss calculus) will be narrowed. In the long term, if growth of relatively new instruments such as catastrophe bonds and practices such as reinsurance increase, the capacity of the market will increase. Many of these factors are readily observable in the growth and maturity of the nuclear power industry; however, it is not reasonable to expect that the number of launch providers, even if RLVs become a viable form of space transportation, will approach the number of nuclear facility licensees.

It should be noted, however, that the "top tier" of the risk liability regime—that is, amounts of $1.5 billion or more—is potentially the area where launch providers may find it most difficult to obtain traditional insurance coverage at a reasonable price, assuming it is available at such levels. Insurers, and most significantly, reinsurers may be reluctant or wholly unwilling to assume catastrophic risk exposure, much like the unwillingness demonstrated following the events of September 11, to insure for war risk or terrorism-related losses.

Commercial launches that are licensed by the FAA are generally considered to be safe, but the potential for damage to third parties exists. Insurers understand and can readily calculate coverage premiums to address all probable losses to third parties while ensuring long-term profits. The likelihood that a catastrophe will occur resulting in billions of dollars in damages to third parties is vanishingly small by comparison, yet underwriting potentially huge amounts becomes more difficult as the upper tier of potential exposure increases. The U.S. Government may be uniquely situated to act as the ultimate insurer for activities such as space launches, where the potential for substantial damages is very small but the potential damages very great (in other words, low risk of a high consequence event). In fact, space transportation launch providers that purchase launch insurance today may in effect be betting that: (1) an accident exceeding the MPL will not occur, and/or (2) if such an event were to occur, the U.S. Government would step in to indemnify third-party losses regardless of the applicable risk-sharing regime.

Finally, the risk-sharing regime may be able to transition fully to the private sector if the market becomes inured to short-term disruption that may make launch insurance temporarily unavailable. Such disruption might be caused by launch-related accidents, as was the case with the *Challenger* disaster, or it might be caused by large insurance losses caused by natural or man-made disasters. To the extent that the space transportation insurance industry remains vulnerable to such short-term disruption, there may always be a possible role for the U.S. Government to step in and assume the risk—the war risk insurance program for commercial airlines is an example.

3.6 Summary

The liability regime for commercial space transportation in the United States, by itself, appears to be adequate, appropriate, necessary, and effective, but many factors influence industry viability, and it is speculative to consider effects resulting from the *absence* of risk sharing. This is true primarily because it is very difficult to separate the competitiveness effects of the risk allocation regime from the dozens of other factors that are taken into account when launch customers decide which launch services provider to employ, as confirmed in discussions with payload manufacturers. Other factors that may play important roles include: the extent to which other governments subsidize programs, whether directly or through indirect means; different regulatory frameworks for launch operations (with impacts on scheduling and customer convenience) and other business practices; the impact of quotas on launch frequency and cost; and technology transfer issues for new launching technologies.

Perspectives on the overall health of the industry vary considerably, but there is competition among launch providers, and the domestic launch services industry remains viable. The current liability-sharing regime is probably adequate in reducing risk exposure of the government and in affording protection to the public for commercial launches, yet the costs of providing insurance to the launch providers does not, by itself, appear to overly impact the profitability of the launching business. In addition, competition among launch firms may drive down costs for companies needing the services, many of which are based in the United States. These companies have suffered recently in the marketplace and could benefit from a reduction in launch costs. Changes to the current risk-sharing regime may affect competition and the health of the domestic industry, but independent variables may generate even greater changes, and marginal changes to the regime alone would likely have little impact.

The suitability of the domestic liability regime as currently configured is a policy judgment and depends largely on whether observers believe the government is not sufficiently involved in supporting commercial space transport, the involvement is just right, or the scope is overreaching. If the industry were to transition substantially either way—for instance, if launch providers began exiting the launch market; if RLVs entered service and changed the economics of the market; if other countries made substantial changes to their risk allocation regimes; or if catastrophes affected the capacity of the insurance market generally and aerospace and liability markets specifically (a post-September 11, 2001, discussion is contained in Appendix F), Congress might consider the industry to be so impacted that reexamination of the liability risk-sharing regime is needed.

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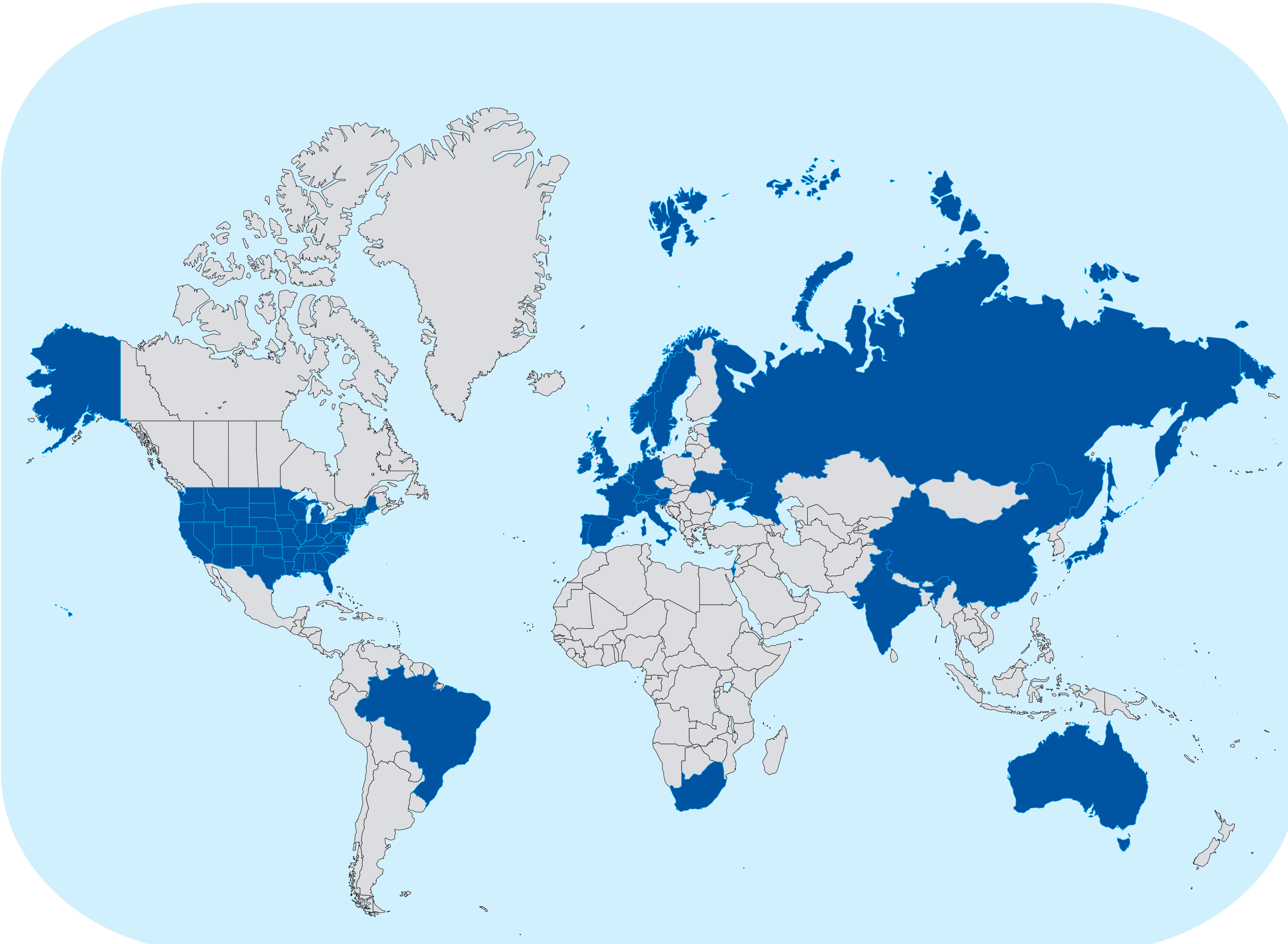
Chapter 4

Current Liability Risk-Sharing Regimes in Other Spacefaring Countries



Chapter 4
Current Liability Risk-Sharing Regimes in Other Spacefaring Countries

Chapter 4 presents the study and analysis of liability risk-sharing regimes in 12 other countries or foreign organizations and compares them to the liability risk-sharing regime of the United States. The 12 foreign countries or entities included in this analysis are: Arianespace, Australia, Brazil, People's Republic of China, India, Israel, Japan, Russia, South Africa, Sweden, Ukraine, and United Kingdom (highlighted, along with the United States, in the associated map.)

4.1 Introduction

As discussed in Section 1.1, Congress directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 2 of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act) states, "*examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities.*" This chapter presents the liability risk-sharing regimes for commercial space launches in 12 other spacefaring countries or entities. Some of the countries discussed in this chapter have established viable commercial space launch capabilities; others are actively developing and testing space launch vehicles; and some have adopted laws for liability risk-sharing even though they have not developed an indigenous space transportation capability. All 12 countries or entities have ratified the Outer Space Treaty of 1967 and the 1972 Convention on International Liability for Damage Caused by Space Objects, with one exception. South Africa has ratified the Outer Space Treaty, but has never ratified the Liability Convention. The principal emphasis for this chapter is commercial space launch third-party liability insurance requirements and government-supplied indemnification. Most launch services provided at foreign launch sites utilize contractual cross-waiver provisions comparable to those of the United States. Doing so tends to resolve issues regarding responsibility for claims settlement between launch providers and their customers, contractors, and subcontractors and has the added beneficial effect of lowering insurance premiums.

4.2 Worldwide Space Transportation Capabilities

4.2.1 Arianespace

Arianespace is the production, marketing, and operations organization for the Ariane Expendable Launch Vehicle (ELV) family. Two other organizations comprise the triad involved in the Ariane launch vehicles: the Centre National d'Études Spatiales (CNES) and the European Space Agency (ESA). CNES is the French space agency; it owns the Kourou Space Center, is the prime contractor for Ariane, and provides site maintenance, operations, and technical support along with payload processing. ESA develops Ariane ELVs and owns launch infrastructure, payload processing and Ariane-V production facilities, as well as down-range tracking stations (Arianespace 2001a).

ESA is an organization comprised of 15 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom) that is headquartered in Paris, France (ESRIN 2001). France, which contributes 30 percent of ESA's budget, selected a launch site in Kourou, French Guiana, in 1964 and successfully launched a French sounding rocket from this site in 1968. Today, the Kourou Space Center is the sole launch site, with geostationary, low Earth, and polar orbits available for all Ariane space launch vehicles (ESA 2001a). Kourou's close proximity to the equator at 5.2 degrees North latitude gives it an advantage in payload delivery because less fuel is required for launch compared to the primary U.S. launch sites at Cape Canaveral Air Force Station, Florida, and Vandenberg Air Force Base, California (ST 2001a).

Over 100 Ariane launches have occurred at Kourou since the Ariane launch vehicle became operational in 1982 (CNIE 2001). ESA's two primary ELVs are the Ariane IV and the Ariane V, which collectively offer low Earth orbit (LEO) and geosynchronous transfer orbit (GTO) payload delivery capabilities similar to the currently licensed Delta and Atlas ELVs as well as the Titan (ESA 2001b). Arianespace is one of the major competitors of U.S. commercial space launch operators. Between 1996 and 2000, Arianespace captured 41 percent of all worldwide commercial space launch revenues compared to the 34 percent share captured by U.S. launch operators. Arianespace performed 27 percent of all worldwide commercial launches during this same five-year period (AST 2001).

Arianespace obtains primary third-party launch liability insurance on behalf of its customer in the amount of 400 million French francs, the equivalent of approximately $53 million U.S. at the current exchange rate (Arianespace 2001b). Insurance covers the liability of the French Government, CNES, ESA, Arianespace, their contractors and subcontractors, in addition to the launch customer and its contractors, arising out of the launch. This indemnification coverage is in effect for a period of three years following the launch. Any third-party claims exceeding this insurance coverage are the responsibility of ESA (ultimately, the European government owners, principally France). Any damage to the launch site or property owned by ESA is the sole responsibility of ESA and is not covered by any launch-specific insurance requirements. Cross-waivers of claims modeled on the National Aeronautics and Space Administration (NASA) precedent exist for each launch, which, as in the case of U.S. launches, simplifies responsibility for losses and makes each customer, contractor, subcontractor, and supplier responsible for his or her own respective losses due to a launch failure. Third-party losses beyond 400 million French francs are not subject to any appropriation actions by the French government or any other participating European country's government body.

4.2.2 Australia

Australia has a long history of involvement in the exploration of space, starting with a joint project with the United Kingdom in 1946 that encompassed military space rocket testing at the Woomera Range in South Central Australia (CRCSS 2001). Woomera was selected because it is surrounded by a vast, uninhabited land area to the north and northeast that is ideal for weapon-, missile-, and rocket-testing purposes. Woomera is located inland about 280 miles north of Adelaide at 31.1 degrees South latitude (ST 2001a). U.S. military satellites use ground tracking stations at several locations in Australia, as NASA does for civilian tracking purposes. In 1967, Australia became the fourth country to successfully launch its indigenous WRESTAT satellite, designed and constructed in Australia using a U.S. Redstone rocket from the Woomera launch site. British and joint European sounding rocket launches and LEO launches continued from Woomera in the 1960s and 1970s (Pandora 2001). Over 35 different types of small sounding and LEO rockets were launched from Woomera between 1949 and 2000. Australia has pursued a modest space program since 1985, but remains an importer of space goods and services. In 1994, the Australian Space Council Act established the Australian Space Council to integrate and direct the National Space Program using an executive arm called the Australian Space Office. Currently, Australia's limited research funding has precluded development of any indigenous launch vehicles and Woomera remains the only operational launch site. Kistler Aerospace Corporation has expressed interest in using Woomera for launching its RLV design, which is under development. While Woomera is considered a good candidate for sounding rocket and LEO launches, the Australian Government has announced interest in developing Christmas Island, which is owned by Australia and is located south of Indonesia in the Indian Ocean at 10.5 degrees South latitude, as a potential launch site for GTO launches (ABC 2001).

Australia passed the Space Activities Act of 1998 to set a legislative framework for regulation of space activities in Australia. This act was modeled after the U.S. Commercial Space Launch Act of 1984. The Space Activities Act requires that a launcher, after receiving a permit from the Australian Government's Space Licensing and Safety Office, must obtain third-party liability launch insurance for an amount not less than the maximum probable loss (MPL) that may be incurred by third parties for damage resulting from launch, as determined by regulations. A launch permit is required for any entity that plans to launch from Australian territory, regardless of nationality. The responsible party for the launch is not liable to pay compensation for third-party damage to the extent it exceeds the insured amount, absent gross negligence of the responsible party or related party. The Australian Government thereby relieves the responsible party of excess liability, which effectively amounts to indemnification of excess liability. According to Australian officials, modifications to the Space Activities Act may be forthcoming that further refine provisions regarding excess liability management. Australia has not specified numerical values for MPL for any ELV or reusable launch vehicle (RLV) to date because no launch company has applied for a license (Morris 2001). Australia has hosted and authorized an FAA-licensed suborbital launch, conducted by Astrotech Space Operations, Inc., and continues to pursue entry into this business area by offering sites to prospective launch operators.

4.2.3 Brazil

Space activity in Brazil began in 1964 with the creation of a space national research commission that initially focused on development and launching of a series of indigenous sounding rockets. Hundreds of these sounding rockets, denoted SONDA I, SONDA II, SONDA III, and SONDA IV, were successfully launched in the 1960s, 1970s, and 1980s (Brazil 2001). Brazil modified some rockets into surface-to-surface missiles for export. Sounding rockets were launched from a launch site located approximately 12 miles south of Natal, Brazil, on the Atlantic coast. Brazil initiated ballistic missile development activities in the mid-1980s. Brazil's pursuit of military applications for missile technology in the 1960s through the 1980s coincided with ongoing mutual distrust and nuclear weapons development competition between Brazil and Argentina during this time period. After 1991, when civilian governments had replaced the military regimes in both countries, both countries reached agreements that defused this situation (CEIP 2001).

The change in emphasis from military to civilian and scientific applications for Space Launch Vehicles (SLVs) occurred in the 1990s. The Brazilian Space Agency (Agencia Espacial Brasileira, or AEB) was created within the Ministry of Science and Technology in 1994 and given responsibility for national space activity and development. Since the 1980s, Brazil has been developing the Veiculo Lancador de Satelites (VLS) satellite launch vehicle, which is derived from the SONDA sounding rocket technology. The VLS is designed to deliver satellites to LEO with a design payload capacity smaller than that of the U.S. Pegasus or Minotaur LEO ELVs. Launches of the VLS in 1997 and 1999 both resulted in failures. Brazil now launches its sounding rockets and VLS from the Alcantara Launch Center, located on Brazil's northern Atlantic coast near Sao Luis at 2.3 degrees South latitude (ST 2001a), which began development in the 1980s and is now operational. Due to its proximity to the equator (with its associated centrifugal "boost" advantage for launch vehicles), China, Israel, and Ukraine have expressed interest in using Alcantara for their ELVs.

The Brazilian Government has developed a draft law, Regulation No. 8 of the Ministry of Science and Technology Brazilian Space Agency, which stipulates that the AEB licenses all launches and would establish the required amount of third-party liability insurance for each launch, which the launch operator must obtain. The amount of insurance would be determined in accordance with the degree of risk for the launch activity. AEB has stated that the Brazilian Government would be responsible for claims exceeding the launch operator's third-party liability insurance coverage (BSA 2001). Specific insurance amounts have not been determined because no license has been requested for a commercial launch to date. The law would apply to any applicant, regardless of nationality, that requests a license to launch from Brazilian territory.

4.2.4 People's Republic of China

The People's Republic of China (PRC) has been involved in development and deployment of ballistic missiles and extension of their use in launching satellites since the PRC Twelve-Year Plan for the Development of Science and Technology in 1956. As a result of its Korean War involvement against the United States and with initial technical support from the Soviet Union, the PRC received its first ballistic missiles from the Soviet Union in 1956. After the Sino-Soviet split in 1960, PRC missile development was continued indigenously with the help of Qian Xuesen, a Chinese citizen trained in the United States and involved in U.S. missile development programs until he was charged with spying for the PRC and was allowed to return to mainland China. Under his leadership, the PRC developed a series of intercontinental ballistic missiles (ICBMs) in the 1960s and 1970s. China launched its first satellite into LEO in 1970 using a modified military ICBM named Long March I (Cox 1999). Much of the missile guidance technology used by the PRC was stolen from U.S. military missiles and military aircraft.

Following the 1970 Long March I satellite launch, the PRC modified successive ICBMs to create the commercial derivative ELVs Long March II, III, and IV in the 1970s, 1980s, and 1990s. Since the breakup of the Soviet Union, the PRC has acquired space launch technology from Russia, especially engine technology (Cox 1999).

Due to the 1986 *Challenger* Space Shuttle explosion and Delta and Titan ELV launch failures in 1985 and 1986, there was a dearth of available U.S. launch capability in the late 1980s. A lack of ESA capacity and the U.S. policy precluding the use of Soviet launch vehicles for U.S. satellites resulted in the U.S. Government adopting a "Green Line" policy to transfer some missile technology to the PRC and allow the PRC to launch U.S.-manufactured commercial satellites. The PRC launched its first U.S. satellite in 1990, followed by 23 additional successful PRC launches of U.S. satellites (Cox 1999). The PRC currently offers several versions of its Long March II, Long March III, and Long March IV ELVs, each of which is capable of launching payloads into LEO or geostationary and polar orbits. They can launch payloads similar in weight to that of medium-size U.S. ELVs, such as the Delta II and Atlas II families of vehicles.

The PRC operates three inland satellite launch centers at Jiuquan (in the Gobi Desert in northwestern China at 40.6 degrees North latitude), Taiyuan (northeastern China at 37.5 degrees North latitude), and Xichang (southwestern China at 28.25 degrees North latitude) (ST 2001a). Most commercial satellite launches have occurred at Xichang due to its launch center infrastructure and its relatively closer latitude to the equator. All international commercial space launches performed by the PRC are offered by the China Great Wall Industry Corporation (CGWIC), founded in 1980, and authorized by the PRC

Government. During the five-year period from 1996 to 2000, the PRC accounted for 3 percent of all worldwide commercial launch revenues and 6 percent of all commercial launches (AST 2001).

Insurance is obtained through an indigenous PRC insurance company, the Peoples' Insurance Company of China, which seeks coverage from underwriters in Europe. Third-party liability insurance is in effect for a period of two years following launch. The PRC Government will cover any claims above $100 million (CGWIC 2001). The PRC Government, not a jury, would determine the amount of any third-party claims, although a third party can theoretically file claims if he or she does not believe the amount of the government-determined settlement is sufficient. If a client is concerned that the $100 million is not adequate, the CGWIC can arrange for an additional $300 million in third-party launch liability insurance paid for by the client. The CGWIC estimated that an additional $300 million in insurance would cost a client approximately $900,000 (CGWIC 2001, SAIC 2001a). Two Long March launch accidents occurred at Xichang, one in 1995 and one in 1996 (ST 2001a). These accidents, which involved fatalities and injuries in the local population, resulted in total payment of third-party liability claims of less than $10 million for both accidents. The PRC Government assumes all responsibility for any launch-related damages to government property.

4.2.5 India

India's space program began with the 1969 creation of the India Space Research Organization (ISRO), which is currently under the auspices of the Department of Space. India conducted its first domestic space launch in 1980 and has developed four different ELVs: Space Launch Vehicle-III (SLV-III) (first satellite launched in 1980, designed for LEO missions); Advanced Satellite Launch Vehicle (ASLV) (first successful launch in 1992, designed for LEO missions); Polar Satellite Launch Vehicle (PSLV) (first successful launch in 1996; designed for polar orbits); and Geosynchronous Satellite Launch Vehicle (GSLV) (first successful launch in 2001, designed for GTO missions). The GSLV uses rocket engine technology from Russia and is comparable in payload delivery capability to the Delta II ELV (FAS 2001a, ISRO 2001).

India's government created the ANTRIX Corporation to market launch services worldwide. India launched two small, secondary payloads to LEO for Germany and Korea on a single vehicle in 1999. ANTRIX uses the ELVs and launch facilities of ISRO in much the same way as the Rocket System Corporation uses the National Space Development Agency's resources in Japan. The ISRO launch site is located at the Sriharikota Range Centre on Sriharikota Island off the southeast coast of India (about 62 miles north of Chennai at 13.9 degrees North latitude) (ST 2001a). India has not launched any commercial payloads to date (AST 2001).

India self-insures all indigenous satellite launches. Through commercial contracts for launch services with ANTRIX, India obtains liability insurance covering third-party liability. India includes no-fault, no-subrogation, interparty waivers of liability in its commercial satellite launch contracts. ANTRIX relies upon government procedures for indemnification in the event of third-party liability in excess of insurance. The specific amount of third-party commercial space launch liability insurance coverage for each ELV was not provided by ANTRIX or ISRO for the Indian ELVs in the conduct of this study (SAIC 2001e).

4.2.6 Israel

Israel's space program can be traced back to the 1960s with the advent of indigenous university-based research. The Israel Academy of Sciences and Humanities established the National Committee for Space

Research in 1963 (Israel 2001). The Israel Space Agency was created in 1983 to develop scientific and industrial infrastructure for a national space program (NASDA 2001c). As in the case of many other countries, Israel's development of a launch vehicle for satellites was derived from its military need to develop missiles. Thus, the Israeli launch vehicle, called the Shavit (Hebrew for "Comet") was derived from the Jericho II medium-range ballistic missile (FAS 2001b). The Shavit is a small LEO ELV that was first launched in 1988, with a satellite payload, from the Palmachim Air Force Base, which is situated south of Tel Aviv and Jerusalem (31.9 degrees North latitude) (Friends 2001a, ST 2001b). Since 1988, Shavit has been used in four satellite launches with a 75 percent success rate (i.e., one of the four launches was unsuccessful). To avoid overflight of foreign territory, all Shavit launch trajectories have been retrograde orbits over the Mediterranean Sea and the Straits of Gibraltar, which imposes a significant penalty on payload capacity (FAS 2001b). Israel has been involved in cooperative agreements, satellite launches, and/or space launch Memoranda of Understanding (MOUs) with the ESA, Russia, China, India, and Ukraine (Israel 2001).

Currently, Israel has no government regulation that establishes any liability risk-sharing regime for commercial space launches from Israeli launch sites. Property and/or third-party damages arising from any government satellite launches would be paid by the government. Since the Shavit ELV was developed and would be launched by a private company, the Israel Aircraft Industries (IAI), IAI would be responsible to fully pay any damages due to its launch, including third-party liability claims, in a manner similar to the responsibility of aircraft manufacturers. No specific launch liability coverage exists for Shavit launches. Previous Israeli-designed and -built satellites have been launched by Ariane or Zenit ELVs, but launch liability was subject to the regulations governing those nations' launch operators (SAIC 2001f). Israel has been marketing derivatives of the Shavit to other nations for commercial launches. However, no Shavit derivatives have yet been launched outside of Israel.

4.2.7 Japan

The Japanese space program is conducted under the auspices of the National Space Development Agency (NASDA) of Japan, a government-supported organization. Japan launched its first small rockets in the 1960s with its first orbital launch success in 1970 (NASDA 2001a). Early Japanese ELVs, the N-I and N-II, were based on U.S. Thor/Delta technology, and satellites were successfully launched from 1975 through 1986. However, a 1969 United States-Japan agreement prohibited commercial launches using these rockets without U.S. permission (CNIE 2001). The next generation of Japanese ELVs, the H-I and H-II, have been Japan's principal launch vehicles since the 1990s for GTO and LEO payloads. The H-I is subject to the same U.S. permission constraints for commercial launches. The H-II is the first completely Japanese-designed launch vehicle not subject to any restrictions by the United States. The smaller, mobile J-I is an ELV designed for smaller payloads and LEO missions. The M-V is another small Japanese ELV. The next generation of larger ELVs, the H-IIA, began development in 1995 and is currently undergoing testing as a replacement for the H-II, which has suffered a series of launch failures. The H-IIA is envisioned by NASDA as competition for the next generation of U.S. Evolved ELVs (known as EELVs), as well as Ariane and Long March launch vehicles. The H-IIA payload capability is approximately twice that of either Titan II or Delta II to LEO. The successful launch of an H-IIA on August 29, 2001, from Tanegashima Space Center bolstered NASDA's confidence and the continuing development of this ELV (NASDA 2001b).

Japan has two launch sites at the Tanegashima (Tanegashima Island in southern Japan at 30.4 degrees North latitude) and Kagoshima (Kyushu Island in southern Japan at 31.2 degrees North latitude) Space Centers (ST 2001a). Tanegashima is the preferred launch site, but its use is hampered by restrictions imposed by the local fishing industry, which reached an agreement with the Japanese Government in 1997 limiting activity to eight annual launches during a 190-day time period of the year (CNIE 2001).

Although Japan has signed contracts with customers, no commercial launches have taken place from the country to date (AST 2001).

Although NASDA is the Japanese Government's space development agency, private or commercial launching services are provided by the Rocket System Corporation (RSC), which uses NASDA ELVs and the NASDA Tanegashima launch site. RSC, funded by 73 Japanese space-oriented companies, was founded in 1990. A Japanese law, the Space Development Enterprise Corporate Law, was first enacted in 1969 and later revised in 1997 and 1998. This law specifies that the launch operator, RSC, must have third-party liability insurance and defines cross-waiver provisions. A launch requires government approval, with NASDA setting the required amount of third-party launch liability coverage on a case-by-case basis considering launch vehicle size and launch site. NASDA is charged with responsibility for setting a conservative value for the primary insurance that RSC obtains for each launch in order to provide victim compensation and financial soundness of NASDA. Based on previous experience, NASDA has applied the following third-party launch insurance requirements for different Japanese ELVs: about $50 million for J-I and about $200 million for H-I, H-II, and H-IIA. NASDA would be responsible for paying losses exceeding these insurance amounts (SAIC 2001b). This law does not specify how the government would appropriate funds to cover losses exceeding the insurance amounts.

4.2.8 Russia

Russia, and its predecessor government, the former Soviet Union, has been a world leader in space launch technology since it started the Space Age with the first launch of the Sputnik satellite in 1957 (Boeing 2001). Since the dissolution of the Soviet Union, Russian companies have aggressively entered the commercial space launch market and have also been successful in selling rocket engine technology. Russian rocket engine technology is used in some U.S. ELVs.

Russia offers a series of launch vehicles for LEO and GTO orbits and a range of payload weights. These ELVs are based on military missiles and the indigenous space exploration program of the 1960s, 1970s, 1980s, and 1990s. For LEO missions, Russia offers Cosmos, Cyclone III[1], Dnepr[1], Rockot, Start, Soyuz, and Zenit II[1] ELVs. The Proton ELV is Russia's workhorse GTO mission vehicle as well as one of its LEO launch vehicles. Russia's ELV capability is similar to that of the range of U.S. launch vehicles. Russia's four launch sites, known as *cosmodromes*, are located at Baikonur (Central Kazakhstan at 45.6 degrees North latitude); Plesetsk (European Russia at 62.8 degrees North latitude); Kapustin Yar (European Russia at 48.4 degrees North latitude); and Svobodny (Far Eastern Russia at 51.4 degrees North latitude) (ST 2001a). Other than Baikonur in Kazakhstan, all of the launch sites are located in Russia. During the five years from 1996 through 2000, Russia accounted for 19 percent of worldwide commercial space launch revenues and 23 percent of worldwide commercial launches (AST 2001).

Two laws in Russia pertain to commercial space launch insurance requirements. The *Civil Code of the Russian Federation, Part Two*, No. 14-F3, dated January 26, 1996, approved by the Duma on December 22, 1995, and amended on October 24, 1997 (No. 133-F3), defines an insurance contract, explains third-party insurance requirements, and addresses the rights of insurance companies to assess risk. The Russian Federation Law on Organizing the Insurance System in Russia, No. 4015-1, dated November 27, 1992, and amended on December 31, 1997 (No. 157-F3), and on November 20, 1999 (No. 204-F3), establishes the general principles of state oversight of insurance practices and regulates relations between insurance companies and citizens or other organizations. In addition, Article 25 of the Russian Federation Law on Space Activity (Federal Law No. 147-F3 dated 29 November 1996: Decree No. 5663-1) of the Russian House of the Soviets requires compulsory insurance coverage for "…damage

[1] These ELVs are principally manufactured in Ukraine with Russian participation (see Section 4.2.11).

to the life and health of cosmonauts and the personnel on the ground and other objects of space infrastructure, as well as against property damage to third parties." Article 30 of this decree states that, "the Russian Federation shall guarantee full compensation for direct damage inflicted as a result of accidents while carrying out space activity in accordance with the legislation of the Russian Federation." Furthermore, Article 30 specifies that liability rests with the responsible organization(s) (SAIC 2001d).

According to Megaruss (a leading Russian space insurance company), an order of Rosaviakosmos (the Russian Aviation and Space Agency) states that minimal amounts of third-party launch liability insurance must be obtained, depending on the specific Russian launch vehicle. Typically, the launch service customer purchases the third-party launch liability insurance. If specified in the launch services contract, the Russian Government would pay for damages in excess of the insurance coverage if claims exceed it. However, if not specified in the launch contract, the launch services customer would be liable for claims above the insurance coverage. In the case of Baikonur, Kazakhstan is not considered a launching state, and Russia assumes all responsibility for damages incurred by launches from this *cosmodrome*. Three recent launch failures from Baikonur (Zenit in September 1998; Proton in July 1999 and October 1999) resulted in payment of third-party claims for contamination due to fuel dumping, forest and fish stock damage, imported feed, environmental assessment, and healthcare. These third-party claims totaled between $260,000 and $400,000 for each of the three incidents, never approaching insurance limits that would require government indemnification, and were paid by insurance companies in two cases (SAIC 2001d).

Megaruss has insured space launches since 1992 and is involved in insuring all stages of the launch cycle (manufacturing, transit, storage, integration, prelaunch, launch, payload delivery, in-orbit life, etc.). **Table 4–1** provides third-party launch liability insurance coverage, in U.S. dollars, for specific Russian ELVs.

Table 4–1 Russian ELV Third-Party Liability Insurance

Launch Vehicle	*3rd -Party Liability Insurance*	*Launch Vehicle*	*3rd -Party Liability Insurance*
Cosmos	$100-150 million	Zenit	$150-500 million
Dnepr	$100-150 million	Proton	$300 million
Rockot	$100 million	Molniya	$150 million
Start	$80 million	Cyclone (Tsyklon)	$100 million
Soyuz	$100-300 million	Strela	$100 million

The range in required third-party launch liability insurance for some ELVs reflects the fact that there are different models of a specific ELV and different missions with an associated range of risks. It should also be noted that all Russian launch sites are landlocked. A landlocked ELV launch site has concomitantly higher risks to land and the public than vehicles launched from a coastal site such as Kourou or Cape Canaveral (SAIC 2001d). Launch operators are also responsible for government property damage and are required to obtain insurance to cover such damages.

4.2.9 South Africa

South Africa's involvement in space launch commenced in the 1980s with the development of the RSA-3 satellite launcher, which originally began as an intermediate-range ballistic missile with assistance from Israel. Designed as a LEO satellite ELV, the RSA-3 was cancelled in 1994 after extensive testing because it was not commercially viable. RSA-3 tests were conducted at the Overberg Range near

Bredasdorp, located about 120 miles east of Capetown. South Africa currently has no indigenous launch vehicle or active launch site (Friends 2001b).

The South Africa Space Affairs Act No. 84 of 1993, as amended by the Space Affairs Amendment Act No. 64 of 1995, constitutes South Africa's legislation governing space policy and established the South African Council for Space Affairs with licensing and regulatory authority. The launch operator may be required to assume some or all financial responsibility for claims, losses, and/or liability associated with a space launch (RSA 1993).

4.2.10 Sweden

Sweden's space activity began in 1964 with its participation in the European Space Research Organization (ESRO), which was created by ten western European countries to coordinate peaceful space research and support European industry. The ESRO built the Esrange rocket launching area in 1966, which has been used to launch sounding rockets and balloons. Esrange is located in northern Sweden at 67.9 degrees North latitude and has been managed by the Swedish Space Corporation (SSC) since 1972. SSC and Sweden's participation in the ESA are under the auspices of the Swedish National Space Board, which is part of the Swedish Government's Ministry of Industry, Employment, and Communications. Sweden has no indigenous commercial launch sites or launch vehicles, but participates in Ariane launch activities from the Kourou launch site as a member of the ESA (SSC 2001).

Commercial space launch activities are regulated by the 1982 Act on Space Activities, which provides for the licensing of any applicant desiring to launch from Swedish territory. This Act is augmented by the 1982 Decree on Space Activities. Collectively, these laws require any space launch licensee to compensate the Swedish Government for any damages or claims arising from the launch, without specifying any particular requirement for third-party liability launch insurance (SAIC 2001c). Except for its participation in the ESA, Sweden has not been involved in orbital launch activity or any other facet of the commercial space launch business (AST 2001).

4.2.11 Ukraine

Ukraine's involvement in space transportation coincided with that of the Soviet Union until it became independent (FAS 2001c). Ukraine's domestic industry has manufactured over 400 satellites and continues to manufacture the Cyclone (Tsyklon) and Zenit ELVs. However, Ukraine does not have any space launch facilities. Ukraine is a partner with Boeing, Russia, and Norway in the U.S.-licensed Sea Launch Limited Partnership ELV venture, which was formed in 1995 and has had seven successful FAA-licensed launches in the Pacific Ocean since its inaugural launch in 1999. Ukraine has also been involved in discussions with Australia and India regarding collaboration in launch vehicle technology and launch sites.

The Law of Ukraine on Space Activity (No. 503/96-VR) of 1996 established the Ukrainian National Space Agency to regulate and license space activity in Ukraine. This law does not specify responsibility or requirements for liability for damages due to commercial space activities, but instead implies that the Ukrainian legislation will address liability for damages sustained in the course of space activity as well as procedures for determining the extent of such damage for which compensation shall be payable.[2] It does specify that all launch organizations will comply with safety requirements regarding third parties (UN 2001). To date, all Ukrainian launch vehicles have been used at non-Ukrainian launch sites and

[2] Ordinance of Supreme Soviet of Ukraine on Space Activity (Law of Ukraine of 15 November 1996) Articles 24 and 25.

subject to the regulations for liability insurance of the licensing authority for those launch operations (e.g., United States for Sea Launch; Russia for Zenit from Baikonur).

4.2.12 United Kingdom

Space launch development in the United Kingdom centered on the use of the Woomera launch site in Australia, from which the United Kingdom became the sixth country to launch a satellite in 1971 (CRCSS 2001, Pandora 2001). As a participant in the ESA, the United Kingdom continues its involvement in space research and conducts launches via the Ariane ELVs at the Kourou launch site in French Guiana (ESRIN 2001).

Commercial space activity by United Kingdom nationals and corporations, including Scottish firms, is regulated by the Outer Space Act 1986, which assigns licensing responsibility to the Secretary of State acting through the British National Space Centre. The Outer Space Act requires a licensee to indemnify the British Government from any claims arising from the launch and stipulates that an applicant for a license must provide evidence of 100 million pounds sterling (approximately $142 million U.S. at the current exchange rate) of third-party launch liability claim insurance, listing the government as an insured. British law does not indemnify any launch licensee and places all financial responsibility for claims due to third-party injury or damage completely on the licensee (UK 1986). Except for its participation in the ESA, the United Kingdom is not involved in the commercial space launch business. Licensees under the Outer Space Act may therefore be satellite owners or operators that procure launch services from other providers, but are not typically launch vehicle operators.

4.3 Comparison of Liability Risk-Sharing Regimes

This section compares the liability risk-sharing regimes of the "spacefaring" countries discussed in this chapter. **Table 4–2** provides an historical perspective and a launch site latitude comparison for spacefaring countries.[3] A useful perspective for comparing the risk-sharing liability regimes of spacefaring countries is presented in **Table 4–3**. This table presents a comparison of the third-party liability insurance required for ELVs from different countries, but grouped by payload delivery capability. **Table 4–4** presents liability risk-sharing regime information for each country in terms of key relevant parameters.

Although by no means a complete point of comparison between U.S. and foreign launch competitors, Table 4–4 does present some useful data. For small LEO, medium LEO, and small GTO payloads, U.S. launch licensees are required to purchase third-party liability insurance coverage similar to the lowest insurance coverage competitor, Arianespace. For larger vehicles with greater payload lift capability, U.S. launch licensees are required to purchase third-party liability insurance coverage amounts greater than that provided by Arianespace, but lower or comparable to that purchased by China, Russia, and Japan. The one exception is the third-party insurance coverage for the multinational Sea Launch venture, which is much lower than that of all foreign competitors, including Arianespace, due to its unique and remote launch locations in the Pacific Ocean. **Figure 4–1** illustrates the geographic location of worldwide operational launch sites.

[3] Excluding Sea Launch: Sea Launch uses a mobile ship launch platform which is positioned at 0 degrees latitude in the Pacific Ocean.

Table 4–2 Space Transportation History and Orbital Launch Site Characterization

Country	*Year of First Space Satellite Launch*	*Number of Orbital Launches 1957 – 1995 (% of Total)*[1]	*Most Active Current Launch Sites (O = Ocean/Coastal) (L = Inland)*	*Latitude of Launch Sites (degrees)*[2]
United States	1958	1,048 (28%)	Cape Canaveral (O) Vandenberg (O) Wallops Island (O) Kodiak, Alaska (O) **Kwajalein (O)** White Sands[3] (L)	28.5 North 34.4 North 37.8 North 57.5 North **9.0 North** 32.0 North
Arianespace/ France/ESA	1979 (Ariane) 1965 (France)	84 (2.2%)	**Kourou, French Guiana (O)**	**5.2 North**
People's Republic of China	1970	41 (1.1%)	Jiuquan (L) Taiyuan (L) Xichang (L)	40.6 North 37.5 North 28.25 North
Russia (and USSR before 1991)	1957 (USSR)	2,496 (66.7%)	Baikonur[4] (L) Plesetsk (L) Kapustin Yar (L) Svobodny (L)	45.6 North 62.8 North 48.4 North 51.4 North
Japan	1970	49 (1.3%)	Tanegashima (O) Kagoshima (O)	30.4 North 31.2 North
India	1980	6 (0.2%)	Sriharikota (O)	13.9 North
Israel	1988	3 (0.1%)	Palmachim (O)	31.9 North[5]
Australia	1967	2 (0.1%)	Woomera (L)	31.5 South
Brazil	None	0	**Alcantara (O)**	**2.3 South**
United Kingdom	1971	0	None	Not applicable
Sweden	None	0	Esrange[6] (O)	67.9 North
South Africa	None	0	None	Not applicable
Ukraine (since 1991)	1992	see note 7	see note 8	Not applicable

USSR = Union of Soviet Socialist Republics; **bold** = launch advantage from site latitude.
1 Percents do not add up to 100 due to rounding of percentages.
2 Launch sites closer to the equator (0 degrees) benefit from an orbital boost from the Earth's rotation, with greater payload delivery capability with the same launch thrust.
3 Suborbital launches only.
4 Located in Kazakhstan and leased to Russia.
5 Retrograde orbit to preclude foreign territory overflight further penalizes the launch site from any boost by the Earth's rotation.
6 Sounding rockets and balloons only.
7 Part of USSR's launches from 1957 to 1995.
8 Ukrainian designed and built launch vehicles are used by Russia at Baikonur and by Sea Launch in the Pacific Ocean.
Sources: Braeunig 2001, NASA 1998, NASDA 2001d.

Table 4–3 Comparison of Third-Party Liability Insurance Requirements for Different Payload Classes

Country: Launch Vehicle	*Small LEO Orbit Payload*[1]	*Medium LEO Orbit Payload*[2]	*Large LEO Orbit Payload*[3]	*Heavy LEO Orbit Payload*[4]	*Small GTO Orbit Payload*[5]	*Medium GTO Orbit Payload*[6]	*Large GTO Orbit Payload*[7]
Arianespace: (ESA, France):							
Ariane IV[8]	$53M[9]	$53M	$53M		$53M	$53M	
Ariane V				$53M			$53M
People's Republic of China:							
Long March[10]		$100M[11]	$100M	$100M	$100M	$100M	
Japan:							
J-I	$50M						
H-I, H-II, H-IIA		$200M	$200M	$200M	$200M	$200M	$200M
Russia:							
Cosmos	$100M-150M						
Cyclone		$100M					
Dnepr		$100M-150M					
Molniya	$150M[12]						
Proton			$300M	$300M	$300M	$300M	$300M
Rockot	$100M						
Soyuz		$100M-300M	$100M-300M				
Start	$80M						
Strela	$100M						
Zenit				$150M-500M	$150M-500M	$150M-500M	
United States[13]:							
Atlas II/IIA		$113M	$113M		$113M	$113M	
Atlas IIAS		$135M	$135M		$135M	$135M	
Atlas IIIA/IIIB					$149M	$149M	
Atlas V-401		$45M	$45M	$45M	$45M	$45M	
Delta II		$40M or[14] $76.5M			$40M or $76.5M[14]		
Delta III			$126M	$126M		$126M	$126M
Delta IV		$261M	$261M	$261M		$261M	$261M
Pegasus	$28M-57M[15]						
Taurus	$40M				$40M		
Zenit-3SL[16]				$10M	$10M	$10M	$10M

M = million; LEO = low Earth orbit; GTO = geosynchronous transfer orbit; ESA = European Space Agency.
[1] Capability to deliver a payload of up to 2,000 kg to LEO.
[2] Capability to deliver a payload of between 2,000 and 5,000 kg to LEO.
[3] Capability to deliver a payload of between 5,000 and 10,000 kg to LEO.
[4] Capability to deliver a payload greater than 10,000 kg to LEO.
[5] Capability to deliver a payload of up to 2,000 kg to GTO.
[6] Capability to deliver a payload of between 2,000 and 5,000 kg to GTO.
[7] Capability to deliver a payload greater than 5,000 kg to GTO.
[8] Includes all operational model variations of Ariane IV ELVs including: Ariane-40; 42L; 42P; 44L; 44LP; and 44P.
[9] 400 million French francs at the 2001 exchange rate.
[10] Includes all operational model variations of the Long March II and III ELVs.
[11] An additional $300 million can be obtained if requested by the client.
[12] Molniya elliptical orbit.
[13] Highest value of MPL for each ELV flight at its authorized launch site.
[14] Depending on launch site (i.e., Vandenberg versus Cape Canaveral).
[15] Depending on launch site (i.e., Vandenberg, Cape Canaveral, Wallops, or Kwajalein).
[16] Multinational Sea Launch ELV.
To convert kilograms to pounds multiply kilograms by 2.2.
Sources: ST 2001a, AST 2001.

Table 4–4 Comparison of Spacefaring Countries' Liability Risk-Sharing Regimes

Country	*Commercial Space Launch Capability – ELV Name(s) (launcher affiliation)*	*Insurance Requirements for Third-Party Launch Liability*[1]	*Number of Tiers of Licensee-Government Third-Party Risk-Sharing*	*Launch Licensee's Required Amount of Third-Party Liability Insurance*	*Cross-Waiver Request*	*Government Supplied Third-Party Liability Indemnification*
United States[2]	Yes – Atlas, Delta, Minotaur, Taurus, Pegasus (commercial) Athena	Yes	3	MPL (but not more than $500 million). Current licensed ELVs have MPLs of from $0.25 million to $261 million (Delta IV)	Yes	$1.5 billion above the MPL (as adjusted post-1988 inflation)
ESA/France	Yes – Ariane (government)	Yes	2	$53 million at current exchange rate (400 million French francs)	Yes	No Limit
People's Republic of China	Yes – Long March (government)	Yes	2	$100 million (client can request another $300 million)	Yes	No Limit
Russia	Yes – Cosmos, Dnepr, Rockot, START, Soyuz, Zenit, Proton, Molniya, Tsyklon, Strela (government)	Yes	2	$80 million to $500 million (depending on launch vehicle)	Yes	No Limit – By contract only
Japan	Under development – H-IIA (government)	Yes	2	$50 million or $200 million (depending on launch vehicle)	Yes	No Limit
India	Under development – GSLV (government)	Yes	2	Not Specified	Yes	No Limit
Israel	Under Development – Shavit (commercial)	No	Not available	Not Specified	Unknown	None
Australia	No, but foreign interest (foreign commercial)	Yes	2	MPL, similar to U.S. method	Unknown	No Limit – Under current law
Brazil	Under development – VLS (government)	Draft	2 (Proposed)	Not Specified (but launch risk-based)	Unknown	Unknown
United Kingdom[3]	No	Yes	1	$142 million at current exchange rate (100 million pounds sterling)[4]	Unknown	None
Sweden[3]	No	Yes	2	Not Specified	Unknown	None
South Africa	No	Yes	1	Not Specified	Unknown	None
Ukraine	No, but affiliated with foreign ventures – Zenit (commercial)	Yes	Not available	Not Specified	Unknown	Not Specified

ESA = European Space Agency; MPL = maximum probable loss; ELV = expendable launch vehicle; VLS = Veiculo Lancador de Satelites.

[1] In the form of a law, requirement, or edict on the license condition.

[2] Includes Multinational Sea Launch Limited Partnership joint venture with Boeing, Russia, Ukraine, and Norway (licensed by the Federal Aviation Administration).

[3] ESA member.

[4] For satellite customer.

bold = Countries that have captured some market share of the commercial space launch business from 1996 through 2000.

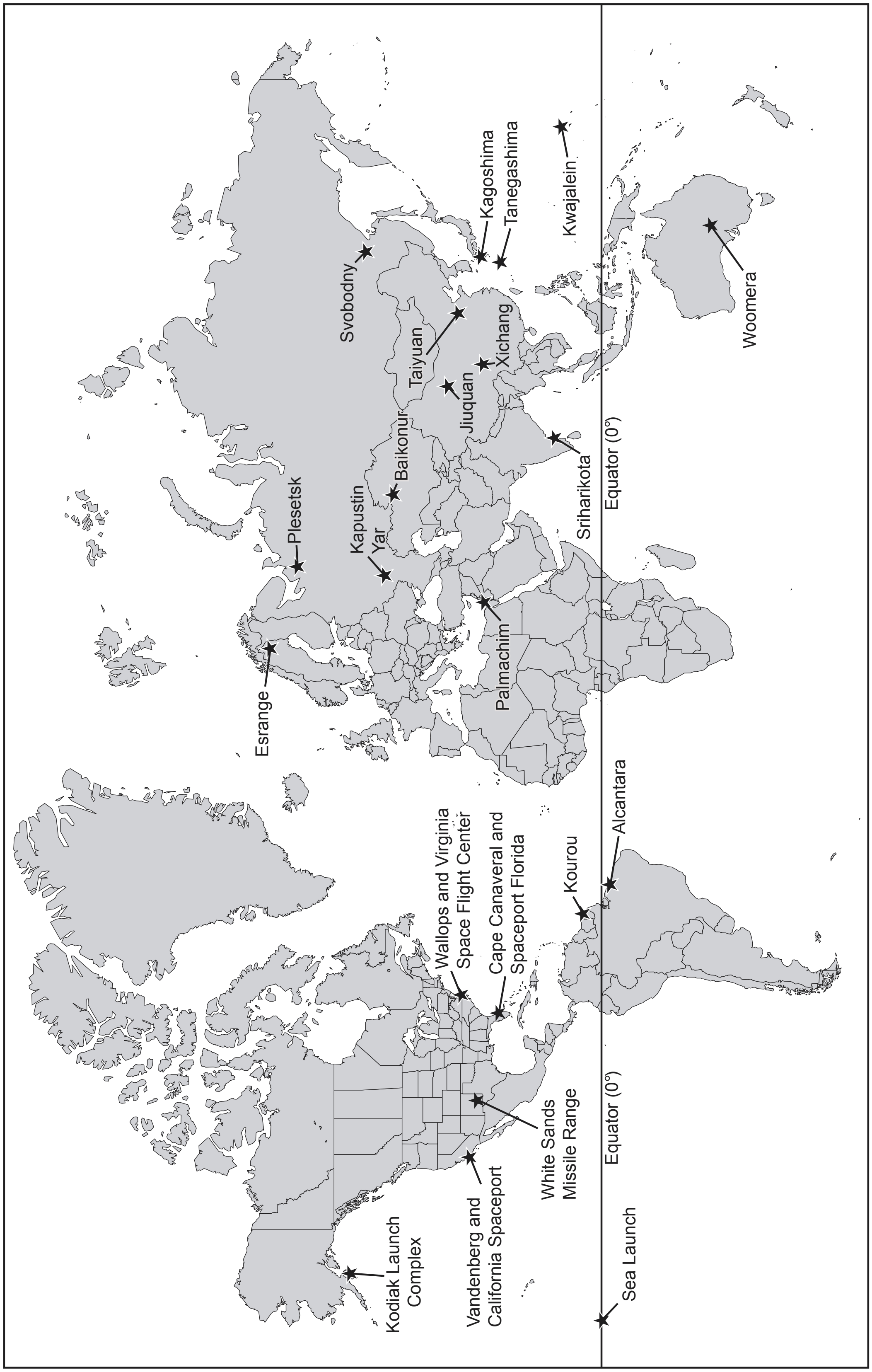


Figure 4–1 Worldwide Operational Launch Sites

4.4 Summary

The following summary presents observations that can be made from Tables 4–1, 4–2, 4–3, and 4–4 regarding liability risk-sharing regimes of spacefaring countries and their launch sites.

- Currently, the United States is the only country that has a three-tier system for risk sharing, compared to the one- or two-tier systems used by other countries.
- Many foreign competitors offer government indemnification and do so without any specified limit or requirement for appropriation.
- The United States is the only country with a sunset provision (expiration date) associated with its government indemnification provision.
- Currently viable foreign competitors set a constant launch vehicle primary insurance amount without performing MPL analyses.
- Launch sites that benefit from the Earth's natural rotation to boost launch payloads into space are: Arianespace's Kourou; Brazil's Alacantara; and the U.S. Kwajalein Missile Range. Sea Launch's equatorial position in the Pacific Ocean affords this benefit as well.
- Russia, the PRC, and Australia are the only spacefaring countries with inland operational orbital launch sites.
- An orbital ELV launched from an inland launch site generally has concomitantly higher risks to property and the public than a launch of an ELV from a coastal site such as Kourou or Cape Canaveral (SAIC 2001d).

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Chapter 5

Ultrahazardous Activities and Applicable Legal Standards

Photo courtesy of FEMA

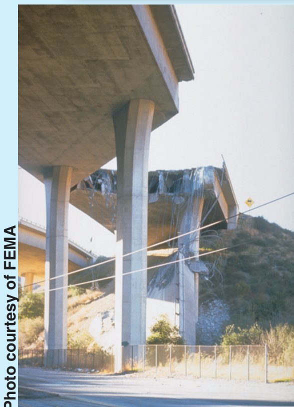

Photo courtesy of FEMA

Chapter 5
Ultrahazardous Activities and Applicable Legal Standards

Chapter 5 presents a legal analysis of the term "ultrahazardous activities," including the concepts of strict liability and fault-based negligence liability. For comparison purposes, liability risk-sharing regimes for other activities that may (at times) be categorized as "ultrahazardous" and for catastrophic events are also included in this chapter. These other activities and risk-sharing regimes are: commercial nuclear power generation; chemical industry pollution; Federal Aviation Administration war risk insurance; and U.S. Department of Defense Civil Reserve Air Fleet. Risk management for natural disasters and catastrophes such as hurricanes, earthquakes, tornadoes, and floods is also discussed.

5.1 Introduction

As discussed in Section 1.1, Congress directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 3 of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act) states, "*examine the appropriateness of deeming all space transportation activities to be 'ultrahazardous activities' for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous activities or not*." This chapter presents the results of an evaluation and analysis of defining space transportation activities as ultrahazardous. This section also discusses how the various tort rules complement the goals of victim compensation and adherence to a duty of care by an operator under domestic tort law. A description of other ultrahazardous activities and their respective risk-sharing and liability regimes is also presented for comparison purposes and to provide a context for assessing commercial space launch risk and how it is managed without declaration of a federal standard of liability.

5.2 Legal Analysis of "Ultrahazardous Activities"

Under the modern tort system of civil law, negligence is the standard basis for finding liability—the person whose fault caused the damage is typically the responsible party. However, under certain circumstances, either by application of common law, applicable legal precedent, or by statute, other rules may sometimes be used. "Ultrahazardous activities" is a legal term for certain activities for which strict liability, or liability regardless of fault, may be applied. Regardless of which liability regime applies, one major goal of the tort system is to shift the costs of negligent or wrongful activity from victims to tortfeasors (wrongdoers). Differences among regimes often alter burdens of proof and procedural requirements so as to more efficiently compensate tort victims. The following section briefly describes strict liability and ultrahazardous activities within the larger field of tort liability.

5.2.1 Strict Liability

The concept of strict liability originated in English common law and has been adopted in one form or another by most common law systems, including those in the United States. Tort cases, with very few exceptions, are determined under state law.

The seminal case for the imposition of a strict liability standard is *Rylands v. Fletcher*,[1] which involved an impoundment dam whose waters unexpectedly broke through an abandoned mine shaft and flooded a nearby operating mine. The court found that the pond construction was “unnatural” and that, by intervening in the flow of the water, the pond owners were liable for the consequences of the water’s escape.

Over time, a more useful rationale for strict liability apart from issues of “naturalness” evolved. Some courts found when one party performing an act for profit injures another uninvolved party, even when the activity is necessary and the actor takes precautions to prevent harm, it seemed reasonable that, among the two, the first actor should be responsible. A classic example is heavy construction operations in a residential neighborhood. In effect, by being made to indemnify others who may incur damages, the company undertaking the enterprise incorporates such expenses into its cost of doing business, either by self-insuring (by risking its assets) or by purchasing insurance. Strict liability for defective manufacture has evolved from this rationale into modern products liability law, which can apply to everything from ladders to baby toys.

Early courts also recognized that some dangerous activities were, from a societal standpoint, worth the risk; however, before strict liability became more widely available, plaintiffs sometimes had little recourse. In an 1873 case involving a boiler explosion, the courts stated, “we must have factories, machinery, dams, canals, and railroads. They are demanded by the manifold wants of mankind, and lay at the basis of all our civilization” (Jones 1992a).[2] In this case, the burden remained where it fell; the plaintiff was denied recovery.

Some analysts have argued that the application of strict liability may help influence more “economically efficient” and accordingly safe, responsible behavior. A leading proponent of the economic theory of law, Judge Richard Posner, set out in his opinion in *Indiana Harbor Belt R.R. v. American Cyanamid Co*.[3], to show why, in certain instances, strict liability may provide economically superior results.

> By making the actor strictly liable…we give him an incentive, missing in a negligence regime, to experiment with methods of preventing accidents that involve not greater exertions of care, assumed to be futile, but instead relocating, changing, or reducing (perhaps to the vanishing point) the activity giving rise to the accident...[t]he greater the risk of an accident and the costs of an accident if one occurs, the more we want the actor to consider the possibility of making accident-reducing activity changes; the stronger, therefore, is the case for strict liability (Jones 1992b).[4]

Applying the strict liability regime in certain circumstances would, in other words, require the potential defendant to determine: “(1) whether to proceed at all; (2) if so, at what level of output; and (3) in what manner, including place and mode of operation and extent of precautions” (Jones 1992c). Strict liability

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[1] L.R. 3 H.L. 330 (1868).
[2] Losee v. Buchanan, 51 N.Y. 476 (1873).
[3] 916 F. 2d 1174 97th Cir. 1990.
[4] 916 F. 2d 1174, 1177.

doctrine could, in other words, operate as a "patch" where the broader fabric of negligence theory failed to achieve the correct outcome.

The "strict liability" standard is less strict than that of absolute liability, although the two terms are frequently used interchangeably. Under the regime of strict liability, there may be several affirmative defenses a defendant may offer which may mitigate or even excuse liability. For example, if a plaintiff knowingly assumes the risk, either as a participant in the dangerous activity, or as an uninvolved party who deliberately moves into harm's way, the defendant may escape liability (Jones 1992d).

The Federal Tort Claims Act, codified at 28 U.S.C. Sections 2671-2680, prohibits the application of strict liability against the government, regardless of whether such liability is part of the substantive law of the forum state. In effect, under the Federal Tort Claims Act, the United States can be sued only for negligence for injuries resulting from its actions or under circumstances where it directly controls contractors' activities or is substantially involved in the activity.[5]

5.2.2 Legal Definition of "Ultrahazardous Activities"

The definitions of "ultrahazardous" and "abnormally dangerous" are similar, but have important differences. "Ultrahazardous" activities are generally defined as those with a risk of serious harm, which cannot be eliminated by exercise of the utmost care. "Abnormally dangerous" activities can also be subject to strict liability, even though they could possibly be made safe. As technology has evolved and the science of risk analysis has come into being, the distinctions have been blurred, but the following test factors for identifying abnormally dangerous activities are useful. Activities are "abnormally dangerous" when there is:

- existence of a high degree or risk of some harm to the person, land, or chattels (personal property) of others;
- likelihood that the harm that results from it will be great;
- inability to eliminate the risk by the exercise of reasonable care;
- extent to which the activity is not a matter of common usage;
- inappropriateness of the activity to the place where it is carried on; and
- extent to which its value to the community is outweighed by its dangerous attributes (Restatement on Torts, 2d).

The analysis of the above factors is done on a case-by-case basis.[6] Strict liability under the theory of ultrahazardous activity is typically applied to explosives manufacturers, transporters of dangerous chemicals, and producers of nuclear energy.

Strict liability has been applied in cases involving rocket engine testing on the ground. In *Smith v. Lockheed Propulsion Co.*,[7] the wells of landowners became muddied as a result of vibrations from ground testing of rockets. The court imposed strict liability, noting the unusually large size of the engines used.

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[5] United States v. Orleans, 425, U.S. 807, 814-15 (1976).
[6] Examining the propriety of strict liability for space launches may focus on these primary factors.
[7] 56 Cal. Rptr. 128 (Ct. App. 1967).

The court also noted that the large exclusion area required by the defendant for testing indicated it knew some risk existed despite the exercise of due care.

Strict liability can sometimes be applied without resorting to defining the activity as ultrahazardous. Strict liability for rocket testing has been applied under the doctrine of "nuisance." Legally, "nuisance" is defined as a wrongful action that infringes on the use or enjoyment of property without physically damaging or intruding upon the property. Activities giving rise to a nuisance may themselves be legal. Examples of nuisance actions include loud guitar playing at night, smells from cattle operations, or noise from industrial operations. In *Berg v. Reaction Motors Div*.,[8] the court held that strict liability was appropriate under a nuisance theory as applied against a government contractor who had been test-firing rocket engines. Notably, the plaintiffs did not assert claims against the government, and the defendant was not allowed to claim sovereign immunity as an agent of the government.

5.2.3 Fault-Based Liability

In tort law, the general rule of liability is fault-based; that is, negligence must be proved. Three elements are usually required to sustain a finding of negligence:

- a legal duty to a standard of due care;
- a breach of that duty; and
- legal causation of harm resulting from the breach (Kreindler 1998).

The standard of proof for negligence is "preponderance of the evidence," that is, the defendant is presumed to not have been negligent until the plaintiff proves he is more likely negligent than not. A test put forward by Judge Learned Hand in *United States v. Carroll Towing Co*.,[9] further refined the concept of fault and defined liability as a function of three variables:

- the probability that the accident will occur;
- the gravity of the injury which will be suffered if the accident does occur; and
- the burden of precautions adequate to prevent such accidents.

Put another way, if the cost of taking precautions is less than the cost of the accident (discounted by the probability of the event occurring), and the accident occurs anyway, then the defendant is held to be negligent (Calabresi and Hirschoff 1972). The Hand test is useful in placing negligence in an economic framework, although, in some cases, the lack of information (such as an imperfect understanding of risk) hampers its usefulness.

As the law of negligence has evolved, several modifying doctrines have been developed to help address some of the problems inherent in proving negligence, including contributory negligence, comparative negligence, and the doctrine of *res ipsa loquitur* (literally, "the thing speaks for itself").

The doctrine of *res ipsa loquitur* shifts the burden of proof to the defendant, and can be particularly useful in situations where it may be difficult or impossible for the plaintiff to prove fault, as when vital evidence

[8] 37 N.J. 396, 181 A2d 487 (1962).
[9] 159 F.2d 169 (2d Cir. 1947).

is destroyed in the incident giving rise to the claim. If the defendant loses unless he can show he was not negligent, it becomes much easier for the plaintiff to obtain a judgment. Application of the *res ipsa loquitur* doctrine varies from state to state. Where it is applied, three conditions usually must apply:

- the accident is of a kind that does not normally occur absent negligence;
- the instrumentality that caused the accident was under the exclusive control of the person charged with the negligence; and
- the injury suffered must not have been due to any voluntary act on the part of the plaintiff.

The practical effect of *res ipsa loquitur* application and the operation of other doctrines is that the plaintiff's burden of proof becomes very similar to that required for strict liability; therefore, the compensatory result is achieved in the absence of a strict liability regime.

Res ipsa loquitur is frequently applied when the circumstances of the accident are such that evidence is difficult to obtain—such as in cases involving explosions, fires, or similar events. One court has indicated that plaintiffs may be able to recover in tort under negligence principles where damages on the ground resulted from rocket testing,[10] although it did not reach the issue of whether *res ipsa loquitur* applied to shift the burden of proof.

Other doctrines have evolved regarding proof of fault, defenses and damages, such as contributory negligence. As originally espoused, if a plaintiff himself behaved negligently and, by doing so, contributed to the accident, his negligence would bar recovery from the defendant (Calabresi and Hirschoff 1972). Some jurisdictions have modified contributory negligence into the variant of comparative negligence, where the levels of negligence of both plaintiff and defendant are examined and damages assessed proportionally. A related doctrine in some jurisdictions is that of "last clear chance," which prevents or limits recovery when a plaintiff, by exercising reasonable care, could have avoided or mitigated the accident.

5.2.4 Potential Effects of Changes to the Current Liability Regime

Because the history of claims and lawsuits involving space launches is so limited, it is difficult to state whether changing the current regime, perhaps establishing a uniform claims process at the federal level, would be appropriate. As discussed earlier, the current liability regimes of strict liability and negligence are opposite ends of a spectrum, and different rules, exceptions, and doctrines operate to move appropriate outcomes along that spectrum. That said, both offer compelling features by comparison. Commercial space launches arguably possess most, if not all, of the Second Restatement on Torts factors for ultrahazardous activities. On the other hand, negligence with application of *res ipsa loquitur* also offers relative ease in adjudication—a rocket engine crashing into a residential area does, in a very powerful way, speak for itself.

In practice, the outcome may be the same regardless of which regime applies. Take an example where a plaintiff knowingly sails a watercraft into a launch exclusion zone and is injured. In a forum jurisdiction that applies strict liability with an affirmative defense of assumption of the risk, the defendant would likely prevail if he could show the plaintiff knew or should have known about the exclusion zone. Under a negligence regime with an affirmative defense of contributory negligence, the deliberate placement in harm's way would again excuse the defendant. Another example could be a case where a rocket crashes

[10] *Pigot v. Boeing Co.,* 240 So. 2d 63 (Miss. 1971).

into a resident's backyard, causing damages. Under a strict liability regime, the existence of damages is sufficient to impose liability on the launcher. Under a negligence regime with *res ipsa loquitur*, the plaintiff would again win because the burden of proof would be on the defendant.

Changes in the overall regime would shift the burden of proof, but it is unclear whether any real change in ultimate outcome, that is, compensation of innocent victims, would provide more certainty, stability, or protection for either potential defendants (the commercial space launch industry) or plaintiffs, the innocent injured victims (the general public). As a practical matter, most lawsuits are settled out of court, and, in a case that would likely involve the government as well as large corporations, there would be strong incentives from a societal and political standpoint to quickly settle cases and compensate victims, thus avoiding protracted legal battles. Chapter 7 discusses the experiences of the airline industry in dealing with liability, and, despite the liability regime in place, one trend is obvious—the plaintiff on the ground nearly always recovers. Applying that analogy to commercial space launches, it could be argued that the outcome of cases involving liability will likely be the same regardless of which regime applies. However, there may be costs associated with imposition of a federal legal standard, such as litigation costs or higher insurance costs due to perception of greater risk of hazard or liability.

As an additional matter, the difficulty of actually imposing a uniform liability regime for commercial space launch liability to third persons may be outweighed by the rarity of claims. Some analysts have recommended the establishment of a uniform liability regime for commercial space launches; many of the same arguments for uniformity have been made in regard to the airline industry. In 1970, Senator Tydings introduced an amendment to confer federal jurisdiction on airline claims and to provide for common rules "based on the principles of common law as they may be interpreted by the courts of the United States in the light of reason and experience" (Lowenfeld 1989).[11] The measure failed, and although the legislation failed for a number of reasons it might be inferred that if Congress did not think it necessary to impose such a regime on the airline business, it might also not impose such a regime on the space launch industry.

5.3 Liability and Risk-Sharing Regimes for Other "Ultrahazardous Activities" and "Catastrophic Events"

The discussion presented in the previous sections cover the legal definition of "ultrahazardous activities" and its ramifications to the commercial space launch industry. In the following sections, the liability risk-sharing regimes for other abnormally (or unusually) hazardous activities are discussed. The discussion focuses on those organizations and industries that have similar characteristics to U.S. commercial launch capability, i.e., importance to national defense or security, viability of industry and importance to the U.S. economy. These include government space launch activities (National Defense Contract Authorization Act, Public Law 85-804), nuclear industry (Price Anderson Act), chemical and processing industry (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), War Risk Insurance (49 U.S.C 443), Civil Reserve Air Fleet (10 U.S.C 931), and coverage for natural disasters and catastrophes (Stafford Act, Public Law 93-288).

5.3.1 Government Space Launch Activities Liability and Risk-Sharing

Government space launch activities are, at times, considered part of national defense activities. When conducted for national defense purposes, contractor liability resulting from government launch activities may be covered under Public Law 85-804. Congress enacted Public Law 85-804 (50 U.S.C. 1431-1435)

[11] S. 3305, 90th Cong., 2d Sess. §1112(a)(1968).

on August 28, 1958, giving the President authority to exercise actions for the protection of the government in matters related to national defense. The President issued Executive Order 10789 on November 14, 1958, authorizing agencies of the government to exercise certain contracting authority in connection with national defense functions and prescribing regulations governing the exercise of such authority. Public Law 85-804 and the Executive Order authorized the U.S. Department of Defense (DOD) to enter into contracts and contract amendments or modifications and to make advance payment, "without regard to the provisions of the law relating to the making, performance, amendment, or modification of contracts, whenever, in the judgment of the Secretary of Defense, Secretary of Army, Secretary of Navy, or Secretary of Air Force, or duly authorized representative of any such Secretary, the national defense will be facilitated." Under the provisions of Public Law 85-804 and the Executive Order, the U.S. Government will hold harmless and indemnify the contractor against any claims or losses. The risks for which indemnification is sought must be directly related to the contracts and defined as "unusually hazardous or nuclear in nature." The need for indemnification arose primarily with the advent of nuclear power and the use of highly volatile fuels in missile programs. The U.S. Government and industry were concerned about the possibility of enormous damage suits for uninsurable risks and risks for which insurance coverage was limited. In essence, Public Law 85-804 authorizes indemnification of a government contractor in its performance of unusually hazardous activities in advance of appropriations, but without running afoul of the Anti-Deficiency Act.

According to the Executive Order, in deciding whether to approve the use of an indemnification provision and in determining the amount of financial protection to be provided and maintained by the indemnified contractor, the appropriate official should take into account such factors as the availability, costs, and terms of insurance (private, self-insurance, or other proof of financial responsibility and workman's compensation insurance). The indemnification provision of Public Law 85-804 must apply to claims (including reasonable expenses of litigation and settlement) and losses, not compensated by insurance, of the following types:

- Claims by third persons, including employees of the contractor, for death; injury; or loss of, damage to, or loss of use of property
- Loss of, damage to, or loss of use of property of the contractor
- Loss of, damage to, or loss of use of property of the government
- Claims arising (1) from indemnification agreements between the contractor and a subcontractor or subcontractors, or (2) from such arrangements and further indemnification arrangements between subcontractors at any tier, provided that all such arrangements were entered into pursuant to regulations prescribed or approved by the Secretaries of Defense, the Army, the Navy, or the Air Force

When the claim, loss, or damage is caused by willful misconduct or lack of good faith on the part of the contractor's principal official, the contractor would not be indemnified for:

- Government claims against the contractor (other than those arising through subrogation)
- Loss or damage affecting the contractor's property

Executive Order 10789 has been amended a number of times since 1958[12] to further clarify the provisions of Public Law 85-804 and extend the authorization to utilize its provisions to the heads of the following agencies:

- Department of Treasury
- Department of Interior
- Department of Agriculture
- Department of Commerce
- Department of Transportation
- Atomic Energy Commission (now Nuclear Regulatory Commission and Department of Energy)
- General Services Administration
- National Aeronautics and Space Administration
- Tennessee Valley Authority
- Government Printing Office
- Federal Emergency Management Agency

Indemnification under Public Law 85-804 is now part of the contractual provisions of the Federal Acquisition Regulations System (FARS), allowing the heads or representatives of authorized government agencies to approve the contractor's indemnification clause under "Extraordinary Contractual Actions." The standard for use of indemnification under Public Law 85-804 is when the risk arises from an activity that is unusually hazardous or nuclear in nature, with risk of loss so potentially great that the contractor's financial and productive capabilities would be severely impaired or disrupted. Requests for such indemnification "shall focus on those risks for which insurance is not available at a reasonable cost or for which indemnification is necessary to further programmatic purposes."

FARS regulations (FARS 50.403-2[13]) emphasize that, prior to recommending indemnification, the contracting officer must ascertain that the contractor is maintaining financial protection in the form of liability insurance in amounts considered prudent in the ordinary course of business within the industry. The agencies may choose to indemnify the contractor only against losses in excess of an identified dollar amount. Facts considered in determining the contractor's indemnification request include (Air Force FARS 5350.403-2[14]):

- The nature of the risk for which indemnification is being requested

[12] Executive Order 11051 of September 27, 1962; Executive Order 11382 of November 28, 1967; Executive Order 11610 of July 22, 1971; and Executive Order 12148 of July 20, 1979.

[13] Federal Acquisition Regulation System Part 50 Available at http://farsite.hill.af.mil/reghtml/regs/far2afmcfars/fardfars/far/50.htm.

[14] Air Force FARS, Available at: http://farsite.hill.af.mil/reghtml/regs/far2afmcfars/af_afmc/affars/5350.htm.

- The specific definition of the unusually hazardous risk to which the contractor is exposed in performing the contract

- The time frame of the indemnification

- The programmatic objectives for providing the indemnification requested, such as assuring competition, avoiding prohibitive insurance costs, assuring protection of contractors from catastrophic loss where, for security reasons, adequate information about activities cannot be disclosed to establish insurance coverage

- The degree to which the indemnification provided serves the identified programmatic purposes

The indemnification provision of the Act has been approved for a range of contractor activities including space launch activities, Anthrax vaccine development,[15] and nuclear contamination cleanup.[16]

The Air Force practice is to grant indemnification under the Act when a contractor is exposed to risks that are unusually hazardous or nuclear in nature. The determination of what constitutes unusually hazardous or nuclear risks requires a reasoned judgment based on the facts and circumstances of each use. The Air Force has created a guidance document to assist the acquisition community in preparing and reviewing indemnification requests.[17] The guide emphasizes that the risks must result directly from the performance of activities under the particular contract. It must be shown that the activity is "unusually hazardous" as distinguished from "hazardous." For example, the manufacturing, storing, loading, or burning of jet aircraft fuel is hazardous—there is a possibility for explosion resulting in death and property damage. By contrast, the manufacturing, casting, storing, or burning of solid rocket propellants used in space launch vehicles is unusually hazardous—solid propellants are highly volatile and their explosive potential several times greater than jet fuel. While adequate insurance against the risks associated with the jet aircraft fuel is available at reasonable cost, the availability of insurance against the risks associated with solid propellants is limited and significantly more costly. The indemnification guide emphasizes early identification of the need for indemnification—as early as the acquisition planning phase, especially, in contracts for which indemnification has historically been granted (i.e., space launch activities). The Air Force routinely uses the indemnification provision of Public Law 85-804 to indemnify its contractors from potential launch accidents. In addition to the unusually hazardous nature of space launch activities, the contracting officer can grant the indemnification clause in the contract for situations where, because of national security, no launch/payload information could be disclosed to acquire the needed insurance at reasonable cost.

The National Aeronautics and Space Administration (NASA) used Public Law 85-804 in the past to provide indemnification to its contractors for national defense launch activities. In the past, space vehicles were generally developed to serve national defense purposes, and indemnification was available under Public Law 85-804. Public Law 85-804 allowed NASA to indemnify contractors when such an action facilitates the national defense. Under NASA FARS 1850, "Extraordinary Contractual Action," the contractor can request indemnification for unusually hazardous or nuclear risk activities (protection under Public Law 85-804). For the request to be granted, it must be related to national defense, and the contractor must provide evidence of sufficient insurance coverage and information required to establish

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[15] Army Memorandum of Decision to Indemnify, "Authority under Public Law 85-804 to Include an Indemnification Clause in Contract DAM17-91-C1086 with Michigan Biologic Product Institute," Secretary of the Army, Washington, D.C., September 3, 1998.

[16] "Department of Energy Amendment No. 2 to Delegation Order No. 0204-98 to the Assistant Secretary, Management and Administration," D. P. Hodel, Secretary of Energy, December 12, 1984.

[17] "Air Force Indemnification Guide for Unusually Hazardous or Nuclear Risk," Revision A, SAF/AQCS, Air Force Pentagon, Washington D.C., April 1, 1998. Available at http://www.safaq.hq.af.mil/contracting/toolkit/part50/rev-a.doc.

the need under FARS 50.403. (Note: the elements in FARS 50.403 appear in 5350.403 [Air Force FARS], as well).

When the purpose of the contract is to demonstrate technologies needed to lower purely commercial risk and lead to a commercial vehicle designed to meet the needs of the commercial marketplace, a national defense link cannot be used; however, other payment authority may apply.

NASA's "risk sharing" mechanism for expendable launch vehicle (ELV) launch services recognizes the contractual right of ELV contractors to submit meritorious claims for compensation to third-parties, but only after contractor-purchased insurance against such third party claims has been exhausted. The authority for this mechanism is Section 203 (c)(13) of the Space Act (42 U.S.C. Section 2473(c)(13)), which authorizes NASA:

> *(A) to consider, ascertain, adjust, determine, settle, and pay, on behalf of the United States, in full satisfaction thereof, any claim for $25,000 or less against the United States for bodily injury, death, or damage to or loss of real or personal property resulting from the conduct of the Administration's functions as specified in subsection (a) of this section, where such claim is presented to the Administration in writing within two years after the accident or incident out of which the claim arises; and*
>
> *(B) if the Administration considers that a claim in excess of $25,000 is meritorious and would otherwise be covered by this paragraph, to report the facts and circumstances."*

Subparagraph (B) was amplified by the Supplemental Appropriations Act of 1978, Public Law No. 95-240, Section 201, 92 Stat. 107, 116-7 (March 7, 1978), authorizing access to the permanent indefinite appropriation for the payment of judgments established under 31 U.S.C. Section 1304. The General Accounting Office Act of 1996, Public Law No. 104-316, Section 202(m), 110 Stat. 3826, 3843 (Oct. 19, 1996), further amended 31 U.S.C. Section 1304, so that claims under subparagraph (B) are now submitted to the Secretary of the Treasury for certification.

Acting under this authority, NASA's procurement contracts with its ELV contractors include clauses instituting a risk-sharing arrangement somewhat analogous to that provided by the FAA to licensed commercial launch firms under the Commercial Space Launch Act of 1988. If no Maximum Probable Loss determination is made for the NASA launch, the amount of the required insurance shall be the maximum amount available in the commercial marketplace at reasonable cost, but shall not exceed $500 million for each launch. For third party claims exceeding, in the aggregate, this amount – to a limit of $1.5 billion – ELV contractors could submit claims to NASA pursuant to Section 203(c)(13) above, and NASA would submit such claims to the Department of the Treasury for payment from the permanent indefinite appropriation for the payment of judgments against the United States, also known as the Judgment Fund.[18]

For users[19] of a space vehicle, such as the STS, popularly referred to as the Shuttle, NASA has a limited authority to provide indemnification under the National Aeronautics and Space Act of 1958, as amended, hereinafter called the Space Act. Under Section 308 of the Space Act, the agency can indemnify a user of a space vehicle for third-party liability in excess of an accepted amount of insurance coverage that must

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[18] If for any reason the claims submitted to the Treasury Department were not certified for payment, this would result in an alternate means for an ELV contractor to seek compensation: an action under the Disputes clause of the ELV contract that could be filed before the Armed Services Board of Contract Appeals or the U.S. Court of Federal Claims.

[19] "User" is defined in the Space Act as anyone who enters into agreement with NASA for use of all or a portion of a space vehicle, who owns and provides property to be flown in a space vehicle, or who employs a person to be flown in a space vehicle.

be obtained by the user. The amount of insurance that the agency requires users to obtain is indicated in NASA Procedures Guidelines 1050.1, "Space Act Agreement," as the maximum amount (not more than $500 million) of liability coverage available at a reasonable cost.[20] The process by which NASA, in its discretion, provides indemnification is based on an analysis, on a case-by-case basis of the inherent risks, available insurance and relationship of the activity to NASA's mission.[21] With the Shuttle Program, NASA has generally required users with the primary payloads to buy the full amount of the third-party liability insurance on the market. In addition, cross-waivers are always used where indemnification has been provided so that there is no risk of indemnifying against claims that have been waived. NASA limits its risk through rigorous program management and oversight of the Shuttle vehicle operation program.

5.3.2 Commercial Nuclear Power Industry Liability and Risk Sharing

The commercial nuclear power industry operates under a liability and risk-sharing regime created by the Price-Anderson Act. The Price-Anderson Act was first enacted into law as Section 170 of the Atomic Energy Act of 1954 on September 2, 1957 (NRC 2001). Its purpose was to protect private industry from the potentially huge liability that could arise from a severe nuclear accident and to assure the public that adequate funds would be available for liability claims if such an accident occurred. It is important to note that Congress believed that the nuclear industry might not develop without government indemnification.

Construction of the first completely commercial large-scale nuclear power plant, Dresden 1, coincidentally commenced in 1958 (ANL 2001). The original provision of the Price-Anderson Act established a U.S. Government indemnification of up to $500 million for each nuclear power plant per event that, in addition to the maximum available private insurance at that time of $60 million, constituted a maximum total of $560 million in liability coverage for any accident at a nuclear power plant (NRC 1998b). All liability to the public was limited to this sum. The coverage included all parties involved in the design, construction, operation, and maintenance of a nuclear power plant; and in fact, any other person who may be liable except in an act of war. The sponsors of this bill selected $500 million arbitrarily as a value that would not frighten Congress or the public and would override objections to limiting liability that had arisen. In 1957, the Atomic Energy Commission (AEC) commissioned a study, documented as *WASH-740*, which used probabilistic methods to analyze the consequences of a severe accident at a nuclear power plant (AEC 1957). For the most conservative accident scenario with an estimated likelihood of occurrence of one in a billion per year, this report estimated that total damages to persons and property would equal approximately $7 billion.

From the outset of the Price-Anderson Act, nuclear power plant licensees were required to maintain the maximum available insurance coverage (NRC 1998b). A 1975 amendment to the Price-Anderson Act, which extended it for 10 years, required licensees to create a self-funded secondary insurance pool (second tier)[22]. In the event of a nuclear accident, each licensee would pay for a pro-rated share of damages in excess of the primary insurance up to $5 million per nuclear reactor per incident in retrospective or "deferred premiums." This secondary layer of industry self-insurance reduced the government indemnification, since the total required remained at $560 million at this time. By 1982, with 80 licensed nuclear power plants and $160 million of primary insurance (first tier) available to each nuclear power plant, the government indemnity under Price-Anderson was replaced (80 × $5 million =

[20]NASA applies a "rule of reason" that examines relative cost, that is, the cost of insurance as compared to the "cost" of a mission. If insurance is too high relative to mission costs, then it is not a reasonable cost.

[21] "Statement of Edward A. Frankle, General Counsel of the National Aeronautic and Space Administration before the Subcommittee on Space and Aeronautics Committee on Science U.S. House of Representatives," October 30, 1997, available at: http://www.house.gov/science/frankle_10-30.htm.

[22] This insurance pool is supported by licensee obligations to pay a pro-rated share of damages in excess of the primary insurance amount up to a specified limit per reactor per incident.

$400 million + $160 million = $560 million). A follow-on probabilistic study commissioned by the AEC, known as *WASH-1400*, or the *Rasmussen Study*, which was published in 1975, concluded that a severe nuclear power accident could result in damages of about $14 billion, with a probability of 1 in a billion, per year of reactor operation (NRC 1975:Table5-4).

Another amendment to the Price-Anderson Act in 1988 increased the maximum secondary insurance assessment for each nuclear reactor to $63 million, payable in annual installments of $10 million and adjusted for inflation at five-year intervals. In addition, the maximum primary insurance available to each nuclear power plant increased to $200 million. With the number of operating nuclear power plants in 1988, this amendment increased the total available insurance, primary and secondary, for any nuclear power plant accident to $7.34 billion. The most recent inflation adjustment increased the individual secondary insurance per nuclear reactor to $83.9 million, thereby creating a maximum available primary and secondary insurance of $9.43 billion per incident (NRC 1998b).

In a 1998 report (NRC 1998b), the U.S. Nuclear Regulatory Commission (NRC) stated that, as the number of licensed U.S. commercial nuclear power plants decreases over the next two decades, the total available primary and secondary insurance may be conservatively expected to decrease to about $7.6 billion in 2008 and $4.5 billion in 2013, under the current requirements for secondary insurance pooling and the current available primary insurance. These insurance figures were based on conservatively low estimates for operating nuclear power plant license renewals past their current 40-year licenses. Based on the history of claims in the commercial nuclear power industry, the NRC believed that an insurance pool of $4.5 to $6 billion would be adequate. As discussed later in this section, recent developments regarding a growth in the number of nuclear power plant license renewals has caused the NRC to alter its view, in testimony to Congress, on the expected future amount in the insurance pool.

The 40-year claims history under the Price-Anderson Act from 1957 to 1997 shows that a total of $131 million in claims were paid, out of which $70 million was due to the Three Mile Island accident in 1979 (NRC 1998b). It is interesting to note that the maximum available primary insurance for nuclear power plants, $160 million at the time, was not affected by the Three Mile Island accident and later increased to $200 million in 1988, two years after the much more serious Chernobyl accident in the Soviet Union.

In a report to Congress (SECY-98-160) in July 1998 (NRC 1998a), the NRC recommended a 10-year extension to the Price-Anderson Act, raising the retrospective secondary insurance payment schedule from $10 to $20 million per year per nuclear plant in the event of an accident and investigating the potential for increasing the maximum primary insurance coverage, which has not followed inflation since 1988. Current reauthorization without significant change with a 10-year extension was recommended because it seemed too soon to predict the numbers of license renewals and other significant changes in the marketplace. The NRC anticipated that the additional 10 years was needed to ensure increased stability and predictability of coverage. This report also supported a ban on any punitive damages arising from a nuclear reactor accident subject to clarification from Congress. In addition, the NRC suggested clarification as to whether a nonprofit NRC licensee should be indemnified from legal costs associated with settlement of a claim and whether a claim can be filed in a tribal court.

Since the issuance of SECY-98-160, the NRC has rescinded its suggestion that the retrospective secondary insurance payment schedule be accelerated from $10 million per year to $20 million per year. The original basis for this recommendation was the NRC's perception that many nuclear power plants would be shutting down in the next decade and that the pool of licensees would be shrinking rapidly. Since then, however, the growth in license renewal applications has convinced the NRC that the number of nuclear power plants will not be shrinking as rapidly as previously projected. This growth in license renewal applications was motivated by the economics of continuing operation of existing nuclear power plants. The continuation of the Price-Anderson Act is a factor in these economic evaluations. A discussion of U.S. Government support of the commercial nuclear power industry is presented in Appendix E.

Currently, Congress is considering H.R. 2983, which would extend the Price-Anderson Act from 2002 to 2017, increase secondary insurance for each nuclear plant from $63 to $94 million, increase annual payment from this insurance obligation (i.e., requirement to pay a retrospective premium) from $10 to $15 million, and provide congressional consideration of means to provide payment for damages above the liability limit[23]. It should be noted that the secondary insurance is the licensee's obligation to pay should there be an accident exceeding the primary insurance capacity.

Some of the unique and noteworthy aspects of the Price-Anderson Act are outlined below (NRC 1998b).

- Claims for casualties and property damage, other than the licensee's nuclear power plant facility itself, are paid from this insurance regardless of who is to blame for the incident, including saboteurs (excepting acts of war) or reckless human actions, such as an inept pilot.

- The Price-Anderson Act covers both commercial and U.S. Government nuclear facilities, but under somewhat different provisions.

- Once licensed by the NRC, a nuclear facility is covered by the Price-Anderson Act for the length of its license (40 years for a nuclear power plant), plus any license renewals (20 years for a nuclear power plant), even if the Price-Anderson Act is not renewed by Congress.

- The Price-Anderson Act extension authorization lapsed from 1987 to 1988 without any effect on the commercial nuclear industry because no new commercial nuclear power plant licenses were issued during this time period.

- In the 45 years since its inception in 1957, the Price-Anderson Act has not cost the U.S. Government any money for commercial nuclear power claims.

- Prospective nuclear power plant licensees must meet specific financial assurance requirements, certain of which are related to the Price-Anderson Act, prior to being granted a license.

- A licensee is responsible for paying for its own facility cleanup and repairs, since this is not included in the Price-Anderson Act.

- Along with nuclear power plants, the Price-Anderson system currently covers the transport of fresh and spent nuclear fuel, but not uranium mining or milling facilities.

- The Price-Anderson Act, in the case of claims exceeding the total insurance available from the nuclear industry, includes a provision for Congress to "…provide full and prompt compensation to the public for all public liability claims resulting from a disaster of such magnitude," which is specified in 42 U.S.C. 2210 Section 170(e)(2).

[23] The sum of primary and secondary insurance capacity at any given time establishes the legal limit on liability.

5.3.3 Chemical Industry Environmental Liability and Risk Sharing

This section discusses the management of liability resulting from the handling of hazardous material, principally that associated with the chemical industry and cleanup of waste sites. Strict liability has been applied to a number of chemical and related industries under the theory of ultrahazardous liability, including natural gas storage and drilling (McLane v. Northwest Natural Gas Co.),[24] fumigation of buildings (Luthringer v. Moore),[25] blasting (Bedell v. Goulter),[26] and manufacturing using chlorine gas (Erbich Prods. Co. v. Wills),[27] although different jurisdictions have applied negligence theory to the same kinds of cases. The current trend in most jurisdictions regarding strict liability for ultrahazardous activities seems to be moving toward negligence theory (Boston 1999).

Broad liability for health and environmental impacts resulting from releases of hazardous substances is conferred by statute by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. Chapter 103), commonly known as CERCLA. CERCLA established the Superfund Program, which was employed to locate, investigate and clean up contaminated sites. Broad liability exists for parties responsible for response costs and natural resource damages resulting from the release or threatened release of hazardous substances into the environment, but there are some narrowly defined limitations, primarily for vessels and other non-stationary facilities, on the amount of liability that are set forth in CERCLA section 107(c). Some limitations on the amount of liability are in place for certain carriers of hazardous materials like pipelines and vessels, and the Oil Pollution Act (OPA) of 1990 (33 U.S.C. Chapter 26) similarly confers some limitations on tankers. In the case of CERCLA, these limitations do not apply if the release is the result of "willful misconduct," "willful negligence," or was a violation (with the operator's knowledge) of applicable safety, construction, or operating standards or regulations.[28] These liability limitations are narrow in scope in comparison to the broader liability conferred by CERCLA, under which there is broad, unlimited strict (and joint and several) liability for releases of hazardous substances, and OPA. CERCLA established a trust fund, paid for by environmental taxes, to ensure that cleanup and restoration activities could be initiated by the U.S. prior to obtaining cost recovery from responsible parties or in the event that no responsible parties were available or able pay. However, Superfund's authority to tax lapsed on December 31, 1995, and has not been renewed. Funding continues to come from three sources: cost recovery from responsible parties; investment income from existing funds; and appropriations from Congress. The Oil Spill Liability Trust Fund is similarly funded by a per-barrel tax on oil.

5.3.4 Federal Aviation Administration War Risk Insurance

Commercial airlines purchase war risk insurance to cover losses due to terrorism, acts of war, or other hostile acts at an annual cost of approximately 0.03 to 0.06 percent of the hull value of the aircraft (Donovan 1996). Most commercial insurance policies have a war risk exclusion clause and a separate war risk policy is purchased to fill this risk gap. The commercial insurers can cancel or charge relatively high surcharges for this war risk coverage for flights to high-risk areas, such as countries at war or on the verge of war. For instance, during the Persian Gulf War, commercial insurers raised the price of war risk insurance to approximately 0.25 percent of the value of the aircraft per mission (Donovan 1996). The war risk insurance program protects commercial air carriers from these types of eventualities and ensures adequate coverage.

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[24] 467 P.2d 635 (Ore. 1970).
[25] 190 P.2d 1(1948).
[26] 261 P.2d 842 (1953).
[27] 509 N.E. 2d 850 (Ind. Ct. App. 1987).
[28] CERCLA, 42 U.S.C. 9607, paragraph (c)(2).

The FAA may issue premium insurance, for which a risk-based premium is charged to the air carrier, and non-premium insurance. Premium war risk insurance requires a premium to be paid by the carrier for the coverage based on the risks involved. These premiums are typically higher than those carriers pay for peacetime war risk coverage (Donovan 1996).

Non-premium insurance requires a one-time registration fee, which in 1998 was changed from $200 to a fee of $575 based on the cumulative consumer price index, as described in 14 CFR 198.15. The non-premium insurance can be obtained provided the contracting federal agency has an indemnification agreement with DOT that ensures the FAA is reimbursed for any incurred loss or damage. Claims on the FAA's war risk insurance are paid from the Aviation Insurance Revolving Fund, into which registration fees and premiums are deposited. The Aviation Insurance Revolving Fund invests in U.S. Treasury securities, such that the Aviation Insurance Program is self-financed. Following the terrorist attacks of September 11, 2001, all Aviation Insurance Revolving Fund investments were redeemed so the funds would be available for various aviation insurance initiatives (FAA 2002).

Insurance was provided under this program in the early 1970s in the aftermath of attacks by Palestinian terrorists and also during the final days of the Vietnam War. More recently, it was employed during the Persian Gulf conflict. Since the inception of the program (including the predecessor Aviation War Risk Insurance Program dating back to 1951), only four claims ranging between $626 and $122,469 have been paid (FAA 2002).

The FAA is authorized to issue hull (1st party property) and liability insurance under the Aviation Insurance Program for air carrier operations where commercial insurance is not available on reasonable terms and the operation to be insured is necessary to carry out the U.S. Government's foreign policy. The Aviation Insurance Program is administered by the FAA under 49 U.S.C. Chapter 443, and the regulations are prescribed in 14 CFR 198. After the events of September 11, 2001, Congress passed Public Law 107-42, "Air Transport Safety and Stabilization Act," on September 22, 2001. Section 202 of this act authorizes the Secretary of Transportation to extend any provisions of Chapter 443 of Title 49 (i.e., war risk insurance) directly available to vendors, agents, and subcontractors of air carriers. The Secretary may extend or amend any such provisions within 180 days of enactment of this act, to ensure that the above entities are not responsible in cases of acts of terrorism for losses suffered by third parties that exceed the amount of their liability coverage.

The FAA normally insures only a small number of air carrier operations at any time. Airspace and airport capacity in areas where FAA insurance coverage would apply is usually very limited, so the FAA expects to be able to terminate insurance coverage and/or insured air carrier operations in high-risk areas after the loss of no more than two aircraft. The FAA usually establishes maximum liability for losing one insured aircraft at the limit of commercial insurance that applied to that aircraft before the FAA issued its insurance. This liability includes third-party losses. In many cases, the FAA's maximum liability for both hull loss and liability is $1.75 billion, but it is usually less (FAA 2002). Assuming a loss of not more than two aircraft per year, the range of possible cost exposure to the FAA in any year is assumed to be between $0 and $3.5 billion (FAA 2002).

Before such insurance can be issued, two tests must be satisfied. First, the Secretary of DOT must find that the airline cannot acquire the insurance from a domestic commercial insurance company on reasonable terms and conditions. Second, the President must find that the Nation's foreign policy or national security interests would be threatened if air service to the foreign country could not be continued because commercial insurance was unavailable. The war risk insurance may be provided for only 60 days unless the President determines that an extension is needed.

In the aftermath of September 11, 2001, and the requirements of the Air Transport Safety and Stabilization Act, FAA issued a new policy on insurance coverage offering to air carriers that carry passenger and/or cargo, third-party war risk liability coverage beyond $50 million per occurrence.[29] The insurance will cover third-party liability up to twice the pre-occurrence limit prior to September 11, 2001. This insurance will cost airlines $7.50 per departure and the policy will remain in effect[30] until May 19, 2002. FAA also is offering partial reimbursement to air carriers for their increase in war risk insurance premium for commercially purchased insurance policies.

Currently, the FAA maintains standby non-premium war risk insurance policies for 48 air carriers having approximately 1,050 aircraft available for DOD or State Department charter operations. The program has been reauthorized nine times and is now scheduled to expire on December 31, 2003 (FAA 2002).

5.3.5 Department of Defense Civil Reserve Air Fleet

In 1951, President Truman issued Executive Order 10219, *Defining Certain Responsibilities of Federal Agencies with Respect to Transportation and Storage*, directing that a plan be established for the use of the Nation's civilian airlines during a national emergency. The Civil Reserve Air Fleet (CRAF) Program was designed to provide DOD with access to commercial aircraft to augment military airlift during emergencies. The CRAF Program is managed under 10 U.S.C. Chapter 931 by the Air Mobility Command, a component of the U.S. Transportation Command, located at Scott Air Force Base, Illinois.

CRAF is composed of civil air carriers that voluntarily commit cargo and passenger aircraft to augment DOD's military airlift capability. A major benefit of the CRAF Program is that it provides up to half of the Nation's strategic airlift capability without the government having to purchase additional aircraft, pay personnel costs, or fly and maintain the aircraft during peacetime.

Currently, about 20 airlines have contracted with the Military Airlift Command to provide 674 aircraft for the CRAF Program (SA 2001). This constitutes over 50 percent of our Nation's airlift capacity in times of war. In return for agreeing to make their aircraft available during an emergency, DOD gives these airlines preference in selecting carriers for commercial peacetime flights. The value of the DOD contracts to the commercial carriers for the year 2000 was $656,618,974 (Renner 2001).

Airlines performing missions for DOD under CRAF are insured under the war risk program. DOD has an indemnity agreement with DOT whereby the FAA extends war risk insurance to airlines without a premium, with the understanding that any losses resulting from insurance claims will be reimbursed by DOD. This is necessary because many commercial insurance policies have a CRAF mission exclusion clause, such that commercial insurers can cancel war risk coverage upon activation of CRAF or charge unreasonably high surcharges for the coverage.

Until the Persian Gulf War, CRAF had never been used. During the war, 62 percent of passenger deployment, 84 percent of passenger redeployment, 27 percent of cargo deployment, and 40 percent of cargo redeployment missions were flown by CRAF carriers (Renner 2001). Activation during the Persian Gulf War did not necessitate calling up all the aircraft that had agreed to participate. If that had occurred, it probably would have caused many civilian flights to be cancelled. As it happened, a drop in civilian traffic meant that there were aircraft available for the limited CRAF that was needed.

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[29] "FAA APO Aviation Insurance Program web site," available at http://www.api.faa.gov/911Policies/InsCover.html.
[30] As of March 29, 2002 the termination date of this policy has been changed three times since its inception.

5.3.6 Natural Disasters and Catastrophes

Introduction

This section discusses the role of the Federal Government in providing assistance following natural disasters, including hurricanes, earthquakes, tornadoes, floods, and fires. Although no legal liability applies to such acts of God, this discussion illustrates how government risk-sharing mechanisms compensate victims under catastrophic circumstances. It has been estimated that any of these natural events, particularly a hurricane or earthquake, could result in damages in excess of $100 billion (Pielke, Simonpoetri, and Oxelson 1999); damages of approximately $40 billion have been experienced (e.g., the Northridge Earthquake of 1994 in Southern California). While the Federal Government will not assume full financial responsibility for damages that result from natural disasters, it does provide assistance to state and local governments and to individuals and businesses.

In 1988, the Federal Government enacted the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), Public Law 93-288 to support state and local governments when disasters occur. The Stafford Act identifies the type of assistance available during disaster relief to state and local governments and to individuals and businesses. Assistance can be provided to cope with the immediate aftermath of the disaster, including provision of temporary housing, food, transportation, health needs, and debris removal. In addition, disaster recovery assistance can be provided for the repair of damage to public, nonprofit, and private facilities.

The Stafford Act

The Stafford Act was enacted with the "intent…to provide an orderly and continuing means of assistance by the Federal Government to state and local governments in carrying out their responsibilities to alleviate the suffering and damage which result from such disasters." One of the six items specifically identified by the Stafford Act as a responsibility of the Federal Government in meeting the intent of the act is "providing federal assistance programs for both public and private losses sustained in disasters" (Stafford Act, Section 5121). Most recently, the Stafford Act has been amended through the implementation of the Disaster Mitigation Act of 2000.

The Stafford Act outlines the provisions for the President to declare a major disaster or an emergency upon a request by the governor(s) of the affected state(s). The request is made through the Federal Emergency Management Agency (FEMA) (FEMA 2001e). Federal involvement in disaster relief can occur only after the state has implemented its emergency plan and if the severity of the disaster is such that the magnitude of the response required is beyond the state and local capability. As part of the process, a preliminary damage assessment is performed to estimate the extent of the disaster and its impact on private and public facilities. This assessment is used by the President in his decision to declare the event a disaster or emergency and to determine the amount of federal assistance to be provided.

Disaster relief assistance is provided in the form of grants and loans and is available in the form of individual, public, and hazard mitigation assistance. Individual assistance is available to individuals, families, and business owners. Public assistance is available to public and nonprofit private entities for emergency service and repair of disaster-damaged facilities. Hazard mitigation assistance is provided to fund measures to reduce future losses to public and private property.

The Stafford Act specifies that the Federal Government is not to be the primary source of disaster funds. Both state and local government and private sources of funding are to be used first. Only when the state funding is determined to be inadequate is the President to declare the event a disaster. In recouping funds, private sources of funds (such as insurance, including flood insurance) are to be used first, and any federal funds expended on an emergency basis that duplicate these privately available funds are to be refunded to the Federal Government (Stafford Act, Section 5155).

Section 5193 of the Stafford Act identifies limitations on the amount of assistance that can be provided in an emergency or disaster. Total assistance is limited to $5 million, unless the President determines that it is necessary to exceed this limit because: (1) continued emergency assistance is required, (2) there is a continuing and immediate risk to life, and (3) necessary assistance will not otherwise be provided. In this event, the President must report to Congress on the extent of the continuing assistance required. It should be noted that the $5 million limit is regularly exceeded, and additional funding has been provided in response to several disasters over the last 10 years. (Information on the 10 costliest disasters, in terms of FEMA expenditures, is provided later in this section.)

Individual assistance can be made available for disaster relief in the form of grants, loans, and counseling services. Individual assistance is available to provide for temporary housing, individual and family grants, Small Business Administration disaster loans, disaster unemployment assistance, legal services, and crisis counseling.

Temporary housing assistance (Stafford Act, Section 5174) includes—in addition to the provision of temporary housing—home repair assistance, rental assistance, mortgage and rental assistance, lodging reimbursement, and referral to other housing programs. Home repair assistance provides funds to help repair a home to a habitable condition. Rental assistance provides funds to rent a home for the displaced household to live in. Mortgage and rental assistance provides funds to pay the rent or mortgage to prevent eviction or foreclosure, provided that the action is a direct result of hardships associated with the natural disaster.

Individual and family grants (IFG) are authorized by the Stafford Act (Section 5178) to provide funds for necessary disaster-related expenses and needs of disaster victims that cannot be met through insurance or other forms of disaster assistance. The maximum amount (indexed for inflation) of each grant per family was $13,900 in 2000. The IFG contribution by the Federal Government is specified to be 75 percent of the actual costs incurred. Recipients of IFG funds may not be required to apply for Small Business Administration disaster loans prior to receiving IFG funds.

The Small Business Administration can make loans to repair or replace homes, personal property, or businesses. The three types of these disaster loans are home disaster loans to homeowners and renters, business physical disaster loans, and economic injury disaster loans (to assist small businesses through the recovery period—essentially to cover lost income).

Disaster unemployment assistance under Section 5177 of the Stafford Act provides unemployment payments for any individual not eligible for benefits under normal unemployment insurance programs. The unemployment must be a direct result of the natural disaster, and funds can be made available for a period of up to 26 weeks.

Legal services are provided to disaster victims (Stafford Act, Section 5182) to assist in filing insurance claims, counseling on landlord/tenant problems, counseling on consumer protection issues, and replacement of important legal documents (including wills) lost in the disaster.

Section 5183 of the Stafford Act provides for crisis counseling for victims of a natural disaster. Counseling services can be provided for up to nine months after the disaster and can include crisis counseling, community outreach, and consultation and education services.

Public assistance can be used to fund the repair, restoration, reconstruction, or replacement of a public facility or infrastructure damaged or destroyed by a disaster (Stafford Act, Section 5172). Eligible applicants include state governments, political subdivisions of the state, and Native American tribes. Nonprofit private organizations that provide services similar to those provided by the government are also eligible for assistance. Eligible services include education, utility, emergency, medical, rehabilitation, and temporary or permanent custodial care. Assistance is available for projects that address:

- debris removal
- emergency protective measures
- road systems and bridges
- water control facilities
- public buildings and contents
- public utilities
- parks and recreation

Federal funding for approved projects must be at least 75 percent of the actual or estimated costs.

FEMA encourages and helps fund damage mitigation measures when repairing disaster-damaged structures. The mitigation measures are intended to reduce or eliminate long-term risk to people and property from natural hazards. Examples of mitigation measures include the elevation or relocation of chronically flood-damaged homes away from flood hazard areas; retrofitting buildings to make them resistant to earthquakes or strong winds; and adoption and enforcement of adequate codes and standards by federal, state, and local governments.

During the 1990s, FEMA spent more than $25.4 billion for declared disasters and emergencies. Of this total, more than $6.3 billion was provided in grants for temporary housing, home repairs, and other disaster-related needs for individual and families. States and local governments received $14.8 billion for cleanup and restoration projects (FEMA 1999). In 1997 alone, the outlay from the Disaster Relief Fund was over $4.6 billion (FEMA 2001a).

Table 5–1 lists the 10 costliest, in terms of FEMA funding, natural disasters in the United States. FEMA was not the only agency to provide assistance in each of these events. The total Federal Government relief assistance for the Red River Valley Flood amounted to approximately $2 billion (FEMA 1997). The total federal relief contribution for the Northridge Earthquake is estimated at over $12 billion. The majority of these funds, nearly $7 billion, were funds administered by FEMA. The next largest source ($4.1 billion) of federal funds was loans from the Small Business Administration. Additional funds were provided by the Department of Labor, the DOT, and the Department of Housing and Urban Development (FEMA 2001d). Similarly, the total costs associated with the other events were greater than the FEMA funds.

Federal funds offset only a fraction of the damage costs associated with disaster relief efforts. For example, the total damage estimates, according to FEMA, for the Northridge Earthquake were approximately $40 billion. Similarly, the total costs for two hurricanes, Andrew and Hugo, were $27 billion and $9 billion, respectively. The balance of these costs were paid for by insurance.

Table 5–1 Costliest Natural Disasters

Event	*Year*	*FEMA Funds*[1]	*SBA Loan Assistance*[2]
Northridge Earthquake	1994	$6.95 billion	$4.1 billion
Hurricane Georges	1998	$2.39 billion	$201.5 million
Hurricane Andrew	1992	$1.85 billion	$696 million
Hurricane Hugo	1989	$1.31 billion	$491 million
Midwest Floods	1993	$1.13 billion	$626 million
Hurricane Floyd	1999	$880 million	$441 million
Loma Prieta Earthquake	1989	$869 million	$584 million
Red River Valley Flood	1997	$725 million	$225.9 million
Hurricane Fran	1996	$630 million	$110 million
Tropical Storm Alberto	1994	$543 million	$210 million

FEMA = Federal Emergency Management Agency, SBA = Small Business Administration.
[1]All expenditures may not be in the year of the event (FEMA 2001b).
[2]All expenditures may not be in the year of the event (FEMA 2001c).
Events of September 11, 2001 are not included because they are not a natural disaster. Also, note that these costs are not limited to the disaster relief costs associated with each event. Costs include those associated with activities performed by the Federal Government in compliance with Section 5170 of the Stafford Act that include the use of federal resources (equipment, supplies, facilities, personnel, and other resources) for use by state and local governments; medicine, food, and other consumables; and work and services to save lives and protect property.

5.4 Comparison of U.S. Government Risk Sharing

A number of industries, which could be viewed as being engaged in "ultrahazardous activities," were evaluated in terms of whether the U.S. Government provides any risk-sharing liability regime as it does in the case of commercial space launches. A comparison of risk-sharing for these five other activities and commercial space transportation is presented in **Table 5–2**.

Table 5–2 Comparison of U.S. Government Risk-Sharing for Different Activities

Activity or Industry	*U.S. Government Indemnification*	*Risk-Sharing Liability Regime Tier(s)* *(Relevant Law or Regulation)*
Commercial space launches	Yes	3 tiers; USG assumes 2nd tier subject to appropriations of $1.5 billion [1988]; (CSLA of 1988 as amended)
Commercial nuclear power	Yes*	3 tiers; USG assumes 3rd tier subject to congressional decision of the means above the primary and secondary pooled insurance; (Price-Anderson Act of 1957 as amended)
Chemical industry (chemical pollution)	Yes	2 tiers; USG funds part of EPA Superfund beyond chemical industry trust fund environmental taxes; (CERCLA, OPA)
U.S. Government space launches	Yes	1 or 2 tiers for USAF (Public Law 85-804, as amended); 2 tiers for NASA (Public Law 85-568, as amended)
FAA war risk insurance	Yes	1 tier; FAA insures if no insurance reasonably available; (14 CFR 198)
DOD Civil Reserve Air Fleet	Yes	1 tier; FAA extends the war risk insurance without premium, but DOD would pay claims; (10 U.S.C. 931)

USG = U.S. Government; CSLA = Commercial Space Launch Act; EPA = U.S. Environmental Protection Agency; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; OPA = Oil Pollution Act; CFR = *Code of Federal Regulations*; FAA = Federal Aviation Administration; DOD = U.S. Department of Defense; USAF = U.S. Air Force; NASA = National Aeronautics and Space Administration.
*Congress would review and decide on means (sources of funds) to provide for payment of any damage over the limit of liability.

In addition to the activities delineated in Table 5–2, the U.S. Government has provided over $25 billion in disaster relief during the 1990s for natural catastrophes, in accordance with the Stafford Act. Table 5–2 shows that the U.S. Government has provided varying degrees of indemnification and risk sharing for high risk activities other than commercial space transportation successfully using such tools as insurance pooling, industry-specific taxes, and government insurance. However, in all such cases, the industry benefited from broad participation by many entities. The commercial launch industry is unable to adequately benefit from pooled risk, as in a Superfund scenario, because of the low number of participants. Suitability of alternatives, such as pooled insurance funds, is evaluated in Chapter 9 of this report.

5.5 Appropriate Legal Standard – Market Reaction to Legislative Declaration

As a general matter, costs of private insurance for hazardous activities tend to be more stable over time when the circumstances under which government intervention would occur are well known. Industries that share certain features, such as provision of essential services or products, or those with a high degree of government involvement either as a regulator or a participant in the activity, have made forceful arguments that, absent some kind of legislative protection, the desired activity could not be adequately covered by the private insurance market, or the added insurance costs would be prohibitive.

Generally, it is the view of government agencies that a legislative declaration that a risk is ultrahazardous and subject to a federal strict liability regime would raise premiums to alleviate underwriter perceptions of assumption of greater risk of claims and loss, and higher damage pay-outs. In essence, insurance for the same risk would cost more assuming it remains available. This industry insurance reaction to the terrorist attack of September 11, 2001 is discussed in Appendix F. Because victim compensation is generally achieved through the existing domestic legal regime, without a legislative declaration of the applicable liability standard or that activities are ultrahazardous, federal involvement in the form of legislating a strict liability legal standard would not further the societal goal of victim compensation but could impede cost efficiencies necessary to enhance and sustain national launch capability.

5.6 Summary

Some industries that pose possible risk to the public, such as nuclear power, have complex legislatively directed liability regimes; others (such as railroads) do not, so it appears that public risk by itself is not typically a measure by which liability regimes are imposed. Some commentors have suggested the commercial space launch industry needs a liability cap beyond which the responsible party would not be responsible, particularly in a strict liability situation. Absent such protection, they argue, the domestic industry may not be competitive in the international marketplace. However, the view among those in government charged with defending U.S. interests is that caps or limits on damages are avoided or circumvented more often than not and do not achieve their objective whether or not activities causing the damage are legislatively declared to be ultrahazardous or subject to a strict liability legal standard.

The need for and ramifications of tort reform generally are beyond the scope of this report. The ultimate goal of any tort liability regime is to compensate the victim when another's action causes injury. Given the status of the case law for high risk industries, as well as tort law generally, it seems likely that third-party victims of a commercial space launch-related accident will recover, no matter which regime applies—negligence or strict liability. In addition, the government would likely be a substantial participant in the launch or reentry activity and would have powerful incentives to quickly resolve victim compensation questions, including those arising under international law.

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Chapter 6

Effect of Outer Space Treaties on Government Launch Liability

Chapter 6
Effect of Outer Space Treaties on Government Launch Liability

Chapter 6 presents aspects of the two international treaties (Outer Space Treaty of 1967 and Liability Convention of 1972) most relevant to the U.S. commercial space transportation liability risk-sharing regime. This chapter evaluates the applicability and coverage of the U.S. liability risk-sharing regime as compared to the obligations established by the two treaties.

6.1 Introduction

As discussed in Section 1.1, Congress directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 4 of the Commercial Space Transportation Competitiveness Act of 2000, (also known as the Space Competitiveness Act) states, "*examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties.*" Presented in this chapter are those treaty provisions under which the government would be liable internationally as a launching State. The analysis follows in three parts. The first part examines treaty-based circumstances under which the government is liable for damage caused by a commercial space launch. The second part explains how the existing statutory licensing regime for commercial launches responds to cover government obligations under the treaties. A third part demonstrates the extent to which the statutory financial responsibility regime, as implemented by the Federal Aviation Administration (FAA) through its regulatory program, satisfies relevant U.S. treaty obligations.

6.2 United Nations Treaties on Outer Space

The United States is a party to four major multilateral treaties concerning outer space. Two of these treaties specifically address liability for space activities.

6.2.1 Outer Space Treaty of 1967

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") was opened for signature and entered into force in 1967 (18 U.S.T. 2410). It is the foundation agreement among its State Parties concerning the exploration and use of outer space. It establishes basic principles of responsibility and liability concerning use of outer space. In addition, it directs that State Parties to the treaty shall carry on activities in the use of outer space in accordance with international law (Outer Space Treaty, Article III).

Article VI of the Outer Space Treaty imposes "international responsibility" on a state party for the conduct of national activities carried on in outer space, whether those activities are performed by a government agency or a nongovernmental enterprise. It further provides that activities of nongovernmental entities in outer space require authorization and continuing supervision by the appropriate State Party to the treaty. The full text of the Outer Space Treaty, Article VI, follows:

> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.

Article VII of the Outer Space Treaty addresses liability specifically. It provides that:

> Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.

6.2.2 Liability Convention of 1972

The 1972 Convention on International Liability for Damage Caused by Space Objects, referred to herein as the "Liability Convention," addresses liability in more particular terms than does the Outer Space Treaty (24 U.S.T. 2389). It defines the specific circumstances in which a state bears absolute liability (i.e., virtually no defenses available) for certain damage and those in which a state is liable for damage based on a finding of fault, either of the state itself or of persons for whom the state is responsible. The Liability Convention is victim-oriented in that it provides a mechanism for injured parties to obtain compensation. It does not replace or supersede obligations assumed by states as parties to the Outer Space Treaty.

Under Article II of the Liability Convention, a launching State (as defined in the Liability Convention) is absolutely liable for damage occurring on the surface of the Earth or to aircraft in flight. The Liability Convention defines when a state qualifies as a launching State. Satisfying any one part of the definition qualifies a state as a launching State.

There are four bases upon which a state may qualify as a launching State. A launching State is defined in Article I of the Liability convention as:

- "A state which launches or procures the launching of a space object," or
- "A state from whose territory or facility a space object is launched."

The term "space object" is defined in Article I of the Liability Convention to include "component parts of a space object as well as its launch vehicle and parts thereof."

The Liability Convention defines whether liability is absolute or fault-based, depending upon the location where damage occurs. Absolute liability applies where the damage has occurred on the ground or to aircraft in airspace. Damage that occurs elsewhere, such as to spacecraft in orbit, would be subject to a fault-based standard, that is, fault of the launching State or of persons for whom it is responsible.

Because there are four bases for qualifying as a launching State, there may be more than one launching State for a particular launch. The Liability Convention addresses such situations by providing that "whenever two or more states jointly launch a space object, they shall be jointly and severally liable for any damage caused" (Liability Convention, Article V). States participating in a joint launching may conclude agreements regarding the apportioning among themselves of the financial obligation for which they are jointly and severally liable (Liability Convention, Article V).

6.3 Launch Licensing under the Commercial Space Launch Act of 1984

The extent of launch licensing jurisdiction granted to the U.S. Department of Transportation under the 1984 Commercial Space Launch Act (CSLA) is intended to implement certain obligations of the United States for launch activities arising under the Outer Space Treaty and the Liability Convention. As stated above, the United States is internationally responsible for the conduct of national activities in outer space, and activities of nongovernmental entities in outer space must be authorized and supervised by the appropriate State Party to the Outer Space Treaty.

The extent of FAA licensing jurisdiction granted by Congress acknowledges that the U.S. Government has certain responsibilities under treaty and international law when its citizens or nationals conduct launch operations outside of the United States. In those instances, Congress intended to extend personal jurisdiction through the CSLA over U.S. citizens operating abroad; therefore, they are required to obtain an FAA license. Thus, under the CSLA, a launch license is required for a U.S. citizen to launch a launch vehicle from anywhere in the world. An FAA launch license is also required for any person to launch a launch vehicle from the United States (49 U.S.C. 70104(a)). (Parallel licensing jurisdiction applies to reentry of a reusable launch vehicle.)

Additionally, a U.S.-citizen-controlled foreign entity must obtain an FAA license to launch a launch vehicle from a place that is both outside the United States and any foreign country's territory (e.g., a launch from the global commons, as illustrated by the Sea Launch technology), unless another foreign government, by agreement, exercises jurisdiction over the launch (49 U.S.C. 70104(a)). A U.S.-citizen-controlled foreign entity must also be licensed by the FAA if it is launching from a foreign country's territory and, by agreement with that foreign government, the U.S. Government will exercise jurisdiction over the launch (49 U.S.C. 70104(a)).

6.4 Comparative Assessment of Launch Licensing Jurisdiction and Treaty Requirements

To assist the United States in meeting its obligations under the relevant space treaties and to promote commercial uses of outer space, Congress enacted the CSLA and has provided for regulatory oversight through Department of Transportation, and therefore FAA, licensing. Liability under the Outer Space Treaty and the Liability Convention does not directly result from government licensing of commercial launches, however. The relevant treaties assign liability to a launching State in accordance with their terms.

In enacting the CSLA of 1984, Congress provided a breadth of licensing jurisdiction that promotes supervision of space launches where the United States is a launching State. The Senate Committee stated in its report accompanying passage of H.R. 3942, the legislation that became Public Law 98-575, known as the CSLA, that:

"The Committee believes that the licensing requirements, as prescribed in Section 6(a) with respect to any activities outside the United States, provide, to the greatest extent possible, licensing coverage that is consistent with international law and the international convention on liability. In establishing these requirements, the Committee gave serious consideration to the extent of U.S. jurisdiction and the extent of U.S. liability for launch-related activities pursuant to international law and international obligations. Section 7(a), therefore, is intended to ensure comprehensive coverage of the licensing regime to the fullest extent permitted. Accordingly, Section 6(a)(1) provides for U.S. jurisdiction over all activities in U.S. territory. In addition, with respect to activities of U.S. nationals and corporations, Section 6(a)(2) provides for U.S. jurisdiction over activities not only in U.S. territory but also on the high seas and in international airspace and foreign territory.

Finally, with respect to activities of foreign subsidiaries in which U.S. nationals have a controlling interest, Section 6(a)(3) would provide for U.S. jurisdiction over (and would require a license for) activities on the high seas or in international airspace" (S. Rep. 98-656, 98th Congress, 2nd Session, at 14 [1984]).

Accordingly, launch licensing under the CSLA implements certain U.S. obligations to authorize and supervise entities that provide launch services and for which the United States is responsible.

6.5 Applicability of CSLA Liability Risk-Sharing Regime to Licensed Launches

Financial responsibility requirements, codified in 14 CFR 440, accompany a launch license implementing the statutory liability risk-sharing regime of the CSLA. The CSLA does not extend the liability obligations of the U.S. Government under the treaties. Rather, satisfaction of CSLA-based requirements, as set forth in FAA licenses and regulations, assists the government in satisfying obligations assumed by the United States under the Outer Space Treaty and the Liability Convention by assuring that insurance covering the most probable loss to third parties is obtained and that the government is an additional insured under the policy.

The burdens and benefits of the statutory risk-sharing regime attach to an FAA-licensed launch wherever conducted by a U.S. entity. A licensee must demonstrate financial responsibility to cover the government's liability arising under the Outer Space Treaty, the Liability Convention, and international law, regardless of the location of the launch site. The statute also does not differentiate between licensed launches conducted within the United States by a U.S. citizen or foreign entity in terms of requiring financial responsibility for the launch. That is because, regardless of the citizenship of the launcher, the United States would be a launching State, among other things, when a launch takes place from U.S. territory or a U.S. facility and, therefore, may be liable under the terms of the Liability Convention, Article II. FAA licensing jurisdiction under the CSLA covers nonfederal launches from the United States and launches abroad by U.S. citizens. However, FAA licensing jurisdiction is inapplicable to—and the associated statutory liability risk-sharing regime does not cover liability considerations associated with—the launch of a satellite owned by a U.S. entity when it is launched by an operator that is not a U.S. citizen and the launch takes place outside of U.S. territory or facilities. For example, a Federal Communications Commission-licensed communications satellite launched from foreign territory by a foreign entity would not be subject to FAA licensing or to CSLA-based financial responsibility requirements.

The liability insurance obtained by the launch licensee covers its liability to third parties for damage, injury, or loss, as well as third-party liability of its customer, the U.S. Government, and the contractors and subcontractors of each of them. Liability of the government includes that arising out of treaty obligations, as previously described.[1] The amount of liability insurance is established based upon maximum probable loss (MPL), up to a statutory ceiling of $500 million or the maximum available on the world market at reasonable cost, whichever is less. Up to $1.5 billion (as adjusted for post-1988 inflation) beyond that amount may be appropriated by Congress to cover catastrophic claims against the covered entities. By regulation, financial responsibility for liability above the combined amount of insurance plus appropriated funds is borne by the launch operator unless it can show it has no liability whatsoever.

The United States is responsible and may be liable as a launching State for damage whether there exists a liability risk-sharing regime under 49 U.S.C. Chapter 701 or not. That is, regardless of the CSLA risk allocation scheme, the U.S. Government has obligated itself, by treaty, to accept international liability for ground damage and for damage to aircraft in flight. Similarly, the United States has agreed to be liable for damage occurring on orbit when it is a launching State and the damage is its fault or the fault of persons for whom it is responsible. The CSLA provides a means by which the government is insured and can financially cover certain of its treaty-based liability obligations, at no cost to the government, up to the amount of liability that it is most likely to bear in the event of an errant launch or reentry. The CSLA risk allocation scheme provides a mechanism whereby the government obtains the benefits of insurance, at no cost to the government.

Insurance provided by a launch licensee will cover the launch participants' liability as well as certain of the government's treaty obligations up to the amount prescribed by the FAA in a license, at no cost to the government. However, claims resulting from an errant launch may exceed the required amount of insurance and, ultimately, the government may have to satisfy the full amount of the liability under the terms of the relevant treaties, regardless of the CSLA.

The discussion below illustrates how the financial responsibility regime, as implemented by the FAA in regulations (14 CFR 440), would assist in satisfying U.S. Government liability obligations under the outer space treaties for commercial launches.

6.5.1 Absolute Liability as a Launching State

Assume damage occurs on the surface of the Earth outside of the United States as a result of an FAA-licensed launch and the United States is a launching State. Based upon the Liability Convention, Article II, the government's liability is absolute. Under the existing risk-sharing regime, the government's absolute liability is covered by statutory-based financial responsibility up to the amount of insurance determined by the FAA and obtained by the launch operator under the terms of its license. There is no cost to the government for the coverage. The government, which is absolutely liable for damage on the ground outside the United States, retains international responsibility for covering liability that is in excess of insurance.

With the existing liability risk-sharing regime in place, if a third-party claim is pursued against the launch participants,[2] the licensee's liability insurance would respond to cover the claim up to the MPL-based

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[1] 14 CFR 440.3(a)(8) defines "liability" to mean a legal obligation to pay claims for bodily injury or property damage resulting from licensed launch activities. The preamble explains that a legal obligation includes that accepted by the U.S. Government under treaty. Thus, liability insurance requirements of the current regime would cover treaty-based claims presented diplomatically against the United States as sole or co-launching State.

[2] The government also benefits from a launch or reentry licensee's insurance coverage where the government may be potentially liable as a result of its direct participation in licensed launch activities. Often the government is involved in launch operations as the range operator or provider of range safety services, such as activation of destructive flight termination systems. Failure of such services and systems to operate as intended may also result in third-party claims against the United States. Assuming those claims could succeed under the limitations of the Federal Tort Claims Act, an injured victim outside of the United States may pursue claims under domestic law. Because the U.S. Government is an additional insured under the licensee's liability coverage,

limit determined by the FAA. Then, under 49 U.S.C. 70113, the licensee would be eligible for indemnification of the excess claim, up to the statutory ceiling, under procedures of the CSLA. If the claim were pursued through diplomatic channels on behalf of the injured victim, the United States would be jointly and severally liable, along with any other launching State, for the full amount of the claim. The licensee's liability policy would cover the government's liability up to the MPL-based limit, at no cost to the government, because the government is an additional insured under the licensee's insurance as required by the CSLA. The government retains international responsibility for covering excess claims.

6.5.2 Fault-Based Liability as a Launching State for On-Orbit Damage

Liability insurance coverage dictated by the FAA under the current regime would cover fault-based on-orbit damage to other space objects that results directly from a licensed launch. The U.S. Government can be liable in such instances when it is a launching State. Under FAA regulations, insurance is required to remain in effect for 30 days after the later of vehicle ignition or payload separation for an orbital launch, as explained below. Thus, claims of this nature that may be presented to the United States when it is a launching State are also covered by CSLA-based financial responsibility provided by the launch licensee, at no cost to the government, in accordance with the terms of the launch license.

6.5.3 Extent of Insurance Coverage/Duration

By regulation, for orbital launches, the FAA requires launch liability insurance for a period of 30 days following payload separation (or attempted separation in the event of a separation anomaly) or ignition, whichever occurs last. Thirty days was determined by the FAA as the appropriate duration of required insurance through a combined time/event test. Based upon FAA analysis, the probability of a launch-related event causing damage is sufficiently low after 30 days from payload separation such that insurance under the CSLA would no longer be required. Indemnification may extend beyond the 30-day period if a clear causal nexus to a licensed launch is shown. Should a launch-related event occur at any time thereafter, indemnification may be available if "there is a clear causal nexus between the loss and the behavior of the launch or reentry vehicle" (H. Rpt. 105-347, 105th Congress, 1st Session, at 23 [1997]). According to the report issued by the House Committee on Science accompanying the Commercial Space Act of 1997, predecessor legislation to the subsequently enacted Commercial Space Act of 1998, "[o]nce a launch or a reentry is completed, no protection against third-party liability is intended to be provided under Chapter 701 [of 49 U.S.C. Subtitle IX] unless that nexus is shown." The report also states that, under the CSLA as enacted in 1984, it was intended that a "launch ends, as far as the launch vehicle's payload is concerned, once the launch vehicle places the payload in Earth orbit or in the planned trajectory in outer space." It should be noted, however, that treaty obligations and liability exposure of the U.S. Government, related to a launch, do not end with the initial 30-day period.

6.6 Summary

Under the Outer Space Treaty, Article VI, the United States is internationally responsible for activities of its nationals in outer space. Under the Liability Convention, the U.S. Government accepts liability, either absolute or fault-based, depending upon the location where damage occurs, when it is a launching state. The United States is a launching State under the terms of the Liability Convention when it is either "[a] state which launches or procures the launching of a space object", or "[a] state from whose territory

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as required by the CSLA and FAA regulations, its liability is covered up to the MPL limit, at no cost to the government or U.S. taxpayer.

or facility a space object is launched" (Liability Convention, Article I). Consistent with CSLA requirements, FAA financial responsibility regulations apply to all FAA-licensed launches, wherever they occur. Accordingly, under the existing liability risk-sharing regime of the CSLA, potential liability obligations of the United States under relevant space treaties are satisfied up to the MPL amount, at no cost to the government, with respect to FAA-licensed launches that take place from U.S. territory or facilities or are conducted by U.S. entities abroad.

6.7 References

United States Treaty, 1967, Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, January 27 (18 U.S.T. 2410, T.I.A.S. 6437).

United States Treaty, 1972, Convention on International Liability for Damage Caused by Space Objects, March 29 (24 U.S.T. 2389, T.I.A.S. 7762).

H. Rpt. 105-347, 105th Congress, 1st Session (1997), House Committee on Science, *The Commercial Space Act of 1997*, October 24.

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Chapter 7

Commercial Reusable Launch Vehicles and Airline Liability


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Chapter 7
Commercial Reusable Launch Vehicles and Airline Liability

Chapter 7 presents the current range of reusable launch vehicle (RLV) concepts along with the history, current status, and future of RLVs. RLV risk is compared to airline risk in terms of third-party hazards and risk mitigation aspects. The risk-sharing regime applicable to airline liability is compared to the current RLV liability risk-sharing regime to assess its suitability for RLVs.

7.1 Introduction

As discussed in Section 1.1, Congress has directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 5 of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act) directs the Department of Transportation to "*examine the appropriateness, as commercial Reusable Launch Vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime towards the approach of the airline liability regime*." This chapter presents an assessment and evaluation of reusable launch vehicle (RLV) technology and its potential liability treatment in a manner similar to that of airline liability. First, the status and progress of RLV development is examined, including a review of some RLV concepts. Second, this report examines whether and when an airline model for liability may be appropriate. The latter part of the analysis includes a review of the current airline liability regime, domestically and internationally.

7.2 Range of Reusable Launch Vehicle Technology Concepts

Today's RLV concepts illustrate a range of vehicle design, launch, refueling, and recovery methods. Concepts include vertical and horizontal takeoff, rocket, combined jet and rocket engine configurations, terrestrial and aerial fueling, and recovery systems that include conventional horizontal landings and vertical returns using protective cushioning systems to allow vehicles and stages to be reused. RLV technology could enhance the profitability of existing space markets and enable the growth of new space markets.

Seven commercial RLV concepts are identified in the Federal Aviation Administration's (FAA) January 2001 publication, *Reusable Launch Vehicles and Spaceports: Programs and Concepts for 2001*. To date, none of the RLVs identified in the FAA publication have flown. Of the seven, two developmental concepts have been terminated (Lockheed Martin's VentureStar and Rotary Rocket's Roton) and two more have almost no funding stream to continue development (Space Cruiser and Space Access) and must await additional financing. Three other competitors identified in the FAA report are Pioneer Rocketplane Corporation (Pioneer), which is developing the Pathfinder; Kelly Space and

Technology (Kelly), which is developing the Astroliner; and Kistler Aerospace Corporation (Kistler), which is developing the K-I. Of these three, Kistler and Kelly have an advertised reference payload weight to orbit—10,000 pounds (4,545 kilograms) to low Earth orbit (LEO)—that is attractive to a broad market base. If configured with an upper stage, Kistler and Kelly could host satellites planned for geosynchronous orbits. Both rely on robust, though dated, 1960s vintage Russian NK-33/43 engines as their primary propulsion source. Kistler was recently awarded $135 million for a flight demonstration by 2003 as part of the National Aeronautics and Space Administration's (NASA) Second-Generation RLV Program. All major expendable launch vehicle (ELV) companies, Boeing, Lockheed Martin and Orbital Sciences, will remain involved in reusable vehicle projects and technology development efforts, but to a limited extent. Although not discussed above, Boeing has been working with the Air Force on a reusable space maneuver vehicle, while Orbital Sciences was actively involved in NASA's X-34 project, now terminated. Lockheed Martin had been involved in X-33 under a cooperative agreement with NASA. NASA terminated both the X-33 and X-34 projects.

Kistler's K-1 is arguably the most developmentally advanced and well-funded RLV concept. It launches vertically, using a three-rocket-engine pod to power the first stage. Upon burnout, the first stage returns to Earth via parachutes and balloons to cushion its return and is refurbished for additional flights. The second stage is propelled to LEO using a single rocket engine where the payload is ejected. After a short duration in orbit, a reentry process is executed that brings the second stage back to the landing area using balloons and parachutes for touchdown. Kistler plans launch sites in Nevada and in Woomera, an Australian launch range. To launch from Nevada, Kistler would need to transit overland launch corridors approved by the FAA.

Pioneer Rocketplane's Pathfinder, at one time, intended to use conventional jet engines to launch horizontally to about 20,000 feet (6,096 meters), obtain in-flight liquid oxygen fueling from a "tanker," and then proceed to its space pop-up altitude of 70 miles (112 kilometers) using its single RD-120 rocket engine. At altitude, its small- or medium-class payload would be discharged. The vehicle concept has since changed to a vehicle designed to carry passengers and conduct experiments in the upper atmosphere on suborbital flights. In-flight LOX refueling has been abandoned. Recovery will be a standard high-altitude reentry pattern with jet-engine-assist landing at either Vandenberg Air Force Base, California, or Cape Canaveral Air Force Station, Florida. Pioneer has also signed a $300 million Memorandum of Understanding with the Oklahoma Space Industry Development Authority for revenue bond financing in exchange for a commitment to conduct launches from the Oklahoma Spaceport (FAA 2001a). FAA will need to approve overland launch corridors.

Kelly's Astroliner uses a different approach. Astroliner takes off horizontally using a tow line from a Boeing 747 airplane. At altitude, rocket engines ignite until the first stage burns out and returns to base using conventional jet engines. The second stage holds a small-to-medium payload and burns until it reaches LEO at 28.5 degrees latitude inclination. Once the payload is jettisoned, the second stage returns to base. Kelly is planning to launch from coastal sites at Vandenberg Air Force Base, California, or Cape Canaveral Air Force Station, Florida.

7.3 RLV Development

With the advent of LEO commercial satellite constellations, primarily communications-related, the RLV industry began to blossom in the 1990s. Seen as a less expensive "access to space" for replacing LEO satellites, RLVs began to develop a niche market that could have proved rewarding had the LEO satellite market sustained itself. With 40 years of experience in lifting bodies (X-24); hypersonic flight (X-15 and SR-71); the National Aerospace Plane (NASP); the partially reusable two-stage-to-orbit (TSTO) Space Transportation System known as the Shuttle; and NASA's development efforts for a future Shuttle replacement, there was a strong belief among the engineering and entrepreneurial communities that RLVs were positioned to make key contributions to U.S. space capabilities.

7.3.1 RLV History

A golden period of rocketry existed from the 1950s through the 1980s. American scientists, engineers, and space proponents experimented with a variety of approaches to develop space technologies and programs to field RLVs. These often took the form of winged space planes, consistent with Air Force and NASA expectations that pilots would fly into space, conduct missions, and return. The M2-F2, HL-10, X-24 lifting bodies, the Dyna-Soar space plane and concepts called Saint and Pied Piper were developed. The X-15 flew 199 test flights from 1958-1969. Additional conceptual studies continued through the early 1980s, but their technology costs outpaced available budgets (AWST 1958-69). By the late 1970s, the government-funded Space Shuttle was poised to become the first, yet only partially, reusable space launch vehicle.

In the 1980s, three events contributed to the Air Force turning away from manned reusable launch missions. First, through the early Shuttle period, military "manned spaceflight engineers" accompanied their national security Shuttle payloads into space to ensure in-orbit satellite expertise was available to the NASA crew. The program was terminated immediately following the *Challenger* accident in 1986.

Second, a key strategic finding by the Air Force's *Military Man in Space Study* concluded that autonomous satellites, controlled by sophisticated mission ground stations and launched by unmanned ELVs, obviated the need for military members to go into space to conduct military space missions (USAF 1988).

Third, Air Force and National Reconnaissance Office (NRO) leadership, reluctant partners in NASA's Space Shuttle efforts, were directed to transition from ELVs to NASA's Space Transportation System (STS), more commonly called the Space Shuttle, to meet NASA's launch manifest and projected savings from economies of scale. The Air Force invested billions of dollars to redesign their satellites and secure NASA's Shuttle training; payload integration; planning, launch, communications, and operations activities under a program called "Controlled Mode." During this period, the Air Force's ELV providers and infrastructure began to atrophy. As a hedge against an STS stand-down, the national security space community worked with Congress to procure 10 heavy-lift complementary ELVs as a ready reserve if the Shuttle became unable to complete its missions. Following the *Challenger* accident in 1986, the transition back to expendables took years and cost billions of dollars, leaving the Air Force and NRO reticent to team on future NASA space vehicle projects, especially for the conduct of national security space missions.

NASA, on the other hand, also had a public responsibility for advanced flight exploration and teamed with DOD in the late 1980s on a more identifiable program called the National Aerospace Plane (NASP). President Reagan, in his 1986 State of the Union message, stimulated a political constituency and funding for a single-stage-to-orbit (SSTO) space plane referred to as the Orient Express. While the Orient Express was actually envisioned to be a commercial hypersonic transport project and never got off the drawing boards, NASA and Department of Defense (DOD) and an industry consortium funded NASP. As a Presidentially-directed effort, it tested and evaluated propulsion systems, landing systems, aerodynamic shapes, thermal-control systems, fuels, materials, human interfaces, control systems, and structures. DOD and the Air Force cut their funding and terminated their participation in the 1992-1993 timeframe because NASP had failed to overcome critical technology barriers. Remnants of the program were officially canceled in January 1995 after some $2.7 billion was spent by government and industry. This was a serious blow to the Strategic Defense Initiative and its titular heads, like General Daniel

Graham and other High Frontier proponents, who were eager for reusable SSTO space planes to host possible ballistic missile defense weapons and launch large numbers of satellites. The Strategic Defense Initiative Organization tried again in the early to mid-1990's with the McDonnell Douglas DC-X, which conducted a series of experimental low-altitude liftoffs, translations across the launch pad, and touchdowns using existing technologies. After a structural failure on the last demonstration resulted in a fire, the program (then under NASA) was subsequently curtailed.

Mass fractions and thrust-to-weight ratios have not yet been sufficient for an SSTO space plane to reach LEO. Mass fractions are those portions of the flight vehicle devoted to certain sections. For example, the propellant mass fraction is the mass of propellant divided by the total flight vehicle mass. Nominal mass fractions for propellant are 0.85; structures are 0.14; and payload mass is 0.01 (Wertz and Larson 1999). Weight penalties (primarily from fuel and oxidizer) and insufficient propulsion (ISP and thrust) have combined to prevent an operation in the aerospace regime from Mach 2 to 25. Add the costly safety enhancements associated with human missions, and RLV developmental budgets have fallen short of the necessary technological advancements (Wertz and Larson 1999).

Today, the promise of SSTO reusable space vehicles has not improved. Air Force investments in advanced launch propulsion over the last decade have hovered around $50 million per year (USAF 2001a). This has been insufficient to spur the technological leap from today's kerosene/liquid oxygen or liquid hydrogen/liquid oxygen engines into more powerful ones. NASA's 1970s' Space Shuttle main engine (SSME) development was the last major rocket engine development program in the United States until the RS-68 to be used by Delta IV. Development of a second-generation RLV to potentially replace the current Space Shuttle will continue into the next decade. In accordance with the 1994 National Space Transportation Policy, responsibility for developing ELVs and RLVs was divided between the DOD and NASA, respectively (NSTP 94). NASA has taken a comprehensive approach to replacing the Space Shuttle, which is on course to serve well beyond its expected 20-year life span. Baselining intentions in their Integrated Space Transportation Plan, NASA has identified four RLV generations. The first-generation RLV was the Space Shuttle. While the venerable Shuttle fleet will fly until 2012 or longer it has not matured to the level of reliability and cost-effectiveness envisioned by many in the 1970s.

Confident of large LEO constellations and a robust launch market through the 1990s and into 2000, NASA and its industry partners worked to develop several X-vehicles. The X-vehicle program consisted of the X-33 project with Lockheed Martin and the X-34 technology test project with Orbital Sciences. The X-33 was a joint venture program with Lockheed Martin to develop a suborbital flight demonstrator that could ultimately lead to a larger commercially operated SSTO called VentureStar. VentureStar was designed to use eight updated linear aerospike engines, originally developed in the 1960s, to power the vehicle through a vertical takeoff into space and back through the atmosphere for a horizontal landing. Aerospike engines were expected to produce 455 seconds of specific impulse known as initial seconds of propulsion (ISP)[1] (OTA 1989) and 431,000 pounds (1.92 million newtons) of thrust at sea level. However, the mass fractions for propellant and structures remained too large, and NASA and Lockheed Martin chose to develop a large composite fuel tank to save weight. The tank failed a critical test, and the engines were unable to complete full flight and reliability testing (FAA 2001a). An X-37 technology demonstrator was begun in 1999 to test orbital and reentry flight phases (NASA 2001c). NASA cancelled the X-33 and X-34 projects in the spring of 2001, explaining that, "after the contractor determined that the commercial launch market could not justify their continued private investment, the Office of Management and Budget and NASA agreed that additional government funds to complete the X-33/X-34 exceeded the benefits that could be derived from flight demonstration of the vehicle" (NASA 2001c). After billions of

[1] ISP (initial seconds of propulsion) is thrust delivered per unit weight of propellant burning in one second. High ISP and thrust levels are required to develop the velocity needed to achieve orbital velocity.

investment dollars, experimentation, developmental flight articles, national study teams, and industry outlays, the Nation has fielded only one partially reusable TSTO space launch vehicle, the Space Shuttle.

NASA has now budgeted $4.85 billion from fiscal years 2001 to 2006 (FY01-06) for Space Shuttle safety upgrades and to begin second-generation RLV architecture and technology efforts leading to full-scale development of a new RLV selected from two competing architectures. This entire effort is sometimes referred to as NASA's Space Launch Initiative (SLI), but the intent of the Second-Generation RLV Program is to provide safer, more cost-effective and reliable transportation, primarily to the International Space Station, and to place U.S. Government scientific payloads in orbit. If a business plan supports commercial development and operation of a second-generation RLV, then commercial payloads could be launched as well.

NASA's second-generation RLV systems will be designed for "safe, low-cost Earth-to-orbit space transportation," which is the "key enabler of the commercial development and civil exploration of space" (NASA 2000). Not unlike military support to early commercial aviation transport aircraft development, U.S. Government technology and risk reduction support for RLVs are necessary investments. While many were hopeful that the commercial market for LEO communications and launch vehicles would grow into the 2000s, "NASA has learned that commercial markets are not growing as previously projected" (NASA 2001a).

Without sufficient commercial stimulation to sustain RLV entrepreneurs who rely on venture capital investments, NASA must provide the high-cost, low-return on investment initial technology push needed to develop follow-on RLVs. NASA's Space Launch Initiative investments in its industry partners will focus on ensuring three goals are foremost—safety, reliability, and affordability. Areas of interest will be crew safety, RLV escape systems, main propulsion, integrated structures, and subsystems. Advancements in these areas will support second-generation RLV goals of 10-person launch crews; one-week reflight preparation; 100 flights per year; and a reduction in launch costs from $10,000 per pound ($22,000 per kilogram) to $1,000 per pound ($2,200 per kilogram) (NASA 2001a). These goals are orders of magnitude above current capabilities, but may be achievable with proper resource allocation and technology development.

In May 2001, NASA awarded contracts to 20 companies totaling $791,432,000 for second-generation RLV work. Small RLV companies who were awarded funding were Kistler Aerospace, Space Access, and Kelly Space and Technology.

A third-generation RLV is due in the 2025 era with breakthrough technologies that will reduce the cost to orbit from $10,000 per pound ($22,000 per kilogram) to under $1,000 per pound ($2,200 per kilogram). Technologies are to be developed that will allow ambient air to be burned by advanced rocket engines along with advanced propulsion using magnetic levitation and solar-powered technologies. NASA's Advanced Space Transportation Program will be responsible for third-generation research and technology concentrating on three areas: hypersonic propulsion, in-space propulsion, and long-term research (NASA 2001d).

Fourth-generation RLVs could be available by 2040, featuring many advanced second- and third-generation propulsion and reusability technologies for long-duration space flight to the edges of our solar system (NASA 2001e)

In TSTO rockets (like a heavy ELV), the "first" stage is usually propelled by a combination of solid and liquid rocket motors and the "second" stage is usually the liquid-fueled main rocket engines. In some cases, additional first-stage solid rocket motors (sometimes referred to as strap-ons) are needed to provide rockets with additional thrust to lift the vehicle and a notional 30,000-pound (13,608-kilogram) satellite to a velocity of 17,000 miles per hour (27,353 kilometers per hour) and achieve Earth orbit. For example, while the three Space Shuttle main engines, or SSMEs, deliver the highest ISP of any domestic space launch vehicle engine, 455 seconds at vacuum, they are completely insufficient to lift the STS and its payload into orbit (Wertz and Larson 1999). Only by using two solid-stage rocket motors to create an additional 5.3 million pounds (23.57 million newtons or 2.4 million kilogram force) of thrust can the Shuttle launch itself and a payload into space (MSFC 2001).

Further, rockets do not rely on just one or two engines to get into space. The STS and even EELVs use upwards of seven to ten engines to complete their missions. All must operate within specifications for the mission to be successful. Solid rocket motors must fire correctly. Then, first-, second-, and third-stage liquid rocket engines must ignite and burn correctly. An upper-stage or apogee-kick motor might be required to propel the satellite to a specific orbit. Once in orbit, there are a variety of attitude-control motors that must fire repeatedly to maintain a specific orbit and attitude. The VentureStar would have used eight aerospike engines just to achieve LEO. Commercial or military satellites going to geostationary orbit (GSO) would still need to use additional upper-stage engines and may have their own thrusters.

Today's space planes and RLV concepts, whether SSTO or TSTO, face the same vexing challenges faced by the Air Force in the 1960s, NASA's Space Shuttle or STS in the 1970s, NASP in the 1980s, and X-33/VentureStar in the 1990s. In the case of commercial RLV developers, not only must technology and licensing/safety approval issues be addressed, but the enterprise must eventually generate a profit. If government-procured, an RLV generally must satisfy competing military, civil and or commercial requirements and undergo sufficient development to reach its design and performance objectives. Satisfying these competing needs requires a complex solution that integrates requirements, technology development, customer needs, launch rates, turnaround times, reliability, operations and maintenance (O&M) costs, and profits, as discussed below.

7.3.2 Current Status of RLV Development

The status of the seven commercial RLV programs identified in the FAA publication and others that NASA and different aerospace contractors have examined may eventually need to satisfy the following criteria in order to remain viable and ultimately become operational. There are many other technical evaluation criteria, but these broad categories must be addressed to proceed with a successful RLV program. These criteria include discussions as to why RLVs might prove slow in achieving airline-type operations.

Markets and Requirements

Current ELV configurations and future Evolved Expendable Launch Vehicles are sufficient to meet military requirements. The Air Force process has approved generic "needs" (mission needs statements) over the years for quick turnaround launch and small "tactical" satellites, which could benefit from RLVs. But, to date, there are no Joint Requirements Oversight Council-validated military requirements for an RLV or space plane. As principal launch agent for all of DOD, the Air Force conducts around 6 to 12 orbital launches per year.

The Air Force has a long history of participation in reusable research and development and is involved in SLI with NASA. A review of military requirements is being studied during 2002 to assess synergy with NASA requirements.

Today's commercial satellite builders have no requirements unique to RLVs but would be interested in proven, low cost access to space vehicles. While the geosynchronous orbit (GSO) market for launches has decreased slightly since 1997, there are more launch providers in the market. After a surge of launches during 1997-1999 in the non-geosynchronous orbit (NGSO) market, business failures of high profile telecommunications systems have had a negative impact on the entire NGSO satellite sector and emerging new launch vehicle companies, particularly fledgling RLV firms. The reduced demand for potential RLV satellite launches is in marked contrast to the large, if not vast, number of commercial aircraft departures each year, as discussed in Appendix E. However, it should also be noted that another potential, but unquantified, market for RLVs is that of carrying passengers.

Some commercially sponsored RLVs are designed to carry small GSO payloads but the majority of the GSO market is beyond mass capability of most RLVs. However, the SLI program could produce a heavier lift RLV. The geosynchronous orbit (GSO) market was estimated by the Commercial Space Transportation Advisory Committee (COMSTAC) to be about 24 launches per year worldwide over each of the next ten years. The NGSO market was estimated by FAA to averaged around 8 launches during the same time period. (FAA 2001b). NASA conducts about 10-12 launches per year (including NOAA payloads) with slight increases planned in the future. Considering its costly experience with the Shuttle and the lack of a commercial RLV variant to offset expenses, NASA will be looking to technologies emerging from its Space Launch Initiative (Second-Generation RLV Program) to replace the current Space Shuttles. RLVs could resupply the ISS or be used to support Mars missions, and if flight proven and cost-effective, launch NASA payloads. In addition, an ISS crew ascent and/or return craft could be a key motivating factor in RLV development.

Technology Development and Customer Needs

Currently, planned RLV systems have identified scramjet, aerospike, and vintage rocket engines that require rigorous testing and qualifications. Combining jet and small rocket engines for "pop-up" satellite deployment is indicative of reduced payload capacity, which limits market appeal. More importantly, hybrid concepts that mix different propulsion systems, fuels, and operating characteristics will require significant integration and testing efforts.

Large composite components (high-pressure tanks, filament-wound solid rocket motors, etc.) have unproven reliability. Small carbon-fiber applications like NASA's Thermal Protection System have improved over the years. Systems for rapid payload checkout and changeout have not been developed. Satellites designed to launch on different reusable and expendable launch vehicles will require a robust design and always require expensive satellite modeling, load, thermal, environmental, and vibro/acoustic qualifications for each launch vehicle. Following the *Challenger* accident, for example, it cost the Air Force $205 million for the delay of Air Force Program-675 and to transition the Combined Release and Radiation Effects Satellite (CRRES) from the Space Shuttle to Atlas/Centaur (Whitehair 1997). Integrating various technologies into a reliable RLV, overcoming unseen technological hurdles, and building sufficient flight articles within fiscal constraints will remain a challenge.

Commercial customers have not yet articulated a compelling need to launch their satellites in hours or days. Their revenue streams are planned around a contractually agreed-upon launch date. Often, the commercial satellite architecture and launch campaign anticipates a 1-in-10 launch failure, and commercially available insurance is used to contain financial risk. The military community has a different set of needs. Since they are "self-insured" and often launch very expensive one-of-a-kind satellites, emphasis is directed at repeatable ground system testing and analysis of the payload and the launch vehicle. There is no premium for speed of launch or deployment. NASA, on the other hand, has astronaut requirements that add weight and safety complexities to launch vehicles and to its mission. If passengers are added as "cargo" to routine RLV flights, then additional safety and checkout precautions will need to be implemented.

A good illustration of changing requirements can be found in a basic RLV component, the payload bay. Since launch rates create revenue streams, the more customers a vehicle has, the better. But customers from the civil, commercial, and national security sectors have very different payload bay requirements. Designing an RLV that can satisfy customers from all three sectors has proven problematic. For example, the Shuttle's payload bay was specifically sized (15 × 60 feet [4.6 × 18.3 meters]) for national security missions. National security missions no longer use the Shuttle. The vehicle and the bay doors are too large to economically launch small satellites. While NASA can make full use of the Space Shuttle to launch large space station structures, after ISS completion, its optimal use is unclear. Conversely, similar models of ELVs and EELVs have a multitude of fairing sizes and payload/upper-stage configurations that can be installed to accommodate a range of payload sizes and performance parameters.

Launch Rates

A key determinant in the cost-effectiveness equation is launch rates. Mathematica, Inc., of Princeton, New Jersey, analyzed the launch rate for the Shuttle in the early 1970s and concluded that NASA needed four Shuttles to conduct a total of 50 launches per year to bring the cost per launch down to $6 million to $10 million per launch (Logsdon 1995). Without military and intelligence payloads manifested on the Space Shuttle, NASA would have been unable to meet its cost reduction goals. This analysis was used to alter national space policy and direct Air Force and NRO satellites be launched on the Shuttle (NSP 1978). That decision proved extremely costly to the Air Force and the NRO.

Actual launch rates for the four Shuttles never reached the "knee-in-the-curve" cost-effective launch rate of 14 per vehicle per year (OTA 1989). Today, about 7 Shuttle flights per year are amortized at a cost per launch of about $400 million to $450 million per launch (FY00 costs) (USAF 2001c). A recent study by the Air Force's Developmental Planning Directorate at the Space and Missile Systems Center in Los Angeles concluded that future RLVs would have to launch almost 40 payloads of 30,000 pounds (13,600 kilograms) each and upwards of 160 payloads of 10,000 pounds (4,536 kilograms) each per year to reach their "investment break-even" mark (USAF 2001c). Clearly, this is an extraordinary technological challenge for space launch and range providers, resulting in a capacity for which satellite providers do not have a demand.

Hidden in launch rate analysis is the need for adequate numbers of vehicles and the O&M support to sustain a given flight rate. An example is the X-15 hypersonic research program. Three X-15 airframes were built to endure the grueling flight profiles that included altitudes of 315,000 feet (96 kilometers) and speeds to Mach 6.7 (7,344 kilometers per hour). By comparison, RLVs will have to reach a minimum altitude of 475,200 feet (145 kilometers) or higher and speeds in excess of Mach 22 (26,930 kilometers per hour). Each of the three X-15 platforms crashed at some point during the program and had to be taken out of service for repairs. One pilot was killed in the program. The Space Shuttle provides us with another example. At least one orbiter is out of service and in depot repair at all times, so spare vehicles must be available. Adequate hangar or maintenance space must be built, ground crews trained and devoted to refurbishment, and adequate stores of spare parts must be provided. Finally, the possibility that an accident will, at some point, ground the fleet must be taken into account.

Turnaround Times

If RLV turnaround times could be on par with aircraft, fuel, reload, and go - it arguably would result in breakthrough strategies for satellite launch and replenishment. Unfortunately, satellite builders do not build satellites that can be changed out and tested in hours, nor do satellites begin operating in space quickly. Payload integration into launch vehicles for commercial, civil, or military satellites may take weeks, if not months. Since there is no repair capability for GEO space systems, each satellite must work the first time and function consistently for the next 10 to 15 years. Deliberate and cautious electrical, mechanical, and software verification of all aspects of the satellite, the launch vehicle, and the integrated stack is crucial. Once the satellite reaches its final orbit, anywhere from 30 to 60 days are needed to outgas the satellite, calibrate sensors, establish communication links, optimize antenna pointing and power requirements, thermally stabilize the vehicle, etc. For example, after 20 years of STS flights, it still takes 4 months and 2 million checks and changes to prepare a Shuttle for a 2-week mission (Siceloff 2001).

Reliability

One of the key components in the selection of a launch vehicle provider is reliability. All major launch vehicle providers generally have approximately comparable reliability. The amount of time it takes to qualify RLV components and systems and build a reliability record similar to ELVs is to be determined. Collecting flight data from launch records and telemetered performance will require multiple launches to establish reliability. RLV reliability may be measured differently than ELVs, especially those that carry passengers. RLVs, like ELVs, have to launch and deploy their payloads (if any) successfully to be considered a mission success. RLVs then have an additional challenge to return safely to Earth.

Operations & Maintenance

Most studies of RLVs consistently undervalue the cost of operations and maintenance (O&M) in their models. And there is little data or evidence to suggest that technology improvements will adequately lower O&M costs for RLVs/space planes, whether SSTO or TSTO. NASA spends about $4 billion per year on Shuttle O&M. Space operations today generally do not incur significant recurring O&M costs because most investments are directed at development and procurement of launch vehicles and satellites. Once on orbit, satellites are fairly inexpensive to operate and maintain, mission ground station and communication links being the most obvious costs. Introducing RLVs into launch architectures, will require the amortization of space operations and maintenance costs for ground operations, repair, maintenance, payload integration, testing, and refurbishment of reusable systems. It remains to be seen whether O&M costs associated with new RLV operation can be significantly reduced and still meet safety and operational standards.

Profits

Ultimately, cost-effective operations lead to profits, which are the underpinning of any venture. Profit is directly tied to launch rates and O&M costs. Launch rates need to stay up; O&M costs need to stay down. Lockheed Martin became increasingly concerned about return on investment when it sought return on its proposed $6-billion VentureStar investment in 5 years. Ultimately, Lockheed Martin could not sustain a viable business model. Coupled with a slow LEO launch market and high technology risk, Lockheed Martin determined it could no longer justify corporate investment in VentureStar. Industry representatives have stressed in public fora that profit margins on ELV operations are tight. Even small costs associated with sharing additional insurance burdens or range costs could make them noncompetitive. RLV providers will have to consider regulatory insurance/risk allocation mandates, return on investment, and competition from ELV providers in their profit projections.

Cost of Reusables

RLV costs may also include unrealized economies of scale and industrial-base shortages. For example, the military services wrestle with affordability curves that balance resources, production runs, and cost per item. The more planes bought over a long performance contract, the cheaper each plane would become. The industrial base stays intact, lessons learned are integrated into succeeding production runs, human capital skills remain on the program, and spiral improvements and modifications can be made at substantial savings. Conversely, a single, short production run of a specialized vehicle, like the B-2 or Space Shuttle, leads to high costs per item (about $2 billion per B-2 copy amortized) and leaves little industrial base or production line skills, once the program is terminated. In such a situation, vendors and those with manufacturing and engineering skills move on to other projects, O&M costs skyrocket and replacement vehicles become impractical.

Government and commercial RLVs are likely to be manufactured and procured at rates similar to B-2s or the Shuttle. After initial research, development, and procurement investments are made, it is reasonable to presume a run of less than six to eight vehicles would be purchased. Once the assembly and production are complete, it would not be cost-effective to keep the production facility operational. Concurrently, subcontractors that produce engines, avionics, structures, etc., will terminate their research, development, and manufacturing activities. Additional subassemblies could be required, but, as found with the Shuttle and the B-2, they are eventually used up. After a short efficiency curve, the “reusable” economy is lost. This aspect is in contrast with the economies possible with aircraft production having much larger unit numbers.

Replacement vehicles will eventually be needed to sustain launch commitments leading to replacement subsystems and components. Improvements and modernization programs will be needed. Integration and refurbishment efforts will be required, as will skilled technicians and engineers. Costs soar with no ongoing production line and the loss of vendor tiers to support upgrades and replacements. Parts and assemblies often become unavailable. The U.S. Government is then forced to purchase specially built replacement items at a far greater cost than for a production run or integrated commercial off-the-shelf items. Commercial RLV operators could be expected to encounter similar problems.

7.3.3 Future of RLVs

While the future of RLVs is optimistic, its development has been punctuated by lessons learned from other high-risk, developmental, advanced technology, leading-edge programs. It will be decades before RLV operation would be on a frequency such as that of the airline industry. All spacefaring nations currently use expendable space launch systems as their primary launch vehicle. Only the United States currently has an operational “reusable” vehicle, and that is the Space Transportation System known as the Space Shuttle. ELVs are used because the industry has defined the market and improved its product over the last 50 years. Economies of scale, production facilities, and supplier tiers have been established. Launch rates, launch infrastructure, and range capacity are generally in balance.

Despite these market economies, all ELV providers have relied in some fashion on government support, either direct or indirect, to sustain an otherwise costly and hazardous operation. It appears that government investment will ultimately have to be made in RLVs if they are to replace or operate in parallel with ELVs, as evidenced by NASA’s Space Launch Initiative. But the technological and investment jump to RLVs is expensive, as has been demonstrated by the ill-fated NASP and X-33/VentureStar. And, if not for considerable NASA funding for the Shuttle, it too would have been unaffordable for commercial and military customers.

Without question, the ability to rapidly launch satellites and people into space in a safe, reliable, and cost-effective manner would revolutionize space transportation, not only for the government, but for the commercial sector as well. Some RLV companies believe existing propulsion options are adequate. Commercial investment may not create the critical mass needed to develop propulsion systems for RLVs until launch designs and business models justify the added investment. Satellite makers and users will find it difficult to build a business case for reusable launch systems for routine payload deployments unless the costs are less than ELV costs. The low projections for LEO launches, the lack of growth projected for GEO launches, high development costs of RLV, and a worldwide abundance of ELVs suggest that commercial RLVs dependent on commercial satellite launches will find it difficult to close their business cases in the near term. However, new RLVs may be able to generate new markets such as public space travel. Low cost access to space may make some commercial satellite systems more affordable.

Absent a galvanizing space event that forces the U.S. Government space program into a "Manhattan Project" effort, military and intelligence space programs are faced with the same force mix dilemma. While rapid launch and replacement concepts may be attractive, they belie the substantial cost of sustaining and operating a fleet of RLVs and surge satellites. Additional costs would be incurred to improve military space surveillance and satellite command and control operations to manage and direct a fleet of RLV/space planes and their payloads. The Air Force has begun a technology roadmap effort for use with NASA's Space Launch Initiative.

7.4 Comparison of RLV Risk to Aircraft Risk

This section highlights the differences and similarities between the hazards to the uninvolved public associated with operation of RLVs and commercial aircraft. Risk is typically defined as a combination of the probability of an event and the consequences of the event. For example, one risk of commercial airline travel is that the plane will crash and that the passengers and crew will be injured or killed. The airline industry often quotes this risk in terms of fatal accidents per miles flown, currently estimated at one fatal accident per 14 billion miles (22 billion kilometers) flown (Boeing 2001). Two-thirds of these accidents occur during either takeoff or landing. The events, which result in accidents and their consequences, are based on the hazards associated with an activity. In the case of commercial aircraft and RLVs, the most common hazard for the crew and passengers would be the possibility of an explosion or a crash.

Aircraft accident data indicate that most accidents occur at either takeoff or landing. This is the period of time during which the greatest transitions occur in the operating mode of the aircraft. Aircraft speed and altitude rapidly increase or decrease. Major evolutions in the configuration of the aircraft occur: wing shape is modified as flaps, rudders, and ailerons are repositioned, and landing gear is raised or lowered. The aircraft pilot is more actively involved in the operation of the aircraft. Takeoff demands the most from the aircraft in terms of thrust and structural integrity. Landing puts the most stress on the crew. Additionally, due to the proximity of the aircraft to the ground, the pilot has less time to respond to any unexpected event.

The following discussion is focused on hazards to third-party individuals, those not directly involved in operation of the vehicles. Hazards to passengers or personnel involved in operation of the aircraft and RLVs are excluded from the discussion of third-party hazards.

Third-Party Hazards

While there are potential hazards that can result in risks to third parties or members of the general public that are not the result of a vehicle crash, the consequences of these events are significantly smaller than those that result from a crash. There are anecdotal stories of parts of aircraft falling off and damaging property on the ground. However, these incidents are relatively rare, and the damage resulting from these events is relatively limited. The significant hazards and the majority of third-party risks are the result of aircraft crashes. The third-party risks associated with RLVs and aircraft are primarily associated with the volatility of the fuel used to power the vehicles and the kinetic energy of the vehicles.

There are three readily identifiable hazards associated with the operation of commercial aircraft and RLVs. The first of these hazards is the potential for damage resulting from the impact of the vehicle itself. The kinetic energy of the vehicle (a function of the mass and velocity of the vehicle) can damage relatively large areas. Second, in a crash, there is the possibility of a fire and an explosion, which would amplify the amount of damage resulting from the impact. The fuels used in commercial aviation (commercial jet fuels JP-4 and JP-8), although flammable, are typically not considered to be explosive. However, some of the fuels used as RLV propellants, as auxiliary power supplies, or carried as part of its payload are both flammable and explosive. The greater the amount of fuel on board at the time of the crash, the greater the potential fire damage, as was so vividly and horribly demonstrated by the September 11, 2001, terrorist attacks on the World Trade Center in New York City and the Pentagon near Washington, D.C. Third, some of the fuels used by RLVs and satellites may be carcinogenic and highly toxic. The toxicity of the fuel increases the size of the area that could be impacted by the crash, as unburned fuel could drift to areas not directly impacted by the crash and fire.

There is a wide range of commercial aircraft currently in operation, and there are several proposed designs for RLVs. The characteristics of all of these vehicles will not be discussed in this report. For purposes of comparison to RLV risk, the only commercial aircraft discussed will be the Boeing 747. This aircraft cannot be considered to be representative of all commercial aircraft, but rather is taken as a bounding case. It is the largest commercial aircraft in operation and has one of the highest takeoff and landing speeds. Four RLVs will be discussed: the NASA Space Shuttle, the Kelly Astroliner, the Kistler K-I, and the Pioneer's Pathfinder. Only the Space Shuttle is currently in operation.

The potential for damage from the impact of an airborne vehicle is a function of the amount of energy that would be dissipated in a crash. This energy is directly proportional to the mass and the square of the velocity of the vehicle at the moment of impact. (The amount of damage can be affected by other factors, including the angle of impact, but the driving factors are speed and mass.) The heavier and faster the vehicle, the greater its potential for damage. Because most accidents (crashes) occur either during takeoff or landing, the characteristics of the vehicles during these two phases of operation will be discussed.

The Kelly Astroliner and Pioneer Pathfinder take off much like aircraft. The Kistler K-I and the Shuttle take off with rocket motors like an ELV. The hazards associated with impact damage during takeoff range from a high for the Space Shuttle to a low for the Pathfinder. At takeoff, the Space Shuttle is by far the heaviest of all of these vehicles, and, although its initial velocity is very low, it rapidly surpasses the takeoff speed for the Boeing 747. At takeoff, the maximum weight of the Boeing 747 is approximately 875,000 pounds (396,900 kilograms). Of this weight, approximately 350,000 pounds (158,760 kilograms) is fuel. Takeoff speed is approximately 180 miles per hour (287 kilometers per hour), and the 747 reaches a cruising speed of approximately 550 miles per hour (885 kilometers per hour). The Space Shuttle has a takeoff weight of approximately 4.5 million pounds (2 million kilograms) (including 2.6 million pounds [1.2 million kilograms] for the solid rocket boosters and 1.6 million pounds [725,760 kilograms] for the external fuel tank). The other three RLVs are considerably lighter, ranging from 250,000 pounds (113,400 kilograms) for Pioneer's Pathfinder (of which 180,000 pounds

[81,650 kilograms] is fuel) to 840,000 pounds (381,000 kilograms) for the Kistler K-I (of which 750,000 pounds [340,200 kilograms] is fuel). Both the Space Shuttle and the Kistler K-I are vertical launch vehicles. Although, technically, the takeoff speed for these vehicles is almost zero, both rapidly reach speeds exceeding that of the Boeing 747. The Pathfinder and Astroliner are horizontal launch vehicles; they take off like an aircraft. Although both of these vehicles are in the design stage and have not yet been launched, the takeoff speeds for the heavier of the two should be slightly greater than that for the Boeing 747.

All of these vehicles are considerably lighter at landing than at takeoff due to the consumption of fuel. The weight of the Boeing 747 is approximately 550,000 pounds (249,500 kilograms). All of the RLVs would be lighter than the Boeing 747 when they land. Both the Kistler K-I and the Pioneer's Pathfinder weigh less than 100,000 pounds (45,360 kilograms); the Astroliner and Space Shuttle weigh about 230,000 pounds (104,330 kilograms). Although most RLVs must reduce speed from orbital velocities to landing speeds, most of the speed reduction (and resulting heat and pressure changes) occurs in the upper atmosphere relatively far from the landing site. For instance, the landing speed for the Space Shuttle, approximately 200 miles per hour (322 kilometers per hour), is comparable to that for the Boeing 747, about 160 miles per hour (258 kilometers per hour). Based on this information, the hazard associated with vehicle impact during landing should be about the same for horizontally landing RLVs as for the Boeing 747.

The primary hazard associated with the fuel used in commercial aircraft is the possibility of a fire upon impact. Aviation jet fuel, JP-4 and JP-8, is not typically explosive. The three RLVs use RP-1 (a kerosene-based rocket fuel) in their design phase that has an energy content similar to that of aviation jet fuel. It also is not explosive under normal circumstances. However, the RLVs use RP-1 in combination with liquid oxygen. The combination of these two chemicals is considered to be explosive, with an explosive equivalence of 10 to 20 percent of TNT. The main engines of the Space Shuttle use a liquid oxygen/liquid hydrogen mix. Liquid hydrogen has an explosive equivalence of 14 percent. Additionally, the RLVs will have on board relatively small amounts of hydrazine- or nitrogen-tetroxide-based fuels. These fuels are also explosive, with an explosive equivalency of 10 percent of TNT (DDESB 1999).

As noted earlier, the Boeing 747 carries approximately 350,000 pounds (158,760 kilograms) of fuel at takeoff. The Astroliner carries nearly 500,000 pounds (226,800 kilograms), and the K-I carries about 750,000 pounds (340,200 kilograms). The Pathfinder carries significantly less RP-1 (180,000 pounds [81,650 kilograms]), but this is augmented with aviation jet fuel. The RLVs may carry more than twice as much fuel as a Boeing 747. However, the fuel for the RLVs is in a potentially explosive combination, while the aviation fuel in the Boeing 747 is not. The risks associated with a fire at impact would not be significantly different than in the event of a crash of a Boeing 747 or one of the RLVs; however, the RLVs have the added risks associated with the explosive nature of the fuel.

Although fire and explosion risks are greatest at takeoff, when the vehicles are fully loaded with fuel, there is a risk associated with landing for each of these vehicles. All of them will land with some residual fuel under normal circumstances. Additionally, there may be instances where launch must be aborted and an emergency landing is necessary. Also, for the RLVs, it is possible that the mission would not be a success and the landing would occur with the payload intact. Unlike commercial aircraft, a payload in the RLV could contain additional fuel, which would add to the hazard associated with landing.

Finally, the third hazard associated with operation of the RLVs is the toxicity of the propellants. The commercial aviation fuels, which are essentially kerosene, are moderately toxic to humans, but only via intravenous introduction or ingestion. This is also true of RP-1. However, in addition to the propellants for the main engines, RLVs would also carry propellant for smaller engines/thrusters and auxiliary power units. Typically, the propellants for these other engines are either a nitrogen tetroxide- and/or a hydrazine-based fuel. Nitrogen tetroxide is a poison, moderately toxic by inhalation. It decomposes by heat into toxic nitrogen oxide fumes. Nitrogen oxides are toxic gases and a severe eye, skin, and mucus membrane irritant. Hydrazine is a poison by inhalation, ingestion, skin contact, and intravenous introduction. Hydrazine is also a carcinogen. Although these propellants are carried on RLVs in significantly smaller quantities than RP-1 and liquid hydrogen, they are present. After a successful mission, it is anticipated that the amount of these toxic fuels remaining on the vehicle would be on the order of hundreds of pounds.

Table 7–1 summarizes the hazards to the general public associated with operation of RLVs as compared to commercial aircraft. Three hazards have been identified: impacts of the vehicle during either takeoff or landing (commercial aviation and rocket launch experience show that most accidents occur during either takeoff or landing), fuel volatility, and fuel toxicity. The size of the hazard associated with impact is a function of the expected speed of the vehicle and its mass. These two parameters provide the measure of kinetic energy that will be dissipated in an impact and are provided for each vehicle. Fuel volatility has been categorized as either flammable or explosive. Fuel toxicity is based on the toxicity of the fuels on contact; toxicity from ingestion is not included. The mass of fuel carried by each vehicle is identified.

Risk Mitigation

The discussion above on the hazards of commercial space launch activities associated with RLVs addresses only a part of the risk equation. Accident probability and accident consequences are needed to present a full picture of the risks. **Table 7–2** presents vehicle failure data for space launch vehicles. Except for the Space Shuttle, existing launch vehicles are unmanned, and the failure probability is for mission failure, most often the failure to deliver payload to orbit. The FAA regulations on licensing commercial space launch and reentry operations (14 CFR parts 415 and 431) require that the risk of public casualty from the launch of a launch vehicle (14 CFR part 413.35(a)), and the launch and reentry of an RLV (14 CFR part 431.35(a)), shall not exceed 30×10^{-6} per mission.

To put this risk limit in perspective with the current commercial airline risk, commercial aircraft crash data from 1996 through 2000 were reviewed and it was found that, of 65 crashes of commercial aircraft capable of carrying 50 or more people, 12 crashes (about 18 percent of the crashes) resulted in the deaths of people on the ground.[2] Using the aircraft crash data,[3] this is the equivalent of a probability that about 1 in 13,000,000 (7.7×10^{-8}) aircraft departures result in a fatality other than of the flight crew or passengers. Commercial airline accident data statistics are not directly comparable to space launch vehicle data. However, they are provided to show the level of safety that has been achieved by a mature aviation industry.

The Air Force has developed risk acceptance criteria to be used in determining the allowable risk associated with each launch. According to Air Force Instruction 91-202, "risk should be quantified and acceptable limits established" (USAF 1991). Air Force range safety manual EWR 127-1 describes the principal risk criteria for space launches at Air Force facilities (currently Cape Canaveral Air Force Station and Vandenberg Air Force Base) (EWR 1997). This range safety manual defines a collective casualty expectation (E_c) of 30×10^{-6} (30 in one million) to be used as a level defining "acceptable launch risk without high management (Range Commander) review." E_c can be viewed as the acceptable population risk per flight operation.

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[2] Aircraft crash data were taken from Air Safety Online Crash Database, available at http://www.crashdatabase.com.

[3] Aircraft crash probability with fatality for major airlines (one in 2,300,000), based on 18 years of data, 1982–1999 (Safe Skies 2001).

Table 7–1 Comparison of U.S. Commercial Aircraft and Space Launch Vehicle Operation Hazards

Vehicle	*Hazard*	*Parameters*
Commercial aircraft (Boeing 747)	Impact during takeoff	Weight 875,000 pounds[1] Velocity 180 mph[2] at takeoff; reaches speeds of about 550 mph
	Impact during landing	Weight 500,000 pounds Velocity 160 mph
	Fuel volatility -JP fuel burns, but is not explosive	350,000 pounds at takeoff
	Fuel toxicity- JP fuels are not toxic	
Kelly Astroliner	Impact during takeoff	Weight 720,000 pounds Velocity approximately same as Boeing 747 at takeoff; reaches speeds of about 6,000 mph
	Impact during landing	Weight 220,000 pounds Velocity comparable to commercial aircraft
	Fuel volatility- RP fuel is explosive in combination with LO2	500,000 pounds of RP-1 and LO2 at takeoff
	Fuel toxicity - payload may have nitrogen-tetroxide- or hydrazine-based fuels	Several hundred pounds
Pioneer Rocketplane "Pathfinder"	Impact during launch	Weight 140,000 pounds Velocity comparable to commercial aircraft; reaches speeds of Mach 15
	Impact during landing	Weight 70,000 pounds Velocity comparable to commercial aircraft
	Fuel volatility - RP-1 and JP fuel are explosive in combination with LO2[3]	80,000 pounds of RP-1 and JP fuel 130,000 pounds LO2
	Fuel toxicity - payload may have nitrogen tetroxide- or hydrazine-based fuels	Several hundred pounds
Kistler K-I	Impact during launch	Weight 840,000 pounds Velocity – vertical takeoff; orbiter vehicle (second stage) reaches low Earth orbital velocities
	Impact during landing	Weight 90,000 pounds Velocity- first and second stage soft land through use of parachutes
	Fuel volatility- RP-1 fuel is explosive in combination with LO2	750,000 pounds of RP and LO2
	Fuel toxicity - payload may have nitrogen tetroxide- or hydrazine-based fuels	Several hundred pounds
Space Shuttle	Impact during launch	Weight 4.7 million pounds Velocity- vertical takeoff; Shuttle reaches orbital velocities
	Impact during landing	Weight 230,000 pounds Velocity 200 mph
	Fuel volatility - liquid oxygen/hydrogen combination is explosive	1.6 million pounds LO2 0.23 million pounds LH2 ~2.5 million pounds solid rocket fuel
	Fuel toxicity – nitrogen tetroxide- or hydrazine-based fuels are used by the Shuttle auxiliary power units and may be part of payload power supplies	Hundreds to thousands of pounds

mph = miles per hour, LO2 = liquid oxygen, LH2 = liquid hydrogen.

[1]To convert pounds to kilograms divide pounds by 2.2.

[2]To convert miles per hour (mph) to kilometers per hour multiply mph by 1.609.

[3]The Pioneer Rocketplane Pathfinder thrust is from the combustion of jet fuel and liquid oxygen. This combination is considered to be explosive. However, the liquid oxygen is not on board the Pathfinder at takeoff, it is loaded during an in-flight "refueling" operation.

Table 7–2 U.S. Space Launch Vehicle Failure Probabilities

Space Launch Vehicle	*Basis*	*Failure Probability*
Atlas	Operational Experience [1]	1 in 50 (0.02)
Delta	Operational Experience [1]	1 in 50 (0.02)
Titan II	Operational Experience [1]	3 in 50 (0.06)
Titan IV	Operational Experience [1]	1 in 25 (0.04)
EELV (ATLAS V and Delta IV)	Calculated [1]	1 in 50 (0.02)
Space Shuttle	Operational Calculated [1]	1 in 483 (0.002)
X-33	Estimated [2, 3]	1 in 250 (0.004)

[1]2001 values from U.S. Air Force Directorate of Space Operations Integration.
[2]From X-33 environmental impact statement (NASA 1997).
[3]Based on the average of the four other space launch vehicles.

EWR 127-1 also uses an individual risk criterion (P_c) to describe the probability of an individual in any particular place being killed or severely injured during a launch. P_c can be used to determine whether specific personnel are at high risk in a given area. EWR 127-1 prohibits exposing members of the general public to a P_c greater than 1×10^{-6} (1 in 1,000,000).

Most of the launches subject to the Air Force standard utilize vehicles for which launch failure data have been provided in Table 7–2. The relatively high launch failure rates presented in the table do not mean that the public risks from operations of these vehicles are higher than the values for P_c and E_c contained in the Air Force range safety manual, EWR 127-1. Although these limits can be adjusted based upon other factors associated with each launch (mission importance, etc.) these criteria provide the safety basis for allowing individual launches and have been codified in FAA licensing regulations for ELV launches (14 CFR part 415) and RLV missions (14 CFR part 431). The FAA would not license the launch if the expected public risk could exceed the limits identified in the aforementioned regulations.

Commercial aviation has spent years and billions of dollars improving air travel safety and in portraying air travel as safe, notwithstanding the recent increased risk of a terrorism-related event. These efforts have resulted in a safety record that exhibits extremely low risk for the passengers. The perception is that the risks associated with air travel are reasonable and that the benefits associated with air travel are worth the risks. The events of September 11, 2001, have shown that the risk to the public from an intentional crash is catastrophic, with an unknown probability. Commercial space launch activities using RLVs do not have this history to draw upon. Commercial aviation has evolved to the point where the risks are “old risks,” that is, people are familiar with and accepting of the risks. RLV operations, on the other hand, are “new risks,” that, while perhaps similar to commercial aviation risks, are associated with an activity not as familiar to the general population.

Currently, all U.S. space launches—government, military, and commercial—are performed at coastal launch facilities. The location of these facilities provides some third-party risk mitigation, in that, should an accident occur during or soon after ignition and lift-off, the impacts would occur at either the launch facility or over a large body of water. Thus, third parties would not be subject to the risks from most accidents.

Future launches and, maybe more importantly, RLV landings, may occur at new inland facilities. The hazards do not necessarily change (the principal third-party hazards being from vehicle impact, fire, explosion, and the release of toxic fumes), and the probability of accidents would not change simply as a result of the move from coastal to inland facilities (although an increase in the number of flight operations would increase the accident frequency.) Also, the failure frequencies associated with new RLV designs may not be the same as for existing launch vehicles. However, the potential affected population could change. If it is assumed that the historical accident data holds and most accidents would occur during or soon after lift-off and during or just preceding landing, then the move to inland facilities may increase the population at risk during these accidents. The potentially larger affected population results in larger calculated consequences and, therefore, higher risks associated with inland facilities.

The fact that the risks may be larger than those currently experienced does not necessarily mean that the risks would be unacceptable, only that they have increased. Inland launches and RLV missions would have to satisfy FAA safety criteria. However, the move to inland launch and landing facilities would increase the number of people who would show an interest in the operations. To this larger audience, the commercial space launch activity is a "new risk," and they may have a different perspective on what constitutes acceptable risk. As a result, it may be necessary to show that additional measures have been taken to control the risks associated with these commercial launch operations.

Regardless of what the actual risks of an inland commercial space launch facility are, it will be necessary to provide evidence that the risks have been evaluated and that effective risk mitigation measures have been taken to provide adequate levels of safety for the public. Several risk mitigation procedures have been identified, but have not yet been fully analyzed to determine their effectiveness. For example, those activities identified as being higher risk could be restricted to designated areas (i.e., over oceans or sparsely populated areas), where the potentially affected populations would be minimal. Compared to commercial aviation airports, it may be necessary to be more restrictive with siting criteria. Larger (in terms of land area), remotely located facilities reduce the potential for launch accidents to have an impact on third parties.

7.5 Comparative Liability Regimes

7.5.1 Current RLV Liability and Risk-Sharing Regime

As discussed in Chapter 1, under current law, FAA-licensed launch operators share with the Federal Government the risk of liability to third parties (persons uninvolved in launch activities). Risks include possible damage or loss to persons or property resulting from licensed launch and reentry operations. On September 19, 2000, the FAA issued final rules regulating the licensing of and financial responsibility for commercial RLVs and reentry vehicles (14 CFR parts 431, 435, and 450, respectively). These regulations are designed to provide protection against RLV risk at levels at least equivalent to that of launch of conventional ELVs (65 FR 56620). RLV mission licensees are required by 14 CFR part 450 to comply with applicable financial responsibility requirements specified in their licenses. Requirements are based upon maximum probable loss calculations as described above. To date, there have been no launches of RLVs and, hence, no accidents with resultant litigation involving RLV launches.

7.5.2 Current Airline Liability Regime – International and Domestic

As tort law has evolved during the birth, growth and maturity of the airline industry, the compensation regime has focused primarily on the most common accident victims in plane crashes, the passengers. Injuries and deaths suffered by persons—and damage to property—on the ground have been comparatively rare (excluding the recent terrorist attack of September 11, 2001). Most of the existing case law on liability resulting from airline crashes deals with litigation by passengers (or their families) against airlines, aircraft manufacturers, airports, governmental regulating and responding authorities, secondary manufacturers, equipment maintenance firms, software developers, and others—in essence, against virtually anyone a skillful plaintiff's attorney can reach under various theories ranging from negligence to product liability to trespass.

Current U.S. Liability Risk-Sharing Regime Under 49 U.S.C. Subtitle IX, Chapter 701, (popularly known as the CSLA)

The U.S. liability risk-sharing regime for commercial space transportation is comprised of three tiers:

Tier I: **Maximum Probable Loss (MPL)-Based Financial Responsibility Requirements**

- Launch or reentry licensee obtains insurance to cover claims of third parties, including Government personnel, for injury, loss or damage, against launch or reentry participants. Participants include the licensee, its customer, and the U.S. Government and its agencies, and the contractors and subcontractors of each of them.
- Launch or reentry licensee obtains insurance covering damage to U.S. Government range property.
- The Federal Aviation Administration (FAA) sets insurance requirements based upon the FAA's determination of the MPL that would result from licensed launch or reentry activities, within statutory ceilings, not to exceed the lesser of:
  - $500 million for third-party liability, or the maximum available on the world market at reasonable cost.
  - $100 million for U.S. Government range property, or the maximum available on the world market at reasonable cost.
- Participants enter into no fault, no subrogation reciprocal or cross-waivers of claims under which each participant accepts its own risk of property damage or loss and agrees to be responsible for injury, damage or loss suffered by its employees, except that claims of Government personnel are covered claims under the licensee's liability insurance coverage.

Tier II: **Catastrophic Loss Protection (Government Payment of Excess Claims, Known as "Indemnification")**

- Subject to appropriations, the U.S. Government may pay successful third-party liability claims in excess of required MPL-based insurance, up to $1.5 billion (as adjusted for post-1988 inflation) above the amount of MPL-based insurance.
- U.S. Government waives claims for property damage above required property insurance.

Tier III: **Above MPL-Based Insurance plus Indemnification**

- By regulation, financial responsibility remains with the licensee, or legally liable party.

Exceptions

- The government does not indemnify a party's willful misconduct.
- The government may pay claims from the first dollar of loss in the event of an insurance policy exclusion that is determined to be "usual."

By doing so, plaintiffs' attorneys can set defendant companies' interests at odds with one another, potentially increasing the settlement value of a case (ABA 1998a). In addition to these practical considerations, there are myriad procedural complications emanating from the nature of air travel itself; however, for purposes of comparison to commercial space transportation liability, the discussion focuses more narrowly on ground damages resulting from accidents.

With a few very limited exceptions, torts in the United States are matters of state law; under the *Erie* doctrine, even federal courts hearing civil suits must apply substantive state law.[4] Existing case law and

[4] Erie R. Co. v. Tompkins, 304 U.S. 64 (1938).

precedent are a primary driver of trends in tort law; thus, while the domestic regulatory structure is important, it is usually not controlling in the sense that the civil codes in many foreign countries are.

Liability for International Aviation Accidents

The Warsaw Convention is the primary international agreement under which aviation liability in international commerce is assigned.[5] The Convention essentially placed strict liability for damages or injuries resulting from a crash upon the airlines. In exchange, caps were placed on the amounts recoverable by plaintiff passengers or their estate, except in limited circumstances such as willful misconduct by the carrier.[6] The Warsaw Convention entered into force for the United States in 1934, as commercial aviation began to mature. The underlying rationale for the provisions was that commercial airline transport was in its infancy, and unlimited liability for crashes resulting from this relatively new technology would jeopardize the industry just as it was emerging. Passengers who voluntarily flew (and by implication assumed the associated risk) would be limited in damage awards, but because the liability question was essentially settled in their favor, compensation would be made more quickly and with less reliance on legal wrangling. From the beginning, the Convention has been criticized for unfairly low limitations on liability (ABA 1998b). Currently, under an agreement between airlines, most major scheduled air carriers have waived the liability limits in their entirety with strict liability provided up to approximately $130,000. For carriers not party to the inter-carrier agreement, the applicable limit to and from the United States is $75,000. Under the 1999 Montreal Convention, designed to replace the Warsaw Convention, like the inter-carrier agreement, passenger liability limits are eliminated, with strict liability up to approximately $130,000. The United States has not yet ratified the 1999 Convention. Punitive damages are not available under the 1999 Convention or the original Warsaw Convention.

The Conventions provide that the airline may be exonerated “to the extent” that the person injured contributed to the damage (a comparative contributory negligence concept). The 1999 Montreal Convention also permits a carrier defense that the “damage was solely due to the negligence or other wrongful act or omission of a third party.” These defenses were not available under earlier conventions.

The 1952 Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface, also known as the Rome Convention, is similar to the Warsaw Convention in that it limits liability of airlines for damages that may occur on the ground to uninvolved third parties. It also imposes a strict liability standard intended to speed settlement of claims. The United States is not a party to the Rome Convention.

Regulations Governing Airline Liability in the United States

Regulations governing airline financial responsibility for liability within the United States can be viewed as analogous to that for operating an automobile. The government requires the purchase of certain minimum levels of insurance, but, unlike the structure envisioned by the Warsaw Convention, liability is unlimited. Under 14 CFR 205, carriers operating within the United States must carry insurance in the amount of $300,000 for any one person not a passenger and a total of $20 million per involved aircraft; for passenger carriage, the minimum is set at $300,000 per passenger up to a limit of $300,000 times 75 percent of the number of installed seats (14 CFR 205). Air taxis are required to purchase insurance in lesser amounts, due to their smaller size and capacity. However, because the domestic regulatory regime

[5] 49 Stat. 3000, 876 U.N.T.S. 11 (1934), reprinted in 49 U.S.C. app. 40105 (Warsaw Convention). For a thorough discussion of the Warsaw Convention and its progeny, see Tory A. Weigland, “The Modernization of the Warsaw Convention and the New Liability Scheme Arising out of International Flight,” Massachusetts Bar Association 2000 (available at http://massbar.org/phpslash/punlibc_html).

[6] Warsaw Convention, Art. 25.

does not set limits on liability, airlines routinely purchase insurance coverage that dwarfs the required amount, providing individual coverage in the millions and incident coverage in the billions of dollars.

From a domestic standpoint, the liability regime for both airline operations and space launches is governed by state law. Internationally, the regime differs for cargo by virtue of reciprocal or cross-waivers of claims required of RLV customers placing a payload on board the vehicle. Liability

considerations for RLV passengers are yet to be determined and are beyond the scope of this report.

Liability Resulting from Air Crashes in the United States: Current Case Law

Mass torts such as airline crash cases are complex, intensive, fact-specific proceedings, and differences in substantive law may well determine the outcome of a particular case. Litigants have been known to "forum shop" in an effort to gain advantage; but, while a typical tort case (such as a two-car accident) may afford limited opportunities to apply different legal standards, because applicable tort law is usually that of the place where the wrong occurred, airline cases can become vastly more complex, as guidance from the American Bar Association indicates:

> Consider this scenario, which is taken from a recent case: a domestic air carrier is incorporated in Delaware, has its headquarters in Virginia, maintains its major hub in Pennsylvania, and operates a maintenance facility in Oklahoma. Its aircraft crashes in Los Angeles, California, on a flight from Ohio, killing and injuring passengers from Massachusetts, Michigan, Ohio, California, and other states and foreign countries. Air traffic control [performed by federal employees] is implicated as a cause of the crash, although crashworthiness allegations are made against the carrier. The heirs of two Massachusetts passengers file a wrongful death case in federal court in Los Angeles against the United States for compensatory damages and against the carrier for compensatory and punitive damages. Now punitive damages are not allowed in California for a wrongful death case, but are allowed in Massachusetts. On the other hand, Pennsylvania allows punitive damages for the survival cause of action, but not for the wrongful death claim (ABA 1998c).

Applicable law may turn on creative theories of which actions in which places constituted the "legal wrong" that caused the accident. The authors suggest the complexity and uncertainty surrounding the above case were strong incentives for the parties to settle (ABA 1998c). Indeed, as is the case with most civil litigation, most airline liability cases are settled out of court. The crash of a DC-10 on takeoff from Chicago's O'Hare airport in 1979 resulted in "118 actions filed on behalf of 271 persons on the aircraft and two on the ground. The decedents were residents of 10 states of the United States, plus Puerto Rico, Japan, the Netherlands, and Saudi Arabia" (Lowenfeld 1989).

When passengers who are residents of countries other than the United States are involved, the situation becomes even more complex. These plaintiffs may sue to apply the law in force in their domiciliary state (which is customary in some jurisdictions) for various reasons. In Japan, for instance, parents are allowed to sue on behalf of the estate regardless of whether there are dependents, and they may recover for grief. French law allows "moral damages," which are similar to punitive damages in operation (Bender 1995). Generally speaking, however, plaintiffs attempt to bring suits under U.S. law because remedies such as wrongful death, pain and suffering, product liability, economic loss, and punitive damages may not be available in other jurisdictions (Bender 1995).

Plaintiffs in mass torts like airline crashes frequently file product liability suits against manufacturers of aircraft components, and such suits are decided upon strict liability standards that have evolved to protect consumers from defective products. Product liability law is worth noting because of the interplay among litigating parties that may be expected in such cases. As one commentor notes, "[i]f an air carrier is successful in capping its liability, attention will shift to the manufacturing and other defendants. Manufacturers rarely have a dollar limit on the recovery that may be obtained against them. Additionally, a products liability claim (which would come under a strict liability regime) may be easier to plead and prove than a negligence claim against the carrier" (ABA 1998d). It should be noted that the Aviation and Transportation Security Act of 2001, enacted after the September 11 attacks, expressly limited the liability of airlines, aircraft manufacturers, and airports. This act covers only suits that may arise specifically from events of September 11, 2001.[7]

The general law of airline liability is fault-based; that is, negligence must be proved. Three elements are usually required to sustain a finding of negligence:

- A legal duty to a standard of due care
- A breach of that duty
- Legal causation of harm resulting from the breach (Kreindler a)

In many jurisdictions and subject areas, negligence law is modified by the doctrine of *res ipsa loquitur* (literally, "the thing speaks for itself"). The standard of proof for negligence is "preponderance of the evidence," that is, the defendant is presumed to not have been negligent until the plaintiff proves he is more likely negligent than not. *Res ipsa loquitur* shifts the burden of proof to the defendant. If the defendant loses unless he can show he was not negligent, it becomes much easier for the plaintiff to win the case.

Application of *res ipsa loquitur* varies from state to state. Where it is applied, three conditions usually must apply:

- The accident is of a kind that does not normally occur absent negligence.
- The instrumentality that caused the accident was under the exclusive control of the person charged with the negligence.
- The injury suffered must not have been due to any voluntary act on the part of the plaintiff.

In the early days of aviation, applying the doctrine of *res ipsa loquitur* was very difficult because the technology was so new—there simply was not enough known about aviation to enable courts to decide that negligence, and not some other cause, was most probably responsible in a particular case. As air travel has become more common and much more became known about aeronautical science, courts began to apply *res ipsa loquitur* to negligence-based actions against air carriers.

Some jurisdictions deciding early aviation cases followed variations on the doctrine of strict liability, on the theory that aviation is an ultrahazardous activity and that damages were analogous to that caused by trespass (Speiser and Krause). As the air transport industry matured and air travel became more commonplace, negligence theory began to become more prevalent in the common law. However, some states enacted laws conferring strict liability on air carriers, which were modeled upon the Uniform Aeronautics Act, promulgated by the Commission on Uniform State Laws in 1922. The commission withdrew the Uniform Act in 1943 on the grounds that it had become obsolete.

[7] Aviation and Transportation Security Act of 2001, Section 201.

Liability for Ground Damages: Differing Regimes

In several states, ground damages resulting from falling aircraft or aircraft parts are treated differently than cases involving passenger liability. This area may have particular applicability in examining issues related to commercial space transportation, as damage from falling debris from an RLV or ELV could pose a risk to third parties.

Strict liability in the absence of a specific statute for ground damages resulting from falling aircraft or debris is, despite its prominence in the Restatement on Torts, relatively rare. Although the trend for aviation law generally is away from strict liability and toward negligence, several jurisdictions have argued strongly in favor of strict liability for ground damages because the plaintiffs in these cases are wholly innocent; they cannot even be said to assume some risk as passengers might. Other courts have found strict liability appropriate based on a theory of "enterprise liability;" that is, those profiting from creation of a risk should be responsible for accidents that occur (Kreindler b).

Courts applying West Virginia law[8] have held that an airplane crash is analogous to a trespass for which strict liability is available, and courts in California and North Carolina have indicated the same may be the case in certain circumstances, such as flight by an incompetent pilot or at supersonic speed.[9] Early courts relied on old cases such as *Guille v. Swan*, 19 Johns. 381 (New York Supreme Court, 1822), which found strict liability for trespass on the part of a balloonist crash-landing in a field (Kreindler c). Noting differences between 19th-century ballooning and modern air travel, modern courts have moved away from absolute liability at common law.

Strict liability was once conferred by statute in about half the states, many of which used the now-obsolete Uniform Aeronautics Act as a model (Kreindler c). The ground damage provision of the act read as follows:

> The owner of every aircraft which is operated over the lands or waters of this State is absolutely liable for injuries to persons or property on the land or water beneath, caused by the ascent, descent or flight of the aircraft...whether such owner was negligent or not…"[10]

Today, six states—Delaware, Hawaii, Minnesota, New Jersey, South Carolina, and Vermont—retain parts of the original act.[11] Therefore, for ground damages resulting from the fall of an aircraft or debris onto the ground, strict liability by statute could apply in possibly seven states.

Two cases brought under the Federal Tort Claims Act, which forbids application of strict liability against the government, nevertheless found that statutes conferring a rebuttable presumption of liability were lawful. Section 5-1005 of the Annotated Code of Maryland states that owners of aircraft are *prima facie* liable for ground damages, but may offer proof to rebut such liability (Kreindler d). Applying Virginia law, another court found that violation of a Commonwealth statute making negligent operation of an aircraft a misdemeanor constituted negligence *per se* (Kreindler c).[12]

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[8] *Parcell v. United States*, 104 F. Supp. 110 (D.C. W.Va. 1951).
[9] *Boyd v. White*, 128 Cal. App. 2d 641, 276 P. 2d 92.
[10] Uniform Aeronautics Act, §5.
[11] Del. Code Ann. Tit 2, §305; Haw. Rev. Stat. Ann. §§263-265; Minn. Stat. §360.0112; N.J. Rev. Stat. §6:2-7; S.C. Code Ann. §55-360; Vt. Stat. Ann. tit. 5, §224.
[12] *Musick v. United States*, 768 F. Supp. 183, 23 Av. Cas. (CCH) 18,803 (W.D. Va. 1991), applying federal and Virginia law.

Aviation Accident Ground Damages: Negligence (and *Res Ipsa Loquitur*)

As stated earlier, negligence (with or without *res ipsa loquitur*) is the rule in the majority of states. Thus, an innocent bystander injured by aircraft debris on the ground must prove the aircraft operator was negligent in order to recover. However, because it would be difficult at best for an uninvolved bystander to prove an airline or aircraft manufacturer negligent, in regard to ground damages, case law in several jurisdictions has held that *res ipsa loquitur* was appropriate when:

- A man was killed while fishing in the Gulf of Mexico when an iron pipe fell from an airborne naval target.[13]
- An auxiliary fuel tank from a Navy airplane crushed a fruit stand, injuring bystanders.[14]
- A boat was sunk when a practice bomb was dropped on it.[15]

Other jurisdictions have not ruled on the specific question, but have indicated in similar cases that *res ipsa loquitur* might apply. In other words, although the plaintiff must prove fault on the part of the defendant, the burden shifts to the defendant to show that it was not at fault. The result is generally comparable to that where strict liability applies.

The predominant liability regime for airline accidents, including those involving ground damages, tends increasingly toward negligence, with or without application of *res ipsa loquitur*. The development of aviation science and industry has helped reduce uncertainty about the causes of accidents and makes such transport commonplace, two factors that would otherwise make a strict liability regime potentially more equitable. Strict liability persists in some jurisdictions and under some circumstances, but does not appear to be increasing in breadth or scope.

Perhaps more important than the predominant regime, however, is the trend toward ultimate results in liability cases. As one commentor on ground damage cases noted, "the varied theories used to determine liability are a contrast to the uniformity of results—in practically all reported cases the plaintiff has recovered. Even in the absence of the supposed basis of absolute liability—an ultrahazardous activity—the courts have imposed liability which is absolute in effect" (ILJ 1995). As stated earlier, most tort suits are settled before a trial takes place. Therefore, although the amount recoverable from ground damages may be uncertain in particular circumstances, the finding of liability is virtually certain. Judges and juries faced with a plaintiff injured by falling aircraft debris will overwhelmingly find for the plaintiff no matter what liability regime applies.

7.5.3 Relationship between Airline Liability Regime and Industry Development

As stated earlier, one early rationale for imposing limitations on liability for international air travel was that commercial air transport was in its infancy; that the industry relied on a new technology that provided great benefits to society; and that, absent some special legislative intervention, passenger and cargo liability for crashes would be so substantial that the industry could not survive and expand. However, even when the Warsaw Convention came into force, there were immediate complaints about unfairly low limits for airline liability, and within a few years, the plaintiffs' bar began finding ways to circumvent those limits. Today, in nearly every state, limits on liability for airline crashes such as those outlined in

[13] *Skeels v. United States*, 72.F. Supp 372 (La. 1947).
[14] *D'Anna v. United States*, 181 F2d 335 (Md. 1950).
[15] *Goodwin v. United States*, 141 F. Supp 445 (N.D. 1956).

the Warsaw Convention are held to be void as against public policy. For this reason, plaintiffs' attorneys typically employ every argument, no matter how tenuous, to have their case removed to a United States court.

The Warsaw Convention and its progeny agreements remain, but for airlines, manufacturers, service companies, or any other potential defendants doing business in the United States, it has little if any practical effect, due to inter-carrier agreements waiving the Convention's liability limits. This erosion of liability limitation began almost immediately after enactment of the international agreements—in effect, the airline industry has never really had full liability limitation (although this may change in the aftermath of September 11, 2001). Certainly, at the time of the convention enactment, the framers of the agreement felt the industry would not survive without it. Today, with a fully mature airline industry and essentially no liability protection in the United States (except regarding the terrorist events of September 11, 2001), we cannot know with certainty whether the industry seven or eight decades ago could not have prospered under a different regime.

7.5.4 Implications of the Airline Liability Regime for the RLV Industry Development

Several aspects of the liability regime for airlines and aircraft may have implications for RLV operations in the future. First, because of practical and procedural considerations, parties to a commercial, FAA-licensed RLV launch or reentry activity resulting in injuries to third parties may reasonably expect to be sued in the United States. Under the existing Commercial Space Launch Act (CSLA) regime, all parties would be covered by the licensee's insurance. Domestically, without limits on liability, it would appear that the CSLA risk-sharing regime for liability would benefit the RLV industry much like Warsaw Convention limits did for early international aviation. However, Warsaw Convention limits apply to passengers and cargo which for present purposes is beyond the scope of this analysis of how to manage third-party liability. Thus, the notion of capped but strict liability of the Warsaw Convention is inapplicable to discussion of RLV liability for ground damage. With respect to cargo, to the extent that the waiver of claims required for space launch customers is somewhat akin to limiting vehicle operator liability for damage to cargo (or achieves the same objectives), such limitations are already in place for RLVs and, in fact, may prove more effective under the CSLA liability risk-sharing regime than that of the Convention. In other words, insuring one's payload or cargo remains a personal or business decision of the cargo owner. Finally, judging from airline liability cases generally, and ground damage cases in particular, regardless of which liability regime applies, whether strict liability or fault-based, settlement or payment of judgments is by far the more likely outcome, so that the goal of victim compensation is achieved.

7.6 Possible Transition Factors

Modern commercial airlines have carried millions of tons of cargo and billions of passengers since the turn of the century. It is difficult to predict when, if ever, RLV transport would ever approach the commercial airline industry in terms of numbers of passengers and tons of cargo hauled. As compared to aviation, a considerably shorter track record would likely be sufficient to determine whether an international airline liability regime would be appropriate for RLVs, at least in terms of cargo. At this stage, however, the RLV industry has essentially no track record at all. For this reason, it would be speculative at this point to assert that an alternative regime for RLVs is preferable to that of the CSLA.

7.7 Summary

A range of government RLV concepts has been considered since the early days of space travel. The Space Shuttle, a partially reusable launch vehicle developed in the 1970s, is a result of the first major work toward RLVs. Major government programs in the 1980s and 1990s were canceled for various technical and commercial reasons before a viable vehicle could be flown. NASA has recently initiated RLV architecture and technology efforts to lead to development of a new RLV. This RLV will be focused on cost-effective and reliable transportation to the International Space Station and to place government scientific payloads in orbit. It is expected that over the next 50 years under NASA's SLI, reusable launch operations will become more routine and affordable. Commercial and military launch needs currently served by ELVs are not putting increased demand on NASA or a commercial entity to produce an RLV.

A strong field of RLV competitors ten years ago has been reduced to several key players, most of whom are dependent on continued involvement with NASA's SLI to advance their development efforts. It remains to be seen whether a commercially viable RLV will arrive on the market and be fully operational within the next decade.

Absent customers with compelling needs for reusable launch attributes, the prospects for commercial RLV will remain tempered and founded primarily on technology development and systems integration efforts.

The next generation of RLV may or may not be the first to fly commercially, and is unlikely to have airline-type operations. This depends on cost and performance issues described in this chapter. However it is apparent that any RLV will be based on solid and liquid rocket technology that is not revolutionarily different from that currently in use. Launch failure probabilities for existing space vehicle technologies vary from about 3 in 50 to 1 in 483. For commercial aviation, the takeoff failure probability is estimated to be 1 in 2.3 million. Although several order-of-magnitude improvements could theoretically be achieved with new designs, it must be concluded that space launch vehicle launch failure probabilities will remain much higher than those for commercial aviation. The hazards to third parties are generally comparable for space launch vehicles and commercial aircraft, so the higher risk of space launch vehicles is driven by the higher failure probabilities per flight and the likelihood of damaging launch facilities and possible risk to surrounding population centers. Because of the high per-flight cost and visibility of manned space travel for the foreseeable future, the public may have a different perception of the risk from future RLVs.

Because no commercial RLVs have been launched, no accidents with resultant damage and litigation have occurred. Therefore, it is premature to make firm predictions about consequences and amount of liability. The financial responsibility requirements associated with commercial RLV mission licenses are based on protection against risk at least equivalent to that of conventional ELVs. The major liability issue facing commercial aviation has been victim compensation for passengers, which is beyond the scope of this report.

Domestically, whether liability for ground damages falls under strict liability or negligence-based standards of proof, depending upon the applicable state law, the goal of victim compensation is achieved under the existing liability risk-sharing regime and is handled much the same way for aviation and space transportation, that is, under applicable state law. Whether strict liability or negligence theory applies, damage to uninvolved victims is generally compensated under the domestic legal regime. Internationally, the United States has not agreed to strict liability for aviation-related ground damage, unlike its acceptance of absolute liability for damage on the surface of the Earth under the terms of the Liability Convention. It would be more likely that as the commercial RLV industry matures, it may more closely resemble general aviation by private aircraft than commercial aviation. However, it is premature to speculate whether and when transition in the applicable liability risk-sharing regime for commercial RLVs would be appropriate.

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Chapter 8

Commercial Spaceport Operations

SPACEPORT FLORIDA

VIRGINIA SPACE FLIGHT CENTER

Chapter 8
Commercial Spaceport Operations

Chapter 8 defines and identifies currently licensed U.S. commercial spaceports followed by a discussion of planned future U.S. commercial spaceports. State laws and regulations that may affect spaceport liability are presented and evaluated in terms of their relevance to the current commercial space transportation liability risk-sharing regime. This chapter explores whether spaceport activities not otherwise eligible for indemnification under the CSLA require federal indemnification.

8.1 Introduction

As discussed in Section 1.1, Congress directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 6 of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act) states, "*examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations.*" This chapter presents an assessment and evaluation of currently licensed and future potential commercial spaceports, summarizes their coverage under the current U.S. risk-sharing liability regime, and examines whether change in federal law or policy may be appropriate to address spaceport operational risk.

8.2 Unique Commercial Spaceport Liability and Risk-Sharing Issues

The Commercial Space Launch Act of 1984, as amended (CSLA), envisioned the development of nonfederal launch sites that would be subject to licensing and safety regulation by the Secretary of Transportation. About 10 years after enactment of the CSLA, the first nonfederal launch sites were presented for Federal Aviation Administration (FAA) licensing, beginning with the California Spaceport, operated by Spaceport Systems International, L.P., which obtained a license in September 1996, followed by the Spaceport Florida Authority, which obtained a license in May 1997. Next, the Alaska Aerospace Development Corporation was licensed to operate a site at Kodiak, Alaska, and, finally, the Virginia Space Flight Center was licensed to operate on Virginia's Eastern Shore. Although other states have expressed significant interest in developing launch site infrastructure and facilities, many targeting the potential reusable launch vehicle (RLV) market in particular, none have yet been presented for FAA licensing.

Development of commercial spaceports has at various times been acknowledged as an important aspect of the Nation's spacefaring capability. The benefit of nonfederal launch infrastructure development is acknowledged by the CSLA, as amended, which directs the Secretary of Transportation to "take actions to facilitate private sector involvement in commercial space transportation activity, and to promote public-private partnerships involving the Federal Government, State governments, and the private sector to build, expand, modernize, or operate a space launch infrastructure" (49 U.S.C. 70103(b)(2)). In the

1990s, state-sponsored or -supported spaceports were created with assistance provided under a U.S. Department of Defense (DOD) grant program, which for two years provided funding to grant recipients for nonfederal launch site development. In 1997, in response to Administration tasking, the DOD, the National Aeronautics and Space Administration (NASA), and the FAA issued joint guidelines for federal interaction with launch site operators. A memorandum of agreement was signed by all three agencies explaining their respective roles and responsibilities with respect to launch site operators, whether located on or off of a federal installation, to enhance and facilitate launch site development by commercial and state government or state-chartered or -sponsored entities.

Commercial spaceports state that they support the operational and economic viability of U.S. commercial space transportation services and that they would benefit from a liability risk-sharing regime comparable to that applicable to licensed launch and reentry activities when providing associated launch site services not part of licensed launch or reentry. However, because the federal liability risk-sharing regime is in place only during licensed launch or reentry activities, commercial spaceports that wish to offer additional services or services extending beyond a site at which launch or reentry occurs must either:

- accept the risk and "bet" their assets in the event the amount is inadequate;
- buy some amount of insurance without federal guidance on limits (possibly erasing potential profit margins) and "bet" assets in the event the amount is inadequate;
- require iron-clad cross-waivers and liability coverage from customers (potentially chasing away customers by exposing them to risk and greater costs); or
- forego that line of business (not realizing needed revenue).

Further, because commercial spaceports are often quasi-public entities existing under certain authority conferred by state governments, they may not be permitted to risk state assets (as in the first option, above) that might be in jeopardy from a third-party liability claim. None of the four options are attractive, say proponents of changes in existing laws, and therefore they suggest that the federal liability risk-sharing regime for launch and reentry should apply to facilitate the ability of commercial spaceports to offer a full range of services to the commercial space industry and to cover unbounded risk from nonlaunch or reentry operations. One commercial spaceport stated publicly that without the benefit of a government-supplied maximum probable loss (MPL) determination and associated risk-sharing measures, they lack necessary guidance in determining how much insurance to obtain and remain perilously at risk if their determination is erroneously low (*see* Appendix A).

The four existing licensed launch sites are at coastal locations where they support launches of expendable launch vehicles (ELVs) operated by nonfederal entities and/or the U.S. Government. As described below in greater detail, three of the licensed sites are co-located on federal launch range installations. A number of states seek to develop inland launch and reentry sites to support future RLV operations. Both coastal and inland launch or reentry site operators would need to cover liability arising out of operations, whether hazardous or not, conducted at their sites, that are not part of an FAA-licensed launch or reentry, through insurance or other risk-sharing arrangements with customers or site users.

8.2.1 Definition of a Commercial Spaceport

The term "spaceport" has no legal significance or definition under the CSLA; it is a popular term used to describe entities involved in launch site-related activities. For purposes of this report, a commercial spaceport is a launch site whose operator has been licensed by the FAA. To be licensed by the FAA, a commercial spaceport operator must satisfy certain safety, operations, and environmental requirements. FAA regulatory requirements for a launch site operator license are codified at 14 CFR part 420 and include provisions governing public safety. Reentry site operator licensing requirements are codified at 14 CFR part 433.

8.2.2 Applicability of CSLA Liability Risk-Sharing Regime to Commercial Spaceports

Commercial spaceports participate in and benefit from the statutory liability risk-sharing regime, including indemnification, when they participate in a licensed launch or reentry as defined in FAA regulations. As explained by the FAA in supplementary information accompanying final rules governing financial responsibility requirements for licensed launch activities, "a licensed launch site operator would obtain the benefits and responsibilities of a contractor to the launch licensee as a provider of launch property and services" (*see* 63 FR 45592-45625, at 45594, issued August 26, 1998). As a contractor to the launch operator, the launch site operator would be an additional insured under the launch licensee's liability insurance and would participate in reciprocal waiver of claims agreements whereby it would assume its own risk of property damage or loss and agree to be responsible for its employees' claims. Accordingly, the site operator is insured against liability for third-party claims up to the MPL amount, eligible for indemnification in accordance with statutory provisions up to the prescribed amount, and insulated from certain interparty litigation.

The liability risk-sharing regime, including indemnification, applies to licensed launch activities, defined to commence upon arrival of a launch vehicle at a U.S. launch site (14 CFR 401.5). (A comparable regime would apply to licensed reentry activities.) The U.S. Government may appropriate the same indemnification level of up to $1.5 billion (adjusted for post-1988 inflation) above the MPL for third-party claims resulting from an FAA-licensed launch from a licensed launch site (or commercial spaceport,) as it would for a launch from a federal launch range. However, commercial spaceport-owned facilities would not be covered by FAA-required insurance, and the U.S. Government does not assume any responsibility for damage to commercial spaceport property, because it is not U.S. Government property. The commercial spaceport owner/operator (e.g., state agency) assumes financial responsibility for its own property and may obtain insurance to cover damage or loss to its property. The FAA does not dictate insurance requirements to cover spaceport property or liability apart from that arising out of a licensed launch or reentry. Each state may have its own specific insurance requirements under state law. Further complicating the matter are state laws regarding sovereign immunity of the state. In this chapter, U.S. Government law and policy with respect to spaceport liability risk-sharing is an issue only for those activities that are not part of licensed launch or reentry activities, e.g., those that precede launch and therefore arrival of the launch vehicle at the spaceport, those that follow the conduct of a launch, and those that may be conducted without any nexus to a launch vehicle being placed at the site for purposes of a launch (e.g., component testing, payload assembly). In those instances, a spaceport assumes responsibility for its third-party liability unless, by agreement, its liability is assumed (and therefore indemnified) by a customer using spaceport property or services.

For purposes of applicability of the statutory liability risk-sharing regime, inland launch and reentry sites present no unique issues from those confronted by coastal sites. It appears that the most hazardous operations that would be performed at inland sites would be launch or reentry of a launch vehicle, and such operations would either be performed under authority of an FAA license and therefore subject to the statutory risk-sharing regime, as described above, or government activities subject to government contractual risk allocation under other federal authority. Although many inland sites may not benefit from ready access to proven range safety capability, such as exists at Cape Canaveral, Vandenberg, Wallops, and White Sands Missile Range in New Mexico, concerns over additional launch or reentry safety risk, insurability, and insurance cost would be addressed as part of a launch or reentry licensee's demonstration of financial responsibility.

8.3 Current Licensed U.S. Commercial Spaceports

Currently, there are four FAA-licensed commercial spaceports in the United States, located in Florida, Virginia, Alaska, and California. Three of the licensed spaceports are co-located on federal ranges operated by the U.S. Air Force (USAF) and NASA in Florida, California, and Virginia. The Spaceport Florida Authority (SFA) is licensed to operate at Launch Complex 46 located on Cape Canaveral Air Force Station. The California Space Authority operates at Space Launch Complexes 6 and 7 at Vandenberg Air Force Base. The Virginia Space Flight Center operates on Virginia's Eastern Shore at NASA's Goddard Space Flight Center, Wallops Flight Facility. Alaska, using $18 million in federal grants, established the state-owned and –operated Kodiak Launch Complex, operated by the Alaska Aerospace Development Corporation on Kodiak Island, Alaska. Prospective commercial spaceport operators have entered into preapplication consultation with the FAA and are at various stages of concept maturity. Inland sites have been proposed in Oklahoma, Texas, New Mexico, Idaho, Utah, Montana, and California (Mojave Desert), among others, but an operator has not yet applied for FAA licensing. A prospective RLV operator is seeking to develop a private launch and reentry site for its exclusive use in Nevada at a location on the Nevada Test Site and is undergoing the environmental reviews necessary before developing the site. Inland commercial spaceports would likely be precluded from launching ELVs due to public safety considerations and would be restricted to RLVs proven sufficiently reliable to launch over populated areas. Currently, there is no operational nonfederal RLV, nor has an application been formally submitted to the FAA to operate an RLV. The Alaska Aerospace Development Corporation has successfully supported a number of DOD launches, and California has supported two government launches. These launches were government operations and therefore not licensed by the FAA. SFA has been the launch site for several licensed Lockheed Martin Athena rocket launches since 1998.

Each currently licensed launch site, or spaceport, is described below in greater detail.

Spaceport Florida Authority (SFA)

The SFA was created in 1989 as a state government agency to advance the state's space-related industry. According to the SFA, its powers are "similar to other types of transportation authorities (airport, seaport, etc.) to support and regulate the state's space transportation industry." SFA is broadly empowered to "own, operate, construct, finance, acquire, extend, equip, and improve landing areas, ranges, spaceflight hardware, payloads, payload assembly buildings, payload processing facilities, laboratories, and space business incubators."

To date, the SFA has sponsored, invested, and brokered about $500 million in space-related facilities throughout Florida, predominately at Cape Canaveral. While SFA owns these new facilities, it has created leaseback arrangements with commercial space providers at Cape Canaveral Air Force Station, which stimulate commercial activities.

One of the Nation's "oldest" commercial spaceports, SFA is evolving. No longer billing itself as just a commercial spaceport with launch pads and support facilities, SFA has embarked on a two-pronged approach to improve Florida's space-related activities.

First, SFA is not constrained simply to launching small rockets. It has in place, or is procuring (via capital purchase or long-term lease) facilities and infrastructure to support government and private customers with payload processing, launch integration, and launch itself. SFA considers that future space activities may not need the same kind of support currently rewired and that the savvy civil, military, or commercial customer is looking for more than a launch pad.

Second, SFA recognizes that it has a responsibility to enhance space as an economic driver throughout Florida. With a view to the future, SFA is looking at ways to facilitate technology and capabilities for 20 years into the future, growing industrial, economic, and education/research bases for future space activities in Florida. To highlight these new directions, there is even talk of changing its name to the Florida Space Authority.

These adjustments have been driven in large part by the dwindling small launch vehicle and corresponding low Earth orbit (LEO) communications satellite markets. SFA, like other commercial spaceports a decade ago, focused on the large LEO communications satellite constellations and replenishment opportunities for entrepreneurial launch providers. Fiber optic cable providers had a different view of the international communications grid and began laying fiber at rapid rates. Large satellite constellations, led by Iridium's fee and connectivity problems, caused the venture capitalists to lose faith in the space-based solutions, and similar providers, such as Globalstar and ICO, confronted financial difficulties.

Over the last year, SFA has reinvented itself. Not only is it positioning itself to provide what it touts as "world-class space services," it is also assisting entrepreneurial and established space launch providers with financing, public-market bonding, and alternative funding. SFA is licensed to operate Launch Complex 46 as a commercial launch site and will also operate Launch Complex 20; has committed $30 million for construction on a 400-acre (162-hectares) site for a life sciences research facility for the International Space Station; and is refurbishing NASA Hangar L. SFA is also the anchor tenant at the Florida Research Institute, a commercial space business park at the NASA-operated Kennedy Space Center.

In addition to providing economic assistance to space launch providers, SFA also works closely with the state legislature and relies on the state's "Space Ambassador," Lt. Governor Frank Brogan, to advocate Florida as a center of space excellence. Ed Gormel, SFA's new Executive Director, has a staff of 20 people and has begun to instill a business development culture. Mr. Gormel doesn't see SFA as simply an alternative launch site. Rather, SFA is posturing to respond to the needs of the community 20 years hence with a flavor not unlike that of the Orlando International Airport, according to Mr. Gormel. Mr. Gormel observes that the airport doesn't own the airlines or fly the airplanes, but they do provide them the best facilities and support services possible.

California Spaceport

Coalescing California commercial space activities began in 1986 and evolved into the Western Commercial Space Center, Inc. (WCSC), as a nonprofit 501(c)(4) corporation established in May 1992. Its mission was to promote development of commercial space in California. WCSC received its California State mandate in 1993 and became the California Spaceport Authority. Over the next several years, WCSC, the California Spaceport Authority, and the California Space Technology Alliance merged into the California Space Authority, which has been actively consolidating space-related activities and potential commercial space customers. California has a 50-year heritage with space and space-related activities and boasts of a unique resource chain beginning with higher-level education, a skilled workforce, 42,000 companies supplying space-related products and services, satellite manufacturing, and launch capabilities. The California Space Authority alliance intends to build upon these "natural" resources to enable and advance commercial space activities in California.

The California Spaceport is a licensed U.S. commercial launch site, operated by FAA-licensed Spaceport Systems International, Inc. (SSI), a limited partnership 90 percent owned by ITT Industries. The California Spaceport consists of 107 acres (43.3 hectares) co-located with Vandenberg Air Force Base, which have been leased from the USAF by SSI for a 25-year period commencing in 1995. At the end of this lease, all property and facilities on the property will revert back to the USAF. ITT invested less than $40 million to improve the existing satellite processing facility, install support facilities, and construct a launch site, designed for small launch vehicles (i.e., Minotaur, Athena, and Taurus). The infrastructure to support Delta II launches was incorporated into this launch site design. To date, the California Spaceport has successfully launched two Minotaur rockets for the USAF, but has not been involved in any commercial launches. Along with these launches, the California Space Authority derives income from satellite processing and engineering services.

Under the lease agreement with the Air Force, SSI has insurance coverage in the following amounts (per occurrence):

- $10 million for environmental damage and cleanup
- $10 million for its own and leased property, including buildings, land improvements, and personal property
- $20 million for third-party liability

Government launches performed at the California Spaceport on behalf of NASA or the Air Force are subject to Federal Government risk allocation authority, as opposed to the CSLA regime, including any potential indemnification that may be authorized for government activities. (*See* discussion of Public Law 85-804, in Chapter 5.) There has not been an FAA-licensed launch conducted at the California Spaceport; however, an FAA-licensed launch operator would be expected to provide insurance as required by the FAA under 14 CFR 440, with coverage for SSI as an additional insured. When satellite processing occurs, an activity not authorized by an FAA launch license, the satellite company as a customer provides insurance coverage with a rider for SSI, thereby protecting SSI from liability risk. Thus, SSI protects itself from risk by requiring commercial clients to assume the liability risk and obtaining insurance for the value of SSI property and improvements.

Virginia Space Flight Center

The National Advisory Committee for Aeronautics established NASA Goddard Space Flight Center, Wallops Flight Facility, in 1945. It is now one of the oldest launch sites in the world, located on the Virginia Eastern Shore. It supports scientific research and launches of orbital and suborbital payloads and has become home to the Virginia Space Flight Center (VSFC), which was licensed by the FAA in December 1997 to operate a launch site. VSFC offers two pads to launch small- to medium-size boosters. DynCorp established a subsidiary company, DynSpace, which entered into a 15-year renewable public-private limited liability partnership with the Virginia Commercial Space Flight Authority (VCSFA) in June 1999. DynSpace has made at-risk equity investments of $4.5 million to develop facilities and operate VSFC's Flight Center One. No commercial launches have occurred at the facility to date and neither DynSpace nor VCSFA is investing further in infrastructure until the space launch market improves, according to them.

VSFC is a state-sponsored commercial spaceport co-located with NASA's Goddard Space Flight Center, Wallops Flight Facility. VCSFA's Executive Director, Dr. Billie Reed, is enthusiastic about the prospects of the facilities and believes they, like other commercial spaceports, are preparing for a period in the future when access to space is comprised not only of ELVs but RLVs as well. Virginia authorities are devoted to building an infrastructure that will provide long-term economic, prestige, education, and development opportunities for Virginia and its citizens. VSFC sees itself like an airport. It plays a role in providing the infrastructure for supporting local needs for the space customer the way local airports and depots do for airlines.

Future business will depend on launch and satellite markets, but VCSFA/DynSpace has been aggressive in signing memoranda of agreement with most of the potential RLV developers for test, development, basing, and launching. Hopeful that this will lead to firm contracts in the future, VSFC in some cases has funded some RLV efforts to include design reviews, safety reviews, and engineering consultation. Its business plan includes launch facilities, but also payload processing and other launch services for customers.

Kodiak Launch Complex

Narrow Cape on Kodiak Island, Alaska, is the home of the recently completed Alaska commercial spaceport, operated by FAA-licensed Alaska Aerospace Development Corporation (AADC). Constructing new launch facilities with federal and state grants, the Kodiak Launch Complex (KLC) is an all-weather site on 27 acres (10.93 hectares) with four facilities: the Launch Control and Management Center; the Payload Processing Facility; the Integration and Processing Facility/Spacecraft Assemblies Transfer Facility; and the Launch Pad and Service Structure. The KLC has been the site of five government launches. Four have been successful, but no FAA-licensed launches have been conducted to date.

AADC was created as a public company in 1991, by Alaska state legislation to develop aerospace-related economic, technical, and educational opportunities for the State of Alaska. In January 1998, AADC began building a commercial spaceport at Narrow Cape of Kodiak Island, about 250 miles (402 kilometers) south of Anchorage and 25 miles (40 kilometers) southwest of the City of Kodiak. In 2000, AADC completed the Kodiak Launch Complex (KLC)—at a cost of $28 million—the first entirely new U.S. launch site since the 1960s and the only FAA-licensed launch site not co-located with a federal launch site. The 27 acre (10.93 hectare) Kodiak Launch Complex is located on a 3,100-acre (13.7-square-kilometer) site owned by the State of Alaska. The KLC is divided into four areas: (1) the launch control and management center; (2) the payload processing facility, which will include a 100,000-square-foot (9,290-square meter) clean room and processing bay; (3) the integration and processing facility, which includes a spaceport assembly transfer facility; and (4) the launch pad and service structure. A range safety system is also being procured by KLC.

KLC, which is located at 57 degrees North latitude, provides a wide launch azimuth and unobstructed downrange flight path to the south over the Pacific Ocean. KLC's planned markets are telecommunications, remote sensing, and space science payloads of up to 8,000 pounds (3,629 kilograms) into low Earth, polar, and Molniya orbits.[1] There have been five successful rocket launches from KLC. The first launch from Kodiak was a suborbital vehicle, Ait-I, built by Orbital Sciences Corporation for the USAF in November 1998, with the second successful suborbital vehicle Ait launch in September 1999.

The first orbital launch from KLC occurred in September 2001 for a NASA collaborative mission with the Department of Defense, known as Kodiak Star. The payload consisted of four small satellites launched aboard a Lockheed Martin Athena I launch vehicle. Two other suborbital launches from KLC occurred in 2001, Quick Reaction Launch Vehicle (QRLV-1) for the Air Force and POLARIS-ORBUS-1

[1] Polar orbit allows maximum coverage of the Earth's surface. Molniya orbit is a highly elliptical orbit used primarily for communications. This orbit allows a specific geographical region prolonged exposure to a satellite as it enters its apogee.

for the Army. KLC also intends to provide support for RLV operations as these vehicles are developed and deployed.

8.4 Future U.S. Commercial Spaceports

Viability of inland commercial spaceport operations over the next decade will be dependent upon RLV developments to support launch demand for LEO satellites and emerging space services. In the mid-1990s, many launch projections relied on sustained market demand for LEO telecommunications satellite architectures being offered by Iridium, Globalstar, Teledesic, and others. Some projected that over 1,000 satellites would be launched from 1998 to 2003, most of which contributed to high-density, LEO constellations. Consistent with national and commercial space policies, commercial spaceports were seen as a solution for launching and replenishing hundreds of commercial LEO communications satellites. Unfortunately, the economics and financial returns associated with large constellations of small satellites failed to materialize. As the market changed, a downturn in expected launch activity at commercial spaceports occurred.

RLVs were highly touted throughout the 1990s. Encouraged by an infusion of venture capital, projected expanding launch rates, available off-the-shelf technologies, and a national space policy that charged NASA to develop a Shuttle replacement, industry saw at least five major commercial RLV competitors emerge. They were Kistler Aerospace Corporation (Kistler), Kelly Space and Technology (Kelly), Rotary Rocket Company, Pioneer Rocketplane, and Space Access, LLC. In addition to these commercial competitors, NASA embarked on a cooperative arrangement with Lockheed Martin to develop the X-33, which Lockheed Martin sought to develop into a commercial RLV known as VentureStar, and with Orbital Sciences to develop an X-34. As market forces underpinning large LEO constellations receded, additional capital needed to bring RLVs through demonstration to operations also waned. As a result, NASA recently cancelled its X-33/X-34 programs, Rotary Rocket has gone out of business, and Kistler, Kelly and Space Access have aligned with NASA's Space Launch Initiative technology development efforts. It is not likely that a commercial RLV will become fully operational for at least a decade, or possibly longer. (*See* discussion in Chapter 7.)

A market must emerge that will support commercial RLV development and use. Heretofore, replacement launches for LEO communications satellite constellations that numbered in hundreds of satellites were thought to be the market for RLVs. With fiber optic communications cable being laid at an exploding rate, the networking of worldwide cell phone capabilities, and the venture capital market drying up, the LEO communications satellite market is in steep decline. Without a strong satellite market for RLVs, they will be forced to compete with extant and emerging small ELVs, which are launched from federal coastal commercial spaceports. The cancellation of NASA's X-33 and apparent termination of VentureStar development by Lockheed Martin has further delayed development of inland spaceports.

Interior or inland commercial spaceports are attractive to localities interested in developing space-related commerce because RLVs are presumed to be more reliable than ELV operations, inasmuch as they are designed to return to Earth intact. Many also believe RLVs will be single-stage-to-orbit vehicles and therefore will not have to jettison fuel tanks or solid-fuel rocket segments as do ELVs over populated areas. If financing and technology hurdles can be overcome (and absent an explosion of funds and demand from LEO constellations), RLVs and interior commercial spaceports will likely launch small conventional-type satellites for traditional customers. Other satellites may be university-based experiments and small technology demonstrators. Other potential uses for RLVs include space tourism and space station resupply. Such new markets must emerge to support the RLV business case. A growing alliance of potential commercial spaceports has emerged that seeks to align itself with in-state, high-tech university efforts that will result in robust scientific and space opportunities.

In addition to commercial spaceports located on federal launch ranges in California, Florida, and Virginia, and the state-supported Alaska spaceport, potential commercial spaceport sites have been identified in New Mexico, Oklahoma, Idaho, Nevada, Montana, Utah, and Texas.

New Mexico's Economic Development Department established the New Mexico Office for Space Commercialization (NMOSC) in 1994 to "coordinate, promote, develop, and manage New Mexico's Regional Spaceport Program" (EDD 1994). In conjunction with NMOSC, a Southwest Regional Spaceport has been proposed at Upham in southern New Mexico, close to Las Cruces. The facility plans to build a launch complex, payload assembly facility, support annexes, systems development complex, site infrastructure, and a 12,000-foot (3,660-meter) runway. An RLV launch rate is projected to be once a week, which is projected to generate $574 million per year (EDD 2001).

Oklahoma has also entered the commercial spaceport market, offering to build an Oklahoma Spaceport at the old Clinton-Sherman Air Force Base at Burns Flat in southwest Oklahoma. Under the auspices of the Oklahoma Spaceport Authority and the Oklahoma Space Industry Development Authority (OSIDA), the state legislature approved $925,000 to fund the first year of operation of the commercial spaceport, hoping to be a competitor as a launch site for NASA's $5-billion X-33 and Lockheed Martin's VentureStar project. In addition to the RLV market, Oklahoma Spaceport is also considering the launch of a Super Lo-Ki Rocket Program that would stimulate high-tech education opportunities and student-led launches. Three launch providers have approved "understandings" with Oklahoma Spaceport, with Space Adventures (space tourism), Pioneer, and Space Clipper to operate from the Burns Flat location (Westok 2000, Space 1999, Daily 1999). Chris Shove, an OSIDA board member, expects full operations by 2025 and has flight proposals beginning in 2002 (David 2001).

Idaho entered the commercial spaceport picture in 1998 when the Idaho Department of Commerce initiated a study for hosting polar launches of RLVs from the U.S. Department of Energy's (DOE) Idaho National Engineering and Environmental Laboratory grounds located in southeast Idaho. Plans call for two launch pads; fueling and payload integration facilities; range safety and telemetry tracking facilities; and mission control, maintenance, and integration facilities. Idaho expects commercial spaceport operations to bring more than $1 billion to the state's economy. An element in Idaho's commercial spaceport planning, not unlike other interior commercial spaceports, projects 60 polar satellite launches per year by 2003. No current market projections support this sort of robust launch rate (Idaho 2001).

Montana has established the Montana Space Development Authority, with hopes of supporting RLVs by advertising use of a runway at Malmstrom Air Force Base in Great Falls, Montana, as a landing site.

Utah is also soliciting support for RLV space activities at a launch site near Milford, Utah, in the Wah Wah Valley. All facilities would have to be constructed. The Utah General Assembly enacted the Utah Spaceport Authority Act (found at Section 72-13-101 of the State Code) during the 2001 legislative session, which establishes the Authority and defines its powers.

Texas has proposed several commercial spaceport locations. The two coastal sites with the most promise are the Kenedy Memorial Foundation property in Kenedy County south of Corpus Christi and Brazoria County south of Houston. An inland site is near Fort Stockton in West Texas. Hoping to attract RLV operators to one of these launch sites, Texas has formed the Texas Aerospace Commission, and the state legislature has agreed to the creation of local commercial spaceport authorities with authority to acquire property and issue revenue bonds. A coastal location would allow polar and equatorial launches, and, with proximity to Johnson Space Center in Clear Lake and the petrochemical industries surrounding Houston, Texas believes a commercial spaceport could prove viable. However, like many other commercial spaceport efforts and RLV development programs, projections were premised upon an expanding commercial satellite market.

The State of Nevada may also be the site of RLV launches at the Nevada Test Site, a DOE facility that is a 1,375-square-mile (3,561-square-kilometer) area, which is located 65 miles (105 kilometers) from Las Vegas. Kistler would develop a site for private use under a subpermit from the Nevada Test Site Development Corporation (NV 2001).

8.5 State Laws and Regulations Affecting Commercial Spaceport Liability

In public discussions, supporters of commercial spaceports have raised issues of potential liability as one factor limiting the growth of commercial spaceport operations. A related topic involves sovereign immunity, a complex and multifaceted area of law when dealing with quasi-public entities, subject to differing interpretations of state constitutional law. To better understand the legal/regulatory context involving commercial and/or state-sponsored commercial spaceports, an analysis was undertaken to examine: (1) statutes establishing commercial spaceport facilities, authorities, boards, or other entities; and (2) statutory or other authority that might prevent commercial spaceports from accepting certain risks. State codes examined include those of Florida, Virginia, California, Alaska, Montana, Oklahoma, Texas, Nevada, New Mexico, and Utah.

8.6 Summary of State Laws Affecting Commercial Spaceport Liability and Risk Management

Florida

The statutes creating SFA and the Florida Commercial Space Financing Corporation are found in Chapter 25 of the Florida Statutes Annotated (25 Fl. Stat. Ann.), Sections 331.301 and 331.401, respectively. SFA is a public corporation governed by a board with broad powers to "provide projects in the state which will develop and improve the entrepreneurial atmosphere, to provide coordination among space businesses, Florida universities, space tourism, and the Spaceport Florida launch centers, and to provide activities designed to stimulate the development of space commerce" (Section 331.302). As a state agency, SFA enjoys sovereign immunity in its administrative, day-to-day activities (outside of launch operations and actual launch events).[2]

Section 331.50 of the statute states that, "notwithstanding any other provision of law, the State Risk Management Trust Fund …shall not insure buildings and property owned or leased by the authority" and goes on to state the fund "shall not insure against any liability of the Authority." The authority is directed further to develop a safety program to prevent losses and is directed to purchase, "if available," insurance "within reasonable limits" for liability and "if cost-effective" for its own assets. It would appear, then, that the Florida legislature envisioned the SFA as an independent actor in the area of potential liability.

Virginia

The Virginia Commercial Space Flight Authority (VCSFA) Act is embodied in Chapter 9 of the Virginia Statutes Annotated Section 266.1 *et seq.* and creates a political subdivision of the Commonwealth to address the need to "(i) disseminate knowledge pertaining to scientific and technological research and development among public and private entities, including but not limited to knowledge in the area of space flight; and (ii) promote industrial and economic development." The legislature declared the function of the Authority to be an "essential government function and matter of public necessity for which public moneys may be spent and private property acquired" (Section 266.3). Among other powers, the

[2] Statement of E. Keith Witt, Spaceport Florida Authority, Nov. 14, 2001.

Authority can "sue and be sued, implead and be impleaded, complain and defend in all courts." However, Section 266.6 goes on to state that "no liability shall be incurred by this Authority hereunder beyond the extent to which moneys shall have been provided under the provisions of this chapter." The section deals primarily with the issuance and backing of bonds, however, so it is unclear whether "liability" in this context includes that which may come from injured third parties, or simply debts owed to bondholders.

In discussions with VCSFA, it became apparent that, as a political subdivision of the Commonwealth, the Authority is treated much like a town or city. It participates in the Commonwealth of Virginia Local Government Risk Management Plan, which, despite its name, supports "every type of district, commission, board, or authority" (TRS 2001). This does not mean, VCSFA stressed, that the Commonwealth shoulders all liability for such subdivisions, particularly public corporations. For example, the Commonwealth elected to insure Virginia Rail Express privately. Article VII of the Constitution deals with obligations and liabilities of local governments; the Authority is a "political subdivision" of the Commonwealth and may be treated as a local government for purposes of liability. Like towns and cities, the activities may not expose the Commonwealth to financial risk.

The indemnification issue arose with VCSFA when the FAA first licensed the facility. It appears some nomenclature changes (i.e., "insure" instead of "indemnify") were sufficient to remove state strictures against indemnifying the Federal Government. However, when "launch activities" are not taking place, the insurance levels required of a launch licensee by the FAA (deriving from its maximum probable loss [MPL] calculation) are not in place either, and there are no firm rules by which VCSFA can set insurance levels when conducting activities such as engine balancing or payload processing for a customer. VCSFA is concerned that purchasing insurance could result in either inadequate coverage for an overly optimistic operator or a depletion of the profit margin for a conservative one.

California

The status of commercial spaceport issues is slightly different in California than in other localities, because, although the California Space Authority is a state entity empowered to designate commercial spaceports pursuant to California Statutes Annotated Government Section 1348.5 *et seq*., the single existing commercial spaceport is a private operation. SSI, a wholly owned subsidiary of ITT, operates a commercial spaceport on 107 leased acres (43.30 hectares) co-located with Vandenberg Air Force Base. SSI, as a private entity organized as a limited liability partnership, is the operator of the site, and would be liable in the event of an accident injuring third parties. The commercial spaceport carries liability insurance for non-launch-related activities in the following amounts: $10 million for real and personal property; and $20 million third-party liability (all per occurrence). In the event of a non-launch-related accident resulting in damages in excess of the policy limits, SSI assets would be available to satisfy the judgment. For FAA-licensed commercial launch activities, the launch operator would obtain liability insurance for licensed launch activities and, with the spaceport, would execute a waiver of claims agreement under which each party accepts risk to its own property and is financially responsible for losses to property and personnel.

Alaska

Alaska Statutes Annotated Section 14.40.821 creates the AADC as a public corporation of the state. It is affiliated with the University of Alaska and the State Department of Community and Economic Development. Like the Florida law, Alaska Statutes Annotated Section 14.40.846 requires establishment of a safety program to minimize risk, and also contains insurance requirements. Part B of the statute states that "the corporation shall, to the extent available and consistent with federal requirements, secure insurance coverage within reasonable limits for liability that may arise as a consequence of its activities and the activities of its officers and employees and to insure its buildings, structures, and other facilities against loss." Analysis did not find any clauses in the Alaska Constitution that addressed this specific issue.

Montana

Montana Statutes Annotated 7-15-4283 *et seq.* was amended in 1999 to create an Aerospace Transportation and Technology District that would enjoy special tax status. The statute permits the sale of bonds and specifically confers additional benefits on the condition that Lockheed Martin elects to locate its VentureStar launch and reentry operations facility within Montana. No specific site for the commercial spaceport is identified.

Oklahoma

The Oklahoma Space Industry Development Act is found at Oklahoma Statutes Annotated Section 74-5201 *et seq*. The statute establishes the Oklahoma Space Industry Development Authority as a state agency that "may sue and be sued, implead and be impleaded" (Section 74-5203). Unlike the other state statutes, however, this act specifically grants to the Authority "sovereign immunity in the same manner as this state, and the liability of the Authority and its members, officers, and employees shall be governed by the provisions of the Governmental Tort Claims Act. Provided, however, the Authority is authorized to carry liability insurance to the extent authorized by the Authority" (Section 74-5205). Under certain circumstances, the Authority may therefore be immune from suit in Oklahoma.

Texas

The Development Corporation Act of 1979 is codified at Texas Civil Statutes Sections 5190.6 and was amended in 1999 to specifically permit development of commercial spaceport facilities. Liability for operations is addressed for operating contractors: "the [spaceport] corporation may not contract to operate a commercial spaceport unless the agreement provides that the person contracting with the corporation assumes the corporation's liability for a cause of action arising from environmental damage." Texas Civil Statute 5190.4D(2)(h). It is unclear how liability arising from non-launch-related activities would be addressed; however, as noted below, Texas confers sovereign immunity for public entities like airport authorities by statute.

New Mexico

New Mexico Statutes Annotated Section 9-15-43 *et seq.* establishes the Space Commercialization Division of the New Mexico Economic Development Department, which has a mission broadly defined as establishing a regional commercial spaceport in the state. Activities are overseen by a space commission. Specific actions related to liability do not appear to be defined, although the business plan of the Southwest Regional Spaceport contemplates an array of non-launch-related activities that could take place at the spaceport. These activities include, but are not limited to, manufacturing, testing, maintenance and staging for aircraft, airborne law enforcement activities, flight training, and space-related ground control services. Potential liability for activities undertaken in these areas would likely be addressed through contractual arrangements that may include cross-waivers or the purchase of insurance.

Utah

In July 2001, the Utah General Assembly enacted the Utah Space Authority Act, which is codified at Section 72-13-101 *et seq*. The Act establishes the Authority as an instrumentality of the State, and granted it regulatory and contractual powers. The Authority is to be governed by a Spaceport Advisory Board. No specific sites for potential use as a spaceport are mentioned. The Department of Community and Economic Development has jurisdiction over specific administrative and operational aspects of the Authority and provides staff support to the Advisory Board.

Airport Liability and Potential Analogues with Commercial Spaceports

Most airports in the United States are owned and operated by municipalities or by authorities formed for the specific purpose of owning and operating the airports. From the standpoint of sovereign immunity, municipalities may be liable if the activity in question is of a "proprietary" nature; that is, if the activity has a private, permissive, or corporate nature. The essential question, as outlined in *Wendler v. City of Great Bend* (316 P. 2d 265, 270 [1957]), is in what capacity was the municipality acting at the time. Most jurisdictions have held that operating an airport is a corporate or private activity and have not applied sovereign immunity on that basis. Where sovereign immunity is found for airport authorities, it is typically because a specific statute conferred such immunity from suit, as is the case in Texas (*City of Corsicana v. Wren*, 159 Tex. 202, 317 S.W. 2d 516 [1958]).

In a majority of jurisdictions, a parent municipality may be immune from suit if a subsidiary organization operated completely independently, such as an airport authority. Suits may be filed against the authority itself, which, like other businesses, must purchase liability insurance, but the parent entity is shielded.

8.7 Summary

Liability risk of commercial launch sites, or spaceports as they are popularly called, resulting from licensed launch and reentry is included within the statutory allocation of risk regime of the CSLA. Spaceport third-party liability is covered by insurance obtained by a launch or reentry licensee, and the spaceport would receive the benefits of indemnification for excess liability in the same manner as other covered contractors to the launch or reentry operator.

Those operations performed at or by spaceports that are not part of FAA licensed launch or reentry activities also expose the spaceport to liability for third-party claims not covered by the CSLA risk allocation regime. At the public meeting convened by the FAA in April 2001 to receive public views regarding appropriate liability risk-sharing arrangements under the CSLA, one spaceport stated that it performs certain functions that may expose it to the risk of third-party liability, and that without federal guidance it is unable to determine how much insurance to obtain to adequately cover that risk. However, at the public meeting, none of the spaceport activities identified appear comparable to a launch or reentry of a launch vehicle in terms of hazard or risk so as to expose the state to uninsurable or otherwise unmanageable risk.

State authorities manage spaceport risk under state law in a variety of ways. States having existing licensed commercial spaceports have more fully addressed issues of liability for non-launch-related activities, although they appear to have dealt with those issues differently. California's licensed commercial spaceport operator has obtained insurance in accordance with its agreement with the U.S. Air Force and obtains a waiver before customers undertake non-launch-related activities. Virginia's facility seems to have declined some payload preparation activities due to liability concerns. The Florida and Alaska commercial spaceports seem to address the issue through purchase of insurance and implementation of safety programs. States contemplating establishing commercial spaceports have addressed the issue in varying ways, or not at all. There are indications that legislators regard commercial spaceport establishments in certain states as "public" activities of the state, and they would therefore be considered acts of a sovereign entity and thus immune from suit.

Spaceports may provide technical, research, and educational opportunities that are important functions and as such have garnered state support. Spaceports are developing without indemnification by the Federal Government for non-launch and non-reentry activities, however. At present, there appears no basis on which to seek legislation extending the indemnification (or payment of excess claims) provisions of the CSLA to spaceports for activities not encompassed by the broad coverage of an FAA license for launch activities[3] or future reentry activities. There is no basis on which to conclude that non-launch-related risks are not manageable through insurance or private risk allocation agreements between a spaceport and its customer, that is, a user of spaceport services or facilities, so as to adequately cover spaceport liability risk.

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[3] Licensed launch activities begin with arrival of a launch vehicle at the launch site.

Chapter 9

Consideration of Possible Modifications

Chapter 9
Consideration of Possible Modifications

Chapter 9 presents an identification and analysis of different modifications to the current liability risk-sharing regime for commercial space transportation. New modification options evaluated in this chapter are: trust funds, self-insurance, captive insurance, catastrophe bonds, and publicly subsidized insurance (i.e., through tax subsidies). This chapter also evaluates the following changes to the current liability risk-sharing regime: maintaining current requirements for maximum probable loss (MPL)-based insurance without government indemnification above the MPL; requiring the maximum available insurance at reasonable cost instead of MPL—again, without any government indemnification; increasing the conservatisms and reducing the probability basis so as to increase the numerical value of MPL; and reducing government indemnification to $1 billion, but eliminating the sunset provision. This chapter also provides a summary comparison and analysis of benefits and costs of the range of possible modifications and changes considered to the current liability risk-sharing regime. Recommended options for consideration are discussed in Chapter 10.

9.1 Introduction

As discussed in Section 1.1, Congress directed that the current commercial space transportation liability risk-sharing regime, including indemnification, be evaluated with respect to several key issues that have characterized public debate. Issue 7 of the Commercial Space Transportation Competitiveness Act of 2000 (also know as the Space Competitiveness Act) states, "*recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.*" The extensive public discussion associated with the legislative history since 1988 and continuing to the present, together with greater space launch vehicle experience and changes in insurance markets, leads to consideration of a variety of possible alternatives, should policy makers conclude that modifications are in order. This chapter discusses various options and compares them based on differences in their benefits, costs, and other advantages and disadvantages. Recommended options for consideration are presented in Chapter 10.

9.2 Liability Risk-Sharing and Indemnification Alternatives

This section explores several alternative options. The first set of options presents different approaches to managing liability risk. Included in the discussion are trust funds, self- and captive (pooled or group) insurance, and public tax subsidies for the costs of insurance. The second set of options, presented in the next section, examines changes that might be made within the current regime while maintaining basic elements of its construct. They include: changing the MPL methodology to yield greater dollar value—i.e., "probable plus"), and, more radically, eliminating government indemnification. The options discussed are neither exclusive (there may be other alternatives not considered here) nor mutually exclusive (a combination of alternatives may produce an option). For example, as in the case of the commercial nuclear power industry, the government could require primary and secondary tiers of insurance with the second tier funded by mandatory industry pooling arrangements.

The following options were identified for analysis to facilitate consideration of costs, burdens, and benefits. Before discussing them, some notes may be useful about the value of the government's continued role in setting the MPL and the evolving federal and state roles in spaceport operations.

Government's role in determining MPL. In all of the options, unless otherwise indicated, it is assumed that the government continues to require a demonstration of financial assurance at the MPL amount. Under current law, financial responsibility may be demonstrated by use of the alternative means considered in this section as long as they satisfy terms and conditions of 14 CFR 440. The options considered in this analysis would take the place of insurance and government indemnification. Although the MPL amount could continue to be specified by the government or by commercial insurers, there are significant advantages to the government specifying the MPL. First, the public is likely to demand that provision be made for third-party damages, and credibility is often accorded government specification of the appropriate amount. Probable damage estimates set by private entities are subject to the tendency of the insured to want low estimates to keep the purchase costs down and the tendency of insurers to want higher estimates to increase the coverage purchased. For the same reason, government-established MPL limits also can promote objective compliance monitoring, since insurers, sureties, and banks usually provide the financial products used to demonstrate compliance. If these institutions also set the loss limits, then questions may arise about objectivity in the case of third-party damages.

Second, compliance with financial assurance rules specifying required amounts of liability coverage has come to be routinely accepted by a wide variety of commercial operations, including municipal landfills; ships carrying oil or hazardous cargo; hazardous waste treatment facilities; offshore oil and gas installations; underground gasoline tanks; nuclear disposal and nuclear power facilities; and hard-rock and coal mines (many of these cases are discussed in Chapter 3). Similarly, the space transportation industry appears comfortable with the concept of required financial assurance at government-set levels.

A third reason for government determination of the MPL is that third-party risks can be difficult to value, especially as new launch vehicles and commercial space launch facilities become established. Methods used to calculate these risks can also often be controversial, since damages can be unpredictable and highly sensitive to the valuation methodologies used by the courts. It may be that both government and private risk assessors have access to the same engineering expertise for making these estimates, but government-established “rules of the road” may offer the best approach to mediate the possibly conflicting interests that could be perceived to arise in the event of damages to third parties. A similar difficulty characterizes natural resource damage assessments, for instance. A marine underwriter has commented that “the dangers posed by potentially excessive and arbitrary assessments present the most serious threat to our ability to continue to insure liabilities under the federal pollution statutes” (Hobbie 1996).

Fourth, the government must be satisfied that its own liability, whether arising under international treaty or by virtue of government involvement in licensed activity will, in all likelihood, be satisfied as was the case before enactment of the existing liability risk-sharing regime.

Federal and state roles. The Commercial Space Launch Act (CSLA) currently preempts state laws for launch liability management purposes that are not consistent with the CSLA. However, at some future date when state-sponsored commercial spaceports may have a large volume of business and consequently higher risk profiles, states may reexamine, and attempt to redefine, their risk management approaches.

This has been the case in other areas of liability exposure. As states develop their own spaceport capacity, the relationship between state and Federal Government regulation may call for additional policy discussion. In general, state laws sometimes complement and expand upon federal assurance regulations. States also often implement the assurance rules mandated by federal law. In some cases, individual states can have assurance requirements that exceed those under federal law. Examples include California, Alaska, and Washington State, which have more stringent requirements for potential spills from oil-carrying vessels and other oil-related operations (of terminals, pipelines, and so forth). In other cases, states require assurance when the Federal Government does not. For instance, Michigan requires assurance for the reclamation of sand dune mining areas; other states require assurance for scrap tire disposal facilities; transportation of hazardous medical waste; closure of agricultural operations involving animal waste; and dry-cleaning operations. This may be the situation for state-sponsored spaceports as long as state requirements are not inconsistent with Federal requirements under the CSLA. States are also often responsible for implementing federal law. For example, states must implement assurance requirements under the Resource Conservation and Recovery Act (RCRA) for hazardous waste and for underground storage tanks and landfills. In other cases, states must come to agreement with the Federal Government over bonding criteria (for example, for mines on federal land). The Department of Interior must approve states' "primacy," or "independent enforcement authority," for surface mining reclamation.

In the discussion that follows on alternative approaches to managing third-party liability associated with space transportation, different roles of state and Federal Government are indicated when relevant (for example, for financial assurance for state spaceports). There is significant flexibility in how these roles can be allocated, however, and the discussion is intended to illustrate rather than definitively outline state and federal responsibilities or their interaction. Under the terms of the CSLA preemption provision, a state can require a spaceport to have liability insurance whereas the Federal Government does not, and more generally, the CSLA allows states to have more stringent requirements as long as they are not inconsistent with federal requirements under the CSLA. Although launch safety would be regulated by the FAA for FAA-licensed launches, another issue is whether states have experience commensurate with the Air Force/National Aeronautics and Space Administration (NASA) operation of federal ranges.

9.2.1 Trust Funds

This option includes the concept of a trust fund for the space transportation industry as a whole, as well as the use of trust funds by states establishing spaceports, in amounts at least equal to the MPL-based insurance amount or the amount of indemnification (as noted in Section 9.2).

Trust funds are usually funded by a firm or industry itself. They involve an independent trustee and, when used to demonstrate financial assurance, funds are releasable only on the approval of the regulator. Funds can be set up by firms to demonstrate financial assurance, or they can be established by legislation. When set up by a state or the Federal Government (as in the case of CERCLA for the chemical industry, discussed in Chapter 5), trust funds are typically financed by continuing taxes or fees on a firm's operations. So-called third-party trust funds are administered by an independent trustee in charge of collecting, investing, and disbursing funds. Many liability regimes for activities that may harm third parties center on a trust fund to which parties contribute based on a fee per barrel, passenger, mile, and so forth. Money can be paid in over some period of time; however, the timing of pay-ins should be such that the fund is fully funded in the event of a claim. The regulator (such as the state) is usually the sole beneficiary of the fund. After obligations are fulfilled, trust assets are returned to the firm.

A space transportation fund could be financed by launch fees based on the MPL calculation and used to compensate for property and third-party damages. The government or the private sector could manage the fund. With the development of spaceports, state trust funds could be established to insure against property and third-party damages resulting from spaceport-supported launches and could be modeled after states' approaches for funding underground storage tank assurances (EPA 2001). In that case, states are required to submit information to the U.S. Environmental Protection Agency (EPA) so that EPA can determine that the fund is "equivalent" to other compliance mechanisms allowed by regulation such as insurance, letters of credit, surety bonds, and corporate guarantees. Analogously, state trust funds for space transportation could be required to submit information to the Federal Aviation Administration (FAA) Office of Associate Administrator for Commercial Space Transportation (AST).

An advantage to firms of a trust fund is that, as noted, interest on the fund can be returned to the firms. Trust assets can also be returned. For example, a firm that may decide to exit the industry could receive a portion of the assets. It is common for a board to oversee the fund, and, thus, firms could also have a say in how the fund is managed and its assets invested. There are administrative costs to establishing and maintaining the fund, although these need not be large. There are also administrative and oversight costs to the regulator of ensuring that the fund meets financial assurance requirements. These costs are borne by the regulator if the regulator is the fund administrator (as is the case with the Oil Spill Liability Trust Fund, administered by the U.S. Coast Guard's National Pollution Funds Center). Alternatively, the fund could be administered commercially and a report made regularly to the regulator in the form of letter guarantees from the financial institution managing the fund.

An additional note that offers useful historical perspective is in order about the evolution of state trust funds in the case of insuring underground storage tanks for damage to the environment. The trust fund approach was set up by Congress in 1986 by amending RCRA. Since then, however, the commercial insurance market has evolved such that commercial pollution liability insurance, which also meets the federal financial responsibility requirement, is readily available and generally affordable. Growth of this insurance market has not been hampered by lack of supply, but by lack of demand due to competition from state assurance funds, according to the EPA. As a result, many states are transitioning from a state fund program to permitting commercial insurance as a financial assurance mechanism.

Trust funds can be set up by a single firm – and often are. A key issue with trust funds is the time period over which the fund becomes fully funded. Often, firms are allowed to "pay in" to a fund over a period of years. In the period of time before it is fully funded, there is a level of exposure that can be problematic. A mutual insurance situation, like a group captive, can pose problems if it involves a small number of firms that are unable to effectively spread the risk. The real issue is the degree to which the risk is likely to be correlated across firms, such that the value of the mutual's assets are correlated with the value of a particular firm. Financial distress from one firm can undermine the solvency of the mutual if this risk is correlated. The larger the number of firms, the less correlation. In the case of space transportation providers, this issue can be defined as the likelihood of a systemic problem common to all firms (vehicles) occurring at the same time – probably somewhat unlikely.

9.2.2 Alternative Insurance Markets

Another approach is greater reliance on the insurance market for fuller or even full indemnification. In this case, the government's role in calculating the MPL is likely to remain highly important as a participant in third party liability management. The insurance marketplace has evolved significantly since the mid- and late 1980s. At that time (recall that this is the time of enactment the CSLA and 1988 Amendments), headlines in the trade press talked endlessly about the hard insurance market. These difficulties led to the beginning of adoption of alternative insurance techniques by many large corporations. These include self-insurance and captive insurance companies. New financial instruments for group insurance, such as catastrophe bonds, have also arisen. These insurance options are discussed next.

9.2.2.1 Self-Insurance

Under self-insurance, firms would reserve funds to compensate third parties for liability coverage greater than the MPL amount. Self-demonstrated assurance involves a demonstration of profitability and stability on the part of the firm. It also requires the government to monitor the firm's financial condition over time using such indicators as asset ratios, profitability indicators, and bond ratings. Rules may require that the firm's working capital and net worth (sometimes net worldwide liabilities for firms with overseas operations) both be greater than the coverage amounts. Sometimes a parent corporation can satisfy the coverage requirement by offering a financial guaranty or indemnity agreement. Financial guarantors must themselves pass the corporate financial tests. Self-insurance is a common approach by corporations for covering workers' compensation, general liability, product liability, and property.

Firms often prefer self-demonstrated assurance and parent guarantees because these can reduce the cost of insurance and increase the control the firms have over financial assets. Firms can also combine self-insurance with commercial assurance for greater financial flexibility. For example, most self-insurance covers the primary layer of insurance where there is less variability in the loss results than in excess layers. Disadvantages to the firm are that reserve funds of the size to cover third-party liability represent commitment of a sizeable amount of assets. In addition, there are costs of administration; complexities that can arise when divisions of a firm may be sold or liquidated; and the costs of paperwork that may be required to demonstrate regulatory compliance (which may include actuarial reviews). The cost to regulators is monitoring the programs to ensure financial assurance requirements are met, usually based on assessment of the financial condition of the corporation. The assessment need not be performed by the regulator (for example, FAA in the case of space transportation self-insurance), but could be satisfied by letters of credit or bonds or by independently conducted audits of the firm's insurance provisions. Small businesses can combine self-insurance with commercial insurance, as noted above.

9.2.2.2 Captive Insurance

An alternative institutional structure for pooling risk is a captive insurance organization. In this arrangement, the insurance is pooled together and then owned and controlled by the insureds. A captive insurance company is described as a single-parent captive if it is owned and controlled by one company and insures that company and/or its subsidiaries. A group captive is an insurance arrangement in which pooled insurance is owned and controlled by two or more organizations, usually similarly regulated firms. Members at risk hold the equity, and contributions reflect each member's relative risk. Surpluses can be given back to the members at the end of accounting periods; shortfalls in covering losses can be allocated among members in the form of additional contributions. In the United States, group captives are licensed by a domiciliary state and use a fronting carrier, or they operate under the Federal Risk Retention Act. There are an estimated 3,500 captives worldwide.

Doherty originally proposed that the group captive plan be used for insuring third-party risks associated with space transportation, and Simonoff suggested that a pool could be used in conjunction with other forms of insurance (Doherty 1986, Simonoff 1985). (A captive could also be arranged to include not only space transportation launch providers, but satellite manufacturers and operators as well.) A captive is particularly advantageous for space transportation firms when the relative risk among different types of vehicles is fairly well known. The group can be managed by an insurance broker or firm to avail the captive of the actuarial, investment, claims handling, accounting, reinsurance, and related skills of the insurance industry. Firms usually find that a captive gives them flexibility and reduces the cost of operations. From a wide societal perspective, a group captive has the advantage of encouraging firms to control losses, since they share in income earned by the captive. A disadvantage is that group captives present monitoring problems for the government regulator, in that the regulator must oversee the captive, ensuring that it meets financial assurance requirements. For this reason, the regulator's problem is similar to that in monitoring self-demonstrated insurance. Regulators would include the state in which the captive is licensed, who would oversee the general financial management of the pool and, presumably, for space transportation, would also include federal overseers to make sure that the funds in the pool meet financial assurance requirements.

An example of a group captive in the case of commercial aviation is the Polygon Insurance Company, Limited, owned by SAS, S Group, Austrian Airlines, and Finnair. Polygon underwrites a captive insurance plan that handles the various risks of the airlines and their affiliates. Another example of using a group captive for insurance is the case of the commercial nuclear power industry (*see* detailed discussion in Section 5.3.2 of this report). A 1975 amendment to the Price-Anderson Act required the industry to establish a self-funded secondary insurance pool from which, in the event of a nuclear accident, each licensee would pay a prorated share of damages in excess of required primary insurance. This pool reduced government indemnification by the amount of the total required payments to the pool. In 1988, another amendment increased the maximum secondary insurance assessment, with payments payable in annual installments. The expected value of the pool in future years is anticipated to at least match, if not exceed, a size thought adequate by the U.S. Nuclear Regulatory Commission.

9.2.2.3 Catastrophe Bonds[1]

A new financial instrument, catastrophe (CAT) bonds, could be of interest to space transportation launch providers considering pooling arrangements. Conventional bonds are generally used to guarantee performance of a known, future obligation that is well defined. Recently, a new investment tool—CAT bonds—has been developed for managing the risks of unusual events, such as weather caused by the El Niño current in the Pacific, earthquakes, flooding, and crop losses (DPCRC 1998). The risk is very different from traditional bond offerings, where the uncertainty usually is credit risk or the possibility that an issuer won't be able to repay bondholders. Instead, the risk associated with CAT bonds depends, in part, on the modeling and forecasting ability of geologists, meteorologists, and agronomists. Investors assume that the risk can be spread, since it is less likely that a hurricane hits the United States, for example, during the same year that an earthquake occurs overseas. Some $2 billion were anticipated to be available as CAT bonds by 2000, up from just under $800 million in 1997, the first year of the offerings. Returns to investors are typically higher than market rates; in one case, bonds offered by Tokyo Marine and Fire Insurance for earthquake risk in Japan paid 4 to 4.5 percentage points above the London InterBank Offered Rate (Gutscher 1997). Examples of CAT bonds are those that have been issued for the following perils: U.S. hurricanes, Japanese earthquakes, California earthquakes, Florida hurricanes, and one bond issued for more general "diversified catastrophic risk."

CAT bonds typically require three parties: (1) investors who purchase the bonds and ultimately bear the underwriting risk; (2) a "special-purpose vehicle" (SPV) that is usually a reinsurance company that sells reinsurance to the insurer and funds the reinsurance by issuing CAT bonds to investors; and (3) the insurance company purchasing the reinsurance (which could be a reinsurer or a corporate entity). The insurer pays a premium to the SPV for the reinsurance, and this premium, together with any investment earnings on invested assets, pays the SPV's expenses and interest on the CAT bonds to the investors. If no catastrophic event occurs prior to the maturity of the bond (often, about 10 years), investors receive all of their periodic interest payments plus a full return of principal. If an event occurs, depending on the reinsurance contract and the CAT bond, the investor may lose all or part of his/her investment. The risks associated with the event are hedged by reinsurers who manage portfolios by mixing lines of business

[1] Catastrophe bonds were brought to the attention of authors of this study in discussions with the U.S. Department of Treasury.

covered; the geographical spread of business; underwriting quality and management controls; policy features; and claims management practices.

As an insurance-linked securitization, this form of financial assurance for space transportation has the advantage of encouraging launch providers to invest in safety research and development (R&D), since the launch providers could adjust the size of the bond principal or its interest payments periodically (as the bonds are due) to reflect safety improvements. Administrative costs to the government are probably comparable to the costs of overseeing other commercially obtained financial assurance (that is, reviewing letters of credit, etc.). CAT bonds have also been suggested as a solution to the post-September 11, 2001 liability situation.[2]

9.2.3 Publicly Subsidized Insurance

Several approaches to government involvement that are alternatives to the current regime include tax subsidies; government financing of amounts that could differ from the amounts specified under the current regime; and government-backed insurance pools. Various forms of the second and third of these approaches are now under consideration by the Administration and the Congress as responses to the post-September 11, 2001 terrorist attacks.

9.2.3.1 Tax Subsidies

Another alternative is the use of tax-based policies to subsidize the purchase of launch insurance. The approach could use either tax credits or tax deductions. Under a tax credit for the purchase of launch insurance, a firm's tax liability would be reduced directly by a fixed dollar amount. Under a tax deduction, taxable income would be reduced by the amount of insurance expenditure. The provision of insurance could rely entirely on private markets rather than government indemnification. The credit could cover most or all of the penalty, or it could be capped to some amount eligible for tax subsidization. If the goal is to support the launch industry, but get the government out of the insurance business by relying on private insurers, this approach has an advantage. Politically, the approach can be seen as a tax cut rather than an increase in government spending—usually an advantage. However, public debate will ask why space transportation merits favorable tax treatment, just as it has asked whether the current indemnification regime should continue. In theory, justification for tax subsidies should be based on a demonstration that the benefits of the tax subsidy are: (1) at least as large as the costs to the public treasury of money paid out as credits or deductions, and (2) achieved more cost-effectively than other approaches to liability. Because the current regime has not imposed any costs on the taxpayer and, according to experts in risk assessment, is highly unlikely to impose costs, it is hard to argue that the tax subsidy approach is more cost-effective. On the other hand, as new vehicles and facilities (spaceports) come on line, and if expected third-party liability risk exposure increases significantly, then a tax-based approach to redistribute the full costs of financial assurance, without government indemnification, could be seen as desirable by policy makers.

If adverse selection or high administrative costs were a concern, tax credits could be linked to a purchasing pool or cooperative. The pool would be formed by space transportation firms and could collectively represent them in bargaining with insurers for price and policy attractiveness. It would combine different risk levels among firms and gain efficiencies in administration. A potential problem

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[2] See Hal R. Varian, "Catastrophe Bonds Could Fill the Gaps in Reinsurance," *New York Times*, 25 October 2001, p.C2.

with this approach is that participating launch providers may be reluctant to share proprietary data that may be needed to accurately calculate risk.

9.2.3.2 Alternatives to the Current Regime: Possible Approaches Modeled after Administration and Congressional Proposals in Response to September 11, 2001

In the wake of the terrorist activity in September 2001, several plans were proposed by the Administration and the Congress to assist the overall liability insurance industry. The rationale was that industries such as construction, manufacturing, energy, and transportation could halt if bankers and other lenders stop offering loans or raise rates because insurers were unwilling to renew their coverage for terrorist attacks. Of particular concern was that a large number – some 70 percent – of liability policies were up for renewal by the end of the calendar year, and the concerns were that premiums would be high and terrorist activity not covered at all in renewal policies.

In this section, policy proposals are discussed as possible models for space transportation. They are:

(1) Insurance with a government-financed deductible, essentially like the current CSLA regime with respect to the notion of public/private risk sharing

(2) Insurance by way of a government-backed pool, like the pool discussed in Section 9.2.2.2, but with the important difference that it is government backed.

The Administration's proposal for financial support of the liability insurance industry after September 11, 2001 follows model (1). The proposal is a three-year plan to ease what the Administration sees as severe, but short-term, financial dislocation associated with large claims. The plan would operate as an insurance plan with a deductible, much like the current indemnification regime in that liability is divided between insurers and the government in stipulated amounts. The Administration's proposal, however, is just for three years, after which time the insurance industry is expected to be recovered from what are thought to be short-run losses. In the first year (2002), the federal government would pay 80 percent of the first $20 billion of claims from terrorism events and 90 percent above $20 billion. By the third year, the government would pay amounts in excess of $30 billion.[3] By 2005, the government would withdraw from the sector. The industry's total liability for damages from any future terrorist attacks would be capped at $12 billion in 2002, $23 billion in 2003, and $36 billion in 2004.

Opponents of the plan argue that government should not "pay first dollar" ("first dollar coverage") but rather, the insurance industry should pay first and government should be insurer of "last resort." Opponents also express concern that government would be "bailing out insurance and airline industries but doing nothing for many other industries and labor groups suffering losses and layoffs" (Labaton 2001).

From the discussion of costs and benefits in Section 9.4 of this report, an advantage of requiring insurers to pay first is that they then have incentives to make sure that insured parties are taking reasonable care; investing in safety-related R&D; and taking at least some financial responsibility for damages associated with their activities. An attractive aspect of the plan is its sunset provision, which is appropriate if the problem is indeed a short-term large payout. Over time, the capacity is expected to stabilize; premiums for terrorism coverage will be priced and capital from reinsurers will return to the industry. According to at least one business report (Treaster 2001), rates are already rising high enough to attract numerous investors seeking to take advantage of the insurance industry's growth potential. Thus, insurance

[3] As of April 11, 2002, the Federal Government has not enacted any legislation into law.

coverage is likely to be available. Premiums may be higher, but not so high as to preclude a market for the coverage. These premiums are appropriate costs of doing business if the business is indeed riskier in a post-September 11 world. Similarly in the case of space transportation, if it is susceptible to terrorism with third-party effects, both the MPL and third-party premiums need to reflect this and consumers of launch services need to recognize this as a cost of doing business. In the case of space transportation, and in light of the arguments now being made to justify why the insurance industry needs support, the role for government in supporting space transportation activity would need to be justified.

The Senate plan, backed by insurance companies, follows model (2). Insurance companies would commit their capital to a pool and if losses in any year exceed the pool, the government would finance the remainder. The proposal is modeled after practices in Britain taken after the Irish Republican Army destroyed $500 million of property in a series of bombings in London in 1992. The British government set up a government-backed, mutually owned company, Pool Re. Insurers collect premiums for terrorist insurance, and the government provides additional financing if claims for terrorist attacks exceed the pool's premiums plus reserves. France has a state-guaranteed reinsurer, the Caisee Centrale de Reassurance. It provides coverage when private insurers' losses from policies for natural disaster exceed 150 percent of premiums. The Israeli government covers direct losses from terrorist attacks, although not for business interruptions.

Problems that critics see with this approach are that it keeps government permanently involved and creates a new government entity and new regulations to administer the pool. In addition, if the industry loses money, the government steps in; if the industry makes a profit, the industry gets to keep it.

9.3 Changes within the Current Regime

This second set of options examines changes that might be made within the current regime while maintaining basic elements of its construct.

9.3.1 Elimination of Government Indemnification

One simple modification to the existing regime is eliminating government indemnification but retaining a requirement for demonstrating financial responsibility in some appropriate amount. The first variation of this option is one in which financial assurance and the federally established MPL are maintained as at present. The second is eliminating the federally mandated MPL, but continuing to require financial assurance at levels established by the private insurance market. In the event of greater use of commercial insurance under these options, it is likely that the MPL calculation would still be useful, and even necessary, unless such a calculation were undertaken by private insurers subject to FAA's risk probability requirements (risk thresholds, such as "1 in 10 million," are typically stipulated by regulatory agencies, but the MPL calculation and subsequent financial insurance requirement are not typically mandated).

9.3.1.1 Maintaining the Requirement of Financial Assurance at the Level of MPL

This option requires financial assurance at the level of the MPL valuation but eliminates government indemnification for amounts in excess of the MPL. The current regime does not provide for full cost internalization, but rather includes the possibility of compensation by public funds. Eliminating government indemnification results in cost internalization—the full payment of compensation for damages by firms that cause them. This result, in general, yields the most equitable means of victim compensation. Financial assurance, if fully internalized by the firm, also leads to prices that fully reflect a product's or service's social costs. In addition, cost internalization promotes deterrence by creating incentives to reduce risks before they materialize, including investing in risk-reducing safety innovation (Boyd 2001).

Unfortunately, cost internalization's intended impact is not always achieved in practice. Assurance requirements, even if based on sound MPL estimation, may be exceeded by the eventual costs of liability, and, in practice, the firm's liability may be limited to the assured amount since the firm may have no other funds available to cover the claims. From a public policy perspective, limited liability reduces uncertainty for the firm and may also limit any claims the government may pursue that the firm feels are unsubstantiated. But the obvious disadvantage is that damages above the cap may be uncompensated by responsible parties. And in the international claims arena, damages remain the primary responsibility of the government under international treaties.

Bankruptcy and corporate dissolution can defeat a law's ability to force cost internalization by allowing firms to abandon responsibility. In the case of financial assurance for the abandoned underground petroleum storage tanks capable of soil and water contamination and landfills containing hazardous waste, the U.S. landscape is littered with environmentally damaging operations that were either abandoned entirely or left unreclaimed due to bankruptcy. [However, the courts have generally ruled, in the case of third-party environmental and natural resource damages, that assurance costs are not “money judgments” under bankruptcy code and fit within the “policy and regulatory powers” exception to the automatic stay. Thus, companies are financially liable.]

A common concern is that financial responsibility may harm small business, but this is not borne out in practice. While the government reduces barriers to small business in other ways, it also makes sense to hold parties responsible for third-party damages. The history of financial assurance regulation also shows that it does not bankrupt whole industries, nor does it mean the end of small business. Private financial markets have been developed to provide insurance, bonds, and other instruments necessary to demonstrate assurance, and they provide them at reasonable cost. Ten years ago, underground storage tank assurance rules were supposedly going to bankrupt the retail gas industry. Assurance for oil tankers and vessels carrying hazardous substances was supposedly going to result in mass bankruptcy and the withdrawal of maritime insurance coverage for vessels in U.S. waters. Today, such a tank can be insured for $400 per year, less than it costs to insure a car, and dozens of small firms compete to provide tanker financial assurance at rates that continue to fall.

With this option, as discussed above in surveying other options, firms could purchase assurance in the form of insurance, surety obligations, or letters of credit from a bank, or they could set up trust funds or escrow accounts. They could also demonstrate an adequate asset base and high-quality bond rating or a financial guarantee from a wealthy corporate parent. Insurers interviewed for this report indicated that, at least prior to September 11, 2001, the market seems to have adequate capacity for larger amounts of third-party commercial space transportation insurance. The other options already discussed above, including the formation of captives or the possible use of a special instrument such as a CAT bond, are other possible means for insurance at levels higher than the MPL, should launch providers decide to insure for higher amounts. Regardless, the principle underlying an argument to discontinue government indemnification is that societal costs should be borne by their creators. However, regardless of indemnification, the U.S. Government accepts absolute liability internationally for damage caused by its space object when the United States is a launching State.

9.3.1.2 Maintaining the Requirement of Financial Assurance Subject to the Private Market's Valuation of Probable Loss

The rationale for the possible modified approach of allowing private insurers to determine the level at which they would insure a launch event is fully consistent with that discussed above (when the government sets the MPL) insofar as the principle to be followed is full cost internalization by the firm. The difference in this option is reliance on private markets to establish a basis for financial assurance, much like requirements for auto insurance in states where the insured and the insurer determine the level of insurance. Under this option, a requirement for a launch license could require a demonstration of financial assurance at the level negotiated between the insured and the insurer. Such a rule also facilitates safeguarding the public from the perspective of the government regulator, since insurers, sureties, and banks that usually provide the financial products used to demonstrate compliance have an incentive to train an extra set of eyes on the financial risks.

Largely because third-party risks can be difficult to value, especially as new launch vehicles and space launch facilities become established, it might be argued that the government, not the private market, is the best institution for setting required amounts. Since the government has liability exposure, it is reasonable for the government to be assured of adequate financial responsibility, as is currently done through use of the MPL process. A counter-argument is whether the government has access to better data than the private market for estimating these amounts. Regardless of who determines probability of loss, and in what amount, methods used to calculate risks can also often be controversial, since damages can be unpredictable and highly sensitive to the valuation methodologies used by the government and the courts. Government-established "rules of the road" may offer the best approach to estimate damages to third parties and subsequently to mediate the possibly conflicting interests that could arise.

9.3.2 Revision of MPL-Based Insurance Requirements

The current method and basis for calculating MPL is based on conservative inputs and assumptions and has been accepted by the aerospace industry as well as insurance companies and payload customers. The cost of property damage and third-party liability from historical international launch vehicle accidents, to date, provides validation of the magnitude of the MPL, although all of these accidents occurred at foreign launch sites with different values and legal systems. The current probabilistic basis for third-party MPL is on the order of 1×10^{-7} per launch event, or 1 in 10 million, which can be understood by the following explanation. If 100 launches were conducted each year, an accident resulting in actual third-party claims greater than the MPL amount would be expected to occur once in every 100,000 years although it cannot be said with certainty that damage of this magnitude will not occur tomorrow.

Any additional conservatisms in the MPL calculation could increase its value by factors of as much as 2 to 10, which could reach the $1.5-billion (1988 dollars) indemnification limit currently provided by the U.S. Government and considered to be an important feature of the liability risk-sharing regime by U.S. launch operators and their contractors. Currently, that result is contrary to the statutory ceiling on liability insurance of $500 million. Such higher MPL requirements would result in significant additional insurance costs on U.S. launch providers, affecting their competitiveness.[4]

Current MPL values for licensed U.S. launch vehicles are within the range of insurance requirements for foreign competitors' launch vehicles. Therefore, the value of increasing the calculated MPL is not deemed useful or helpful to either the U.S. launch industry or the U.S. Government. Only changes in the

[4] A high MPL approaching the limit of $500 million for third-party liability could bring into question the overall safety acceptability of such a launch.

MPL calculations due to new data (e.g., increased population density, higher property values, longer overflight times, etc.) should be incorporated. Finally, it is useful to note that the exceedance probability of the current third-party MPL is about 100 times smaller than the probability of being involved in a fatal commercial aircraft or motor vehicle accident based on the identical per-departure or per-trip basis.

However, there may be bases upon which to adjust or increase an MPL determination. The MPL calculation currently does not account for consequential damages. Consequential damages are defined as "losses that do not flow directly and naturally from an injurious act, but that result indirectly from the act."[5] Such damages may be indirect in nature, and may include losses in revenue for damaged businesses, costs for lodging during extensive home repairs, or related evacuation and relocation costs. Generally speaking, consequential damages are recoverable if it is determined they are "proximately caused" by an accident. The determination of causation is normally left to the jury in a damages suit, but is generally understood as having "no intervening, independent, culpable and controlling cause." The amount of consequential damages varies from case to case and depends upon particular circumstances of each case. However, the proportion of consequential damages as compared with other damages is relatively small. Consequential damages are not factored into MPL determinations because of their speculative or uncertain nature. Including them may lead to insurance requirements in excess of that which is necessary to cover true MPL, at additional cost to industry. Such damages would likely comprise a small proportion of any award, and would be addressed by the inherent conservatism in the MPL calculation.

9.3.3 Requiring Demonstration of Financial Assurance at the Level of the Maximum Insurance Available at Reasonable Cost

The current regime specifies that financial assurance be demonstrated at the MPL within the statutory ceiling of the lesser of $500 million or the maximum available capacity available on the world market at reasonable cost. In lieu of the MPL, the maximum available capacity at reasonable cost could be required. This approach is used by NASA and is discussed in detail in Section 5.3.1.

The difficulty with this approach is that it fails to relate the level of risk with the level of financial assurance. It therefore may result in increasing costs to the launch industry without rational basis. In addition, it begs the potentially controversial question of "reasonable cost." And, the $500 million was set by the Congress at a time when the insurance industry was undergoing a "liability crisis" in the 1980s and was believed attainable.

9.3.4 Elimination of "Sunset" Provision and Reduction in Amount of Maximum Government Indemnification

The option of eliminating the sunset provision, but reducing the government's payment of excess claims obligation reduces maximum potential burdens on taxpayer liability as well as uncertainty associated with sunset provisions. One possibility is to reduce the maximum that government might appropriate for indemnification to $1 billion (in 2001 dollars), while at the same time eliminating the sunset.

An advantage of this option to taxpayers is the reduction in their maximum *statutory* risk exposure (although all risk is retained under international obligations). An advantage to the space transportation industry from this option is the reduction in uncertainty associated with the sunset provision and whether Congress will renew the liability regime, assuming a future Congress does not re-impose a sunset

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[5] Black's Law Dictionary.

provision. Indemnification at this lower amount also moves closer to cost internalization by parties imposing the cost, since industry liability for full financial responsibility will resume at a lower amount of $1 billion above MPL. However, the amount of $1 billion seems arbitrary and unrelated to risk, insurance market capacity, or federal budgetary discussions (in other words, is $1 billion likely to be differently viewed by policymakers than $1.5 billion in appropriations). It is also not clear whether eliminating the sunset provision will influence international competitiveness in the short run or whether it will offset any competitive disadvantage of a lower amount of government indemnification. Lowering the amount of the government's obligation could be perceived internationally as a withdrawal by the U.S. Government from its commitment to the U.S. commercial launch industry and its customer and supplier base. However, assuming indemnification has an effect on international competitiveness (recall discussion in Chapter 3 noting the difficulty of empirical support for quantifying actual effects), then eliminating the sunset provision could support competitiveness and offset any possible effect on competition of a lower amount of government indemnification.

9.4 Comparison of Options to the Current Risk-Sharing Regime (with Analysis of Benefits and Costs)

This section consists of several parts. Section 9.4.1 provides an analytical framework with which to compare systematically the advantages (benefits) and disadvantages (costs) of the various possible options and modifications. The framework describes the benefits and costs of the current regime and their distribution—that is, to whom they accrue (the space transportation industry, taxpayers, the insurance industry). Alternatives are then compared based on how these benefits and costs and their distribution would change.

Section 9.4.2 uses this framework to evaluate the four options discussed in Section 9.2: trust funds, self-insurance, captive insurance, and tax subsidies for insurance. The remaining options discussed in Section 9.3 are modifications of the current regime rather than distinct changes and are summarized in Section 9.5.

9.4.1 A Framework for Assessing Benefits and Costs of Third-Party Liability Risk-Sharing and Indemnification

This section describes the benefits and costs of third-party liability risk-sharing and indemnification. In this discussion, two aspects of the organization of the current liability risk-sharing and indemnification regime are inextricably related to benefits and costs: (1) the regulatory safety provisions to protect third parties through the FAA licensing process, and (2) differences between a fully private sector approach to insurance and one in which the government shares financial responsibility. In this discussion, all options presume maintenance of the cross-waiver scheme to relieve participants of cross-litigation.

It is assumed, for both the current approach as well as possible options, that zero risk to third parties is unlikely, irrespective of the level of safety, unless there are no launches whatsoever, and whether government indemnification is provided or the launch insurance market is largely private. Some risk is no doubt tolerable by society, just as some risk is tolerated in everyday life through the usual, and not without risk, activities of driving, working, and engaging in regular daily routine.

Benefits. The top portion of **Table 9–1** lists benefits of liability risk-sharing and indemnification. In the absence of government indemnification, the principal benefits of third-party launch liability insurance are (i) the financial compensation made available to third parties in the event of damages (i.e., victim compensation), and (ii) the benefit to individual launch providers of pooling risk through the insurance market. Government indemnification affects the level of both of these benefits. In all cases it should be noted that international treaty provisions (*see* Chapter 6) require U.S. responsibility for international damages and the sharing of these damages between the space transportation industry and the taxpayer, through government acceptance and assumption of responsibility, is dependent on domestic law and policy.

Table 9–1 Benefits and Costs of Liability Risk-Sharing and Indemnification

Benefits:

i. Financial compensation of third parties
ii. Financial protection of launch providers, their customers, and component suppliers
iii. Possible international market advantage for U.S. launch providers
iv. Supplement to capacity of space launch insurance market
v. Support national space launch capability for economic, national security and civil space goals
vi. Demonstrate national commitment to space launch technology

Costs:

i. Compensation paid to third parties by insurers and launch providers
ii. Cost to launch providers of meeting financial assurance requirements (insurance, bonds, etc.)
iii. Potential costs to launch providers of uninsured risk liability
iv. Potential Federal Government costs borne by U.S. taxpayers (indemnification)
v. Potential for uncompensated third-party losses (victims without remedy)
vi. Potential crowding out of part of commercial insurance market by government indemnification
vii. Possible disincentives to invest in third-party launch risk mitigation and in safety R&D
viii. Other costs to taxpayers specifically associated with different options (see text discussion)
ix. Administrative costs to the government and to launch providers

Repeatedly, launch providers and insurers note that government indemnification confers a competitive necessity to launch providers in international market competition. The ability of U.S. launch providers to compete successfully is one of the statutory rationales for the risk-sharing regime. This possible market advantage is identified as a benefit in (iii) in Table 9–1, but it is important to note that, strictly speaking, this effect may not be a net benefit to the Nation. For instance, if this advantage comes at a cost to the taxpayer (say, in the event that government indemnification is realized), then this benefit to the industry is a cost borne by taxpayers at large, rather than the launch company. In this event, then, on net, the society-wide effect of indemnification for the sake of competitive advantage could be small or even negative. However, there may be a societal benefit for launch capability, such as enhancing economic, civil space or national security that may offset the liability cost over time.

A second statutory rationale for government indemnification under the current regime is in (iv), the issue of capacity in the space transportation insurance market. As discussed elsewhere in this report, at the time of enactment of the existing regime, and for a variety of reasons related more generally to the overall insurance market, legislators were concerned in 1988 about adequate capacity. Capacity pertains to whether the insurance market is able and willing to provide the requisite amount of space launch insurance at rates that launch providers are willing to pay and whether the market can financially withstand large damages. Capacity depends largely on the next-best alternatives that insurers have for investing their money; on "what the market will pay" for insurance; and on the length of time it may take insurers to absorb losses. A related complication noted by insurers is a lack of actuarial information with which to estimate risks in the case of space launch. Repeatedly, insurers report that establishing risk premiums for launch liability is largely a subjective matter in accounting for the track record of the vehicle and range and the nature of the particular mission, but is also sized to what the market will bear. From the launch providers perspective, "what the market will bear" in part reflects the launch providers view of the costs of insurance and uninsured risk. In addition, another complication would result if all component suppliers had to individually insure against liability resulting from commercial space launches.

Determining the optimal amount of insurance is complex in any insurance market for two reasons. The first reason is moral hazard—when the insured parties take less care to avoid risks because the negative consequences of so doing are reduced by insurance, or when the insured engage in too much of the risky activity because the insurance pays for some or all of the cost. In the case of space launch insurance, moral hazard could arise, in principle, if launch providers take greater risk or launch more often than they otherwise would because their activities are insured. Perhaps the largest concern in this case is whether government indemnification in any way reduces incentives of launch providers to invest in innovative safety R&D. Neither factor appears to be a consideration in the context of launch liability insurance. The second factor that complicates the determination of optimal insurance and also affects the extent of capacity in the event of large damages is adverse selection—when the average buyer of insurance has a higher risk than the insurance company anticipates, perhaps because the insurer has inadequate information about the buyer. The insurer may be forced to raise premiums to break even. Relatively lower-risk buyers may leave the insurance market in response to the higher premiums, and the spiral that this begins can continue if premiums are again increased to cover the higher-risk buyers left in the market. If more and more buyers opt out of purchasing insurance, the market is likely to underprovide insurance, other things being the same. Such a situation could conceivably arise if larger, established space transportation launch providers decided to self-insure rather than pay larger premiums that might be required by insurers to cover riskier newcomer launch providers.

Government liability risk sharing and indemnification for the U.S. commercial space transportation industry may also support national space transportation capacity and in turn, benefit U.S. economic, national security and civil space goals (v). Well before the advent of commercial space transportation, the U.S. led the world in its capability to access space. For this reason, while this effect may be a benefit, the actual extent to which the commercial sector benefits national security and civil space objectives is not clear. The size of the effect depends on the exact link between the commercial industry and government needs – is it in maintaining production lines? Engineering expertise? And, how many commercial launches are "optimal"? In turn, what is the specific contribution of the current liability risk-sharing regime to this link? Answers to these questions are key to better understanding the nature and size of this possible benefit and are important in considering possible modifications to the regime if economic, national security and civil space goals are deemed by policymakers to be an objective of the regime (the statutory rationale for the current regime is not based on explicit economic, national security or civil space concerns although Congress found that private sector launch services capability is consistent with U.S. national security and foreign policy interests (49 U.S.C. 70101(a)(6)).

The current regime, as an indicator of the sense of the Congress in supporting the commercial space transportation industry, may also confer what is known as a "psychic" benefit in the methodology of assessing benefits and costs (vi). The policy demonstrates a national commitment to the U.S. industry by indicating a willingness to financially underwrite some part of the cost of doing business in the industry, and thus may confer symbolic as well as monetary benefit. In some applications of benefit and cost methodology in other settings, psychic benefits have been found to be quite large.

Costs. The lower portion of Table 9–1 lists costs of liability risk-sharing and indemnification. Costs include items (i), the compensation paid to third parties, paid by some mix of insurers, launch providers, and government, depending on the amount of loss; (ii) costs of demonstrating financial assurance; and, in the event of damages, (iii) costs to launch providers of any uninsured liability; and (iv) costs to the government of indemnification (paid by the taxpayer). There is also item (v), the potential for uncompensated third-party losses. A regime that provides for sharing these costs between the government and launch providers directly influences the level of financial protection for the launch providers and the level of these liability costs. It also exposes the general public to liability for damages, an exposure it may bear at any rate due to international treaty or government liability under domestic law. In addition, just as government provision of a host of activities (for example, public housing, mortgage insurance, schooling) may "crowd out" opportunities for the private sector to provide these goods and services, so, too, may government launch indemnification crowd out some business that might otherwise be undertaken by private insurers (item (vi) in the table). As mentioned above, insurance can create a moral hazard by which insured parties may have reduced incentives to undertake care (item (vii)). An example is the possible effect of insurance, and government indemnification, on incentives to invest in safety per se and also in safety R&D related to third-party risk. Finally, there may be additional costs to taxpayers (item (viii); examples arise in comparing alternatives) and administrative costs of monitoring compliance with financial assurance requirements (item (ix)).

Benefits and costs of safety regulations. As noted in the introduction to this section, regulatory safety provisions themselves have a set of benefits and costs that in turn directly affect liability and insurance, regardless of government risk-sharing and indemnification. These regulations have implications not only for the level of financial assurance sought by launch providers, but also for the care that is taken by both the launch providers and the launch range operators; the cost of damages that might be incurred by third parties; over time, the track record of launch safety (in turn, a determinant of insurance premiums); and, in short, every aspect of third-party launch liability insurance. It is highly important to note that the safety record to date—upon which rests comparison of the current liability management (risk allocation) and indemnification regime with alternatives—reflects the ground operations and range safety practices in place at federal launch ranges.

Distribution of costs. This discussion of the current regime makes clear that the principal consequence of government indemnification is to affect the distribution (who bears the costs) of the burden of expected loss. **Figure 9–1** illustrates the relationship among insurance coverage, the size of expected loss, and launch company liability. Insurance coverage and expected loss are on the axes. Coverage and expected loss are equal along the diagonal line (which is at 45 degrees in the graph). Each amount of insurance coverage (the MPL amount and up to the statutory $500-million limit and $1.5-billion (inflation-adjusted from 1988) plus MPL coverage, amounts points A, B and C) is matched by the 45-degree line with an expected loss of equal value as indicated by L_1, L_2, and L_3. The amount of coverage required by licensing is indicated by the MPL value.[6]

[6] The financial assurance that must be demonstrated in the amount of the MPL need not take the form of insurance, but insurance has been the usual method to date.

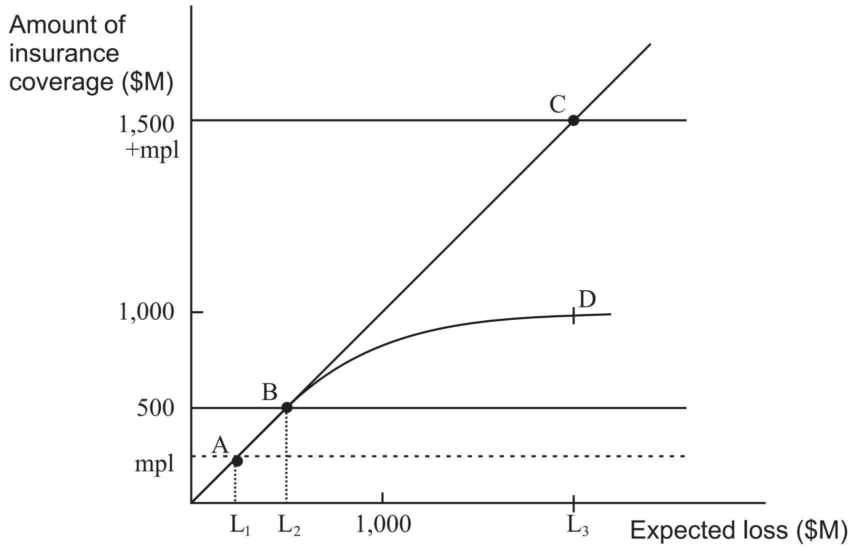

Figure 9–1 Relationships Among Insurance Coverage, Expected Loss, and Launch Company Liability

Launch company. The existing indemnification regime enables the launch operator to insure losses up to L_3 by incurring only potential liability for L_1. Above L_3, the operator again assumes liability. In practice, liability is limited by the amount of assets (possibly including other insurance policies that can be reallocated to launch coverage). Assets can be variously measured as average earnings and net worth. Hence, the financial risk to the launch operator is:

$$\text{Company financial risk (CFR)} = L_1 + (\text{amounts} > L_3)$$

$$\text{Subject to:} \quad \text{CFR} \leq \text{company assets}$$

Taxpayer. The amount represented by the distance between A and C in Figure 9–1 represents taxpayer financial risk exposure assumed under indemnification. Under the current regime, the maximum potential liability exposure that is statutorily imposed is:

$$\text{Taxpayer liability} = L_3 - L_1$$

The full cost of potential taxpayer liability could exceed the statutory amount, however, if other "disaster relief"-type government funding were made available in event of a major accident.

Insurance market. If only a fixed amount of coverage is available from the commercial insurance market, then the relationship between available commercial coverage and loss could be represented by the curve connecting points A, B, and D. For example, many insurers who were contacted (*see* Appendix D) prior to September 11, 2001, indicated that the market could supply probably up to $1 billion in capacity per launch. If so, then government indemnification may crowd out the private market provision of insurance between L_1 and the capacity ceiling. And, in this case, relying on the private insurance market would not cover losses in excess of the capacity ceiling and the losses would be borne by industry.

An alternative depiction of limited insurance market capacity is in **Figure 9–2**, which includes premiums (the dotted line). Figure 9–2 shows premiums gradually rising and then becoming infinite at the capacity limit (the vertical dotted line). Or, capacity may be available, but only at significantly higher premiums (the dotted line sloping up). If an event occurred to fully exhaust capacity, it is likely that the insurance market would revitalize over time. If the event were linked to an isolated incident in a single vehicle, overall premiums might not rise significantly. If the event were found to be widespread among the industry, the increase in premiums could be larger, but appropriately so if the event were indicative of a major risk-related problem in space transportation.

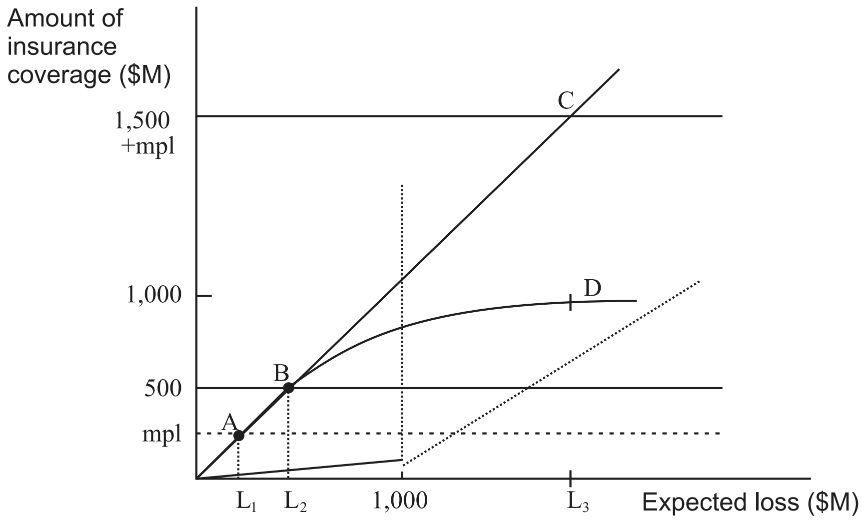

Figure 9–2 Relationships Among Insurance Coverage, Expected Loss, and Launch Company Liability with Premiums

From Figures 9–1 and 9–2, other costs are apparent. For example, uncompensated third-party losses in excess of L_3 could arise if losses exceed a company's assets and government relief is not made available. In addition, because the launch operator may not be ultimately responsible (i.e., government indemnifies) for losses between L_1 and L_3, it may face less incentive to take risk-mitigating actions to guard against losses in this range or to engage in safety-related R&D that might lead to new launch procedures with less risk, although there has been no evidence of this reduced incentive.

This discussion has assumed, as under the current regime, that space transportation providers pay the "first dollar." Under an alternative discussed in Section 9.2.3.2, along the lines of the Administration's current proposal for general liability industry financial aid, the government would pay "first dollar." Liability responsibility would be allocated 80 percent (government) and 20 percent (industry) for the first year, with statutory ceilings, and then government's financial role would phase out over the ensuing three years.

The figures and discussion above can be re-interpreted to illustrate this alternative allocation of responsibility or variations similar to it.

"Betting the company" in commercial space transportation. An argument that has been repeatedly made by U.S. aerospace companies involved in the commercial space launch business is that, without government indemnification, they would not be involved in commercial space transportation because they would not want to "bet the company." By the term, "bet the company," the implication is that potential uninsured liability from a space launch accident could equal or exceed the value of the company. It is important to note that companies appear willing to bear the risk of liability amounts at the third tier, at which government indemnification is capped (the amount L_3 in the figures).

The value of a company can be interpreted in a multitude of ways according to financial accounting. Two representative measures of a company's monetary value in the event of a lawsuit are its total equity and its annual cash flow from operating activities. Total equity is the difference between assets and liabilities, whereas cash flow is the amount of cash received per year from company activities. **Table 9–2** presents these two financial indicators for calendar year 2000 for aerospace companies involved in manufacturing launch vehicles and component parts for commercial space transportation. Interrelationships among these companies may also be important; for example, if one is a major parts supplier to another.

Table 9–2 Manufacturing Aerospace Companies' Cash Flow and Total Equity (Year 2000)

Aerospace Company	*Calendar Year 2000 Cash from Operating Activities ($ million)*	*Total Equity for Calendar Year 2000 ($ million)*
Alliant Techsystems, Inc.	110	115
B.F. Goodrich	297	1,500
Boeing	5,900	11,000
GenCorp	23	195
Lockheed Martin	2,000	30,300
Orbital Science Corp.	30	44
United Technologies Pratt & Whitney	2,500	8,100

As the above table indicates, three companies have a monetary value equal or greater than the $1.5 billion (1988 dollars) of U.S. Government indemnification. It should be noted, however, that these same companies are involved in other business areas, which involve the assumption of risk without any government indemnification. For example, Boeing and United Technologies produce commercial airline aircraft business products. (However, the Aviation and Transportation Security Act relieves them of liability for September 11 events as component manufacturers. S*ee* Appendix F.

Table 9–3 is an analogous table of major U.S. commercial airlines' financial value, prior to September 11, 2001, presented for comparison purposes.

Table 9–3 Major U.S. Commercial Airlines' Financial Value (Year 2000)

Commercial Airline	*Calendar Year 2000 Cash from Operating Activities ($ million)*	*Total Equity for Calendar Year 2000 ($ million)*
Alaska	265	862
American	3,100	7,200
Continental	904	1,900
Delta	2,900	5,300
Northwest	893	231
Southwest	1,300	3,500
United	2,500	5,900
U.S. Airways	697	(-358)

The financial value of large U.S. commercial airlines is comparable to that of the three largest aerospace companies.

9.4.2 Benefits and Costs of Distinct Options: Trust Funds, Self-Insurance, Captive Insurance, and Tax Subsidies for Insurance

In evaluating these options, it is assumed that the government continues to require financial assurance at the level of the MPL as a means of financially protecting the government, its agencies and personnel from liability, damage or loss as a result of licensed launch activity. The options are then evaluated under two scenarios: with and without government indemnification above MPL-based requirements to explore the relative benefits and burdens of indemnification. The discussion largely focuses on how these options compare in the absence of government indemnification, however. This emphasis is taken for several reasons. The first is that it is directly responsive to the public policy issue of whether indemnification should continue or be allowed to expire. If indemnification were eliminated, these might be options. A second reason is that the options (except for tax subsidies) could have been adopted by the industry under the current financial assurance requirement (it does not specify traditional commercial insurance as the only allowable demonstration); however, these options might only be considered by the industry in the absence of indemnification. It should be noted that the relative comparison of the benefits and costs of each option does not markedly change if government indemnification is retained, but again, because the industry has not chosen these kinds of options, it may make sense to discuss them largely as approaches relevant in the context of indemnification elimination.

In addition, it should also be noted that it is possible to combine these options in a variety of ways. For example, as in the commercial nuclear power industry, primary insurance could be purchased in conventional insurance markets subject to their capacity; secondary insurance could be acquired by the industry in the form of contributions to an insurance pool.

Tables 9–4a and **9–4b** summarize the benefits and costs of these options. Table 9–4a discusses them in the case of no government indemnification at any tier, and Table 9–4b assumes that some government indemnification is continued, perhaps as in the current regime or perhaps under modifications discussed in this chapter that change the level of indemnification. In both tables, the current MPL process and required financial assurance at this MPL level are assumed.

Benefits. The options all provide financial compensation of third parties and financial protection of commercial space transportation providers for liability up to the MPL (or beyond, if launch providers choose larger amounts of financial protection). Under government indemnification, compensation would extend beyond the MPL to the statutory limit subject to congressional appropriation. The tax subsidy option reduces insurance costs by the amount of the deduction or credit. By directly reducing insurance expense, compared with the current regime, the tax option could provide a small cost advantage to U.S. launch providers. The cost advantage would be fairly small, equal to the deductible percentage of the insurance premiums or the value of the tax credit. The other options are not likely to confer significant market advantage in terms of cost savings or competitive edge due to customer preference and selection, regardless of whether the government indemnifies (on this point, Chapter 3 discusses at length the difficulty of identifying and measuring any contribution of indemnification to competitiveness). Under self- and group insurance, other benefits may accrue to U.S. launch providers in the form of returns on invested funds. For example, if launch providers placed $1 billion in the insurance pool and earned 10 percent, the $100 million in returns could be returned to the launch providers. Under these options, launch providers also could exercise greater control over their assets in designing and managing self- and group insurance. Under the trust fund option, because it is assumed that it is a government-established fund, it is also assumed that returns on the fund are returned to the fund rather than rebated to launch providers. Retained earnings within the fund could reduce required payments by launch providers to the fund in later years, assuming no pay-out (no third-party liability).

Table 9–4a Benefits and Costs of Distinct Options Assuming No Indemnification (Assume Required Financial Assurance at MPL Value)

Benefits Compared with Current Regime:	***Trust Fund W/O Indem***	***Self- Insurance W/O Indem***	***Captive Insurance W/O Indem***	***Tax Subsidies for Insurance W/O Indem***
Financial compensation of third parties	Some	Some	Some	Some
Financial protection of CST launch providers	Some	Some	Some	Some
International commercial CST market advantage	No	No	No	No
Financial protection of capacity of insurance market	Not applicable	Not applicable	Not applicable	Not applicable
Other benefits to CST	Yes	Yes; ROI	Yes; ROI	Yes; subsidy
Costs Compared with Current Regime:				
Third-party compensation up to MPL paid by -				
CST	Yes	Yes	Yes	Yes
Insurer/financial market	No	No	Depends on design	Yes
Taxpayer	No	No	No	Yes
Cost to CST of financial assurance	Yes	Yes	Yes	Yes; costs shared with taxpayer
Potential costs of uninsured liability to CST	Yes	Yes	Yes	Yes
Additional liability borne by taxpayer	No	No	No	No
Possible uncompensated third-party losses	Yes	Yes	Yes	Yes
Crowding out of commercial insurance/financial market	Yes	No	No	No
Possible disincentives to invest in third-party risk and safety research and development	Some	No	No	Some
Other costs to taxpayer	No	No	No	Yes
Administrative costs to:				
Government	Yes	Low	Low	High
CST	Yes	Yes	Yes	Yes

Notes: Indem. = U.S. Government indemnification; CST = Commercial space transportation industry; MPL = maximum probable loss; ROI = Return on investment

Table 9–4b Benefits and Costs of Distinct Options
(Assume Required Financial Assurance at MPL Value plus Government Indemnification)

Benefits Compared with Current Regime:	***Trust Fund With Indem***	***Self-Insurance With Indem***	***Captive Insurance With Indem***	***Tax Subsidies for Insurance With Indem***
Financial compensation of third parties	Yes	Yes	Yes	Yes
Financial protection of CST launch providers	Yes	Yes	Yes	Yes
International commercial CST market advantage	Inadequate data (uncertain)	Inadequate data (uncertain)	Inadequate data (uncertain)	Inadequate data (uncertain)
Financial protection of capacity of insurance market	Yes	Yes	Yes	Yes
Other benefits to CST	Yes	Yes; ROI	Yes; ROI	Yes; subsidy
Costs Compared with Current Regime:				
Third-party compensation up to MPL paid by -				
CST	Yes	Yes	Yes	Yes
Insurer/financial market	Yes	Yes	Depends on design	Yes
Taxpayer	Yes	Yes	Yes	Yes
Cost to CST of financial assurance	Yes	Yes	Yes	Yes; costs shared with taxpayer
Potential costs of uninsured liability to CST	Some	Some	Some	Some
Additional liability borne by taxpayer	Yes	Yes	Yes	Yes
Possible uncompensated third-party losses	Yes	Yes	Yes	Yes
Crowding out of commercial insurance/financial market	Yes	Yes	Yes	Yes
Possible Disincentives to invest in third party risk and safety research and development	Yes	Yes	Yes	Yes
Other costs to taxpayer	No	No	No	Yes
Administrative costs to:				
Government	Yes	Low	Low	High
CST	Yes	Yes	Yes	Yes

Notes: Indem. = U.S. Government indemnification; CST = Commercial space transportation industry; MPL = maximum probable loss; ROI = Return on investment

Costs. All of the options make launch providers financially responsible for third-party compensation up to the MPL level; these costs may be shared with insurers or the financial market under a group captive insurance plan, depending on how the plan is set up, and are shared with insurers and taxpayers under the tax subsidy option. Launch providers also incur the cost of demonstrating financial assurance in having to set aside funds up to the MPL amount in the form of fees that may be required under a trust fund, contributions required under self- and group insurance plans, or in the purchase of insurance to qualify for tax subsidies. In all of the options, launch providers also assume the costs of potential uninsured liability, as discussed extensively in Section 9.2. Without government indemnification, the crowding out of opportunities for commercial insurers or financial markets may be reduced except for federally or state-mandated trust funds. (Section 9.2 notes that many states are terminating oil spill trust funds to permit greater reliance on private insurers, given greater capacity in the insurance market.) The potential for uncompensated third-party losses remains under all options. Launch providers have less disincentive to invest in risk mitigation and safety R&D when they have direct control over managing their own insurance under all of the options except tax subsidies. Because tax subsidies reduce the cost of insurance, launch providers may continually choose to buy insurance rather than invest in safety-related R&D. Tax subsidies also create additional costs to taxpayers in the form of opportunity costs of foregone tax revenue (monies the government could otherwise spend on other government-provided goods and services).

Under tax subsidies, the administrative costs of tax provisions would be incurred by the government. Launch providers would bear the startup costs of trust funds and alternative self- and group insurance, as well as the longer-term costs of administering these approaches. Launch providers would also bear their internal costs of tax compliance under tax subsidies. One reason that launch providers have not opted for options such as these, but have used traditional commercial insurance under the current regime, may be that the transaction costs for these options may be perceived as too large by the launch providers. Traditional insurance is familiar, and launch providers have established relationships with brokers and underwriters.

Distribution of costs. The distribution of costs of these options is an important dimension in ranking alternatives from a policy perspective.[7] Different options can force greater or full internalization of otherwise avoided obligations for liability, thus creating new costs to the firms from their perspective. From a social perspective, these costs are not new, but are redistributed. From a social welfare standpoint, redistributed costs are not a true cost of changes. There are, however, some real costs associated with changes. These could include the purchase of new assurance products, administrative costs of contracting and other paperwork, and demonstrating compliance. And, as noted, the government has to monitor compliance and enforce rules.

Assuming continued indemnification, the distribution of liability among launch providers is the same under all options. The net cost to launch providers could fall under some of the options. Launch providers could earn a return on investment under an alternative insurance approach such as group insurance, and these earnings could offset some financial risk. For a company able to self-insure, return on investment could also be obtained on the reserves held to satisfy financial assurance. For smaller launch providers, self-insurance is likely to be too expensive, given the opportunity cost of holding large amounts of assets in reserve, but group insurance could be a viable alternative. Under tax subsidies, launch providers will enjoy tax deductions or credits in the amount specified in enabling legislation. Assuming the elimination of indemnification, the distribution of liability is the same among launch providers under the options. Launch providers would still perceive assets at risk, however. Costs could increase if launch providers chose to increase insurance.

From the taxpayer perspective, they bear the cost of financial responsibility if government indemnification is in place, regardless of the option taken. Under government indemnification, in the absence of realized losses in amounts that fall in the second tier of the current regime (L_3 minus L_1), (i.e., absence of an excess claim, consistent with existing track record of no indemnification claims paid) the cost to taxpayers of tax subsidies is larger than the costs of the current regime, since the tax subsidies are a realized cost. However, if second-tier losses were large enough, they could exceed the cost of tax subsidies under some parameterizations of the tax subsidy (that is, depending on the size of the deduction or credit).

[7] These options are assessed assuming that the space transportation market is competitive, and, thus, costs of financial assurance are absorbed by transportation suppliers and not passed through to payload customers.

Taxpayers do not bear the cost of financial responsibility risk if indemnification is eliminated, although it is conceivable that if third-party losses were large, the government may provide emergency assistance as an insurer of last resort (in which case, taxpayers bear this amount of the cost) or in the event of international claims borne fully by the U.S. Government under international treaties in the absence of contribution from launch services providers. The full cost internalization principle is where government indemnification is eliminated and so is taxpayer financial risk exposure, subject to treaty obligations. In terms of the costs of the options to taxpayers, with the tax subsidy option, regardless of government indemnification, taxpayer costs increase because tax deductions and credits reduce the general revenues. Strictly speaking, these costs include both the direct cost of the subsidy and the additional opportunity cost represented by the foregone uses of the revenue (other spending options of taxpayers and the government).

9.5 Summary and Evaluation of the Options

In this section, several of the options and modifications are discussed from a public policy perspective. The benefits and costs listed in Table 9–4 can be applied to any of these options, modifications, and various combinations of them. Fundamentally, the choice depends on the public policy goal. Various goals include the statutory rationale for the current regime: fostering insurance market capacity, adequate liability coverage in the case of a catastrophic event, and international competitiveness. Other objectives, for example, as emphasized by industry representatives in the Commercial Space Transportation Advisory Committee (COMSTAC) report on the current regime, include enhancement of national security. And, from a government perspective, coverage of U.S. Government liability at least cost to taxpayer. From a broader taxpayer perspective, and likely to be questioned by Congress in its consideration of whether to continue the regime, is the extent to which a goal is full cost internalization by parties imposing the costs—including whether space transportation is an industry meriting government indemnification. The recent terrorist attacks suggest additional possible rationale for choosing among options and modifications. Given these numerous goals, ranking the options from a societal perspective, as distinct from solely the perspective of the commercial space transportation industry, depends critically on the goals of public policy. Finally, it should be noted that a federally established trust fund or federally required pooling of insurance, as in commercial nuclear industry insurance, would require specific legislation, as would tax subsidies.[8] In addition, for some options, the FAA may need to set up new systems for monitoring compliance (for example, working with the launch providers to ascertain adequate self-insurance or to monitor the financial health of a group captive; the FAA could choose to rely on independent auditors for this oversight).

The role of the MPL in Assuring Financial Protection from Liability and Victim Compensation: In addition, based on the discussion in Section 9.2, a continued government role in establishing an MPL and requiring a demonstration of financial assurance at this level is consistent with a host of government policies governing activities that pose third-party risks, and comports with optimizing the net benefits of a liability regime. For reasons discussed in that section, the government is probably the most appropriate party for establishing a credible MPL, given the present extensive involvement of the government in operating space transportation facilities. (Even before the 1988 Amendments, the Department of Transportation was responsible for setting requirements for financial responsibility and other assurances necessary to protect the government from liability.) While continuing this aspect of the current regime makes good sense, broad guidelines for the FAA as to whether the current procedures and data used to determine the MPL are appropriate, and whether this process needs to be revisited explicitly to incorporate any potential for terrorist threat and subsequent third-party damages, is discussed in this chapter.

[8] Tax subsidies could perhaps be incorporated into broader legislative proposals for support of commercial space transportation.

If the goal is to maintain the economic viability of commercial space transportation, then much stronger intervention such as tax subsidies may be considered. In terms of near-term actions toward this result (that is, over the next few years), legislators could bundle the subsidy with existing proposals for tax-based support of commercial space activities. As discussed extensively in Chapter 3, it is not possible to identify the actual financial impact, if any, of the existing liability risk-sharing regime on international market share. However, it is reasonable to expect that removal of government support of this nature could have international impacts on customer selection of launch provider so that the customer is assured of its financial protection. A more direct route to financially supporting the industry and helping to allay the costs of insurance, if this is the goal, is a tax subsidy. A possible disadvantage would be if insurers raised the price of premiums to exploit the subsidy (analogous to concerns about the costs of health insurance, given the coverage of insurance costs by third parties). These artificial price increases would then be borne by firms and taxpayers (in the amount of additional foregone tax revenue) and would undo the benefits of the subsidy. Another option is industry captive pools, because industry could share in profits and thereby support its push for market advantage.

If the goal is to establish full cost internalization by parties imposing the costs, then the subsidy is not the best choice[9]. Rather, other options such as trust funds and self- and group insurance arrangements could meet this goal. At the same time, these options could be attractive to launch providers, since these options give them some control over their assets and even offer a return on investment. These options also have the advantage of encouraging investment in risk mitigation innovation. However, self-insurance is extremely expensive for a company; it requires a company to set aside the MPL equivalent in assets, and only the largest launch providers might be expected to have this capability. But trust funds and group captives could be attractive to large and small launch providers. It may be that the startup costs appear large to launch providers compared with the ease of purchasing traditional, commercially available insurance, but these costs can be offset by the return on investment and even the rebating of excess reserves as the funds build up. The successful experience of the commercial nuclear power industry with the primary commercial insurance pool discussed at length in Chapter 3 is illustrative in this regard. However, it is important to note that the success of secondary insurance pools in the nuclear power industry is largely dependent upon the large number of participants in the pool enabling it to build up in relatively brief time, a characteristic that does not appear in the commercial space launch industry.

If the goal is to maintain adequate capacity in the space transportation insurance industry, specifically with regard to adequate coverage for third party damages and in the wake of current losses sustained from terrorism, then several options and modifications are possible. Government liability sharing, but not as payer of first dollar, could be justifiable if it is thought that assessing terrorist risk is so uncertain as to constitute a source of potential market failure in insurance markets, or if policymakers determine that susceptibility to terrorist threat falls within the domain of government national security responsibility and as a result, some burden sharing is appropriate. Both of these arguments have been advanced during post-September 11, 2001 policy discussions about government's role in overall insurance liability markets. Finally, a sunset provision is probably appropriate, if the insurance industry is expected to return to soundness in a few years. If premiums related to terrorist threat are higher in the new market equilibrium, presumably this will be because insurers, and particularly reinsurers, perceive the risk as higher, and in this case, higher premiums are simply going to be a cost of doing business. If the repercussion is higher premiums for third party coverage for space transportation, for example, then this additional cost of business must be borne by the demand side seeking access to space.

[9] This goal is endorsed in the views expressed by the U.S. Department of Justice, and presented in Appendix B.

Table 9–5, below, further illustrates the above discussions. The findings contained within this table are reflected in the recommended options section of Chapter 10 and in Table 10–1 as well as in the Executive Summary.

Table 9–5 Comparison of Liability Risk-Sharing Regime Modifications to Objectives

	Purpose or Objective				
	Maintain Adequate Space Launch Third-Party Insurance Capacity	***Support International Competitiveness of U.S. Launch Providers***	***Maintain Status Quo of Regime Currently Familiar to Launch Clients and Suppliers***	***Maintain CST Economic Viability***	***Establish Full Cost Internalization by Parties Imposing the Cost***
Current Regime	Yes	Yes	Yes	Most Likely Yes*	No
Trust Funds	Likely	Yes	No	Likely	Uncertain
Self-Insurance	Likely	Yes	No	Likely	Uncertain
Captive Insurance	Likely	Yes	No	Likely	Uncertain
Catastrophe Bonds	Likely	Yes	No	Likely	Uncertain
Tax Subsidies	Yes	Yes	No	Yes	No
Current MPL + No Government Indemnification	Uncertain	No	No	Uncertain	Yes
No MPL + No Government Indemnification	Uncertain	No	No	Uncertain	Yes
Higher MPL Amount + Current Government Indemnification	Uncertain	Uncertain	Yes	Uncertain	No
Maximum Available Insurance at Reasonable Cost + Current Government Indemnification	Uncertain	No	No	Uncertain	No
Current MPL + $1 Billion Indemnification but No Sunset Provision	Uncertain	Uncertain	Yes	Uncertain	No

Uncertain = Uncertain; insufficient data to measure effect or effect depends on specific MPL and other limits that may be defined specifically for the proposed modification.
Yes = Furthers the purpose.
No = May be detrimental to furthering the purpose.
Likely = Likely to further the purpose but depends on specific MPL and other limits that may be defined specifically for the proposed modification.
MPL = maximum probable loss.
*Based on historical record (1988-Present).

The left-hand column of Table 9–5 lists all of the modifications discussed in this chapter. Each entry in the table indicates whether the modification would either further or be detrimental to the various purposes associated with public policy for commercial space transportation. The purposes are listed across the top of the table. The entries for several of the modifications indicate that while they are likely to further the purposes, there is also some uncertainty associated with this conclusion. Specifically, these entries are for the modifications of trust funds, self-insurance, captive insurance, and catastrophe bonds. The reason for the uncertainty is that these modifications could be combined with MPL and government indemnification, much like the current regime. In this case, the only change would be that the industry would use a different form of insurance than the current industry practice of relying exclusively on traditional commercial insurance. Or, these modifications could be put in place without MPL, or without government indemnification, or with different levels of government indemnification, or with other combinations of these provisions. In this case, the nature of the provisions would determine whether the modifications do or do not support various purposes.

It can be seen from the table that the purpose of maintaining commercial space transportation economic viability is more likely under arrangements that directly financially benefit the commercial space transportation industry. The modifications that tend to further this goal are: alternative insurance plans (trust funds, self-insurance, captive insurance, or catastrophe bonds) where the industry may earn economic returns on their funds and thus be financially stronger; tax subsidies; and modifications without a sunset provision.

The purpose of supporting international competitiveness of U.S. launch providers is questionable under the current regime for the reasons discussed extensively in Chapter 3: the publicly available quantitative data do not support this claim, and data from the industry on the extent to which customers are won or lost specifically due to the provisions offered by the risk-sharing liability regime are lacking to evaluate this claim. Nevertheless, launch industry arguments that a near-level playing field on indemnification and risk-sharing issues are critical to international competitiveness are compelling in an increasingly competitive market of over supply and limited demand. On the other hand, alternative insurance plans may further competitiveness if they allow the commercial space transportation industry to earn financial returns from interest on their self- or group funds (see discussion in paragraph above). Tax subsidies and modifications in which government indemnification is in larger amounts and modifications without a sunset provision may also further the purpose of competitiveness.

The purpose of full cost internalization by parties imposing the cost is likely achieved under modifications where the space transportation industry bears more of the cost: modifications with less or no government indemnification, higher MPL amounts, and the larger amount of insurance likely to be purchased if the requirement is "maximum available insurance at reasonable cost," since this amount has exceeded the MPL. Under alternative insurance plans, such as trust funds, etc., the industry may bear more of the cost compared with the current regime, depending on whether MPL, government indemnification, and other provisions affecting the division of cost are included with the alternative insurance plan. Tax subsidies allocate greater cost to the taxpayer and thus do not support this goal.

Maintaining adequate space launch third-party liability insurance in the short term—that is, in a scenario with a large loss that insurers need to cover, but from which the insurance market can recover and adjust in the longer run—is more likely when government indemnification is present. It is uncertain what effect modifications without indemnification or that involve self-insurance by the commercial space transportation industry would have on the insurance market, since that market adjusts itself to balance demand and supply (it will offer more, or less, insurance, at higher or lower prices, depending on what customers want and are willing to pay, and depending on what risks investors in the reinsurance market are willing to take and what return they seek on their investment).

Maintaining the status quo is more likely under the current regime, of course, and under modifications that depart only slightly from it and thus are currently familiar to commercial space transportation suppliers and their customers.

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Chapter 10

Summary, Findings, and Recommended Options

Chapter 10
Summary, Findings, and Recommended Options

This report presents the results of a study and analysis of seven liability risk-sharing issues directed by Congress in the Commercial Space Transportation Competitiveness Act of 2000, Public Law 106-405, as well as federal agency views and recommendations regarding the issues. In addition, views and recommendations provided by interested members of the public, including the Commercial Space Transportation Advisory Committee (COMSTAC), are presented in accordance with legislative requirements.

10.1 Scope of Study

The Commercial Space Transportation Competitiveness Act of 2000, Public Law 106-405, referred to in this report as the Space Competitiveness Act, directs the Secretary of Transportation (DOT) prepare a study and analysis of seven key issues regarding the liability risk-sharing regime for U.S. commercial space transportation. These issues are delineated as follows:

(1) *analyze the adequacy, propriety, and effectiveness of, and the need for, the current liability risk-sharing regime in the United States for commercial space transportation;*

(2) examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities;

(3) examine the appropriateness of deeming all space transportation activities to be 'ultrahazardous activities' for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous activities or not;

(4) examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties;

(5) examine the appropriateness, as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime towards the approach of the airline liability regime;

(6) examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations; and

(7) *recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.*

As part of the study and analysis of these elements, Congress directed that public and interested federal agency views and recommendations be provided on each of the seven issues identified in the Space Competitiveness Act. The following Federal agencies were consulted for their views and recommendations: the Office of Associate Administrator for Commercial Space Transportation on behalf of the Federal Aviation Administration; the National Aeronautics and Space Administration; the Department of Defense; the Office of Space Commercialization on behalf of the Department of Commerce; the U.S. Air Force; the Department of State; the Department of Treasury; the Federal Communications Commission; the Department of Justice; and the Nuclear Regulatory Commission. Agency findings are presented in summary form followed by views and recommendations offered by the public, including the Commercial Space Transportation Advisory Committee (COMSTAC). More detailed presentation of public and federal agency views is provided in Appendices A and B. The COMSTAC report is presented, in full, in Appendix C.

Current U.S. Liability Risk-Sharing Regime Under 49 U.S.C. Subtitle IX, Chapter 701, (popularly known as the CSLA)

The U.S. liability risk-sharing regime for commercial space transportation is comprised of three tiers:

Tier I: **Maximum Probable Loss (MPL)-Based Financial Responsibility Requirements**

- Launch or reentry licensee obtains insurance to cover claims of third parties, including Government personnel, for injury, loss or damage, against launch or reentry participants. Participants include the licensee, its customer, and the U.S. Government and its agencies, and the contractors and subcontractors of each of them.
- Launch or reentry licensee obtains insurance covering damage to U.S. Government range property.
- The Federal Aviation Administration (FAA) sets insurance requirements based upon the FAA's determination of the MPL that would result from licensed launch or reentry activities, within statutory ceilings, not to exceed the lesser of:
  – $500 million for third-party liability, or the maximum available on the world market at reasonable cost.
  – $100 million for U.S. Government range property, or the maximum available on the world market at reasonable cost.
- Participants enter into no fault, no subrogation reciprocal or cross-waivers of claims under which each participant accepts its own risk of property damage or loss and agrees to be responsible for injury, damage or loss suffered by its employees, except that claims of Government personnel are covered claims under the licensee's liability insurance coverage.

Tier II: **Catastrophic Loss Protection (Government Payment of Excess Claims, Known as "Indemnification")**

- Subject to appropriations, the U.S. Government may pay successful third-party liability claims in excess of required MPL-based insurance, up to $1.5 billion (as adjusted for post-1988 inflation) above the amount of MPL-based insurance.
- U.S. Government waives claims for property damage above required property insurance.

Tier III: **Above MPL-Based Insurance plus Indemnification**

- By regulation, financial responsibility remains with the licensee, or legally liable party.

Exceptions

– The government does not indemnify a party's willful misconduct.

– The government may pay claims from the first dollar of loss in the event of an insurance policy exclusion that is determined to be "usual."

10.2 Analysis and Findings

The Federal Aviation Administration (FAA), of the Department of Transportation (DOT), in cooperation with interested federal agencies, has performed a study and analysis of seven issues specifically identified in the Space Competitiveness Act, and provides the following summary of findings:

Issue 1 — Adequacy, Propriety, Effectiveness, and Need for the Current Liability Risk-Sharing Regime

Adequacy of the current liability risk-sharing regime was analyzed in terms of probability of exceeding financial responsibility requirements determined under maximum probable loss (MPL) methodology; international treaty obligations; and ability of U.S. launch providers to compete in the international market for launch services. **Propriety** was analyzed in terms of whether it is appropriate for the U.S. Government to be involved in liability risk-sharing through indemnification of the commercial space transportation industry. This analysis was done by evaluating: government involvement in other industries, effects of liability risk-sharing on launch safety, and international competitiveness. **Effectiveness** was analyzed by assessing how third-party liability and government property damage have been managed; the contribution of reciprocal or cross-waivers of claims among launch participants, including component suppliers and customers; effective risk management and insurance market capacity; the safety record of the launch industry; impacts on international competitiveness; and evolution of insurance market capacity from the onset of this regime. Analysis of the **need** for this liability risk-sharing regime included commercial space launch industry maturity assessment; insurance industry capacity analysis and premium history; international competitiveness issues; and consideration of possible transition factors.

Findings: The current liability risk-sharing regime for commercial space transportation is judged to be **adequate** based on historical acceptability of statutory risk allocation, including risk-based insurance requirements; support of U.S. obligations under relevant treaties; and the ability of the U.S. launch industry to compete for a share of the commercial space launch market.

The current liability risk-sharing regime for commercial space transportation has been **appropriate** due to the inherently high risk of commercial space transportation; national security, defense and civil interests, including benefits derived from economies of scale; considerable precedent for government subsidy and support of other industries such as commercial nuclear power, commercial aviation, and semiconductors; and impacts on launch safety and international competitiveness of U.S. industry.

Effectiveness of the current liability risk-sharing regime has been demonstrated by virtue of the facts that: cross-waivers of claims among launch participants have encouraged greater insurance industry participation in launch coverage; the U.S. launch ranges continue to demonstrate the highest safety record in the world; protection of third parties while protecting government interests from excessive risk has been achieved; and available insurance capacity has increased from the inception of this regime (excluding the yet unknown future impact of the terrorist attack of September 11, 2001, on available capacity).

The **need** for U.S. Government involvement in liability risk-sharing with the commercial space transportation industry was assessed with the following findings. Since the inception of the current U.S. liability risk-sharing regime, the commercial space transportation industry has reached maturity for expendable launch vehicles (ELVs), as measured against certain maturity metrics outlined in the report (*see* chapter 3), while available insurance capacity has increased and premiums have decreased during the time period of 1988 to 2001. Potential changes in the worldwide insurance industry (i.e., possibly smaller capacity and rising premiums) stemming from the events of September 11, 2001, may also indicate a continuing need for a liability risk-sharing regime. The current liability risk-sharing regime has existed for all licensed commercial space launches. Although foreign competitors use similar or superior risk sharing regimes, a variety of factors influence competitiveness. It is therefore impossible to quantify the need for the current regime for reasons of competitiveness except to note that the current regime places U.S. industry on a near-level playing field with foreign competitors. Removal of this consideration may have destabilizing effects on competitiveness in an increasingly competitive market, particularly given that, over the next decade, launch vehicle supply is predicted to exceed demand for launch services in the commercial space launch market.

Public Views and Recommendations: The existing liability risk-sharing regime has achieved its initial objectives of ensuring catastrophic risk protection for launch participants and enhancing international competitiveness of the U.S. commercial space launch industry. Those objectives continue to be supported by the current regime, especially in light of increasing competition from government-supported foreign industry. Perturbations or changes in the existing regime could undermine industry competitiveness because of customer concerns over the adequacy of alternative schemes, lack of government support, and perceptions that U.S. launch operators present a higher risk profile to customers than that presented by foreign launch operators. The regime has been and remains adequate, appropriate, effective and necessary to maintain the viability of the U.S. space launch industry .

Issue 2 — Liability Risk-Sharing Regimes in Other Countries with Space Transportation Capabilities

An analysis of liability risk-sharing regimes was performed for 12 foreign countries or entities with either active commercial space launch capability, capability under development, or existing government regulations dealing with space transportation liability risk-sharing regimes. Three foreign entities/countries—Arianespace, Russia, and China—are the current principal competitors of U.S. launch operators. Two other countries—Japan and India—have significantly developed launch capability with a potential near-term competitor status. The remaining seven countries (Australia, Brazil, Israel, South Africa, Sweden, Ukraine, and United Kingdom) have been considered for launch sites or are active in space exploration. Key parameters of foreign risk-sharing regimes were compared to the current U.S. regime. These include the tiers of coverage, existence of government indemnification; cross-waiver provisions; and required primary third-party liability insurance coverage.

Findings: Major competitors of the United States in commercial space transportation (Arianespace, China, and Russia) offer similar or superior liability risk-sharing regimes to that of the United States, by using a two-tier system including unlimited government indemnification, although some manage it contractually. Countries with emerging competitive commercial space launch capability (Australia, Brazil, India, and Japan) have also adopted two-tier risk-sharing regimes featuring unlimited government indemnification provisions. The current U.S. liability risk-sharing regime is nearly comparable to that of current foreign competitors and emerging competitors with the significant exceptions that the United States – (1) uses a more complicated three-tier system, as opposed to two tiers, with a defined limit on government obligations to cover excess claims ("indemnification"); (2) uses a more complex risk-based method to determine primary insurance coverage requirements; (3) has an expiration date (i.e., sunset provision); and (4) has limited government indemnification subject to appropriations.

Public Views and Recommendations: Foreign competitors offer more advantageous risk-sharing regimes. Arianespace, in particular, offers unlimited indemnification over its consistent insurance requirement of 400 million French francs (approximately $53 million at the current exchange rate), with no threat of a sunset provision. Customers require a stable indemnification regime and have demonstrated acceptance of the existing U.S. regime, although it is conditional in nature. Accordingly, for the U.S. commercial launch industry to remain internationally competitive in an increasingly tight market, it remains critical to continue the existing liability risk-sharing program.

Issue 3 — Ultrahazardous Activity and Appropriate Legal Standards

Ultrahazardous activities were assessed under a legal analysis which included an examination of strict and fault-based liability. Two other industries (nuclear and chemical) that could be characterized as ultrahazardous were examined in terms of liability consequences along with risk allocation regimes covering war risk insurance for civil aviation (prior to and post-September 11 approaches to war and terrorism risk exclusions and coverage), the Civil Reserve Air Fleet, and the government's response to natural disasters and catastrophes. The U.S. Government liability risk-sharing regime for these activities was presented for the purpose of comparison to that of commercial space transportation.

Findings: Certain hazardous activities, such as commercial nuclear power, chemical industry pollution, and civil aviation in high risk regions benefit from U.S. Government liability risk sharing. To date, space transportation activities have not been classified as ultrahazardous under federal law and have not been subject to legislatively mandated strict liability standards, whereas activities such as nuclear power generation, explosives manufacturing, and transport of dangerous chemicals are treated under a strict liability standard under state laws without a legislatively conferred "ultrahazardous activity" classification. A federal declaration that commercial space transportation is an "ultrahazardous activity" would likely cause legal complications in claims litigation and settlement and negatively affect insurance market capacity and conditions resulting in higher premiums and reinsurer withdrawal from the market, without affecting the ultimate outcome of managing space launch accident liability claims. Regardless of whether a strict liability or fault-based liability standard is applied, societal and political incentives are expected to ensure quick settlement and victim compensation in the event of a launch accident.

Public Views and Recommendations: A legislative declaration that space transportation activities are ultrahazardous would be problematic in terms of perceptions of increased risks which could translate into increased costs, and would add unnecessary confusion. Such a declaration would be neither necessary nor appropriate.

Issue 4 — Effects of Outer Space Treaties on Government Launch Liability

An examination of relevant international treaties identified two that specifically address liability for space launches, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") of 1967 and the 1972 Convention on International Liability for Damage Caused by Space Objects ("Liability Convention"). Responsibilities of the United States under the treaties were compared to the current liability risk-sharing regime for commercial space transportation to assess its adequacy.

Findings: Two international treaties, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") of 1967 and the 1972 Convention on International Liability for Damage Caused by Space Objects ("Liability Convention") are particularly relevant to the domestic space transportation liability risk-sharing regime. Under the Outer Space Treaty, Article VI, the United States bears international responsibility for national activities in outer space. Under the Outer Space Treaty, Article VII, each State Party that launches or procures the launching of an object into outer space, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its persons for damage on the Earth, in air or in outer space. Under the Liability

Convention, the U.S. Government accepts liability, either absolute or fault-based, depending upon where damage occurs, when it is a launching State. The current liability risk-sharing regime assigns financial responsibility for the most probable third-party damages arising from U.S.-based launches and those conducted by U.S. commercial entities to the launch licensee whose insurance protects the interests of the U.S. Government as an additional insured. Accordingly, under the existing liability risk-sharing regime, the government is afforded financial protection in meeting certain of its international treaty obligations, up to the amount of maximum probable loss, at no cost to the government (or U.S. taxpayer).

Public Views and Recommendation: Through implementation of the CSLA, including FAA licensing and safety responsibility and the liability risk-sharing regime, the government meets its obligations under international treaties at minimal risk to the U.S. taxpayer. By requiring MPL-based insurance, the FAA ensures that the government is protected by private insurance against the maximum probable loss that would result from a launch mission, at no cost to the U.S. taxpayer.

Issue 5 — Propriety of Applying an Airline Liability Regime to Commercial Reusable Launch Vehicles

The history, current status, future, and viability of reusable launch vehicles (RLVs), as well as their principal design features, were analyzed. Risks of RLVs were evaluated and compared to the risks of aircraft, including the aspects of third-party hazards and risk mitigation measures for purposes of considering an alternative risk allocation approach to RLV operations. The current RLV liability risk-sharing regime was compared to that applicable to civil aviation and commercial airlines under domestic and international law to evaluate whether an airline-type liability regime would be suitable for RLV operations.

Findings: RLVs are designed to return to Earth from outer space or Earth orbit, substantially intact and, like aircraft, to be used in subsequent flights. RLV development began in the 1970s with the Space Shuttle and has been supported at various times by the Air Force, NASA, and private industry. After decades of development and billions of dollars of investment, a commercially viable RLV has yet to develop. Routine RLV operation similar to that of commercial airlines may be decades away.

RLV hazards are, in some ways, similar to those of ELVs during liftoff because of the nature of their propellants, and are also similar to those of airlines in that a crash could occur during the reentry and landing phases. Depending upon the actual design of a vehicle, RLV hazards may be greater than those of airlines in terms of the vehicle mass, propellant masses and propellant properties. Under domestic law, RLV mission operators and certificated air carriers are required to obtain a minimum amount of insurance, and there are no limits on liability. The major difference between RLV and airline domestic legal regimes is applicability of the CSLA risk-sharing program to RLV missions, including indemnification. Major airlines, prior to September 11, 2001, have typically obtained between $1 billion and $2 billion in insurance at reasonable rates to protect their assets from accident liabilities. Government-industry liability risk-sharing is regarded as desirable to enable RLV developers to manage risk in a manner comparable to that relied upon by ELV operators. The experimental nature of current commercial RLV design concepts, coupled with realistic expectations that RLV operations will not be as frequent, of proven reliability, or routine as airlines for decades, suggests that it is premature to offer recommendations on transitioning the liability regime for RLVs to that of airlines.

Public Views and Recommendations: Currently, the commercial space transportation industry, including RLVS and ELVs, cannot be compared to the commercial airline industry. Although there may be some similarities between future RLV operations and civil aircraft, significant differences make the airline liability regime inappropriate for RLVs until such time as flight rates reach sustained higher levels more akin to aircraft operations. For example, the airline liability insurance industry depends upon a broad distribution of risk made possible by the size of the industry, its reliability and the vast number of events, that is, flights, all factors that do not exist for RLVs. Internationally, the airline liability regime is concerned with passenger casualties and cargo; whereas RLV liability focus will be on third-party liability.

Issue 6 — Commercial Spaceport Operations

The history, status, and definition of commercial spaceports were presented, along with specific details on the four currently licensed commercial spaceports in Florida, California, Virginia, and Alaska. Currently planned future commercial spaceports were identified, as were state laws and regulations affecting spaceports. Liability and risk management issues for commercial spaceports were examined in terms of specific spaceport state statutes and acts, and unique commercial spaceport-related liability risk-sharing issues.

Findings: Currently, there are four licensed launch sites (popularly referred to as spaceports) in the United States. Three commercial spaceports (Florida, California, and Virginia) are co-located with federal launch facilities and are within the purview of federal range safety oversight. Alaska's Kodiak Launch Complex is not located on a federal facility. Other states have announced plans or interest in developing commercial spaceports, with principal emphasis on their use to support RLVs. The statutory liability risk-sharing regime covers commercial spaceports during licensed launch or reentry activities. Non-launch-related activities, such as rocket motor balancing, are not covered by the liability risk-sharing regime. None of the states operating licensed spaceports or considering spaceports have the legal authority to indemnify non-launch activities, thereby making them reluctant to offer their sites for potentially hazardous services other than licensed launch or reentry, unless their customer accepts liability risk. Government risk-sharing in launch liability protects launch participants, including commercial spaceports, in the event of a catastrophic launch vehicle or reentry vehicle accident, and protects certain interests of the U.S. Government arising under international law. Education, business development, and related opportunities for commercial spaceports are recognized, but are not federally supported through indemnification. Commercially available insurance can be obtained by spaceports for such activities. Spaceports have identified no activity performed at their site that warrants federal risk-sharing due to unmanageable risk or for competitiveness purposes. No changes to the current liability risk-sharing regime as it relates to commercial spaceport activities are recommended.

Public View and Recommendations: State laws may hinder the ability of commercial spaceports to offer their sites to support the conduct of hazardous activities that are not part of licensed launch or reentry activities due to liability considerations. Absent federal indemnification, a spaceport must manage liability risk-sharing with users of its facilities who may be unwilling to accept an uncertain amount of liability. Non-launch activities at a commercial launch site do not implicate international treaty considerations for the government, and the government need not impose special risk management measures in this regard. Generally, launch licensees that would be customers of a commercial spaceport find the existing regime adequate and appropriate. However, one commercial spaceport suggests that indemnification is required for hazardous activities that are not part of licensed launch or reentry but that may be conducted at its site and for which insurance may not be reasonably available.

Issue 7 — Recommended Appropriate Modifications

Ten options (five new alternatives and five modifications of the existing liability risk-sharing regime) were identified and evaluated. The new liability risk-sharing alternatives are: trust funds, self-insurance, captive insurance, catastrophe bonds, and tax subsidies. The five modifications of the existing regime are: maintain use of current MPL-based financial responsibility requirements with no indemnification; eliminate use of MPL and indemnification; utilize higher MPL-based requirements with current indemnification; require maximum available insurance at reasonable cost with current indemnification; and maintain current MPL-based requirements with $1 billion (2002 inflation-adjusted) indemnification (current indemnification is $1.5 billion, inflation-adjusted from 1988), but eliminate the indemnification sunset provision. The aforementioned 10 options, along with the current regime, were evaluated in terms of their effectiveness in the context of five different purposes or objectives. They are: maintaining adequate space launch third-party liability insurance capacity, including catastrophic risk protection; supporting the international competitiveness of the U.S. industry; maintaining the status quo of the current regime, which is familiar to launch customers and suppliers; maintaining commercial space transportation industry viability for economic, national security and civil space goals; and establishing full cost internalization by the parties imposing the cost.

Findings: Ten possible options were analyzed in terms of their capability to fulfill one or more of five different purposes or objectives. Some options or modifications were found to bolster a given purpose, while others were either neutral or detracted from that specific purpose. The modifications that definitively bolster specific purposes or objectives are delineated in Section 10.3.

Public Views and Recommendations: The current liability risk-sharing and indemnification regime should be retained to support the competitiveness of the U.S. industry and is critical in that regard. Any modifications to the existing regime that should be considered by Congress include: elimination of the sunset provision and making it an absolute obligation of the government. Alternatively, a ten-year extension of the existing regime should be granted for ELVs and RLVs, in order for U.S. industry to remain internationally competitive and robust and to enable the emerging RLV industry to benefit from its terms. Long-term policy regarding international competitiveness of the U.S. space transportation industry is not limited to indemnification but should be determined as an integral part of national policy aimed at assuring that the U.S. launch industry remains healthy, robust, and a world leader in this business sector.

10.3 Recommended Options for Consideration

The following summary presents goals and options for consideration, measured by their ability to achieve specific objectives with the following resulting observations. It should be noted that no single recommended modification fulfills all five objectives.

Table 10–1 Goals and Liability Risk-Sharing Regime Options for Consideration

To maintain adequate space launch third-party liability insurance capacity including catastrophic risk protection, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish tax subsidies (with or without government indemnification)

To support the international competitiveness of the U.S. commercial space transportation industry, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish trust funds (with or without government indemnification)
- Require industry to self-insure (with or without government indemnification)
- Require industry to establish captive insurance (with or without government indemnification)
- Require industry to establish catastrophe bonds (with or without government indemnification)

To maintain the framework of the current regime, which is familiar to launch customers and contractors, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Require higher MPL-based insurance (Tier 1) with current government indemnification
- Maintain current MPL-based insurance requirements (Tier 1) with only $1 billion of government indemnification but eliminate the sunset provision

To maintain a viable and robust U.S. commercial space transportation industry, one of the following could be done:

- Maintain the current liability risk-sharing regime
- Establish tax subsidies (with or without government indemnification)

To establish full cost internalization by launch participants, one of the following could be done:

- Maintain current MPL-based insurance requirements (Tier 1) but eliminate government indemnification
- Eliminate MPL-based insurance requirements (Tier 1) and eliminate government indemnification

Chapter 11

Acronyms and Abbreviations

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Acronyms and Abbreviations

AADC	Alaska Aerospace Development Corporation
AEB	Agencia Espacial Brasileira (Brazilian Space Agency)
AEC	U.S. Atomic Energy Commission
AIAA	American Institute of Aeronautics and Astronautics
ASLV	Advanced Satellite Launch Vehicle
AST	Associate Administrator for Commercial Space Transportation
AWST	*Aviation Week and Space Technology*
BORAX-III	Boiling Reactor Experiment III
CAA	Civil Aeronautics Authority
CAB	Civil Aeronautics Board
CAFE	corporate average fuel economy
CAT bond	catastrophe bond
CBO	Congressional Budget Office
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CGWIC	China Great Wall Industry Corporation
CNES	Centre National d'Études Spatiales (French Space Agency)
COMSTAC	Commercial Space Transportation Advisory Committee
CRAF	Civil Reserve Air Fleet
CRRES	Combined Release and Radiation Effects Satellite
CRS	Congressional Research Service
CSI	Commercial Space Initiative
CSLA	Commercial Space Launch Act
CST	commercial space transportation
DARPA	Defense Advanced Research Project Agency
DOC	U.S. Department of Commerce
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DRAM	dynamic random-access memory
EELV	evolved expendable launch vehicle
ELV	expendable launch vehicle
EPA	U.S. Environmental Protection Agency
EPROM	erasable programmable read-only memory
ESA	European Space Agency
ESRO	European Space Research Organization
EWR	Eastern and Western Range
FAA	Federal Aviation Administration
FARS	Federal Acquisition Regulations System
FDIC	Federal Deposit Insurance Corporation
FEMA	Federal Emergency Management Agency
FR	*Federal Register*

FY	fiscal year
GARA	General Aviation Revitalization Act
GEO	geosynchronous Earth orbit
GSLV	Geosynchronous Satellite Launch Vehicle
GSO	geostationary orbit
GTO	geosynchronous transfer orbit
IAI	Israel Aircraft Industries
ICBM	intercontinental ballistic missile
IFG	individual and family grants
ILS	International Launch Services, Lockheed Martin Corporation
ISB	International Space Brokers
ISP	initial seconds of propulsion
ISRO	India Space Research Organization
ISS	International Space Station
JP	jet propellant
KLC	Kodiak Launch Complex
LEO	low Earth orbit
LH2	liquid hydrogen
LO2	liquid oxygen, also referred to as LOX
LOX	liquid oxygen
MOU	memorandum of understanding
MPL	maximum probable loss
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency (of Japan)
NASP	National Aerospace Plane
NGSO	nongeostationary orbit
NMOSC	New Mexico Office for Space Commercialization
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
NRO	National Reconnaissance Organization
O&M	operations and maintenance
OPA	Oil Pollution Act
OSC	Orbital Sciences Corporation
OSIDA	Oklahoma Space Industry Development Authority
OTA	U.S. Office of Technology Assessment
PRC	People's Republic of China
PSLV	Polar Satellite Launch Vehicle
QRLV	Quick Reaction Launch Vehicle
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RLV	reusable launch vehicle
RMWG	Risk Management Working Group, COMSTAC
ROI	return on investment
RP	rocket propellant
RSA	Russian Space Agency
RSC	Rocket System Corporation (of Japan)
SBA	Small Business Administration
SCA	Commercial Space Transportation Competitiveness Act of 2000, Public Law 106-405
SEMATECH	Semiconductor Manufacturing Technology
SFA	Spaceport Florida Authority

SIA	Semiconductor Industry Association
SLI	Space Launch Initiative
SLV	space launch vehicle
SPV	special purpose vehicle
SSC	Swedish Space Corporation
SSI	Spaceport Systems International, Inc.
SSME	Space Shuttle main engine
SSTO	single-stage-to-orbit
STS	Space Transportation System (Space Shuttle)
TNT	trinitrotoluene
TSTO	two-stage-to-orbit
U.K.	United Kingdom
U.S.	United States
USAF	United States Air Force
U.S.C.	*United States Code*
USG	United States Government
USSR	Union of Soviet Socialist Republics
VCSFA	Virginia Commercial Space Flight Authority
VLS	Veiculo Lancador de Satelites (satellite launch vehicle of Brazil)
VSFC	Virginia Space Flight Center
WCSC	Western Commercial Space Center, Inc.

Chapter 12

Glossary

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Glossary

abnormally dangerous activities — Those activities which can be subject to strict liability, even though they could possibly be made safe (see *ultrahazardous activities*).

adverse selection — When the average buyer of insurance has a higher risk than the insurance company anticipates, perhaps because the company has inadequate information about the buyer.

apogee — The point in the orbit of a heavenly body, especially the Moon, or of a man-made satellite, at which it is farthest from the Earth.

azimuth — The arc of the horizon measured clockwise from the south point, in astronomy, or from the north point, in navigation, to the point where a vertical circle through a given heavenly body intersects the horizon.

ballistic missile — A projectile that follows a free-falling path after a controlled, self-powered ascent.

commercial spaceport — A popular term used to characterize a launch site facility (to be licensed by the Federal Aviation Administration) for the conduct of commercial space launches or reentries.

Cosmodromes — Russian launch sites.

cross-waiver agreement — Or reciprocal waiver of claims agreement, under which each signatory accepts responsibility for its own property damage and damage, injury, or loss sustained by its employees, and waives claims for such damage, injury, or loss against other signatories to the agreement. A properly and fully implemented cross-waiver agreement relieves participants from the need to buy liability insurance to protect against claims for damage to another participant's property or personnel, thereby further relieving the drain on the limited supply of insurance for space launch liability.

economies of scale — The ability to buy in quantity at a lower price per item (e.g., the ability to buy a number of launches at a lower price per launch).

evolved expendable launch vehicle (EELV) — An improved expendable launch vehicle (ELV), currently under development, which will provide space lift capabilities with a minimum 25 percent reduction in cost while maintaining current ELV reliability and operability.

expendable launch vehicle (ELV) — A vehicle built to operate in, or place a payload in, outer space or a suborbital rocket. This vehicle utilizes a self-terminating design and ejectable stages.

forum state — The state in which the court sits.

geostationary orbit (GSO) — A satellite or other object orbit which is 22,300 miles directly over the Earth's equator such that its period of rotation is exactly equal to that of the Earth. Also identified by the term, *geosynchronous Earth orbit.*

geosynchronous transfer orbit (GTO) — An orbit used to transfer from a low Earth orbit to a geosynchronous Earth orbit. The apogee is at the geosynchronous orbit altitude, while the perigee is usually at a low Earth orbit altitude.

hazard — A characteristic of an activity that represents a potential for an accident.

H index — Named for Orris Herfindahl and Albert Hirschman, a commonly used summary index of market concentration that accounts for both the number of companies as well as their relative size. It is the sum of the squares of the sizes of firms in a market in which sizes are expressed as a proportion of total market sales, assets, employment, or other measures. The index ranges from zero to one; an index close to zero indicates a fully competitive market; an index approaching one indicates a much more concentrated market in which a single entity may dominate; and an index equal to one describes a monopoly market.

hydrazine — A fuel which is typically used for the smaller engines/thrusters and auxiliary power units on reusable launch vehicles. It is a poison by inhalation, ingestion, skin contact, and intravenously.

initial seconds of propulsion (ISP) — Specific impulse thrust delivered per unit weight of propellant burning per second. High ISP and thrust levels are required to develop the velocity needed to escape gravity.

joint and several liability — A legal term which, as applied, allows full financial responsibility to be assigned to one party, even though other parties are responsible for some or all the damage.

launching State — A state which launches or procures the launch of a space object or a state from whose territory or facility a space object is launched. Liability Convention, Article I.

liability — The legal obligation to pay claims for bodily injury or property damage from any activity, including licensed launch or reentry activities.

liability risk sharing — An agreed-upon allocation of liability among the involved parties.

last clear chance — A legal doctrine which prevents or limits recovery when a plaintiff, by exercising reasonable care, could have avoided or mitigated the accident.

low Earth orbit (LEO) — An orbit of between 100 and 1,000 miles above the Earth's surface for a satellite or an object. To maintain this orbit, a speed of 17,500 miles per hour must be maintained; the Earth can be circled in 90 minutes.

maximum probable loss (MPL) — The greatest dollar amount of loss for bodily injury or property damage that is reasonably expected to result from licensed launch or reentry activities.

Molniya orbit — A highly elliptical (i.e., oval-shaped) orbit used primarily for communications. This orbit allows a specific geographical region prolonged exposure to a satellite as it enters its apogee. This orbit allows a satellite to circle the Earth in about 12 hours.

moral damages — Allowed under French law, similar to punitive damages in operation.

moral hazard — When the insured parties take less care to avoid risks because the negative consequences of so doing are mitigated by insurance, or when an insured engages in too much risky activity because insurance pays for some or all of the cost.

nitrogen tetroxide — A poison, moderately toxic by inhalation, which decomposes by heat into toxic nitrogen oxide fumes, a severe eye, skin, and mucus membrane irritant. Nitrogen-tetroxide- or hydrazine-based fuel is typically used for the smaller engines/thrusters and auxiliary power units on reusable launch vehicles.

no-fault — Liability and indemnification are assigned without consideration of who is at fault.

no-subrogation — The contractual agreement not to allocate the rights of one party to another person or entity, assigned by contract.

nongeostationary orbit (NGSO) — Any orbit of a satellite or other object above the Earth's surface that is not at the same rotational speed as the Earth and, therefore, does not remain stationary over one spot on the Earth's surface.

overflight — A launch vehicle and/or satellite passage over territory on the Earth's surface.

payload — The load carried by a vehicle exclusive of what is necessary for its operation; *especially*: the load carried by an aircraft or spacecraft consisting of things (as passengers or instruments) necessary to the purpose of the flight. Also, the weight of a payload.

polar orbit — An orbit which passes over both the North and South geographic Poles. As a satellite orbits in a north-south direction, the Earth spins beneath it in an east-west direction. As a result, a satellite in polar orbit will over time scan the entire Earth's surface. Polar orbits are useful for viewing the Earth's surface. Therefore, satellites that monitor the global environment such as remote sensing satellites and certain weather satellites are in polar orbits.

preponderance of the evidence — The standard of proof applied in civil cases, including those alleging negligence, under which a defendant is presumed to not have been negligent unless the plaintiff proves he is more likely negligent than not.

propellant mass fraction — The mass of propellant divided by the total flight vehicle mass.

res ipsa loquitur — Literally, "the thing speaks for itself." This legal doctrine shifts the burden of proof to the defendant; if the defendant loses unless he can show he was not negligent, it becomes much easier for the plaintiff to obtain a judgement. *Res ipsa loquitur* is frequently sought when the circumstances of the accident are such that evidence is difficult to obtain, such as in cases involving explosions, fires, or similar events.

retrograde orbit — An orbit above the Earth's surface which is in the counterclockwise (i.e., east-to-west) direction and opposite to the rotation of the Earth. This orbit requires more thrust and propellant to place a satellite than an orbit in the direction of the Earth's rotation (i.e., west-to-east).

reusable launch vehicle (RLV) — A launch vehicle that is designed to return to Earth substantially intact and therefore may be launched more than one time or that contains vehicle stages that may be recovered by a launch operator for future use in the operation of a substantially similar launch vehicle (14 CFR part 401.5).

risk — A measure of economic loss or human injury in terms of the probability of the loss or injury and the magnitude of the loss or injury, should it occur. For purposes of insurance and risk management, characteristics or considerations that may be used in defining risk include the probability of occurrence of an undesirable event and the potential severity of loss.

sounding rocket — A suborbital rocket that carries a payload high into the Earth's atmosphere, but is not used to place a payload into Earth orbit.

Space Competitiveness Act — The Commercial Space Transportation Competitiveness Act of 2000.

strap-ons — First-stage solid rocket motors.

strict liability — Liability without proof of fault (responsibility is assigned regardless of how careful the parties).

sunset provision — An expiration date provision.

third-party liability — Liability for damages to persons, entities, or property not associated with the parties participating in the licensed activity. (For purposes of Federal Aviation Administration regulations, 14 CFR parts 440 and 450, Government personnel are deemed third parties.)

transatmospheric vehicle — A single spacecraft able to operate effectively in both the atmosphere and space. Also known as an aerospace plane.

ultrahazardous activities — Those activities with a risk of serious harm, which cannot be eliminated by exercise of the utmost care (see *abnormally dangerous activities*).

war risk insurance — Insurance purchased to cover losses due to terrorism, acts of war, or other hostile acts.

Warsaw Convention — The primary international agreement, adopted in 1929, under which aviation liability for injury to passengers and damage or loss of cargo in international commerce is assigned and limited.

Appendix A

Public Views

Appendix A
Public Views

A.1 Introduction

As discussed in Section 1.1, Congress asked that the current risk-sharing and indemnification program be evaluated with respect to several key issues that have characterized public debate. Section 7 (c,2) of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act) states that, "*The report required … shall contain sections expressing the views and recommendations of the public, received as a result of notice in Commerce Business Daily, the Federal Register, and appropriate federal agency Internet websites*." This appendix presents a discussion of the means by which public comments were solicited and a summary of public views and recommendations, other than those offered by the Commercial Space Transportation Advisory Committee (COMSTAC), as they pertain to the liability risk-sharing regime for U.S. commercial space transportation. The COMSTAC report on the liability risk-sharing regime is presented in Appendix C.

A.2 Public Meeting Comments

The U.S. Department of Transportation Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation (AST) conducted a public meeting on April 25, 2001. The meeting was held from 9:00 a.m. to 4:00 p.m. in the third-floor auditorium of the FAA building at 800 Independence Avenue in Washington, D.C. (AST 2001). The purpose of this meeting was to solicit public comments on the following seven specific elements of study and analysis as identified in the Space Competitiveness Act.

1. Analyze the adequacy, propriety, effectiveness of, and the need for the current liability risk-sharing regime in the United States for commercial space transportation.

2. Examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities.

3. Examine the appropriateness of deeming all space transportation activities to be "ultrahazardous activities" for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous or not.

4. Examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties.

5. Examine the appropriateness, as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime toward the approach of the airline liability regime.

6. Examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations.

7. Recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.

The FAA contacted the following public interest groups, notified them of public meetings to be conducted by the FAA regarding commercial space launch liability risk-sharing, and invited participation by their membership.

American Association of Retired Persons
National Consumers League
American Council on Consumer Interest
Center for Science for the Public Interest
Consumer Action
Consumer Alert
Consumer Federation of America
Public Citizen, Inc.
U.S. Public Interest Research Group

A total of 37 individuals attended this public meeting. The following list summarizes the attendees according to their affiliations/organizations. Almost all of the attendees were representatives of, or related to, different sectors of the space launch vehicle industry.

Launch Vehicle Industry	15
Law Firms/Attorneys	6
Aerospace Insurance Industry	3
Nonprofit Aerospace-Related	3
Aerospace Industry Associations	2
Aerospace Professional Societies	2
Commercial Spaceports	2
Space-Related Print Media	2
Other Federal Agencies	1
Academia	1

At the meeting, FAA principals briefly discussed the objectives of the financial responsibility and risk allocation under the Commercial Space Launch Act (CSLA), and opened the meeting to public comments or prepared statements. Five attendees read formal prepared statements. These statements were presented by the following entities: International Space Brokers (ISB) Group, Lockheed Martin Corporation International Launch Services (ILS), Orbital Sciences Corporation (OSC), The Boeing Company (Boeing), and the Virginia Commercial Space Flight Authority (AST 2001). It should be noted that the number of public attendees and their comments and responses to questions posed by the FAA allowed this meeting to conclude on April 25, eliminating the need to continue another day.

The following summarizes the five prepared statements delivered at the April 25, 2001, public meeting (AST 2001).

ISB emphasized that the current risk-sharing regime protects the government from maximum probable loss (MPL) damages and allows the U.S. commercial launch industry to compete against subsidized foreign firms. ISB also estimated that the current[1] launch liability insurance industry is reasonably stable with a capacity of about $2 billion. This amount is subject to fluctuations due to future claims, which

[1] References to "current" insurance market conditions refer to pre-September 11 conditions unless otherwise stated.

could occur even in affiliated industries such as airline and aircraft products. ISB also noted that no losses in excess of the MPL level have ever occurred over 35 years of national security and commercial launch services. ISB supported continuing the current risk-sharing regime between the Federal Government and the commercial space launch industry.

ILS stated that the U.S. space launch industry has two advantages which allow it to compete against foreign firms: (1) an outstanding launch safety and reliability record, and (2) the U.S. Government risk-sharing and indemnification regime. ILS noted that U.S. Government indemnification is not equivalent to that of Arianespace, our largest competitor, because Arianespace offers unlimited third-party indemnification and is not subject to government appropriations. ILS noted that all foreign competitors offer similar government indemnification and that, in a market with an excess supply of launch services, the current U.S. Government risk-sharing arrangement is necessary for effective competition. ILS stated that the current CSLA risk-sharing regime limits U.S. Government launch damages and protects the commercial launch industry. ILS supports the continuation of the existing CSLA risk-sharing and liability regime.

OSC pointed out that the current risk-sharing and liability regime protects not only the launch companies, but also suppliers, launch customers, and the public. OSC also noted that the insurance industry can change quickly and that the current government indemnification program provides stability and has not cost the government any money. OSC reemphasized that stiff foreign competition requires the current risk-sharing regime to support the U.S. industry.

Boeing stated that it supports a 10-year extension of the current liability risk-sharing regime for space launches to foster U.S. industry competitiveness. Also, Boeing pointed out, space launches and commercial airline operations cannot be compared due to different risk factors. Boeing noted that the U.S. Department of Defense (DOD) grants indemnity for launches under Public Law 85-804. Boeing stated that the Department of Air Force and National Aeronautics and Space Administration (NASA) needs depend on a robust U.S. commercial space transportation industry, which could not survive a catastrophic failure without government indemnification. Thus, Boeing added, the CSLA indemnification provisions protect the DOD industrial base and the national security's assured access to space.

The Virginia Commercial Space Flight Authority (VCSFA) expressed its support of the current risk-sharing liability regime for space launch activities. VCSFA voiced concerns that non-launch-related activities conducted at commercial spaceports located on federal property are not indemnified by the Federal Government. Commercial spaceport self-insurance for these activities has no comparable MPL standard. VCSFA would like to see a change in regulations that affords the state the same indemnification as onsite contractors at federal launch facilities for co-located commercial spaceports. Alternatively, VCSFA would like to see a method similar to MPL derive an insurance requirement for nonlaunch activities at commercial spaceports.

Following the aforementioned five prepared statements, the FAA and its contractor staff made presentations on each of the seven elements of the Space Competitiveness Act and posed questions to the attending public. The following presents a chronological synopsis of attendee comments.

Industry representatives emphasized that a 10-year extension of the risk-sharing liability regime was not meant to indicate that the industry would be mature in 10 years. Rather, that period of time was believed to be necessary to assure future launch customers of a stable indemnification regime and was related to the effort necessary for Congress to grant another extension. Industry spokespersons repeatedly stated that industry maturity is not a factor in retaining the current risk-sharing and indemnification regime provisions, but that the most important factor is the foreign market and competitiveness with the indemnification offered by such launch companies as Arianespace. It was pointed out that the launch business operates with slim profit margins and that current suppliers for the launch companies would not agree to manufacture components that could become subject to fault-based judgments if the CSLA liability umbrella did not cover them.

VCSFA stated that the Virginia Constitution prohibits it from consenting to indemnify the Federal Government and that the insurance coverage the state must obtain for a commercial spaceport is five to six times greater than that of a commercial company because of all the clauses required to protect the state government. ISB stated that the loss of government indemnification would not affect the premiums paid for MPL insurance, but would affect any premiums for larger insurance coverage above the MPL value (in the $1 billion range and above). Small launch companies and their suppliers indicated that they do not have the financial resources to survive a catastrophic event without government indemnification and that, in fact, they may not be able to stay in business without it. Furthermore, consolidation or purchase of companies in the industry would not be financially viable without government indemnification. Slim profit margins coupled with increasing competition in a fixed-price contract environment require indemnification to remain viable.

ISB stated that approximately $2 billion in current space launch insurance capacity was derived from U.S. insurance companies for 25 percent of this value, with the remaining 75 percent offered from European insurance companies. If significant losses occurred from any launches worldwide, the insurance industry would respond by reducing capacity and increasing premiums. Also, space launch insurance industry revenues are a small fraction of airline liability insurance. Industry representatives stated that the existence of government indemnification is not a disincentive for increasing the safety and reliability of launch vehicle designs. A high reliability and safety record for specific launch vehicles would attract customers.

When asked about the interests of public taxpayers in supporting the risk-sharing liability of the commercial space launch industry, responses emphasized that each launch is actually an exercise of national capability to access space. The commercial space industry actually employs a larger number of people other than workers at launch sites because of the flow-down to suppliers, contractors, and subcontractors. Commercial launches subsidize the cost of launch services provided for DOD and NASA by the same companies, contractors, and subcontractors. Costs for government launches would significantly increase if the commercial segment were lost to foreign competition. When asked why the space launch industry should be indemnified while other industries do not receive this special treatment, the response was that the space launch business, unlike commercial airlines, relies on a very low number of launches. This small number of launches cannot bear “spreading the risk,” e.g., permitting increased insurance premium costs to be passed on to customers when foreign competitors have the advantage of indemnification.

Industry spokespersons reiterated that their customers are used to the current risk-sharing liability regime and any changes to it could cause perturbations that could affect their ability to compete against foreign launch companies. One attendee stated that the CSLA provision requiring congressional appropriation should be reexamined because foreign competitors do not have this additional government indemnification provision. One public commentor suggested that Congress should not declare space transportation to be “ultrahazardous” because this would cause unnecessary controversy. The possibility of a cap on liability associated with such an ultrahazardous definition was, one attorney suggested, not practically useful because of costs associated with proving strict liability and because of the ingenuity of plaintiffs’ lawyers in avoiding such caps in court. Several attendees reiterated their opposition to the government defining space transportation as ultrahazardous for political and perception reasons. ISB discussed the fact that the space launch industry is unlike the commercial airline industry because each launch involves hardware (i.e., launch vehicle and satellite payload) worth several hundred million dollars with no passengers, and that launches occur at a frequency many orders of magnitude less than airline departures and arrivals. There are sufficient statistics and operating experience and statistics for the insurance industry to confidently estimate losses and to spread premiums across the industry. Space launches are insured separately for the value of the launch vehicle and payload, but represent a very low-probability, high-consequence catastrophic event. The 1-in-10 million MPL basis for third-party losses quantifies risk to the insurance companies in concert with government indemnification. The relatively low number of space launches conducted annually will never provide the insurance industry with the kind of data provided by airline and automobile travel. Therefore, government risk sharing compensates for this higher uncertainty and risk.

Commentators also opined that the U.S. Government has control concerning whether the current CSLA risk-sharing regime is adequate to address all foreign treaty obligations, not only by the amount of MPL, but also by the fact that the government (FAA/AST) must issue a license to launch at all. Kistler Aerospace stated that any change in the current government regulations affecting risk-sharing liability for reusable launch vehicles (RLVs) could endanger the willingness of insurance underwriters to cover RLV activities. Participants generally noted that RLVs were not believed to be similar to commercial airlines at this time. It was noted that one important difference in liability risk between airlines and RLVs is that airlines are principally concerned about passenger casualties and luggage, whereas RLVs would be more concerned about third-party casualties. RLV passenger liability would be a function of the terms and conditions RLV passengers agree to in a separate launch agreement. One attorney suggested RLV usage would never become “common carriage,” as have other transport. ILS stated the final report to Congress should specify the differences between expendable launch vehicles (ELVs) and RLVs in their similarities to airlines since ELVs do not carry passengers.

The VCSFA said that the nonlaunch activities they could perform onsite, but do not due to liability concerns, include rocket motor balancing and payload processing when the payload contains hazardous fuels. Basically, any hazardous activity a commercial spaceport would like to perform which is not directly related to a space launch is not indemnified or regulated by the Federal Government under the CSLA. In response to a question concerning whether commercial spaceports should be afforded the same government indemnification for nonlaunch activities, Kistler Aerospace said “no” by pointing out that its Nevada launch site is co-located with nuclear weapons test areas with no adjacent highly valued government assets, unlike commercial spaceports in Florida, California, and Virginia. It was further noted that nonlaunch hazardous activities at a commercial spaceport are not included in international treaties, so the U.S. Government is not liable for the consequences of any accidents. Commercial spaceports are covered for all damages resulting from government launches, but must take out their own insurance to cover their facilities for commercial launches.

ILS again emphasized its desire to maintain the status quo in the risk-sharing liability regime for commercial space transportation. Alliant Techs Systems said “Nothing is broken with the current system, so leave it alone.” One attendee believed any pooling or trust fund arrangement would put an undue financial burden on the industry and would reduce the U.S. industry’s competitiveness. It was reiterated that the requirement for Congress to appropriate the $1.5 billion third-party second-tier indemnification should be eliminated so that no appropriation action is required. In response to a question, ISB stated that no one has ever analyzed a situation in which only the U.S. launch industry is put into its own separate insurance pool, which may result in lower premiums if the U.S. launch experience is superior to foreign competitors.

During discussions and questions about alternatives to the current risk-sharing regime, Kistler Aerospace advocated the identical position portrayed by ILS in terms of keeping the current system because of savvy foreign competition. Two attorneys, one from ILS, also echoed that any change in the risk-sharing regime, even if it saved the launch companies a small amount of premium, would affect their ability to win launch contracts against foreign competitors that offer a simple two-tiered system with government indemnification. ILS expressed its belief that the emphasis of this study for Congress should be placed on study items 1 and 7 and that all of the elements should not be given equal treatment. Additional public comments were made regarding support for the current risk-sharing regime and its importance in winning launch contracts against foreign competitors.

OSC stated that the reason for the decrease in U.S. share of the commercial launch business during the last year was a glut of solid rocket boosters worldwide, a drop in demand for low Earth orbit payloads, and a drop in NASA missions. OSC also pointed out that the numbers of launch companies and actual annual launches are too small for pooling as is done in the airline industry or with automobiles. ILS stated that the market is very competitive and profit margins are thin, so any change in the current CSLA arrangement would cost U.S. companies business. Several speakers emphasized that it is the indemnification provisions and not the actual cost of MPL insurance premiums that is important in winning launch contracts. The current risk-sharing regime offers a safety net and also allows launch companies to reduce launch costs for government launches.

A.3 Public Comments Submitted to the Docket

By the closing date of the public comment period (May 24, 2001), the FAA received four written comments—two from commercial launch operators (ILS and Kistler) (LM 2001, KAC 2001), one from a private entity (Princeton Synergetics, Inc.), and one from an association, the American Institute of Aeronautics and Astronautics (AIAA). The comments were varied, covering various elements presented in the Notice of Public Meeting published in the *Federal Register* (66 FR 15520) and discussed in the public meeting on April 25, 2001. A supplemental comment was provided by Lockheed Martin in February 2002, addressing among other things, the potential effects of September 11, 2001 events on insurance capacity (LM 2002). In addition, a written comment was provided by the U.S. Chamber of Commerce, International Division, in March 2002, endorsing COMSTAC's report findings and recommendations (USCoC 2002).[2] The following summarizes the comments received.

Comments from commercial launch operators emphasized the need for retaining the existing liability and risk-sharing regime provided by the CSLA (LM 2002, LM 2001, KAC 2001). They contend that the risk-sharing regime of the CSLA remains essential to providing a level competitive playing field for the U.S. launch industry in a highly subsidized and extremely competitive international launch industry. One operator asserted that the existing CSLA regime is the optimal means for meeting U.S. Government and commercial industry needs including those of satellite customers, contractors and subcontractors. In addition, the CSLA, as implemented by the FAA, has successfully established a regime that allows the U.S. Government to fulfill its international treaty obligations. Without the indemnification provision of the CSLA, the U.S. commercial space launch industry would be at an extremely severe competitive disadvantage. Its discontinuation would create the perception that U.S. launch operators present a higher risk profile to customers than their foreign competitors. The sunset provision of the existing regime has complicated the process of winning launch contracts because foreign competitors use the uncertainties presented by the CSLA (e.g., need for congressional action and cap on indemnification amount in addition to the sunset provision) as a means of attracting customers to their launch services. There are several instances in which U.S. launch providers were required by prospective customers to obtain FAA written confirmation of the applicability of the current regime before a contract would be fully executed. One operator commented that the FAA could adopt a simpler liability process much like the European approach—by setting a fixed amount of insurance from launch to launch of the same vehicle in

[2] The U.S. Chamber of Commerce letter was signed by the President and Chief Executive Officer of the Aerospace Industries Association, the Executive Director of the Satellite Industry Association, Chairman of the Space Enterprise Council of the U.S. Chamber of Commerce and the President of the Space Transportation Association.

comparison to the U.S. MPL analysis required for each and every launch. Another noted that customers expect and require government-supported risk allocation and that foreign competitors would be able to exploit the inability of U.S. launch providers to offer comparable arrangements to the detriment of U.S. industry. Absent the liability and risk-sharing regime of the CSLA, and indemnification in particular, the U.S. launch industry would, according to the commentor, be at a severe competitive disadvantage, "potentially a fatal one," and this in turn would likely result in increased costs to the U.S. Government in meeting civil and military space launch requirements. (LM2001).

Lockheed Martin commented that the Air Force's Evolved Expendable Launch Vehicle (EELV) Program objective of reducing launch costs while maintaining reliability and operability of current launch systems is being achieved through use of commercial procurement practices and leveraging benefits of the commercial marketplace. In light of the dual-use capability of EELV, changes to the liability and risk allocation regime that make U.S. launch providers less competitive to commercial customers will result in increased costs to the U.S. Government customer (LM2001). Lockheed Martin further commented that existing risk-sharing arrangements protect U.S. national security interests by safeguarding U.S. companies that are responsible for launching U.S. civil and military payloads, including critical national security payloads, in addition to commercial operations. The current liability risk-sharing regime of the CSLA helps provide a solid foundation for the U.S. defense industrial base by, among other things, helping to sustain scientific, engineering and technical resources critical to enhanced and more cost-effective assured access to space (LM 2001).

Kistler urged against transitioning to an airline liability regime for RLVs and Lockheed Martin indicated that it would be premature to consider doing so in light of industry differences—the commercial space launch industry being one of high-risk, low volume business while the commercial airline industry is considered a low-risk, high-volume business (KAC 2001, LM 2001). Lockheed Martin stated that it would be neither appropriate nor necessary to legislatively deem all space transportation activities to be "ultrahazardous activities" to which a strict liability standard may be applied (LM 2001).

Regarding the need for changes to the Federal Government's indemnification policy to accommodate the risk associated with commercial spaceport operation, both commercial launch operators commented that currently only licensed launch operations at the commercial spaceports are subject to and benefit from the government-industry risk-sharing and indemnification regime of the CSLA (LM 2001, KAC 2001). Lockheed Martin noted that interpretation and application of the CSLA to spaceports is appropriate and sufficient for enabling the U.S. Government to meet its obligations under international law (LM 2001). Kistler added that ground operations are no different from other heavy industrial operations with no unusual risks and available insurance on the commercial market. Even if it may be desirable to have indemnified coverage for publicly-owned launch ranges at an earlier point in preflight to protect federal properties, it should not be a general model forced upon the commercially owned and operated launch sites.

Both commercial launch operators commented that the best way to support the U.S. launch industry is to maintain stability in the insurance and indemnification regime. The expiration date provision (the "sunset provision") could be exploited by foreign competitors, who have no monetary caps or expiration date and are not subject to appropriation. A change in risk-sharing regime could raise the risk profile of new launch operators and potentially (1) deter private investment or increase the cost of capital as a result of higher perceived risk; (2) shift customers to foreign launch operators; (3) discourage contractor participation, leading to increased development costs; and (4) expose the company to greater potential liability. These, in turn, could lead to higher costs of operation for government launch operations (LM 2001, KAC 2001). In addition, due to the drop in available insurance market capacity after the events of September 11, 2001, and increased insurance cost, elimination of indemnification and imposition of additional insurance requirements would be prohibitively expensive or unobtainable.

Lockheed Martin recommended that the sunset or expiration date of the indemnification provision be deleted or, alternatively, that it be extended for no less than a 10-year period (LM 2001).

Princeton Synergetics commented on two issues: the insurance industry's perceived risks per launch and whether there remains a continuing need for the existing government indemnification policy to maintain a successful U.S. space transportation industry and improve competitiveness (PS 2001). Concerning the first issue, the commentor stated that a careful assessment should be made to determine the reason for the apparent significant discrepancy between government and insurance industry risk perceptions and the insurance pricing implications, as it might materially affect economic implications of indemnification and alternatives. The commentor added that it appears there is a large difference (about three orders of magnitude) between government and industry risk perceptions (PS 2001). For third-party insurance, the risk perceived by the government is on the order of 10^{-7}. This equates to an expected government cost of $150 assuming that any accident would result in a loss of $1.5 billion, according to the comment. The insurance companies have stated that the cost of $1 billion of insurance (per launch) above the MPL level would likely be about $400,000. This equates to a perceived risk by the insurance industry on the order of 4×10^{-4} per launch (PS 2001).[3]

With respect to the second issue, the commentor stated that the real issue is how to increase the competitiveness of the U.S. commercial space transportation industry, not whether the government should provide indemnification. The commenter added that government programs and policies that could impact competitiveness would need to be identified and evaluated. For example, a recent announcement that the Air Force may ask Congress to amend the fee structure for charging commercial launch customers for use of government ranges to achieve full cost recovery would affect competitiveness (more costs to launch operators). Therefore, a change in launch fee should not be considered only in terms of Air Force budget savings, but also in terms of its impacts on the U.S. economy, i.e., in terms of the change in Treasury revenue and jobs that may result from the change in market value (PS 2001). Decisions concerning indemnification should not be made, according to the comment, without consideration of other programs and policies that can affect international competitiveness (PS 2001). According to the comment, it would be more reasonable to determine what investment the government is willing to make to support the U.S. commercial space transportation industry, as opposed to evaluating separately each government action that may alter competitiveness, and then determine the package of mutually supporting programs and policies (PS 2001). The commentor stated that there may be alternatives that maintain a role for government in liability risk-sharing that could be phased-in over time; however, indemnification should not be instantaneously eliminated because doing so would result in near-term adverse effects.

The AIAA Public Policy Committee commented that indemnification is just one factor in the cost/competitiveness of launch services that is impacted by government policy (AIAA 2001). The cost impact to industry of eliminating indemnification could be more than offset by policy changes in other areas where government policy impacts launch services provider cost, facility availability, and operational schedules. The committee added that the long-term policy regarding commercial launch indemnification should be determined as an integral part of a policy aimed at assuring that the U.S. commercial launch services industry remains healthy, continues as a world leader in this business sector, and expands its contributions to the Nation's economy, in the face of often subsidized global competition (AIAA 2001).

[3] The issue of perceived risk and its relation to insurance premium is evaluated and addressed in Appendix D.

A.4 Internet Public Meeting Comments

The FAA elicited public comments by establishing two Internet online public fora as a vehicle for the public to provide comments. The first Internet public meeting, announced by a notice, was conducted from April 27, 2001, through May 11, 2001, but resulted in no public comments.

The FAA issued a second Notice of Public Meeting on August 15, 2001, announcing an online public forum on the Internet seeking comments and information from the public regarding the government's role in supporting the U.S. commercial launch industry. The online public forum began on September 4, 2001, and ended on September 28, 2001. The notice emphasized that public comments received after September 28, 2001, would be considered to the extent practicable.

The forum was structured in three parts. In Part I, general questions were asked about public awareness of the existence of the U.S. commercial space industry; the importance of having an internationally competitive launch industry; the role of the FAA in licensing and regulating commercial space launches and prescribing specific launch liability insurance; and the government's role in providing indemnification for excess liability to the licensed launch industry and other commercial developments (e.g., the nuclear power industry). In addition, a Part I question asked whether the public believes that the U.S. Government should continue the liability risk-sharing regime as described, and, if so, under what circumstances the support should cease. In Part II, the questions coincided with the seven specific elements of the Space Competitiveness Act, as listed in Section A.2. Part III was a free-style approach in which the public could express views and concerns on launch liability, risk management, and government policies in support of the commercial space launch industry.

By October 1, 2001, FAA/AST had received comments on all questions in Parts I and II from two individuals. Both commentors appear to be aware of the U.S. commercial launch industry; supportive of having a robust and competitive commercial launch industry; cognizant about the role of the FAA in licensing, regulating, and prescribing launch insurance for commercial launches; and supportive of continuing some type of government industry liability risk sharing. One commentor was not aware that the government provided indemnification for excess liability. Both agreed that the government risk-sharing regime is needed because: (1) the commercial launch industry offers great potential benefit to the public at large, and (2) the United States is a state party to various international treaties requiring it to assume the liabilities associated with commercial launch ventures.

One commentor believes that, in the absence of government support, the cost of insurance would become excessive, making commercial launches unavailable. In response to the question of under what circumstances government indemnification should stop, both commentors believe that stopping now would be premature because the commercial launch industry is not ready to assume the full risk, due to an insufficient number of launches for the insurance industry to provide affordable insurance coverage confidently. One commentor stated that insurer confidence will develop on a slow basis and that new vehicles will take decades to become standardized to the extent individuals are comfortable with their use. The commentor added that technological success is important to the extent it mitigates risk; however, it does not eliminate human risk factors. The commentor further noted that such issues as market share are not determinative of risk; rather, they may pertain to such matters as anti-trust law.

In regard to the ability of the U.S. launch industry to compete with foreign launch organizations without the existing liability risk-sharing regime, one commentor did not believe that the United States could compete without this regime. The second commentor argued that there is not sufficient information to evaluate competitiveness without government indemnification. Both agreed, however, that the government liability risk-sharing regime affects the launch industry's international competitiveness.

In regard to strict liability for damages and injuries resulting from launch accidents, one commentor stated that, if the launch companies were not responsible for launch accidents, they might sacrifice safety for lower equipment costs. This individual argued that some companies may set up a separate subsidiary to reduce the risk to the parent company; however, this issue is larger than the space launch (or other space-based) industry and needs to be addressed in Congress and the courts. The second commentor stated that, given the recent events of September 11, 2001, strict liability should be applied only to reasonably foreseeable events.

One commentor stated that risk sharing is better than one party holding liability; however, neither could assess the adequacy of the existing liability risk-sharing regime in light of treaty obligations. One commentor noted that because of treaties requiring the U.S. Government to assume liability associated with commercial launches, risk sharing by the government enables commercial launch operators to develop their industry without excessive insurance costs which, if fully borne by industry, would make commercial launches unviable. In regard to using an airline-like liability regime for RLVs, one commentor stated that it is premature to speculate when it would be appropriate to do so; hence, the existing policy should remain in place The second commentor questioned the adequacy of the insurance limit currently set for airline passengers. This commentor believes in strict liability for the entity that caused the damage. The commentor pointed out that the World Trade Center tragedy showed that an extremely large-scale risk is involved with aircraft and spacecraft and that perhaps a new method needs to be developed to deal with such risks.

In regard to the government's indemnification policy for commercial spaceport operations, one commentor pointed to the lack of adequate information to provide a response and stated that, for those operations involving risks analogous to vehicle launch risks, the government may choose to operate as if a launch were involved. However, in situations not analogous to licensed launch activities, the government should have no liability as the outer space treaties did not contemplate such activities. The second commentor stated that it is hard to believe that a reasonable person would use or work at such a facility without coverage or that any local government planning agency would permit operations at a facility without liability coverage and that the Federal Government would therefore not determine legal requirements.

In regard to the question of what factors Congress should consider in determining whether to change or continue the existing laws on liability risk sharing and the request for any additional suggestions for modifying the existing laws, one commentor responded that Congress might contemplate a change when the industry is more fully developed. The commentor added that there is sufficient room within the status quo to develop the commercial launch industry into a mature business activity. The second commentor provided a list of 20 issues that Congress may consider, including:

1. U.S. obligations under the international treaties

2. U.S. Government desire to promote the exploration and exploitation of resources in the universe and the potential global gains through promoting such development

3. Costs of implementing any plan versus not having any plan, including costs such as launch business opportunities lost to overseas competitors

In addition, the commentor raised concerns: (1) that industries in general have historically shown themselves to be poor at protecting people over making profit; (2) about economic decisions made by industries in general regarding activities that could cause fatalities, where the cost of fatalities is less than the cost of prevention; and (3) that creating laws does not by itself solve any problem.

A.5 Summary of Public Comments

The basic underlying themes presented by public commentors at the meeting and provided through the docket are listed below.

- The current U.S. risk-sharing liability and indemnification regime should either be retained in its existing form without changes or retained with improvements, such as elimination of any sunset provision, to support the competitiveness of the U.S. industry because foreign launch services offer similar or better indemnification in a tight market with small profit margins.

- The only changes that should be considered in order to ensure continued growth and competitiveness of the U.S. launch industry are those that would improve the existing risk allocation regime, e.g., elimination of the sunset provision or a 10-year extension. Modifications to indemnification, such as establishment of trust funds or use of tax credits (to offset cost of additional insurance), would undermine U.S. industry competitiveness.

- The need for Congress to appropriate funds for the $1.5 billion indemnification is a disadvantage of the current U.S. regime because foreign competition indemnifies without requiring any appropriation action from the government.

- Some state government laws limiting liability hinder the use of commercial spaceports for non-space-launch-related hazardous activities because they are not protected by the Federal Government risk-sharing regime.

- The commercial space transportation industry, including both RLVs and ELVs, cannot be compared to the commercial airline industry, and the commercial space liability regime cannot evolve into the type used by airlines.

- Long-term policy regarding commercial launch indemnification should be determined as an integral part of a policy aimed at ensuring that the U.S. commercial launch industry remains healthy, continues as a world leader in this business sector, and expands its contributions to the Nation's industry.

A.6 References

AIAA (American Institute of Aeronautics and Astronautics), 2001, letter submitting comments to the Federal Aviation Administration on Liability Risk-Sharing Regime for Commercial Space Transportation, Docket No. FAA-2001-9119, May 24.

AST (Associate Administrator for Commercial Space Transportation), 2001, transcript of Public Meeting on Liability Risk-Sharing Regime for Commercial Space Transportation, Federal Aviation Administration, U.S. Department of Transportation, Docket No. FAA-2001-9119, April 25.

KAC (Kistler Aerospace Corporation), 2001, letter submitting comments to the Federal Aviation Administration on Liability Risk-Sharing Regime for Commercial Space Transportation, Docket No. FAA-2001-9119, May 7.

LM (Lockheed Martin Corporation), 2002, letter submitting comments to the Federal Aviation Administration on Liability Risk-Sharing Regime for Commercial Space Transportation, Docket No. FAA-2001-9119, February 27.

LM (Lockheed Martin Corporation), 2001, International Launches Services letter submitting comments to the Federal Aviation Administration on Liability Risk-Sharing Regime for Commercial Space Transportation, Docket No. FAA-2001-9119, May 11.

PS (Princeton Synergetics, Inc.), 2001, letter submitting comments to the Federal Aviation Administration on Liability Risk-Sharing Regime for Commercial Space Transportation, Docket No. FAA-2001-119, May 15.

USCoC (U.S. Chamber of Commerce), 2002, facsimile transmission of a letter submitting comments to the Federal Aviation Administration on "Launch Indemnification," March 18.

Appendix B

Federal Agency Views and Recommendations

FEDERAL AVIATION ADMINISTRATION

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

NASA

DEPARTMENT OF STATE UNITED STATES OF AMERICA

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

THE DEPARTMENT OF THE TREASURY 1789

DEPARTMENT OF COMMERCE UNITED STATES OF AMERICA

DEPARTMENT OF JUSTICE QUI PRO DOMINA JUSTITIA SEQUITUR

UNITED STATES NUCLEAR REGULATORY COMMISSION

U.S. AIR FORCE

FC Federal Communications Commision

Appendix B
Federal Agency Views and Recommendations

B.1 Introduction

As discussed in Section 1.1, Congress directed that the current liability risk-sharing program be evaluated with respect to several key issues that have characterized public debate. Section 7 of the Commercial Space Transportation Competitiveness Act of 2000 (also known as the Space Competitiveness Act [SCA]), states that, "*The report required … shall contain sections expressing the views and recommendations of interested federal agencies including (A) the Office of the Associate Administrator for Commercial Space Transportation; (B) the National Aeronautics and Space Administration; (C) the Department of Defense; and (D) the Office of Space Commercialization….*" This appendix presents a summary of federal agency views and recommendations as they pertain to the liability risk-sharing regime for U.S. commercial space transportation. Views and recommendations are presented for each of the following congressional requirements:

- Analyze the adequacy, propriety, effectiveness of, and the need for the current liability risk-sharing regime in the United States for commercial space transportation.
- Examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities.
- Examine the appropriateness of deeming all space transportation activities to be "ultrahazardous activities" for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous or not.
- Examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties.
- Examine the appropriateness, as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime toward the approach of the airline liability regime.
- Examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations.
- Recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.

B.2 Federal Agencies Views and Recommendations

Congress has identified four federal agencies that shall provide views and recommendations. They are AST on behalf of the FAA, the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), and the Office of Space Commercialization on behalf of the Department of Commerce. Views provided by the U.S. Air Force (USAF), operator of the federal launch ranges in the United States as well as DOD's Executive Agent for space, are reflected in this report. The FAA also consulted with the following interested agencies whose authority, responsibilities, and expertise are relevant to aspects of commercial space transportation liability risk sharing. They are:

- Department of State
- Department of Treasury
- Federal Communications Commission, an independent agency
- Department of Justice

Not every agency identified above expressed a view or recommendation on each of the issues studied in this report. In addition, the Nuclear Regulatory Commission (NRC) was consulted regarding the history and status of the Price-Anderson Act, which provides a liability risk-sharing regime for the U.S. commercial nuclear power industry, but expressed no views on SCA issues because they are not within the statutory purview of the NRC.

Issue 1 — Adequacy, Propriety, Effectiveness, and Need for the Current Liability Risk-Sharing Regime

The current commercial space transportation liability risk-sharing regime has been adequate, appropriate, effective and necessary to achieve its principal objectives. The objectives include: (1) relief from potentially catastrophic liability that could not be managed through private insurance; and (2) enhancement of the international competitiveness of the U.S. commercial launch industry. An insurance market for launch liability risk has developed and responded adequately by supplying required levels of liability insurance; accordingly, this study assesses whether the existing regime remains necessary due to insurance capacity constraints. Enhancing international competitiveness of the U.S. launch industry remains a critical concern.

A number of factors indicate the adequacy, propriety, effectiveness, and need for maintenance of the existing liability risk-sharing regime. In particular, because U.S. commercial launch services providers and their suppliers also provide launch services for the government (national security and civil space programs), a strong and viable commercial industry is needed to ensure reliable launch services at the lowest possible costs brought about by economies of scale. The conduct of commercial launches reduces the cost to the government and, therefore, to the taxpayer, of government launch capability and sustains or enhances launch reliability. Many of the licensed U.S. commercial launches are conducted from the same launch facilities as government launches; that is, the USAF-operated launch ranges, using the same launch support personnel. The higher annual launch frequency achieved through a combination of government and commercial launches from the same sites maintains a continuous, stable workforce and management structure, as well as range safety infrastructure and personnel, that provide seamless launch operations.

Government participation in liability risk sharing through indemnification appears to be a principal factor in the ability of U.S. launch services providers to win or secure commercial launch contracts in the face of strong and growing foreign competition that offers government-backed indemnification. All international competitors in the commercial space launch market offer indemnification for launch services. Elimination of the current U.S. liability risk-sharing and indemnification regime could result in a loss of commercial business for U.S. companies, and reduced business and losses could offset the benefits cited above.

Issue 2 — Liability Risk-Sharing Regimes in Other Countries with Space Transportation Capabilities

Federal agencies provided no views or recommendations regarding this issue except to note that international competitors in the space launch market offer government-backed indemnification for launch services. The indemnification provided by foreign risk-sharing regimes has an advantage over that in the United States in that it is not conditional upon passage of additional government legal authority to provide the necessary funds.

Issue 3 — Ultrahazardous Activity Definition /Appropriateness of Liability Regime

Hazards associated with space launches for national defense or security purposes may warrant government-supplied indemnification under Public Law 85-804. Nevertheless, terming all launch-related activities as “ultrahazardous” and legislating the applicable legal liability standard could create impediments to commercial launch competitiveness by potentially increasing the cost of securing launch liability insurance, whether for government or commercial missions, and limiting willingness of underwriters to supply the required insurance. Determination of the appropriate liability regime applicable to launch operations should not be legislated, but should remain the province of the courts.

Issue 4 — Effects of Outer Space Treaties on Government Launch Liability

Under the terms of a number of multilateral treaties to which the United States is a party, the U.S. Government is liable, among other things, for damage occurring within foreign territory or airspace that is caused by a space launch from U.S. territory, regardless of the ownership of the launch vehicle or payload. The current liability risk-sharing regime for licensed launches addresses government liability by assigning financial responsibility for the amount of maximum probable loss (MPL) to the commercial entity that conducts the launch. Doing so affords the U.S. Government financial protection in meeting certain of its international treaty obligations, up to the maximum probable liability, at no cost to the government or U.S. taxpayer. Accordingly, for a licensed launch from the United States or by a U.S. operator, government treaty-based liability for a commercial launch event is satisfied by private insurance up to the MPL at no cost to the U.S. taxpayer.

Issue 5 — Propriety of Applying an Airline Liability Regime to Commercial Reusable Launch Vehicles

RLV technology remains in a developmental stage, including that being pursued under NASA’s $4.5-billion, five-year Space Launch Initiative. As such, it is speculative to forecast whether and when RLV operations may become sufficiently routine to warrant an airline-like liability regime for passengers and cargo. The issue is an important one that should be reexamined in light of existing laws and circumstances once RLV operations become more aircraft-like in terms of frequency, rate, and reliability. Because this eventuality may be decades removed, it would be premature to offer recommendations.

Issue 6 — Commercial Spaceport Operations

Under the existing statutory and regulatory liability risk-sharing regime for commercial space transportation, the U.S. Government is not expected to indemnify all operations at commercial launch sites (known as spaceports); only those that are conducted as part of licensed launch or reentry activities and that are also eligible for indemnification when they are conducted at federal launch sites, are covered by the regime. In that respect, indemnification is important to the continued development and economic health of commercial spaceports. Federal use of commercial spaceports occurs when some advantage for a specific launch is offered. Education, business development, and related opportunities for commercial spaceports are also recognized, but federal support is not provided for these aspects under current regulations. No changes to the current liability risk-sharing regime as it relates to commercial spaceports are recommended.

Issue 7 — Recommended Appropriate Modifications

The report addresses and evaluates a number of options that may be considered, and identifies those that support different purposes or objectives of the current liability risk-sharing regime. Views of the Department of Justice supporting greater cost internalization by commercial industries which could be considered in future legislation follow:

"The Department of Justice has reviewed the DOT report on Liability Risk Sharing Regime for U.S. Commercial Space Transportation. Under the plan, the participants in a commercial space launch are required to obtain liability insurance up to a maximum amount of $500 million per launch. The United States pays up to $1.5 billion per launch (adjusted for inflation) for indemnification of claims exceeding the insurance requirement. The licensee or legally liable party assumes any remaining liability.

The justification for governmental indemnification of the private commercial space transport industry should be critically analyzed before the plan is either renewed as it is or enhanced to provide additional governmental indemnification. In particular, the stated justifications for the indemnification plan – which essentially provides taxpayer-funded insurance support for a private industry – should be considered in light of the Administration's policies regarding such insurance supports following the events of September 11, 2001. As a general matter, except in really extraordinary circumstances involving pressing national interests, broad governmental indemnification of private industries should be disfavored. In this connection, the government's obligations should be explicitly limited to the amount of available appropriations expressly covering this cost.

A potential, specific problem with the current statute lies in 49 U.S.C. 70113(a)(2), which provides: "To the extent insurance required under section 70112(a)(1)(A) of this title is not available to cover a successful third party liability claim because of an insurance policy exclusion the Secretary decides is usual for the type of insurance involved, the Secretary may provide for paying the excluded claims without regard to the limitation contained in section 70112(a)(1)." To the extent this provision can be interpreted to permit the Secretary of Transportation to pay claims without advance congressional appropriations, it contravenes the sound principles underlying the Anti-Deficiency Act and should be stricken or modified to require advance appropriations. (Moreover, this provision presents a potentially significant and problematic loophole in the "first-tier" insurance requirement, as several common liability insurance exclusions [e.g., "your product" exclusions] might be invoked in launch disaster situations.)

While private businesses have often sought such exemptions from the Anti-Deficiency Act for their dealings with the federal government, an organizing principle has been to avoid such exemptions unless the national interest in a particular endeavor is so extreme – and privately-purchased insurance would be so expensive or impossible to secure – that federal assumption of liability for private activity is essential for the national interest.

While it is understandable that newly-developing commercial ventures would like to spread their risks, this is not an appropriate role for government in the context of a vigorous free market. It is one thing for the federal taxpayers to accept such open-ended liability for the torts of private entities when national survival is at stake. It is quite another to do so when it is simply a question of the development of commercial endeavors, however beneficial they may turn out to be.

Rather than renewing the existing plan or enhancing taxpayer-funded indemnification of the commercial space transport industry, we recommend movement toward a more comprehensively market-based approach to insuring the industry. Requiring industry participants to move toward internalization of liability risks would promote competition and launch safety and further tort principles of both compensation and deterrence. If the current plan is maintained, we recommend inclusion of a provision mandating that the United States be subrogated to the rights of indemnities against other liable parties. We also recommend that indemnification be barred in cases involving grossly negligent or reckless conduct by launch participants. We oppose, as contrary to the sound principles of the Anti-Deficiency Act, any proposed modification of the statutory plan to provide for "absolute" indemnification not dependent on advance appropriations."

Appendix C

COMSTAC Report

RISK MANAGEMENT WORKING GROUP REPORT TO COMSTAC

[UNEDITED VERBATUM REPORT]

IN RESPONSE TO THE REQUEST FOR INFORMATION IN THE COMMERCIAL SPACE TRANSPORTATION COMPETITIVENESS ACT OF 2000 ON THE LIABILITY RISK-SHARING REGIME FOR COMMERCIAL SPACE TRANSPORTATION ACTIVITIES

OCTOBER 18, 2001

I. INTRODUCTION

In accordance with the Commercial Space Transportation Competitiveness Act of 2000[1] (the "Space Competitiveness Act"), the Federal Aviation Administration's ("FAA") Office of the Associate Administrator for Commercial Space Transportation ("AST") has been charged with the preparation of a comprehensive report to Congress concerning the appropriateness and adequacy of the U.S. Government's role in the current risk allocation regime for commercial space transportation activities. In addition to public meetings and on-line public forums on the Internet to solicit views and information from the public, as well as interested federal agencies, the AST has asked Livingston L. Holder, Jr., Chairman of the Commercial Space Transportation Advisory Committee ("COMSTAC"), to provide the advice and recommendations of COMSTAC to help facilitate the development and preparation of this congressionally mandated report.[2] In turn, Mr. Holder has asked John Vinter, Chairman of the COMSTAC Risk Management Working Group ("RMWG") to collect the views of the RMWG's membership, which includes representatives of the commercial space industry as well as the insurance community, on the report elements delineated by Congress in the Space Competitiveness Act. The following represents the RMWG's formal report to the COMSTAC on this issue.

A. BACKGROUND

Before 1984, the U.S. Government was the sole provider of space launch services in the United States. Since that time, the Government has encouraged the privatization of commercial launch services by, among other things, adopting a comprehensive financial responsibility and risk allocation regime. Specifically, in 1988, Congress amended the Commercial Space Launch Act ("CSLA")[3] to provide for a liability risk-sharing regime for commercial space transportation activities comprised of (1) a demonstration of financial responsibility by the commercial launch services provider, usually through the purchase of liability insurance that protects not only private launch participants, but also the U.S. Government, its contractors, subcontractors, and personnel, (2) cross-waivers of liability among launch participants, and (3) a promise by the U.S. Government to pay successful third party claims in amounts up to $1.5 billion above the insurance requirement, subject to congressional appropriations.

The CSLA amendments established specific insurance and financial responsibility guidelines that a commercial launch provider was required to meet before the FAA would grant a license to perform launch services.[4] Under § 70112 of the CSLA, the launch services provider is required to obtain appropriate liability insurance or demonstrate the financial ability to compensate third party claims for

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[1] Pub. L. No. 106-405 (Nov. 1, 2000).
[2] Letter from Patricia Grace Smith, Associate Administrator for Commercial Space Transportation, Federal Aviation Administration, to Livingston L. Holder, Jr., Manager, Space & Launch Segment Resource 21, The Boeing Company 1 (January 10, 2001).
[3] 49 U.S.C. §§ 70101-21.
[4] *See* 49 U.S.C. § 70112(a).

damage arising from the performance of the launch services. The liability insurance is required to cover all participants involved in the launch or reentry service, including the United States Government, against third party claims. The FAA calculates the required amount of insurance per launch service based on an analysis of maximum probable loss to third parties and third-party property, up to a statutory limit of $500 million.[5] The cost of the insurance is determined by a variety of factors such as, the amount of insurance required under the policy, the licensee's (*i.e.,* the named insured's) experience as a launch services provider and the experience of the other private party launch participants covered as additional insureds. Market factors affecting the cost and availability of such insurance include the number of launches packaged under an insurance placement, the experience and track record of the launch industry as a whole, insurance market capitalization, reinsurance availability and affordability and experiences in other lines of insurance. Although policy terms and conditions generally follow market standards, they must, at a minimum, meet FAA standards.[6]

In addition to third party liability insurance, the FAA also requires a reciprocal waiver of claims among the U.S. Government, the commercial launch services provider (*i.e.,* the licensee) and its contractors, subcontractors and customers involved in the launch or reentry services, as well as the customer's contractors and subcontractors.[7] All parties involved in the launch agree to be responsible for whatever property damage or loss each sustains.[8] The requirement of comprehensive insurance to cover all participants, as well as the inter-participant cross-waivers of claims, ensures reduced launch costs by significantly limiting the threat of litigation and its associated costs among participants in the licensed activity.[9]

The cornerstone of the CSLA's three-pronged risk allocation regime is what is popularly referred to as the indemnification provision. To protect U.S. commercial launch services providers from potentially limitless third party damages, CSLA § 70113 provides for a commitment on the part of the U.S. Government, subject to congressional appropriations, to pay successful third party claims up to $1.5 billion (plus additional amounts necessary to reflect inflation occurring after January 1, 1989) in excess of the launch provider's liability insurance.[10] Thus, while the U.S. Government is potentially liable for damages to third parties that are in excess of the FAA-determined insurance requirement but less than $1.5 billion above that amount, the launch services provider is liable for third party damages up to the insurance amount required by the FAA and anything in excess of the Government's $1.5 billion limit.

B. EXTENSION OF THE INDEMNIFICATION PROVISION

As stated above, the most important element of the CSLA's risk allocation regime is the indemnification provision. Not only does it ensure the competitiveness of U.S. commercial launch services providers in the global marketplace for reasons discussed below, it protects them from irreparable financial harm in the unlikely event that third party claims arising from licensed launch activities exceed the amount of insurance required under a launch license.

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[5] *See id.*
[6] 14 C.F.R. § 440.13.
[7] *See* 49 U.S.C. § 70112(b).
[8] With respect to the U.S. Government, the waiver applies only to the extent that claims are in excess of any private insurance that the licensee has procured for the U.S. Government's benefit. 49 U.S.C. § 70112(b)(2).
[9] *See* FAA Notice of Public Meeting, 66 Fed. 15,522 (March 19, 2001) *available at* http://ast.faa.gov.
[10] 49 U.S.C. § 70113.

Originally set to expire in 1993, the indemnification provision has been extended by Congress on several occasions. With the passage of the Space Competitiveness Act, FAA-licensed operators are ensured of indemnification under statutorily prescribed procedures through December 31, 2004.[11]

In addition to extending the indemnification provision, Congress, through the Space Competitiveness Act, directed the Secretary of Transportation to conduct a comprehensive and multi-faceted study of the liability risk-sharing regime applicable to U.S. commercial space transportation.[12] Under delegated authority, the FAA's AST is responsible for soliciting comments and information from the public as well as interested federal agencies to incorporate into a final report.[13]

The final report is to address the appropriateness and effectiveness of the current risk-sharing regime, and the need to continue or modify laws governing liability risk-sharing for commercial launches and reentries beyond the December 31, 2004 sunset date.[14] More specifically, the Space Competitiveness Act mandates that the report address the following seven issues:[15]

A. Analyze the adequacy, propriety and effectiveness of, and the need for, the current liability risk-sharing regime in the United States for commercial space transportation;
B. Examine the current liability and liability risk-sharing regimes in other countries with space transportation capabilities;
C. Examine the appropriateness of deeming all space transportation activities to be "ultrahazardous activities" for which a strict liability standard may be applied and which liability regime should attach to space transportation activities, whether ultrahazardous activities or not;
D. Examine the effect of relevant international treaties on the Federal Government's liability for commercial space launches and how the current domestic liability risk-sharing regime meets or exceeds the requirements of those treaties;
E. Examine the appropriateness, as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability, of evolving the commercial space transportation liability regime towards the approach of the airline liability regime;
F. Examine the need for changes to the Federal Government's indemnification policy to accommodate the risks associated with commercial spaceport operations; and
G. Recommend appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications.

The final report is not limited to the aforementioned topics, but the principal purpose of the report is to provide an understanding of the factual and legal bases for continuing or modifying the indemnification and statutory risk-sharing program.[16] As such and as appropriate, each of the above-stated areas of analysis is addressed in turn.

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[11] Commercial Space Transportation Competitiveness Act of 2000, Pub. L. No. 106-405; *see also* FAA Notice of Public Meeting, 66 Fed. 15,520 (March 19, 2001).
[12] *See id.*
[13] *See id.*
[14] *See* FAA Notice of Public Meeting, 66 Fed. 15,521 (March 19, 2001).
[15] Pub. L. No. 106-405, § 7 (Nov. 1, 2000).
[16] *See* FAA Notice of Public Meeting, 66 Fed. 15,522 (March 19, 2001).

II. REPORT REQUIREMENTS

A. ANALYSIS OF CURRENT LIABILITY AND RISK-SHARING REGIME

The current risk allocation regime has numerous benefits, not only to the domestic commercial launch services industry, but also to the U.S. Government. Not only does the current regime sustain and enhance competitiveness, it also ensures financial responsibility and financial security, and is vital to the national security of the United States.

1. The Current Regime Enables U.S. Commercial Launch Services Providers to Compete Globally

For those in the industry, the current risk allocation regime provides reduced risk and increased competitiveness in the global launch services market. First, the indemnification provision creates a level playing field that enables U.S. launch services providers to compete effectively with their non-U.S. counterparts. The European consortium, Arianespace, the U.S. launch services industry's most formidable competitor, offers its customers full indemnification by the French Government, and other participating European governments, for third party liability that exceeds required insurance of 400 million French francs or approximately USD $60 million. Other countries in the commercial launch services market also have risk-sharing regimes in place that are either comparable to or better than what is available under the CSLA. Because of the highly competitive nature of the industry, customers of commercial launch services have come to expect the availability of a risk allocation regime where the government having jurisdiction over the launch services provider will pay successful claims that exceed third party liability insurance. Customers demand a stable and comprehensive risk allocation plan that will respond to third party claims in excess of insurance, and launch services providers that cannot offer this type of protection will be competitively disadvantaged.

In addition, the CSLA-required third party liability insurance protects not only the launch licensee but also the licensee's customers, contractors, subcontractors, and suppliers, enabling U.S. launch providers to attract and maintain domestic and international customers. This system allows for all private party launch participants to be protected under one insurance policy, with a single limit and single defense so that each party is relieved of defending and settling multiple claims against multiple parties. As mentioned earlier, the threat of litigation is significantly reduced by the requirement of cross-waivers of liability under CSLA § 70112(b). Costs to the participants in the launch activity also decrease due to the savings associated with securing a single policy covering all parties for third party liability. This reduction in overall costs associated with launch activities improves the competitiveness of U.S. launch providers. Moreover, the U.S. Government's promise of indemnification increases the affordability of third party liability insurance as it allows the sum insured to be set at an affordable level, and alleviates customer concerns about unlimited liability and litigation. Such customer concerns, which are significant, are based on the view that, in the U.S., the potential for litigation is very high.

2. The Current Regime Ensures Financial Responsibility and Security for Industry and Government

Not only does the current risk allocation regime enable U.S. launch providers to compete in the global marketplace, it also ensures the financial responsibility and enables a significant level of financial security of both the commercial launch services providers and the U.S. Government. It allows U.S. commercial launch services providers to operate with the knowledge that their liability, in the unlikely event of a catastrophe, will be shared, and that the insurance they carry to cover claims arising from such an event is in an amount established by the U.S. Government based on a careful maximum probable loss analysis. This arrangement is vital both to the launch providers and the U.S. Government in light of the fact that the companies that offer commercial launch services are the same companies that are the leaders of the U.S. defense industry. If these companies were open to unlimited liability, they would be subject to the possibility of economic ruin given that potential third party damages from an accident could exceed the launch provider's resources. Such an environment would at best, have a chilling effect on how or whether the major launch services providers pursue a commercial business and at worst, completely exclude from the industry both established and smaller companies that otherwise would introduce to the marketplace new and innovative concepts of space transportation.

The current risk allocation scheme benefits the U.S. Government by extending to it, its contractors, subcontractors and personnel, private insurance coverage at no cost, in amounts established by the U.S. Government, and authorizes the U.S. Government to use this private insurance to pay claims against it arising under private law and public international law. As a participant in launches and reentries at federal ranges and as a signatory to multilateral treaties governing space activities, the United States is liable for damage or loss to third parties arising from its space activities or the space activities of its nationals. However, with the current risk-sharing regime in place, the maximum probable amount of the Government's treaty-based financial responsibility for damages from commercial launch activities are covered by the third-party liability insurance required from the commercial launch provider, at no cost to the U.S. Government or U.S. taxpayers. Also under this regime, U.S. Government employees are treated as third parties, as well as Government launch participants, which allows them to make claims for damages in case of injury or loss, while also being covered by the licensee's third party liability insurance.

It also must be emphasized that thus far, the current regime has cost the American taxpayer nothing. There has never been a claim filed against the CSLA indemnification provision.

3. The Current Regime Protects the National Security of the United States and Encourages Innovation

The CSLA's risk allocation regime indirectly, yet quite significantly, strengthens the national security of the United States. As previously noted, U.S. commercial launch services providers and their contractors and subcontractors represent the majority of the U.S. national defense industry. When they are not launching commercial satellites or providing components, systems and services to those who launch the satellites, they are responsible for U.S. civil and military payloads, including critical national security spacecraft. If these companies were subjected to unlimited liability from third party damages arising from commercial launch activities in the absence of U.S. Government indemnification, these leaders of the defense industry would run the risk of financial ruin with every launch. Consequently, a launch catastrophe resulting in significant third party losses would compromise not only the companies involved in the launch activity, but also U.S. national security, foreign policy and economic interests. If private companies were forced out of the commercial launch business because of unmanageable risks, the entire national capability for space launch would return wholly to the U.S. Government, thereby defeating the fundamental purpose of the CSLA, to encourage commercialization of the space launch industry.

There are societal benefits of the current risk allocation regime as well. The commercial space industry generates thousands of highly-skilled, high technology jobs, employs hundreds of thousands of people and produces critical, cutting-edge hardware and technology. It enables countless important opportunities for advances in many critical areas including communications, medicine, education, weather prediction, navigation and environmental protection. The regime also allows the U.S. Government customer, and therefore the U.S. taxpayer, to benefit from the efficiencies developed through the launch providers' commercial business activities. For example, because of the existence and conduct of commercial launch services, the U.S. Government benefits from overhead allocations. Costs charged by subcontractors also are controlled, in part, due to extension of the CSLA's indemnification provision to them whenever they are engaged in licensed launch activities. Therefore, absent the CSLA's comprehensive risk allocation regime, U.S. jobs could be lost, innovation stifled and costs to the taxpayer increased.

The CSLA helps both the commercial launch operator, by establishing a foundation that supports and encourages the business of performing launch services, and the U.S. Government customer, by providing it reliable and affordable access to space. With the current risk allocation regime in place, U.S. national security interests are furthered because the CSLA creates an environment conducive to sustaining scientific, engineering and technical resources critical to our country's ability to develop safer, more efficient and more cost-effective means of assuring access to space. For the reasons stated above, it is clear that this risk allocation regime is vital to the country in that it provides solid support for the U.S. defense industrial base.

4. Effect of Eliminating the Current Risk Allocation Scheme

If the CSLA's risk allocation regime were no longer available, U.S. launch services providers either would: (a) assume a higher level of risk with each launch; (b) cease to be involved in the commercial launch business; or (c) procure third party liability insurance to replace the amount of coverage that would have been available under the existing indemnification provision. Option (a) would be objectionable to the launch services providers' shareholders, who could deem the assumption of potentially unlimited risk as irresponsible and a breach of a company's decision-makers' duty to the shareholders. Option (b) would be contrary to U.S. Government policy and the CSLA both of which call for the promotion and encouragement of a commercial launch industry. While option (c) might seem to be a reasonable alternative, it is, in fact, unacceptable because it is economically unfeasible and its availability is untested and cannot be guaranteed.

The additional costs associated with having to procure higher amounts of third party liability insurance would increase the price of U.S. launch services, thereby undermining U.S. companies' competitiveness. Moreover, the availability of third party liability insurance in amounts to compensate for the absence of the CSLA's indemnification provision cannot be guaranteed and is likely to be affected by external events. The third party liability insurance market's resiliency has yet to be tested by losses from any commercial launches.

The increased insurance costs that would result from the elimination of U.S. Government indemnification would prove extremely difficult for established launch services providers to manage, would put them at a competitive disadvantage in the global launch services marketplace and ultimately may drive them from the marketplace entirely. Young, start-up launch companies likely would be precluded from entering the industry at all. In summary, both the more established and newer companies that comprise the U.S. commercial space transportation industry would be negatively affected, if not crippled, by the significant hurdles that would be created in the absence of U.S. Government indemnification.

B. COMPARISON TO RISK-SHARING REGIMES OF OTHER COUNTRIES

In comparing the U.S. risk allocation regime to that of foreign countries, it should be clear that elimination of the indemnification provision would result in a severe competitive disadvantage to U.S. commercial launch providers.

The most significant competitor of U.S. commercial launch services providers is Europe's Arianespace. Arianespace offers its customers a risk-sharing plan with similar, yet more generous coverage than that available under the CSLA, including:

1. Required inter-party waivers of liability similar to that under the CSLA, covering both property and persons involved in launch activities;
2. A minimum level of required third party liability insurance that protects Arianespace, its customers and their contractors, subcontractors and suppliers against claims of third parties for bodily injury or property damage at no cost to the customer (set at 400 million French francs or USD $60 million); and
3. Unlimited and unqualified indemnification by the French government for third party liability that exceeds the required insurance.

The fact that the indemnification offered by the French and other European governments, unlike that offered by the U.S. Government, is an unqualified financial commitment demonstrates the European governments' unambiguous support of its launch services provider. This risk allocation regime, which has no monetary cap, is not subject to appropriations and carries with it no expiration date, is extremely helpful to Arianespace and attractive to its customers.

China, Russia, Japan and Australia also have established domestic space laws, regulations or policies that address risk allocation in commercial launch activities. Each of these countries' regimes are comparable to or better than what is available in the U.S. The China Great Wall Industry Corporation, which operates the Long March launch vehicle, offers its customers third party liability insurance in the amount of USD $100 million and full indemnification by the People's Republic of China for claims in excess of the liability insurance. Russia's Khrunichev Enterprise provides its customers up to USD $300 million of third party liability insurance and indemnifies claims in excess of insurance. Japan provides full indemnification for claims that exceed the insurance requirements of USD $64 million. Under Australia's Space Activities Act, any claims in excess of the required insurance amount are paid by the government.

All of the above-mentioned countries have risk allocation regimes that are comparable to or more favorable than that which is offered under U.S. law. An inability on the part of U.S. commercial space launch providers to extend to their customers at least what currently is available under the CSLA would severely compromise their ability to compete in the global marketplace, and jeopardize the economic viability of U.S. commercial launch services.

C. SPACE TRANSPORTATION ACTIVITIES AS ULTRAHAZARDOUS

Industries that are deemed to be ultrahazardous in nature are subject to a strict liability standard upon which liability is based on the dangerous and risky nature of the activity rather than the lack of care on the part of the actor conducting the activity. Under special provisions, contractors that engage in ultrahazardous or unusually hazardous activities for the U.S. Government may receive assurances of Government indemnification above the limit of insurance that is available at a reasonable cost.[17]

Members of the RMWG believe that it is neither necessary nor appropriate to deem all space transportation activities as ultrahazardous. The CSLA's indemnification provision is responsive to U.S. commercial launch services providers' needs, subject to the recommendations for improvement set forth later in this report as required under the Space Competitiveness Act.

[17] *See* FAA Notice of Public Meeting, 66 Fed. 15,523 (March 19, 2001).

D. EFFECT OF INTERNATIONAL TREATIES ON THE U.S. GOVERNMENT'S LIABILITY FOR COMMERCIAL SPACE LAUNCHES

As a signatory to the Convention on International Liability for Damage Caused by Space Objects ("Liability Convention"),[18] the United States accepts liability for certain damages when it launches or procures the launch of a space object, or when the launch takes place from U.S. territory or a U.S. facility, *i.e.,* when it is a "launching state."[19] When it is a launching state, the United States is absolutely liable for damage caused by its space objects on the surface of the Earth or to aircraft in flight.[20] This would include injury or damage arising from an FAA- licensed launch. If, however, damage involving a space object occurs in outer space, then liability is fault-based and the U.S. Government is liable only if the damage is due to the fault of the Government or persons for whom the Government is responsible.[21] If the damage caused is to nationals of the launching state or to foreign nationals participating in the launch activities of the launching state, then no liability for such damage is ascribed under the Liability Convention.[22]

Furthermore, the United States, as a party to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty"), bears international responsibility for activities in outer space carried on by non-governmental entities.[23] The United States is required to authorize and continue supervision of such activities.

Consistent with the obligations under the aforementioned international treaties, the United States, through the CSLA, supervises the launch and reentry activities of its nationals. Through the implementation of the CSLA, not only does the U.S. Government meet its obligations under international treaties, but it does so with minimal risk to the U.S. taxpayer. This is because the FAA, the federal agency that licenses and regulates U.S. space launch operators, determines the amount of risk that the U.S. Government is willing to assume with respect to each licensed launch service. By requiring a commercial launch services provider to obtain third party liability insurance in an amount established by the FAA pursuant to a maximum probable loss analysis, the FAA ensures that the U.S. Government is protected by private insurance against the maximum probable value of third party claims arising from any one launch mission at no cost to the U.S. taxpayer. Claims in excess of such private insurance, which the FAA on behalf of the U.S. Government has deemed are not probable, would be paid directly by the U.S. Government. This two-tiered approach enables the U.S. Government to meet its obligations under international law with minimal risk to the U.S. taxpayer.

E. APPROPRIATENESS OF AIRLINE LIABILITY REGIME TO COMMERCIAL SPACE TRANSPORTATION

As commercial reusable launch vehicles ("RLVs") enter service and demonstrate improved safety and reliability, the issue of whether the current liability risk-sharing regime for space launch and reentry vehicle operations should be transformed to resemble the liability scheme of the commercial airline industry needs to be addressed. Clearly, there are similarities between the operation of airplanes and

[18] Convention on International Liability for Damage Caused by Space Objects, entered into force October 9, 1973, 24 UST 2389, TIAS 7762.
[19] Liability Convention at Article I.
[20] Liability Convention at Article II.
[21] Liability Convention at Article III.
[22] Liability Convention at Article VII.
[23] Treaty on Principles governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, entered into force October 10, 1967, 18 UST 2410, TIAS 6347, at Article VI.

conceptual RLVs. Conventional aircraft operate on a global basis, in multiple airports and with largely unrestricted flight corridors. Future RLVs are intended to have multiple launch and landing sites and a broad range of flight azimuths. Similar to the FAA requirement of liability insurance for commercial launch providers, the Department of Transportation's economic regulations require U.S. and non-U.S. air carriers to have liability insurance coverage in certain minimum amounts.[24] However, the airline liability regime has no provision for government indemnification of commercially operated civil aircraft for third party liability above the required insurance amount.[25]

Privately funded airline liability insurance, moreover, is made possible by the sheer size of the industry and the consequent predictability and distribution of risk. The U.S. airline industry generates almost $273B per year[26] with over 11 million departures per year[27]. Such an industry is capable of self-financing its complete insurance requirements. The most optimistic RLV flight rates, on the other hand, forecast approximately one launch per week making it impossible for the industry to finance its entire insurance requirements and still remain competitive. In summary, despite the similarities, there are fundamental differences between the operation of civil airplanes and RLVs. Though the application of an aviation-style insurance regime may be possible in the future as RLV flight rates reach sustained higher levels, removal of the current indemnification regime at this time would severely disrupt the formation of this industry.

In regard to expendable launch vehicles ("ELVs"), ELVs and commercial airplanes share few similarities, either with respect to operation or risk profile. Therefore, it is inappropriate and premature at this time to consider replacing or modifying the current space launch risk allocation regime to look like a risk management plan that is designed to address the needs of the commercial airline industry.

F. INDEMNIFICATION FOR COMMERCIAL SPACEPORT OPERATIONS

Under the CSLA's liability risk-sharing regime, non-federal launch site and reentry site operators are covered as additional insureds under the launch licensee's third party liability insurance if their site is used to support that licensed launch or reentry. As contractors to the licensees, these "spaceports" are not only extended the benefits of insurance by the licensee but also are eligible for U.S. Government indemnification if third party claims arising from the licensed launch activity exceed the required FAA insurance amount. A spaceport's activities that are separate from licensed launch or reentry activities, however, are not eligible for U.S. Government indemnification and must be covered by insurance or other financial protection. In other words, the CSLA's risk allocation regime has been determined by the FAA not to apply to launch site operations that are unrelated to licensed launch activities.

Current users of the spaceports (*i.e.,* licensed launch operators) find application of the existing statutory scheme to licensed launch site and reentry site operators to be adequate and appropriate. As noted by the FAA, this view is based on the belief that only operations directly related to the launch and reentry mission require government risk-sharing and indemnification.[28] Moreover, as the U.S. Government would bear no liability under international space law in the event of third party injury or loss arising from ground operations at a launch or reentry site, there is no need for the U.S. Government to take any special risk management measures in this regard. Lastly, given the availability and relatively reasonable cost of comprehensive general liability insurance to cover ground activities, a strong argument

[24] *See* FAA Notice of Public Meeting, 66 Fed. 15,523 (March 19, 2001).
[25] *See id.*
[26] Air Transport Association, *Airline Economic Impact*, *available at* http://www.air-transport.org.
[27] National Transportation Safety Board web page, *available at* http://www.ntsb.gov.
[28] *See id.*

can be made that application of the current risk allocation model to non-federal launch site and reentry site operators is sufficient.

However, at least one launch site operator believes that the FAA's current interpretation of the CSLA's risk allocation scheme, which precludes the possibility of U.S. Government indemnification for launch site and reentry site operators even though they are licensed by the FAA, is wrong. The Spaceport Florida Authority ("SFA"), a state government organization licensed by the FAA as a launch site operator, takes issue with the FAA's decision not to establish insurance requirements for such operators. The SFA contends that U.S. Government indemnification is required for licensed launch site operators as well as licensed launch operators because both types of licensees conduct hazardous activities for which insurance may not be reasonably available. Therefore, the SFA would like the FAA to extend to it the full benefits of the CSLA's risk allocation regime, including establishing a requisite amount of insurance and the promise to pay claims in excess of such insurance, subject to appropriations.

G. RECOMMENDATIONS FOR MODIFYING THE CURRENT LIABILITY REGIME

Members of the RMWG carefully considered the congressional request for recommendations for appropriate modifications to the commercial space transportation liability regime and the actions required to accomplish those modifications. In doing so, members were reminded that the competitive environment that gave rise to this regime in the 1980s has not subsided, but intensified. Today, the fierce competition facing this U.S. industry that is critical to the national defense is punctuated by the waning of what already are extremely thin profit margins. Therefore, it is vital to ensure that modifications to the current regime, if any, do not disrupt the relatively level playing field with respect to risk allocation that is achieved by the current regime. Alternatives such as relying more on the aviation insurance market for significantly higher levels of liability coverage, employing alternative institutional structures, such as risk pooling or establishment of a "group captive" or a trust fund, or allowing tax credits[29] to defray, in part, the cost of securing larger amounts of insurance capacity, are mechanisms which neither individually nor in sum would respond to the core concerns that the existing risk allocation regime was carefully designed to address – economic viability and competitiveness.

As stated earlier, the launch industry may not be able to maintain its viability, let alone its competitiveness, if it is forced to depend on the insurance market for higher levels of liability coverage absent the current risk allocation regime. The available liability insurance market's primary application is to the aviation industry, both manufacturers and carriers, and from time to time its full capacity is severely taxed. It is a market whose limited capacity is subject to fluctuation due to a broad range of natural and unnatural disasters. It is a market that has been severely affected by the horrific events of September 11. It is a market whose capacity cannot be guaranteed, particularly in its application to the relatively small but high risk launch industry. To require an industry that is essential to a variety of U.S. interests to depend on an unpredictable insurance market to protect it against potentially incalculable losses could result in irreparable harm to that industry and the attendant national interests.

The suggestion of pooling risk is not new and is useful for certain industries. Its applicability to the commercial space launch services industry was raised and debated prior to enactment of the CSLA's 1988 amendments, which provided for the current risk allocation regime, including the indemnification provision. A 1988 report entitled "Insurance and the Commercial Space Launch Industry," prepared by the Congressional Research Service ("CRS Report") at the request of the Senate Committee on Commerce, Science and Transportation, explored the issue of pooling in a commercial launch context. The CRS Report noted (at the time the report was drafted) that:

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[29] *See* Transcript of Public Meeting, April 25, 2001 (FAA 2001-9119-7), 151-82, available for review at the FAA Building, Room 331, AST-100.

> [t]he U.S. launch services industry consists of only three large companies and several small companies, and the latter would probably be limited in their capability to contribute to a self-insurance pool. Three companies are undoubtedly insufficient to create a pool over the short term, the time period during which the guarantee of third party coverage is needed. Another possibility is that all of the subcontractors participating in the launch industry could contribute to the pool. The subcontractors would, however, pass the cost of contributing to a pool along to the launch company.[30]

In light of the foregoing factors, the CRS Report succinctly concluded that "[i]mposition of payment into a pool could increase costs and make the [launch] companies less competitive."[31] Strikingly, the factors that applied in 1988 apply today. In fact, today's situation is somewhat more severe. Only two large companies and one small company comprise the U.S. commercial launch services industry. It is these companies that today face dwindling profit margins and increasingly tough competition in the world market. New U.S. entrants, primarily RLV companies, are in great need of basic funding and, even more than their established counterparts, are in no position whatsoever to contribute money to a risk pooling scheme. The analysis performed in 1988 yielded the appropriate conclusion then. It remains the appropriate conclusion now.

The notions of trust funds or tax credits also are not responsive to the industry's need to offer its customers a risk allocation regime that is comparable to those offered by their non-U.S. competitors. Consequently, such approaches would not necessarily enhance the competitiveness of the U.S commercial launch services industry. To the contrary, if these options were employed to replace the existing risk allocation regime, they likely would impair the industry's competitive position. More specifically, the establishment of a meaningful trust fund, which would require significant financial participation from the very few participants in the U.S. launch industry, would create the same financial difficulties as the risk pooling scheme. Tax credits, which might be useful tools for further supporting and encouraging this critical industry could be of value in reducing the economic burden of excess insurance costs, but they are not a substitute for a carefully crafted risk sharing regime comprised of privately procured insurance, the amount of which is based on a precisely defined MPL amount and the promise of the U.S. Government to pay claims in excess of that amount.

In summary, the main objective of the 1988 amendments to the CSLA, which established the current risk allocation regime, was to ensure the competitiveness of the emerging U.S. commercial launch industry. Since then, the competition for customers among commercial launch services providers has increased and shows no signs of abating. In comparing the various risk allocation schemes of countries participating in the commercial launch industry, U.S. companies receive less government support and bear a greater financial responsibility than their non-U.S. competitors. To eliminate the U.S. Government indemnification provision, the cornerstone of the current CSLA liability risk-sharing regime, would be a potentially fatal blow to the industry and ultimately result in increased costs to the U.S. Government and the American taxpayer.

The primary weakness in the current risk allocation regime is the unpredictability created by the CSLA indemnification provision's expiration date. It is the industry's recommendation that the CSLA be amended to (1) delete the sunset provision, the preferred option, or (2) extend application of the indemnification provision for no less than a 10-year period.

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[30] *Insurance and the U.S. Commercial Space Launch Industry*, 100th Cong., 2d Sess., 19, Committee on Commerce, Science and Transportation, S. Print 100-112 (July 1988).
[31] *Id.*

The importance of the elimination of the expiration date to the competitiveness of the U.S. launch industry cannot be overstated. The CSLA sunset provision handicaps U.S. launch services providers with a competitive disadvantage that is exploited by non-U.S. competitors with more comprehensive government-supported risk allocation regimes. Because most customers enter into their launch services contracts two to four years before their launch date, they demand a high level of predictability for risk management costs at the time the contract is executed. Doubt as to the availability of government indemnification or the possibility of relying on the fluctuating commercial insurance market ensures a lack of confidence in U.S. launch services providers on the part of their potential customers. An environment of unreliability and unpredictability with respect to risk management will severely impair U.S. commercial launch services providers' ability to market their services to both domestic and international customers.

The RMWG members submit that the risk allocation regime, featuring the indemnification provision, was the best option for the U.S. Government, the U.S. taxpayer and the U.S. commercial launch services industry in 1988 and remains the best option today and for the foreseeable future. The only modification we deem appropriate is, ideally, elimination of the sunset provision or extension of the indemnification provision for no less than a 10-year period.

III. CONCLUSION

The RMWG strongly and respectfully requests that the COMSTAC request the Secretary of Transportation to support this report and submit to Congress a proposal to amend the CSLA by deleting the sunset provision or, alternatively, extending application of the indemnification authority for an additional period of ten years.

Appendix D

Commercial Space Launch Liability Insurance Market

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Commercial Space Launch Liability Insurance Market

D.1 Introduction

As part of this study and analysis of the U.S. commercial space transportation liability risk-sharing regime, it is necessary to understand the role of the commercial space launch liability insurance market. This appendix summarizes a series of interviews conducted with leading insurance brokers and underwriters active in the space launch liability industry. These interviews, all conducted prior to the terrorist attacks of September 11, 2001, characterize the current insurance market, past trends, and predictions for the future.

D.2 Insurance Market Analysis

Three insurance brokers and four insurance underwriters significantly involved in the commercial space launch insurance market, including third-party liability, were contacted to obtain information regarding the insurance market. These brokers and underwriters are located in the United States and the United Kingdom. Collectively, they have been involved in insurance for all active U.S. and foreign launch services providers. The following discussion is intended to convey consensus information and opinions gathered from these interviews (ACE 2001, BAIG 2001, ISBG 2001, Marsh 2001, RUA 2001, USAIG 2001, WC 2001).

The commercial space launch liability insurance market is part of the overall worldwide aerospace insurance market. Total annual third-party launch liability insurance premiums worldwide are estimated to be between $2 and $10 million. To put this in perspective, the total aerospace insurance market has an annual premium estimated to be in the range of $3 to $5 billion. The aerospace market includes commercial airlines, general aviation, satellites, aviation product liability, government space launch range facility property liability, and space launch third-party liability. Thus, the amount of third-party liability insurance premiums collected for commercial space launches represent only about 0.1 percent of all aerospace insurance premiums. Total aerospace insurance premiums constitute a small market compared to other insurance markets. For example, the U.S. general (i.e., homeowner and auto) liability insurance market collects about $300 billion in annual premiums. By comparison, the annual global aerospace insurance premium market is less than the U.S. East Coast plate glass insurance premium market, and also less than California auto insurance premiums. In spite of this relatively small market, the aerospace insurance business is attractive because it offers a higher income per account compared to other insurance business such as home and auto insurance. It is important to note, however, that the space launch insurance business is a small part of the aerospace insurance business, which itself is a niche market within the much larger insurance industry. Furthermore, third-party launch liability insurance is a small fraction of all insurance needs and is usually bundled with other insurance in a comprehensive annual policy for large aerospace companies such as Boeing, Lockheed Martin, and Orbital Sciences. In other words, the $2 to $10 million annual premium market for worldwide space launch third-party liability coverage is not adequate to pay for even one large claim. Such a claim would be paid from capacity built from other insurance industry capacity, but insurance markets are not cross-utilized for profits covering losses of other markets.

Current third-party launch liability insurance coverage varies in the range of about $50 million for the European Space Agency's Ariane and smaller U.S./Russian launch vehicles up to as much as $500 million for some large Russian launch vehicles. Most typical third-party liability insurance requirements are in the $100 million-$300 million range. The premium for typical third-party launch liability insurance was estimated to be in the range of $100,000 to $400,000 per launch. The premium for an insurance policy is determined by a complex process that is neither documented nor precisely defined. Unlike life and auto insurance, space launch third-party liability insurance premiums are not based on actuarial tables or data because the number of launches is too few to obtain statistically significant data.

The broker is used by a launch operator to obtain a specified amount of coverage for the best possible (i.e., lowest) premium. The broker will use underwriters that are secure financially so that they will be solvent if they are needed to pay claims. The broker contacts underwriters asking for premium quotes and uses these quotes to put together a package from a group of underwriters that meets the client's needs. Thus, a launch company seeking $100 million in third-party launch liability insurance would obtain a policy from its broker that consists of several underwriters, each committing to a fraction of that $100 million with a specific premium requirement for their contribution to the overall policy coverage. Frequently, underwriters seek additional protection from losses by obtaining secondary insurance from the reinsurance market. This process spreads their risk.

The methodology by which underwriters determine whether they are willing to offer insurance coverage, how much, and at what premium is not a documented, exact, or rigorous science. Rather, it has been described as a "subjective method" that relies on individuals' judgment, experience, and knowledge of the space launch business and aerospace companies. Underwriters will request and obtain as much information as possible about the launch vehicle design, quality assurance, launch site, mission, payload, historical reliability, and many other tangible or intangible factors. The fact that the United States and Japan are viewed as more litigious societies with concomitant larger court settlements for lawsuits than in China, Russia, and Europe has some effect on the premium charged for third-party launch liability insurance. Underwriters acknowledge the high degree of range safety at U.S. launch sites, but generally believe that all major worldwide launch vehicles and sites have relatively comparable levels of safety and reliability. Depending on the amount of insurance claims, there would be an effect on the premium for all launch vehicles if one vehicle experienced one or more launch accidents that caused third-party damages.

Upon an initial examination, it might appear that the premium charged for launch liability insurance is determined using a ratio of about 1×10^{-4}. In fact, according to representatives of brokers and underwriters actively involved in the commercial space launch liability insurance market, the premium charged for commercial space launch third-party liability insurance in satisfaction of MPL-based requirements is a fraction of approximately 10^{-3} to 10^{-4} times the amount of coverage, hereupon called the premium ratio. [In other words, $100,000 buys about $100 million of insurance coverage (before September 11).] Some observers[1] have noted that this ratio does not agree with a basic premise underlying MPL, i.e., that there is a about a 1×10^{-7} probability of exceeding MPL. The explanation for this apparent disparity between the premium rate charged and the MPL probability threshold lies in the underlying nature of these two parameters.

[1] See comment of Princeton Synergetics in Appendix A.

The MPL probability threshold is specifically determined for each launch vehicle and concomitant launch site using detailed technical and cost analyses, which account for a wide spectrum of factors such as: launch vehicle reliability, population density, property value, propellant explosive equivalence, flight trajectory, structure overpressure integrity, and failed launch vehicle debris distribution. The MPL value is based on sound, documented, and technically reviewed deterministic and probabilistic calculations. The exceedance probability applies to the total MPL amount, but a larger probability would pertain to losses smaller than the MPL. For example, if the third-party launch liability MPL for an ELV is $100 million, the probability of exceeding $100 million is 1×10^{-7}, but the probability of an accident causing $10 million in losses from this same ELV would be greater than 1×10^{-7} and the probability of a $1 million loss would be larger than that for the $10 million loss. The underwriter still has to pay for claims even if the loss is less than, or within, the MPL limit.

Conversely, the third-party launch liability insurance premium ratio is based on market conditions and a qualitative assessment by insurance underwriters and brokers. Regardless of the amount of launch insurance requested, there is a de minimis premium below which insurance company costs would not be covered and there would be no profit potential. The premium is usually derived by the broker, who contacts numerous underwriters to put together the package of insurance coverage and premium with a collection of several underwriters. The underwriters set a premium for a specific amount of coverage using a “subjective method” that does not involve rigorous scientific, engineering, or probabilistic calculations. Rather, the underwriter strives to set a premium that covers all costs of doing business (overhead) and provides funds to cover potential future losses while affording an acceptable return on investment. Each underwriter in the package developed by the broker for launch liability insurance must cover overhead and include reasonable profit in their premium. The principal incentive for underwriters is that of receiving a return commensurate with their perceived risk of paying potential claims. The law of supply and demand directly influences the magnitude of premiums charged by underwriters in accordance with the demand for such insurance, predicated upon the number of launches and the supply of underwriters willing to offer launch insurance. A dearth of willing underwriters coupled with an increase in demand for launches would result in increasing premiums (increased risk of pay-out assumed by fewer participants in pool), whereas a drop in launches in conjunction with an increasing number of willing underwriters would reduce the premiums (each participant accepts less risk of pay-out). Similarly, at higher limits of liability coverage, it is reasonable to expect fewer underwriters willing to share in greater risk, and those that would do so would charge higher premiums to cover their greater risk exposure.

One underwriter provided anecdotal evidence of this method when discussing a request for launch liability insurance for a small university sounding rocket. The university had a limited budget and could only afford $5,000 for its launch insurance premium. The underwriter was not interested or willing to offer this insurance because the $5,000 was below its cost of doing business coupled with some minimum acceptable profit.

The premium charged is also based on specific market conditions such as the general health of the insurance industry in terms of overall profits or losses in the same sector. Commercial space launch liability insurance is part of the aerospace insurance market and its premiums are subject to fluctuations in the overall financial health of the aerospace insurance business. If losses exceed premiums, the industry will increase premiums to compensate for those losses. As premiums increase, at some point in time, the higher rate of return will attract more companies in the underwriting or reinsurance business area for that sector and competition will drive down premium costs.

Overall, the premium ratio is not related to the MPL exceedance probability, which is the probability that a claim on a given launch will exceed the MPL value, whereas the premium ratio is based on minimum overhead costs, a qualitative assessment of the likelihood of claims of specific amounts (e.g., $1 million, $10 million, etc.) tempered by the impact of market conditions, competition, and the overall health of different sectors of the interconnected insurance industry. Given the differences in meaning, it is not unreasonable for the premium ratio to be greater than the MPL exceedance probability.

Since 1995, there have been a number of commercial launch failures in China and Russia that resulted in third-party claims. The insurance payouts were less than $10 million for the Chinese launch failures and less than $1 million for the Russian launch failures. To date, there have been no third-party claims associated with U.S. commercial space launches. However, if a major commercial launch accident occurred that resulted in large insurance payments on the order of $100 million or more, there would be an immediate effect on the market — premiums would rise and available capacity would be reduced. If an accident were to draw upon funds through government indemnification, which becomes effective after the maximum probable loss (MPL)-based insurance coverage is exhausted, it would cause a profound effect on the future of international risk-sharing regimes by affecting insurance capacity and premiums. It could also erode confidence in the protection afforded by the MPL third-party liability insurance amount.

The effect of the current U.S. liability risk-sharing regime for commercial space transportation on the insurance industry is to set specific limits based on MPL calculations of the required amount of third-party liability insurance and to limit risk by application of cross-waivers of claims. If the MPL were eliminated, the insurance industry would respond, to a point, to launch providers' requests for higher levels of coverage. Prior to September 11, 2001, it was estimated that about $1 to $1.5 billion of capacity per launch is available for third-party liability insurance. This current capacity is not a guaranteed amount and would be expected to change from year to year, depending on the overall aerospace insurance market. The aerospace insurance market has experienced large losses due to commercial airline accidents for the last two years. This is predicted to result in increased premiums in the near term. The events of September 11, 2001, are expected to further exacerbate aerospace insurance industry losses when insurance settlements have been determined.

Capacity is subject to market conditions and fluctuations as underwriters seek to invest in a manner that achieves a desired return on investment. Insurance premiums are determined by the law of supply and demand. Available capacity is related to the underwriter's appetite for capital and risk. Currently, it is estimated that an additional third-party launch liability insurance coverage of $1 billion above the MPL would cost an additional premium of between $500,000 and $1 million. In today's very competitive expendable launch vehicle (ELV) market with an excess supply of launch vehicles compared to payload demand, a difference of $500,000 to $1 million in cost could be the deciding factor in selecting a launch contract. This difference becomes more pronounced for smaller ELVs used for low Earth orbit missions because their overall cost is less. Furthermore, these higher insurance costs may be prohibitive for small startup reusable launch vehicle (RLV) providers.

The aforementioned $1 to $1.5 billion in available third-party launch liability insurance capacity has been constant for the last five years, but is significantly greater than the available capacity in the 1980s. The maximum available capacity for this insurance for the Space Shuttle in 1982 was about $750 million. Another estimate is that the maximum available third-party launch liability insurance about 15 years ago was $200 million. The space insurance market was described as being "in mayhem" in 1988 when the United States passed the Commercial Space Launch Act (CSLA) amendments enacting the current risk-sharing regime. During the 13 years following enactment, this insurance market has "settled down," premiums have dropped, and available capacity has increased. However, recent airline losses in 1999 and 2000 are expected to cause some increase in space launch insurance premiums worldwide next year. Certainly, it can be postulated that $1 to $1.5 billion in additional third-party launch liability insurance may always be available, but the variable is "at what price?" especially in light of the events of September 11, 2001. Information regarding new premiums and capacity is discussed in Appendix F.

Current ELVs, depending on their size and mission, cost anywhere from about $10 million to approximately $200 million for a launch. Thus, any additional insurance premium of $500,000 to $1 million could significantly affect the cost of a launch.

The effect of CSLA cross-waivers of claims provisions were deemed equally, if not more, significant than indemnification by the launch liability insurance community. Cross-waivers of claims provide stability and risk assurance to the insurer. If the cross-waiver provisions of the current U.S. risk-sharing regime were eliminated, there would be a pronounced effect on the availability of insurance because this small amount of business would present too much risk. Cross-waivers allow insurers to focus on one managing party and contractors and suppliers to continue to produce their parts and participate in launch activities without the need for individual liability coverage. Absent cross-waivers of claims, contractors and suppliers of component parts and services might not participate in launch-related activities because they could not afford the insurance, liability risk and exposure of a launch accident and its associated liability in terms of inter-party litigation.

The most pronounced effect of the 1988 Amendments to the CSLA was to bring stability to the space insurance market by allowing both the insurers and insured to manage liability exposure and risk and factor them into launch costs. Although the actual risk may have remained constant, the perception of underwriters is that the risks associated with third-party launch liability insurance have been reduced.

Insurance industry representatives favor either continuation of the existing U.S. risk-sharing regime or modifications that eliminate the stipulation that Congress has to appropriate funds for the indemnification provision. Even though elimination of U.S. Government indemnification would result in an increase in business for brokers and underwriters, space insurance representatives are not in favor of this action because they do not believe it is in the best interest of U.S. launch providers in terms of international competitiveness.

The insurance industry consensus is that RLV third-party liability insurance will be available when it is required, but unproven designs and unknown reliability, coupled with the potential for carrying passengers, will cause premiums to be higher on a per-million-dollars-of-coverage basis. It was also recognized that RLVs can be viewed like ELVs during launch and their risk treated accordingly. However, RLVs introduce additional risk elements because of reentry. In addition, unlike commercial airlines, RLVs have the potential of failing and becoming stranded in orbit with passengers on board. Issues of insurance obligations to fund a rescue mission, if feasible, add new risk elements for insurers to consider.

D.3 Summary of Space Launch Liability Insurance Industry Input, Data, and Recommendations

The insurance industry, consisting of brokers and underwriters, is an international market-driven business that responds to the law of supply and demand and seeks to invest in a portfolio of balanced risks to obtain an acceptable return on investment. Profits and losses in one insurance market segment can and do affect premiums and capacity in other insurance market segments.

The commercial space launch insurance sector is treated as part of the aerospace insurance market, which in itself is a small segment of the overall insurance business. Commercial space launch third-party liability insurance premiums, with an annual value of between $2 and $10 million, constitute only about 0.1 percent of the total aerospace insurance premium pool and are generally offered as a service within a larger comprehensive policy for U.S. aerospace companies. As such, third-party launch liability insurance is only attractive to insurers as long as no significant claims arise and the perceived risk remains acceptable. To date, internationally, no large third-party claims have occurred due to commercial space launches. Premiums are determined by underwriters' assessments of risk based on many design and performance factors, but also including the litigious nature of the country of citizenship of the launch operator.

Insurers consider the cross-waiver of claims provisions of U.S. law, 49 U.S.C. 70112(b), to be vital for launch insurance stability. MPL and indemnification are considered to be valuable tools in determining appropriate coverage and suggesting that the risks are manageable. If U.S. Government indemnification ended, the insurance market could currently provide additional coverage for third-party liability in the range of $1 billion to $1.5 billion, but at an additional premium of about $500,000 to $1 million. Year-to-year fluctuations in the insurance market will affect the available capacity and premiums for third-party launch liability insurance, rendering any future projections problematic. With regard to RLVs, the insurers stated that third-party liability coverage would be available for licensed RLVs but, at least initially, at a higher premium than for ELVs. In addition, RLVs will pose unique risk issues regarding reentry, passengers, crew, and accidents that might strand an RLV in space.

The most important impact of the 1988 amendments to the CSLA (the current liability risk-sharing regime) was to stabilize the space insurance market in terms of managing risk and exposure and factoring them into launch costs. The insurance industry supports continuation of the current U.S. risk-sharing regime for commercial space transportation. The only change endorsed would be removing the requirement that indemnification funds must be appropriated by Congress.

The effect of the events of September 11, 2001, on the insurance market are discussed separately in Appendix F.

D.4 References

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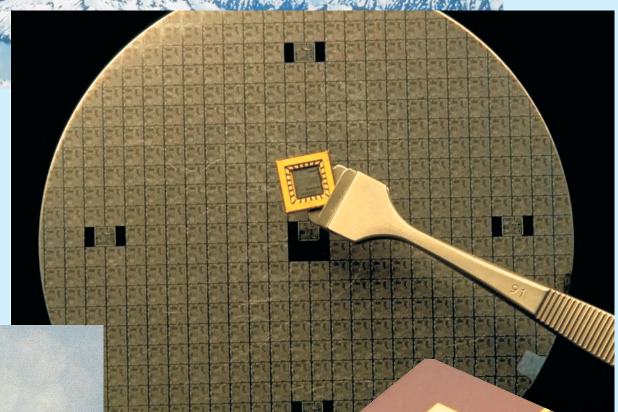
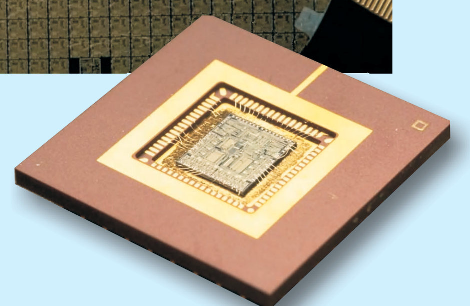
Appendix E

U.S. Government Support of the Commercial Aviation, Semiconductor, and Commercial Nuclear Power Industries





Appendix E
U.S. Government Support of the Commercial Aviation, Semiconductor, and Commercial Nuclear Power Industries

E.1 Introduction

The value and appropriateness of U.S. Government support for the commercial space transportation industry through liability risk-sharing has been a subject of debate. To provide a perspective on the subject of U.S. Government support of commercial industries, Appendix E presents the history and discussion of U.S. Government support of three industries: commercial aviation, semiconductors, and commercial nuclear power. The U.S. Government provided specific and long-term direct and indirect financial support, which was instrumental in the growth, competitiveness, and/or vitality of these industries. Appendix E demonstrates that there is a long and accepted history of U.S. Government involvement in the support of industries, that represent new, capital-intensive, or hazardous technologies.

E.2 U.S. Government Support of the Commercial Aviation Industry

The roots and growth of the commercial airline industry in the United States are based on several historical factors and events during the 20th century:

- The decision of the U.S. Government in 1917 to actively use aircraft to transport mail
- The Air Commerce Act of 1926, which charged the U.S. Department of Commerce (DOC) to foster air commerce
- Charles Lindbergh's nonstop flight across the Atlantic Ocean, which drew attention and investment capital to the aviation industry
- Technological advancements in aircraft design and safety due, in part, to World War I and the DOC construction of radio beacons
- Creation of the Civil Aeronautics Board after enactment of the 1938 Civil Aeronautics Act, which centralized airline regulation and encouraged commercial air transportation development
- Aircraft design technical innovations arising from World War II
- Viable jet aircraft development from cold war funding during the 1950s
- Creation of the Federal Aviation Administration (FAA) by the Federal Aviation Act of 1958, providing centralized civil-military air navigation and air traffic control through one federal agency

The underlying threads promoting commercial aviation development, as outlined above, are the intervention and support of the U.S. Government, both in wartime and peace. The economic viability of aircraft manufacturers was and continues to be inexorably tied to government support through research and military aircraft procurement. Commercial airlines owe their existence to Federal Government financial support from the airmail business, war-related technical advancements in aircraft design and performance, and regulation and development of a nationwide air traffic control system.

The safety record of U.S. commercial airlines has demonstrably improved from its early days of passenger travel in the 1930s and 1940s. In 1938, one fatal accident occurred for every 10.9 million miles (18 million kilometers) flown in an aircraft. In 1999, this fatal-accident probability dropped to one in 3.3 billion miles (5.3 billion kilometers). In 1949, one fatal accident occurred for every 380,000 flights, whereas in 1999, a fatal accident occurred for every 4,348,000 flights. It is instructive to note that, during the five-year time period from 1994 through 1998, the motor vehicle and passenger railway death rate, on a mileage basis, was more than twice that of all U.S. commercial airlines.

E.2.1 A Brief History of Aviation

On December 17, 1903, Orville and Wilbur Wright capped four years of research and design efforts with a 120-foot long (36.6-meter long), 12-second flight at Kitty Hawk, North Carolina—the first powered flight in a heavier-than-air machine. The first person to fly as a passenger flew from a meadow outside of Paris in 1908. The first American airplane passenger flew with Orville Wright at Kitty Hawk later in 1908.

The first scheduled air service began in Florida on January 1, 1914. Glenn Curtiss had designed a plane that could take off and land on water and that could be built larger than any plane to date because it did not need the heavy undercarriage required for landing on hard ground. Thomas Benoist, an auto parts maker, decided to build such a flying boat, or seaplane, for service across Tampa Bay, the "St. Petersburg to Tampa Air Boat Line." He made the 18-mile (28.8-kilometer) trip in 23 minutes, a considerable improvement over the 2-hour trip by boat. The single-plane service accommodated one passenger at a time, and the company charged a one-way fare of $5. After operating two flights a day for four months, the company folded with the end of the winter tourist season.

These and other early flights were headline events, but commercial aviation was very slow to catch on with the general public, most of whom were afraid to ride in the new flying machines. Improvements in aircraft design also were slow. However, with the advent of World War I, the military value of aircraft was quickly recognized and production increased significantly to meet the soaring demand for planes from governments on both sides of the Atlantic. Most significant was the development of more powerful motors, enabling aircraft to reach speeds of up to 130 miles per hour (209 kilometers per hour), more than twice the speed of pre-war aircraft. Increased power also made larger aircraft possible. The salvation of the U.S. commercial aviation industry following World War I was a government program, but one that had nothing to do with the transportation of passengers (ATA 2001a).

E.2.1.1 Airmail

By 1917, the U.S. Government felt that enough progress had been made in the development of planes to warrant the transport of mail by air. That year, Congress appropriated $100,000 for an experimental airmail service to be conducted jointly by the Army and the Post Office between Washington, D.C. and New York, with an intermediate stop in Philadelphia. The first flight left Belmont Park, Long Island, for Philadelphia on May 14, 1918, and the next day continued on to Washington.

The Post Office opened the first segment, between Chicago and Cleveland, on May 15, 1919. Airplanes still could not fly at night when the service first began. Nonetheless, by using airplanes, the Post Office was able to cut 22 hours off coast-to-coast mail deliveries. In 1921, the Army deployed rotating beacons in a line between Columbus and Dayton, Ohio, a distance of about 80 miles (144 kilometers). The beacons, visible to pilots at 10-second intervals, made it possible to fly the route at night.

By the mid-1920s, the Post Office mail air fleet was flying 2.5 million miles (4 million kilometers) and delivering 14 million letters annually. Once the feasibility of airmail was firmly established and airline facilities were in place, the government moved to transfer airmail service to the private sector. Winners of the initial five contracts in 1925 were National Air Transport (owned by the Curtiss Aeroplane Company), Varney Air Lines, Western Air Express, Colonial Air Transport, and Robertson Aircraft Corporation. National and Varney would later become important parts of United Airlines (originally a joint venture of the Boeing Airplane Company and Pratt & Whitney). Western would merge with Transcontinental Air Transport, another Curtiss subsidiary, to form Transcontinental and Western Air (TWA)—later Trans World Airlines, Inc. Robertson would become part of the Universal Aviation Corporation, which in turn would merge with Colonial, Southern Air Transport, and others, to form American Airways, predecessor of American Airlines. Juan Trippe, one of the original partners of Colonial, later pioneered international air travel with Pan Am—a carrier he founded in 1927 to transport mail between Key West, Florida, and Havana, Cuba. Pitcairn Aviation, yet another Curtiss subsidiary that got its start transporting mail, would become Eastern Air Transport, predecessor of Eastern Air Lines (ATA 2001a).

E.2.1.2 Initial Government Involvement

The Air Commerce Act of May 20, 1926, was the cornerstone of the Federal Government's regulation of civil aviation. This landmark legislation was passed at the urging of the aviation industry, whose leaders believed that the airplane could not reach its full commercial potential without federal action to improve and maintain safety standards. The Act charged the Secretary of Commerce with fostering air commerce, issuing and enforcing air traffic rules, licensing pilots, certifying aircraft, establishing airways, and operating and maintaining aids to air navigation. A new Aeronautics Branch of DOC assumed primary responsibility for aviation oversight.

In fulfilling its civil aviation responsibilities, the DOC initially concentrated on such functions as safety rule making and the certification of pilots and aircraft. It took over the building and operation of the Nation's system of lighted airways, a task begun by the Post Office. The DOC improved aeronautical radio communications and introduced radio beacons as an effective aid to air navigation (FAA 2001).

E.2.1.3 Lindbergh

On May 20, 1927, a young pilot named Charles Lindbergh set out on a historic flight across the Atlantic Ocean from New York to Paris. Aviation became a more established industry, attracting millions of private investment dollars almost overnight, as well as the support of millions of Americans. The pilot who sparked all of this attention had dropped out of engineering school to learn how to fly. He became a barnstormer, performing aerial shows across the country, and eventually joined the Robertson Aircraft Corporation to transport mail between St. Louis and Chicago. Lindbergh landed at Le Bourget Field, outside of Paris, at 10:24 p.m. Paris time on May 21, 1927. There was no question about the magnitude of what he had accomplished. The air age had arrived.

In 1934, the Aeronautics Branch was renamed the Bureau of Air Commerce to reflect its enhanced status within DOC. As commercial flying increased, the Bureau encouraged a group of airlines to establish the first three centers for providing air traffic control along the airways. In 1936, the Bureau itself took over the centers and began to expand the air traffic control system. The pioneer air traffic controllers used maps, blackboards, and mental calculations to ensure the safe separation of aircraft traveling along designated routes between cities (Schamel 2000).

E.2.1.4 Aircraft Innovations

For the airlines to attract passengers away from the railroads, they needed both larger and faster airplanes. They also needed safer airplanes. Accidents, such as the one in 1931 that killed Notre Dame football coach Knute Rockne along with six others, kept people from flying.

Aircraft manufacturers responded to the challenge. Air-cooled engines replaced water-cooled engines, reducing weight and making larger and faster planes possible. Cockpit instruments also improved, with better altimeters, airspeed indicators, rate-of-climb indicators, compasses, and the introduction of the artificial horizon, which showed pilots the altitude of the aircraft relative to the ground—important for flying in reduced visibility.

Another development of enormous importance to aviation was the radio. By World War I, some pilots were taking radios up in the air with them so they could communicate with people on the ground. The airlines followed suit after the war, using radios to transmit weather information from the ground to their pilots so they could avoid storms.

An even more significant development, however, was the realization that radios could be used as aids to navigation when visibility was poor and visual navigation aids, such as beacons, were useless. Once technical problems were worked out, DOC constructed 83 radio beacons across the country. They became fully operational in 1932, automatically transmitting directional beams, or tracks, that pilots could follow to their destination. Marker beacons came next, allowing pilots to locate airports in poor visibility. The first air traffic control tower was established in 1935 at what is now Newark International Airport in New Jersey.

Boeing built what is generally considered the first modern passenger airliner, the Boeing 247. It was unveiled in 1933, and United Airlines promptly bought 60 of them. Based on a low-wing, twin-engine bomber with retractable landing gear built for the military, the 247 accommodated 10 passengers and cruised at 155 miles per hour. Its cabin was insulated to reduce engine noise levels inside the plane, and it featured such amenities as upholstered seats and a hot-water heater to make flying more comfortable for passengers.

Not to be outdone by United, TWA went searching for an alternative to the 247 and eventually found what it wanted from the Douglas Aircraft Company. Its DC-1 (and later DC-2) incorporated Boeing's innovations and improved upon many of them. The airframe was designed so that the skin of the aircraft bore most of the plane's stress during flight. The DC-1 was also equipped with automatic pilot and the first efficient wing flaps, for added lift.

Called "the plane that changed the world," the DC-3 was the first aircraft to enable airlines to make money by carrying passengers. Following its debut in 1936 with American Airlines, it became the dominant aircraft in the United States. The DC-3 was much larger than the DC-2 (21 seats versus 14), yet cost only 10 percent more to operate. It was stronger than previous aircraft because of an improved aluminum alloy. It had more powerful engines and could travel coast to coast in only 16 hours—a fast trip for that time. Another important improvement was the use of a hydraulic pump to lower and raise the landing gear (ATA 2001a).

Although planes such as the Boeing 247 and the DC-3 represented significant advances in aircraft design, they could fly no higher than 10,000 feet (3,048 meters). The breakthrough came at Boeing with the Stratoliner, introduced in 1940 and first flown by TWA. It was the first pressurized aircraft that could fly as high as 20,000 feet (6,100 meters) and reach speeds of 200 miles per hour (320 kilometers per hour). As shown in **Figure E–1**, during the late 1930s, commercial aircraft were flying less than 100 million miles per year, with fewer than 2 million annual departures (ATA 2001b).

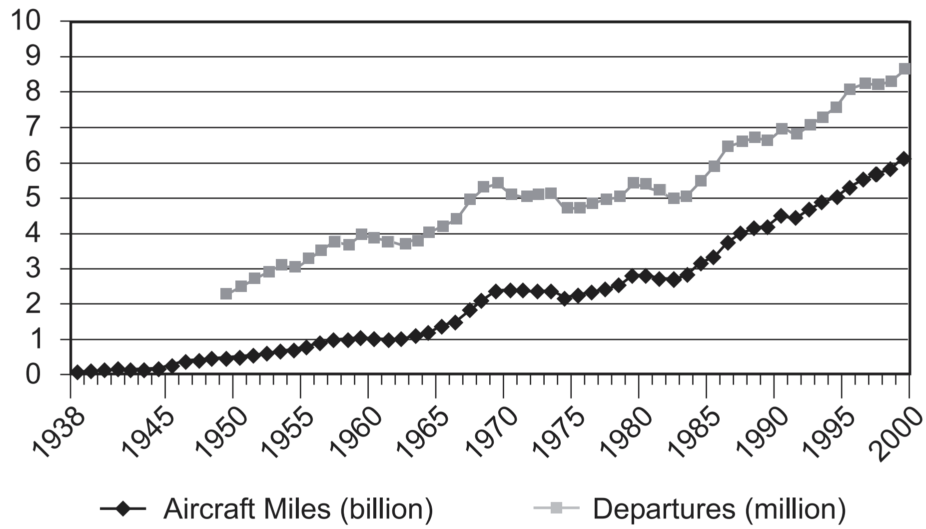


Figure E–1 Scheduled Aircraft Mileage and Departures

E.2.1.5 The Civil Aeronautics Act of 1938

The airlines wanted more rationalized government regulation through an independent agency. The government created the Civil Aeronautics Authority (CAA) and gave the new agency power to regulate airline fares, airmail rates, interline agreements, mergers, and routes. Its mission was to preserve order in the industry, holding rates to reasonable levels while, at the same time, nurturing the still financially shaky airline industry, thereby encouraging the development of commercial air transportation.

Congress created a separate agency, the Air Safety Board, to investigate accidents. In 1940, however, President Roosevelt convinced Congress to transfer the accident investigation function to the CAA, which was then renamed the Civil Aeronautics Board (CAB). These moves, coupled with the tremendous progress made on the technological side, put the industry on the road to success.

While there were numerous advances in U.S. aircraft design during World War II that enabled planes to go faster, higher, and farther than before, mass production was the chief goal of the United States. The major innovations of the wartime period, radar and jet engines, occurred in Europe. Immediately after the war, the number of commercial aircraft miles jumped to over 350 million miles per year (560 million kilometers per year), and the number of departures increased to over 2 million per year (FAA 2001).

E.2.1.6 The Jet Age

In 1952, a 36-seat British-made jet, the Comet, flew from London to Johannesburg, South Africa, at speeds as high as 500 miles per hour. Two years later, the Comet's career ended abruptly following two back-to-back accidents in which the fuselage burst apart during flight, the result of metal fatigue.

The cold war helped secure the funding needed to solve such problems and advance the jet's development. Most of the breakthroughs related to military aircraft were later applied to the commercial sector. The best example of military-to-civilian technology transfer was the jet tanker Boeing designed for the Air Force to refuel bombers in flight. The tanker, the KC-135, was a huge success as a military plane, but even more successful when revamped and introduced, in 1958, as the first U.S. passenger jet, the Boeing 707. With a length of 125 feet (38.1 meters) and four engines with 17,000 pounds (75,616 newtons) of thrust each, the 707 could carry 181 passengers and travel at speeds of 550 miles per hour (880 kilometers per hour). Its engines proved more reliable than piston-driven engines while producing less vibration, putting less stress on the plane's airframe and reducing maintenance expenses. It also burned kerosene, which cost half as much as the high-octane gasoline used in traditional planes. With the 707, first ordered and operated by Pan Am, all questions about the commercial feasibility of jets were answered. The jet age had arrived, and other airlines soon were lining up to buy the new aircraft. As jets were being introduced in the 1950s, the number of air miles flown quickly rose to about 1 billion per year by the end of the decade, and the number of departures rose to about 4 million per year (ATA 2001a).

E.2.1.7 The Birth of the Federal Aviation Administration (FAA)

The approaching introduction of jet airliners and a series of midair collisions spurred passage of the Federal Aviation Act of 1958. This legislation transferred the CAB's functions to a new independent body, the FAA, which had broader authority to combat aviation hazards. The act took safety rule making from the CAB and entrusted it to the new FAA. It also gave the FAA sole responsibility for developing and maintaining a common civil-military system of air navigation and air traffic control, a responsibility the CAA had shared with others.

The scope of the Federal Aviation Act owed much to the leadership of Elwood "Pete" Quesada, an Air Force general who had served as President Eisenhower's principal advisor on civil aeronautics. After becoming the first administrator of the agency he had helped to create, Quesada mounted a vigorous campaign for improved airline safety. In 1967, the FAA became part of the new Department of Transportation (FAA 2001).

During the 1960s, the number of passengers tripled to 170 million; the number of annual air miles more than doubled to about 2.4 billion; and the number of annual departures increased by about 25 percent, as compared to 1958, to around 5 million. As shown in **Figure E–2**, the risks of flying were about a fifth of what they were in the 1940s and 1950s (ATA 2001b).

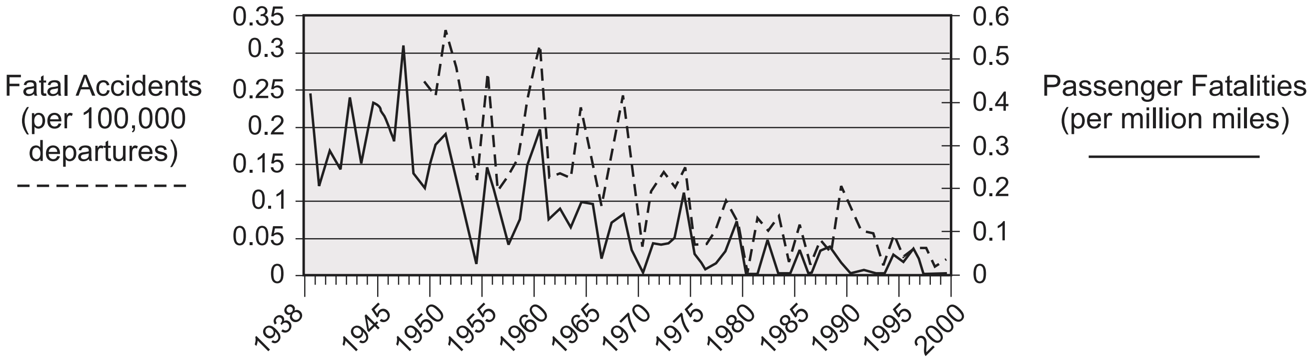


Figure E–2 Safety Record of U.S. Airlines

By the mid-1970s, the FAA had achieved a semi-automated air traffic control system based on a combination of radar and computer technology. By automating certain routine tasks, the system allowed controllers to concentrate more efficiently on the vital task of providing separation. Data appearing directly on the controllers' scopes provided the identity, altitude, and ground speed of aircraft carrying radar beacons. Despite its effectiveness, this system required enhancement to keep pace with the increased air traffic of the late 1970s.

The Boeing 747 was put into commercial service by Pan Am in 1969. It was the first wide-body jet, with two aisles, a distinctive upper deck over the front section of the fuselage, and four engines. With seating for as many as 450 passengers, it was twice as big as any other Boeing jet and 80 percent bigger than the largest jet up until that time, the DC-8.

Recognizing the economies of scale to be gained from larger jets, other aircraft manufacturers quickly followed suit. Douglas built its first wide body, the DC-10, in 1970, and, only a month later, Lockheed flew its contender in the wide-body market, the L-1011. Both of these jets had three engines (one under each wing and one on the tail) and were smaller than the 747, seating about 250 passengers.

A consortium of West European aircraft manufacturers first flew the Concorde in 1969 and eventually produced a number of those small, but fast, jets for commercial service. U.S. efforts to produce a supersonic passenger jet, on the other hand, stalled in 1971 due to public concern about its expense and the sonic boom produced by such aircraft (ATA 2001a).

The growth of air travel was slower throughout the 1970s, 1980s, and 1990s than during the 1960s, but a similar growth pattern continued. During this three-decade period, the number of passengers quadrupled to about 640 million per year; the number of miles flown more than doubled to 6.2 billion per year; and the number of departures increased by about 60 percent to 8.6 million. As shown in **Table E–1**, airline travel has consistently become safer.

Figure E–3 presents a timeline for commercial aviation development superimposed over plots of passenger fatality and aircraft departures in the United States.

Table E–1 Safety Record of U.S. Airlines in Scheduled Service

	Traffic and Operations			*Accidents*				*Fatalities*		
Year	***Passengers Carried***	***Aircraft Miles Flown (000)***	***Departures (000)***	***Total***	***Fatal***	***Fatal Accidents Per Million Aircraft Miles***	***Fatal Accidents Per 100,000 Departures***	***Total***	***Passengers***	***Passenger Fatalities Per Million Aircraft Miles***
1938	1,475,118	76,136	N/A	29	7	0.0919	N/A	54	32	0.4203
1939	2,031,883	90,840	N/A	33	3	0.0330	N/A	26	19	0.2092
1940	3,208,798	120,165	N/A	35	3	0.0250	N/A	45	35	0.2913
1941	4,377,550	149,327	N/A	30	5	0.0335	N/A	46	37	0.2478
1942	3,601,926	130,498	N/A	25	5	0.0383	N/A	71	55	0.4215
1943	3,408,860	123,891	N/A	16	3	0.0242	N/A	44	32	0.2583
1944	4,488,776	161,114	N/A	31	4	0.0248	N/A	73	65	0.4034
1945	7,181,466	241,978	N/A	38	9	0.0372	N/A	114	93	0.3843
1946	13,532,109	369,264	N/A	43	11	0.0298	N/A	149	115	0.3114
1947	14,249,920	411,535	N/A	45	8	0.0194	N/A	250	219	0.5322
1948	14,540,951	440,876	N/A	64	6	0.0136	N/A	128	103	0.2336
1949	16,640,082	463,198	2,280	37	6	0.0130	0.263	106	93	0.2008
1950	19,102,905	477,463	2,482	41	6	0.0126	0.242	167	144	0.3016
1951	24,694,012	526,591	2,713	47	9	0.0171	0.332	207	173	0.3285
1952	27,376,266	589,429	2,847	45	8	0.0136	0.281	170	140	0.2375
1953	31,425,421	657,092	3,070	37	6	0.0091	0.195	107	88	0.1339
1954	35,222,667	689,777	3,094	48	4	0.0058	0.129	26	16	0.0232
1955	41,443,772	779,926	3,276	46	9	0.0115	0.275	229	197	0.2526
1956	45,689,240	869,314	3,503	48	4	0.0046	0.114	156	143	0.1645
1957	49,120,271	976,169	3,769	51	5	0.0051	0.133	79	68	0.0697
1958	48,853,324	972,987	3,633	54	6	0.0062	0.165	144	124	0.1274
1959	56,002,094	1,030,242	3,912	67	10	0.0097	0.256	310	268	0.2601
1960	57,886,566	997,976	3,856	67	12	0.0120	0.311	389	336	0.3367
1961	58,411,977	969,556	3,750	58	5	0.0052	0.133	136	124	0.1279
1962	62,548,399	1,009,784	3,660	43	5	0.0050	0.137	183	158	0.1565
1963	71,437,828	1,095,058	3,788	49	5	0.0046	0.132	145	121	0.1105
1964	81,752,273	1,189,135	3,954	53	9	0.0076	0.228	226	200	0.1682
1965	94,662,314	1,353,503	4,197	63	7	0.0052	0.167	253	226	0.1670
1966	109,390,556	1,482,486	4,373	53	4	0.0027	0.091	72	59	0.0398
1967	132,088,038	1,833,563	4,946	51	8	0.0044	0.162	255	226	0.1233
1968	150,162,701	2,123,993	5,300	53	13	0.0061	0.245	345	305	0.1436
1969	159,213,414	2,359,745	5,377	48	7	0.0030	0.130	152	132	0.0559
1970	171,697,097	2,394,313	5,100	39	2	0.0008	0.039	3	2	0.0008
1971	173,664,737	2,343,578	4,999	41	6	0.0026	0.120	194	174	0.0742

Traffic and Operations				*Accidents*				*Fatalities*		
Year	***Passengers Carried***	***Aircraft Miles Flown (000)***	***Departures (000)***	***Total***	***Fatal***	***Fatal Accidents Per Million Aircraft Miles***	***Fatal Accidents Per 100,000 Departures***	***Total***	***Passengers***	***Passenger Fatalities Per Million Aircraft Miles***
1972	188,938,932	2,336,922	5,044	43	7	0.0030	0.139	186	160	0.0685
1973	202,207,000	2,368,550	5,102	32	6	0.0025	0.118	217	197	0.0832
1974	207,449,006	2,177,253	4,694	42	7	0.0032	0.149	460	420	0.1929
1975	205,059,571	2,240,506	4,704	29	2	0.0009	0.043	122	113	0.0504
1976	223,313,131	2,319,997	4,833	21	2	0.0009	0.041	38	36	0.0155
1977	240,326,516	2,418,645	4,937	19	3	0.0012	0.061	78	69	0.0285
1978	274,717,832	2,520,165	5,015	21	5	0.0020	0.100	160	150	0.0595
1979	316,683,000	2,791,120	5,399	24	4	0.0014	0.074	351	348	0.1247
1980	296,903,000	2,816,303	5,353	15	0	0.0000	0.000	0	0	0.0000
1981	285,976,000	2,703,219	5,212	25	4	0.0015	0.077	4	2	0.0007
1982	294,102,000	2,698,928	4,964	16	4*	0.0011*	0.060*	234	222	0.0823
1983	318,638,000	2,808,566	5,034	22	4	0.0014	0.079	15	14	0.0050
1984	344,683,000	3,133,567	5,448	13	1	0.0003	0.018	4	4	0.0013
1985	382,022,000	3,319,955	5,835	17	4	0.0012	0.069	197	196	0.0590
1986	418,946,000	3,724,581	6,427	21	2*	0.0003*	0.016*	5	4	0.0011
1987	447,678,000	3,988,105	6,581	32	4*	0.0008*	0.046*	231	229	0.0574
1988	454,614,000	4,140,911	6,700	28	3*	0.0005*	0.030*	285	274	0.0662
1989	453,692,000	4,192,820	6,622	24	8	0.0019	0.121	131	130	0.0310
1990	465,560,000	4,490,793	6,924	22	6	0.0013	0.087	39	12	0.0027
1991	452,301,000	4,415,614	6,783	25	4	0.0009	0.059	62	49	0.0111
1992	475,108,000	4,660,757	7,051	16	4	0.0009	0.057	33	31	0.0067
1993	488,520,000	4,846,458	7,245	22	1	0.0002	0.014	1	0	0.0000
1994	528,848,000	5,033,398	7,531	19	4	0.0008	0.053	239	237	0.0471
1995	547,773,000	5,293,401	8,062	34	2	0.0004	0.025	166	160	0.0302
1996	581,234,000	5,500,980	8,230	32	3	0.0005	0.036	342	342	0.0622
1997	599,131,000	5,685,674	8,192	44	3	0.0005	0.037	3	2	0.0004
1998	612,885,000	5,837,726	8,292	43	1	0.0002	0.012	1	0	0.0000
1999	635,402,000	6,161,024	8,617	48	2	0.0003	0.023	12	11	0.0018

49 CFR 121 = Aircraft with 10 or more seats (effective March 1997).
Sabotage-caused accidents are included in the accidents but not accident rates; sabotage-caused fatalities are included in both fatalities and passenger fatality rates.
N/A = Not available.

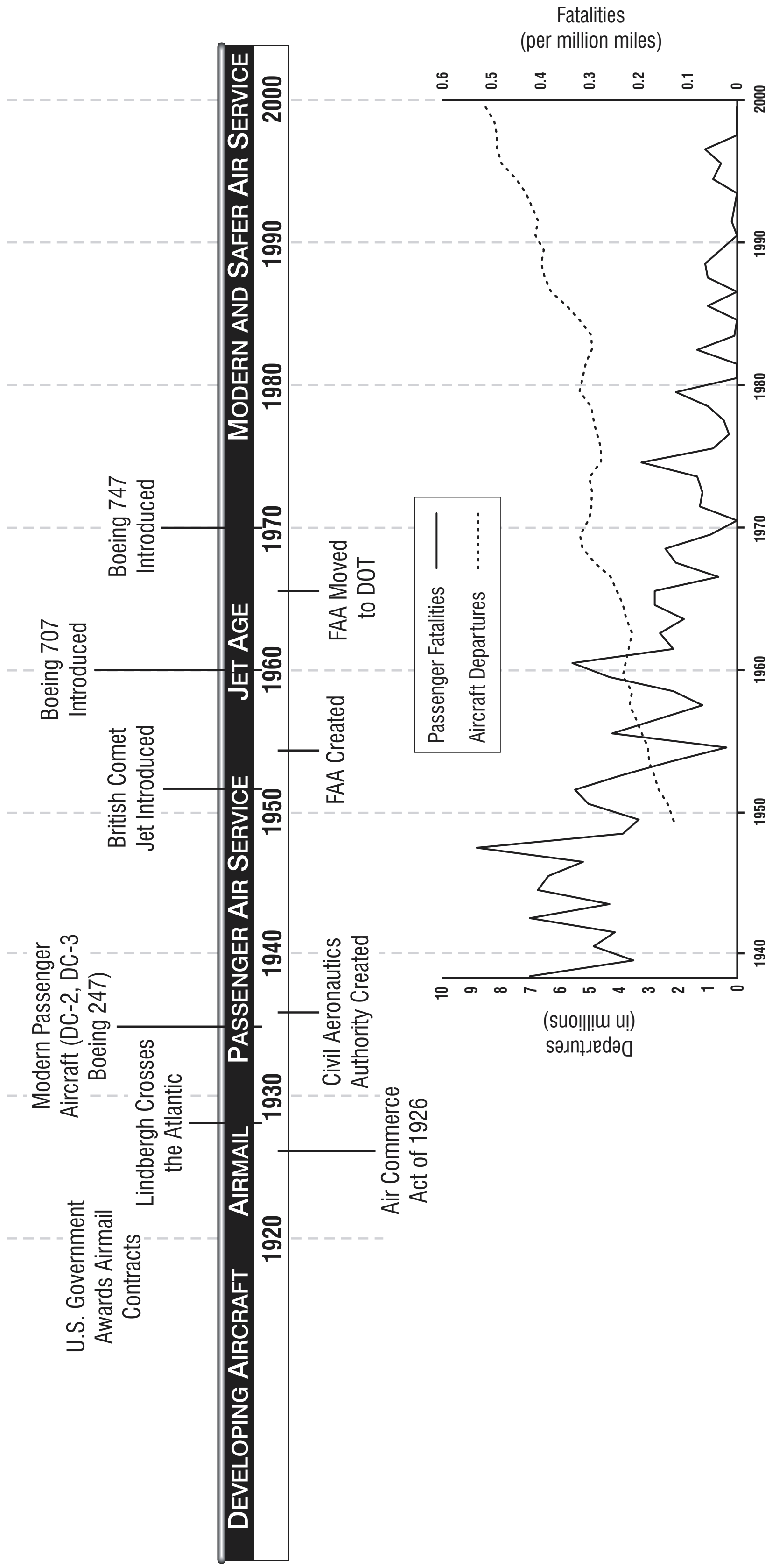


Figure E–3 History of U.S. Commercial Aviation

E.3 U.S. Government Support of the Semiconductor Industry

E.3.1 History of the Semiconductor Industry

In the 1950s, an integrated-circuit industry emerged in the United States. This industry (Bell Labs, Rockwell, Texas Instruments, Fairchild, etc.), known as the American Defense Industry, originally supported projects and developed new electronic technologies for the U.S. Department of Defense (DOD). In the late 1950s and 1960s, a new breed of specialized industry, the semiconductor industry, was formed. These were either new entrants (e.g., Intel) or multidivisional firms (e.g., Texas Instruments, Fairchild, and Motorola). Although the industry experienced rapid growth in the 1970s, its market share gradually decreased. In 1977, the industry created the Semiconductor Industry Association (SIA) to provide leadership for U.S. chip manufacturers on critical issues of trade, technology, environmental protection, and worker safety (SIA 1977).

Meanwhile, the Japanese semiconductor industry was becoming very competitive. In addition, it appeared that the Japanese were undercutting the price (i.e., selling below cost) to gain increased markets in the United States. In 1975, U.S. companies that made chips to sell to others, rather than for just their own use, had 100 percent of the U.S. dynamic random-access memory (DRAM) market. In 1979, Japanese companies captured 42 percent of the U.S. market for 16-kilobit DRAMs. By 1985, Japanese companies had begun dumping second-generation chip technology, called erasable programmable read-only memory (EPROM), in the U.S. market. In 1986, U.S. manufacturers had 5 percent of the market. Taking into account all chips sold by merchant producers, the U.S. producers' market share declined from 60 percent in 1975 to less than 50 percent in 1985, while the Japanese share rose from 20 to 40 percent in the same period (DOD 1987).

Such a loss of industrial competitiveness and the accompanying losses in employment quickly turned the problem from a private one (an industry problem) into a public one. In 1983, the SIA published a report accusing the Japanese of a variety of unfair trade practices (Palmer 1983). In 1986, the United States and Japan signed the Semiconductor Trade Agreement, under which the Japanese promised to take steps designed to alleviate the plight of American chip makers. In December 1986, the SIA Board of Directors established a plan for a collaborative industry-government manufacturing venture, the Semiconductor Manufacturing Technology, informally named SEMATECH, with the goal of restoring the U.S. semiconductor industry's ability to compete against the Japanese in semiconductor manufacturing. In February 1987, DOD's Science Board issued its *Report of the Defense Science Board Task Force on Defense Semiconductor Dependency*, which asserted military reasons for protecting and strengthening America's semiconductor industry. In April 1987, in response to Japanese violations of the 1986 Semiconductor Trade Agreement, the U.S. Government imposed trade sanctions on Japanese imports. In December 1987, Congress approved $100 million in matching federal funding support for SEMATECH as part of the fiscal year 1988 DOD appropriation bill. In August 1988, Congress enacted Public Law 100-418 (15 U.S.C. 271), the Omnibus Trade and Competitive Act. The act included the Training Technology Transfer Act and the Technology Competitive Act, as well as measures to support semiconductor research and development and to protect intellectual property rights.

The government matching fund was reappropriated annually for another nine years at a rate of about $100 million, or half of the annual SEMATECH operating budget. Overall, SEMATECH received direct funding from the U.S. Government of approximately $850 million from 1988 through 1996 (SEMATECH 1999a). In addition, the U.S. Government, through the Defense Advanced Research Project Agency (DARPA) and the Department of Energy (DOE), has funded, and continues to fund, various electronic technology development projects in support of America's defense infrastructure that have an indirect effect on technology development related to the semiconductor industry. This combined DARPA and DOE funding for electronic technology has exceeded $1 billion since 1988.

A combination of an antidumping trade agreement and retooling of U.S. semiconductor manufacturing has resulted in a role reversal in market shares. The first five years of the 1990s were a period of tremendous growth for the semiconductor material industry. The increase in production of computers swelled the need for semiconductors, as did the significant increase in semiconductor orders from communication industries and various consumer product manufacturers. The U.S. semiconductor industry reemerged over that of Japan as the largest producer of semiconductors in 1995 and has continued in this position since then. In 1996, the U.S. industry captured more than 60 percent of the world non-volatile memory, or EPROM, market (SEMI/SEMATECH 1998).

E.3.2 The Semiconductor Industry Today

The U.S. semiconductor industry is a competitive titan today. Many of the competitive moves attempted in the last decade and a half, including countering dumping and the creation of SEMATECH, have worked very well. In 1998, four international semiconductor companies joined the SEMATECH organization, creating an international SEMATECH consortium. By the end of 1999, the consortium was consolidated into one organization (SEMATECH 1999b).

The semiconductor industry is working with the government on a new research and development program, called the Focus Center Research Program, to conduct cutting-edge research deemed critical to the growth of technology industries (SIA 2001). The program began at the end of 1998. The goal of the Focus Center Research Program is to establish six national centers with a long-range (10-year) plan using 14 U.S. research universities. Currently, four focus centers have been established: the University of California at Berkeley (working on chip design and testing); the Georgia Institute of Technology (working on interconnecting technology); the Massachusetts Institute of Technology (working on advanced materials and devices); and Carnegie Mellon University (working on the interaction of circuit, systems, and software design). The program is funded 50 percent by SIA, 25 percent by the Semiconductor Manufacturing Industry, and 25 percent by DOD. The Focus Centers' funding in 2000 was approximately $25 million and will scale up to $35 to $40 million in 2002, eventually reaching $50 million a year (SS 2001). The program is managed by DARPA and Microelectronic Advanced Research Corporation (a subsidiary of Semiconductor Research Corporation, which is also supported by SIA) (SIA 2001).

E.3.3 Summary

In response to the threat of foreign competition and semiconductor dominance, the U.S. Government embarked on a multifaceted cooperative research and support program with the semiconductor industry in 1988. During the last 12 years, mostly under the auspices of DOD and DARPA, more than $2 billion in government funding has been allocated to the growth of this industry. This effort continues today in a number of advanced research and development programs.

E.4 U.S. Government Support of the Commercial Nuclear Power Industry

E.4.1 History of Commercial Nuclear Power

The U.S. (and worldwide) nuclear power industry uses the nuclear fission reaction to generate electricity. The first demonstration of the fission reaction—splitting uranium atoms by neutron bombardment—was observed by Otto Hahn and Fritz Strassmen in 1939 in Germany (DOE 2001a). The United States initiated the top secret Manhattan Project in September 1942 to develop nuclear weapons before the Germans could develop them during World War II. Under the leadership of Enrico Fermi, the first self-sustaining nuclear chain reaction was achieved in a graphite nuclear reactor constructed at the University of Chicago, entitled Chicago Pile 1, in December 1942. The United States expended approximately $2 billion during the Manhattan Project, which culminated in the development of an extensive network and infrastructure for developing nuclear weapons. The United States exploded the first atomic bomb in July 1945 at Alamogordo, New Mexico. The successful test was followed by the use of two atomic bombs on Hiroshima and Nagasaki in Japan, which resulted in the end of World War II (DOE 2001a).

The Atomic Energy Act of 1946 replaced the Manhattan Project with the Atomic Energy Commission (AEC), which created a government monopoly on all aspects of nuclear energy and emphasized military applications. Russia detonated its first atomic bomb in 1949 (DOE 2001a). In December 1951, an experimental nuclear reactor in Idaho, the Experimental Breeder Reactor 1, became the first nuclear reactor to produce a small, but symbolic, amount of electricity from nuclear fission (DOE 2001b). In 1948, the U.S. Navy initiated a program under the leadership of Admiral Hyman Rickover to develop nuclear reactor technology for submarine (and later surface ship) propulsion. This effort resulted in the launching of the first nuclear-powered submarine, the *Nautilus*, in January 1954 (ANL 2001). In August 1954, in response to President Eisenhower's December 1953 "Atoms for Peace" speech, which was given after Russia detonated its first hydrogen bomb, the Atomic Energy Act of 1954 was passed (ANL 2001). This act promoted peaceful uses of nuclear energy through private commercial enterprises, motivated by the government's fear of falling behind other countries in fostering the growth of peaceful uses of nuclear energy. The act also coincided with the U.S. military nuclear weapons program's development of a sufficient supply of weapons-grade nuclear material. The cold war heated up in the 1950s because Russia had developed its own nuclear weapons and the hydrogen bomb had been developed. The motivation for the 1954 Atomic Energy Act was to demonstrate to the world and the American public that nuclear energy could be harnessed for peaceful uses such as electric power production and allow private enterprise to participate in the peaceful use of nuclear energy.

In January 1955, the AEC announced its Power Demonstration Reactor Program, which featured incentives for private companies to develop nuclear power plant technology and directly supported the design and construction of new reactor designs (NRC 2001). Private industry response was subdued and cautious. Meanwhile, in July 1955, another AEC research reactor, Boiling Reactor Experiment III (BORAX-III) in Idaho, generated enough electricity to provide power for the small (population of approximately 1,350) town of Arco, Idaho (ANL 2001). The British completed the first full-scale nuclear power plant in 1956 at Calder Hill. The first U.S. large-scale nuclear power plant in Shippingport, Pennsylvania, which was supported by U.S. Government funds, was completed in December 1957 (ANL 2001). Shippingport used much of the technology in nuclear reactors, which was developed for the Navy's nuclear submarine program.

E.4.2 The Impact of the Price-Anderson Act

In 1957, interested power companies and nuclear reactor design companies lobbied the U.S. Government, expressing reservations regarding the availability and amount of liability insurance (NRC 2001). In response, Congress passed the Price-Anderson Act in August 1957, which indemnified the industry with an arbitrarily selected $500 million (equivalent to $3.2 billion in 2001 dollars, accounting for inflation from 1957 to 2001) above the $60 million that was then available and required (NRC 2001). By the end of 1957, the AEC had 7 experimental nuclear reactors and 11 cooperative or independent industry projects (Mack 2000). By the late 1950s, after the passage of the Price-Anderson Act, some power utilities invested in the construction of pilot commercial nuclear power plants. The first, completed in 1959 at a cost of $18 million, was Dresden 1 in Illinois, which was designed by General Electric and used many concepts from AEC reactors, including BORAX-III (NRC 2001). This was followed by two other commercially funded nuclear power plants, Yankee-Rowe in Massachusetts in 1960 and Indian Point 1 in New York in 1962. These first commercial nuclear power plants were completed with considerable financial incentives offered by the nuclear power plant design companies (Westinghouse, General Electric, and Babcock & Wilcox). It should be noted that these companies had gained considerable technical expertise because of their prior and ongoing involvement in the Navy nuclear submarine and surface ship propulsion program.

E.4.3 Growth of U.S. Commercial Nuclear Power

In the early 1960s, most power companies were still uncertain about committing to nuclear power. There were numerous nuclear power plant designs being proposed other than the types at Shippingport, Dresden 1, Yankee-Rowe, and Indian Point 1 (DOE 2001c, SSS 2001). The AEC funded the design and construction of four nuclear power reactors, which were completed in 1962 and 1964. These government-funded nuclear power plants were instrumental in the power industry's decision to select two nuclear reactor designs for almost all the subsequent nuclear power plant orders. In addition, technological improvements were achieved from the AEC research nuclear reactors at national laboratories across the United States. Subsequent operation of these power plants demonstrated the "proof of principle" for larger-scale power plants and narrowed down the designs, which power utilities later chose when they ordered nuclear power plants. Since operation of the first nuclear reactor, Chicago Pile 1, in 1942, excluding nuclear reactors for nuclear weapons production and Navy nuclear propulsion, the U.S. Government has paid for the construction of over 80 nuclear reactors, which have been used for research, training, and testing. The information derived from these nuclear reactors was critical to the development of the nuclear power industry. Nuclear reactor designs developed by Westinghouse and General Electric for the Navy nuclear submarine program constituted the technical basis for the first pressurized-water power reactors, which are now used in 66 percent of all U.S. nuclear power plants.

The first order of a nuclear power plant by a power company that had no government assistance or special financial incentives from the vendors was the Oyster Creek plant, which was ordered in December 1963, based on purely economic grounds. This plant, completed in 1969, is still operating in New Jersey. Starting in 1965, the nuclear power plant design companies aggressively marketed and sold nuclear power plant projects to utility companies. Nuclear power plant orders grew from 4 in 1965 to 20 in 1966 to 31 in 1967. The time period from 1965 through 1967 represents the true onset of commercial nuclear power growth in the United States. The largest single-year order of nuclear power plants in the United States was 41 units in 1973. The number of operating nuclear power plants reached a peak of 111 in 1991 and currently stands at 104 units (NRC 2000). In 1971, nuclear power provided 2.4 percent of all electricity in the United States, which grew to 12 percent in 1979, 14 percent in 1984, 19 percent in 1989, and 22 percent in 1991. Currently, nuclear power provides 20 percent of the electricity consumed in the United States. In the year 2000, there were 438 operating nuclear power plants worldwide (ANS 2001).

E.4.4 U.S. Government Funding Support

As previously stated, the U.S. Government financially supported the development of the U.S. commercial nuclear power industry through many avenues that were funded by the AEC from 1946 through 1975, and the U.S. Nuclear Regulatory Commission (NRC) which was created by the Energy Reorganization Act of 1974 (DOE 2001d). Additional support was derived by the Navy nuclear propulsion program, which involved key companies in the nuclear industry that later designed and sold nuclear power plants. Since 1975, the NRC has supported the nuclear power industry based on its support of safety experiments, while the U.S. DOE, since its creation in 1977, has also supported the development of advanced civilian nuclear power designs. Analysis of the AEC budget from fiscal years 1951 through 1962, a critical time in the development of the civilian nuclear power industry, showed a specific line item for civilian nuclear reactor development. These AEC annual budgets for civilian nuclear power are provided in **Table E–2** below (AEC 1972).

Table E–2 AEC Civilian Nuclear Power Reactor Budgets from 1951 through 1962

U.S. Government Fiscal Year	*AEC Civilian Nuclear Power Reactor Budget ($)*
1951	3,202,000
1952	5,903,000
1953	10,201,000
1954	20,103,000
1955	28,064,000
1956	48,380,000
1957	58,196,000
1958	78,732,000
1959	105,233,000
1960	117,786,000
1961	102,305,000
1962	94,320,000
1951-1962 Total	672,425,000
2001 equivalent of 1951-1962 (using inflation from 1962)	3,940,410,000 ($3.9 billion) 2001 U.S. dollars

The $3.9-billion inflation-adjusted value in Table E–2 is conservatively low because it only adjusts for inflation from 1962 and does not account for the inflation that occurred between 1951 and 1962. Since 1962, the AEC has reported only a single line item in its budget for all nuclear reactor development, which includes civilian, military, merchant ships, space propulsion, and auxiliary power. For relative comparison purposes, this overall nuclear reactor development budget is presented in **Table E–3** (AEC 1972).

Table E–3 AEC Nuclear Reactor Development Budgets from 1951 through 1971

U.S. Government Fiscal Year	*AEC Nuclear Reactor Development Budget ($)*
1951	44,472,000
1952	64,448,000
1953	104,091,000
1954	99,334,000
1955	114,557,000
1956	168,883,000
1957	255,667,000
1958	306,225,000
1959	355,600,000
1960	399,252,000
1961	437,274,000
1962	433,150,000
1963	507,343,000
1964	561,191,000
1965	535,875,000
1966	488,769,000
1967	528,028,000
1968	548,546,000
1969	508,442,000
1970	496,297,000
1971	504,885,000

A comparison of Tables E–2 and E–3 shows that the AEC budget for civilian nuclear power reactor development, as a fraction of the total nuclear reactor development budget, increased from 7 percent in 1951 to 20 percent in 1954 and remained between 22 and 30 percent from 1955 through 1962. Assuming approximately 25 percent of the reactor development budget continued to be devoted to nuclear power reactors, and using approximately $500 million as the average annual budget for 1963 through 1971, an additional $1.125 billion in 1963 through 1971 U.S. dollars would have been spent by the AEC in direct support of the nuclear power industry. Conservatively accounting for inflation only from 1971, this constitutes another $4.9 billion in U.S. 2001 dollars. It is estimated that, for the 20-year period between 1951 and 1971, the AEC directly supported the development of the commercial nuclear power industry by approximately $8.8 billion in 2001 dollars. It is important to note that the aforementioned AEC budget only reflects direct support of commercial power, and only from 1951 to 1971. In fact, many billions of dollars were spent by the AEC and the Navy in research and development, which indirectly benefited the nuclear power industry by advances in technology, design, and analysis. Furthermore, the AEC and its replacement, the NRC, have also spent billions of dollars in nuclear energy research, which contributed to the growth, maintenance, and safety of the commercial nuclear power industry in the 31 years since 1971. Throughout the development of commercial nuclear power in the United States, the very nature of nuclear power (i.e., high capital costs, handling of highly radioactive material, complex systems) required considerable U.S. Government involvement since its inception in the 1950s. Government support has been supplemented by private industry investment during the last three decades.

As a means of comparing the growth of the U.S. commercial nuclear power industry to funding for development by the AEC and the NRC, **Table E–4** delineates the number of operating commercial nuclear power plants from 1962 to 2000 (NRC 1990, NRC 2000).

Table E–4 Number of U.S. Operating Commercial Nuclear Power Plants, 1963-2001

Year	*U.S. NPPs*	*Year*	*U.S. NPPs*	*Year*	*U.S. NPPs*
1963	3	1976	56	1989	109
1964	4	1977	63	1990	111
1965	4	1978	66	1991	111
1966	4	1979	66	1992	110
1967	5	1980	67	1993	109
1968	5	1981	70	1994	109
1969	7	1982	72	1995	109
1970	9	1983	74	1996	110
1971	10	1984	82	1997	104
1972	16	1985	89	1998	104
1973	29	1986	95	1999	104
1974	46	1987	102	2000	104
1975	48	1988	108	2001	104

NPPs = Operating commercial nuclear power plants in the United States.

Figure E–4 graphically presents the chronology and growth of the U.S. commercial nuclear power industry.

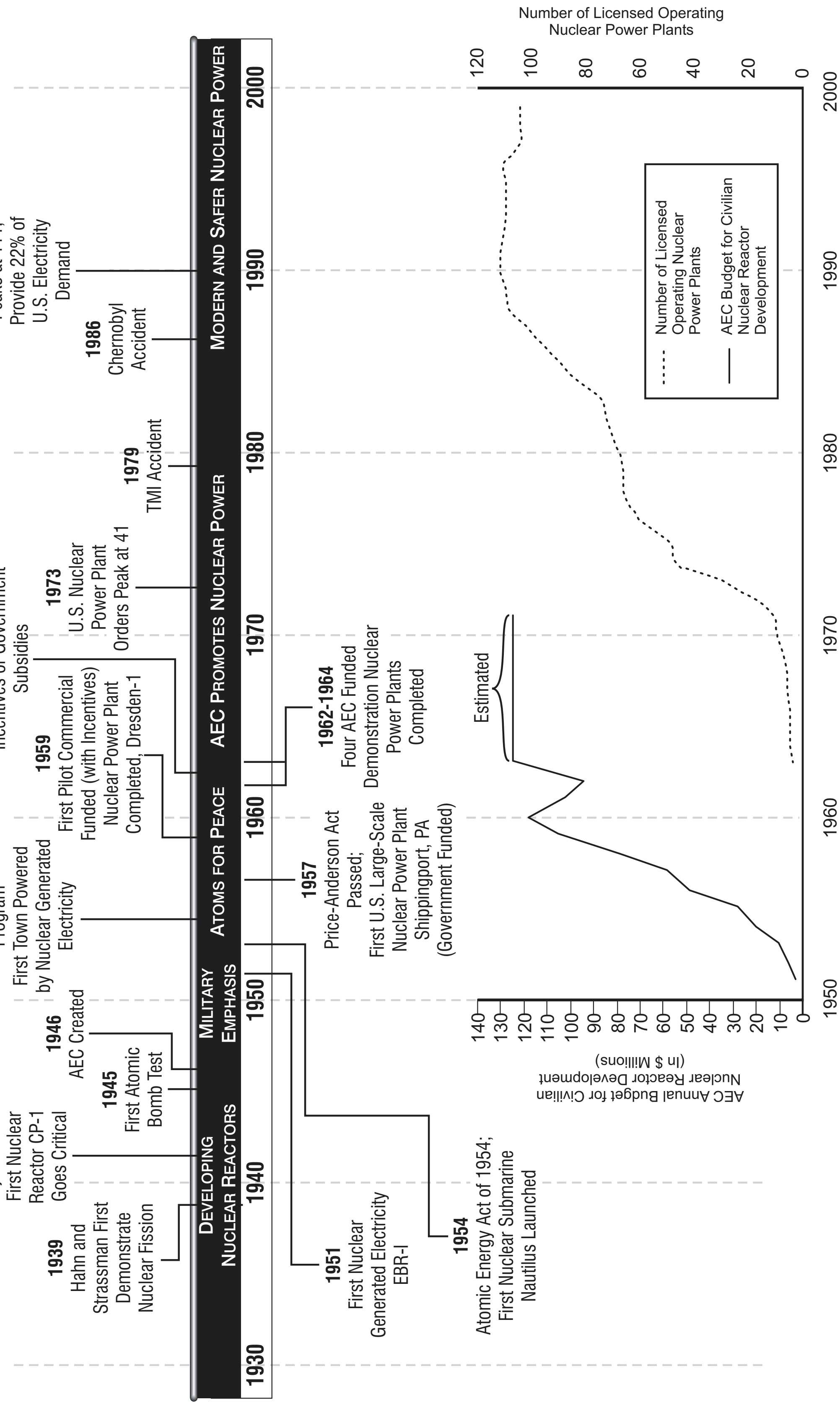


Figure E–4 History of U.S. Commercial Nuclear Power

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Appendix F

Effects on the Commercial Space Transportation Insurance Industry of the September 11, 2001 Terrorist Attacks

Photo courtesy of FEMA

Photo courtesy of FEMA

Appendix F
Effects on the Commercial Space Transportation Insurance Industry of the September 11, 2001 Terrorist Attacks

F.1 Introduction

On September 11, 2001, terrorists hijacked four U.S. commercial aircraft, operated by American Airlines and United Airlines, crashed two into the twin towers of the World Trade Center in New York City, and crashed a third into the Pentagon in Arlington, Virginia. The fourth aircraft crashed near Shanksville, Pennsylvania, following an apparent struggle between the hijackers and the passengers. As a result of these terrorist acts, approximately 3,000 Americans and citizens from other nations were killed, including both passengers and people in the affected buildings. The largest number of fatalities and injuries occurred in the World Trade Center towers, which collapsed soon after the aircraft impact, and at the Pentagon. This event caused an unprecedented number of fatalities and injuries to third parties in the history of commercial aviation. Following this event, the United States temporarily grounded all U.S. civil aircraft while closing all U.S. airports.

Prior to September 11, commercial airlines were experiencing poor financial performance related to the slump in the economy. The temporary cessation of all commercial air travel and airport closures, coupled with a sharp drop in passenger traffic after air travel was restarted, further exacerbated the airlines' financial problems. U.S. airlines announced a series of layoffs approaching 100,000 employees and major reductions in flight service, while one financially weak airline, Midway, filed for bankruptcy. Airlines announced that the losses and drop in passenger traffic would cause further bankruptcies of larger airlines within months.

Government concerns about the future of the airline industry in concert with lobbying by the airlines resulted in the development of the Air Transportation Safety and System Stabilization Act, hereinafter called the Stabilization Act, which was passed by Congress on September 21, 2001, and signed into law (Public Law 107-42) by the President on September 22, 2001. The Act consists of six titles, two of which deal with aviation insurance and victim compensation. A second act of Congress, the Aviation and Transportation Security Act, amended the Stabilization Act by extending liability limits to aircraft manufacturers, airport sponsors, or any person with a property interest in the World Trade Center, in addition to air carriers.

Title II of the Stabilization Act, entitled "Aviation Insurance," allows for the Secretary of Transportation to reimburse airlines for increased insurance premiums (as compared to the week just prior to the events of September 11) for the coverage period ending October 2002, for loss and damage arising out of any risk from the operation of an American airline carrier from risks of operation. Reimbursement authority expires 180 days after enactment. Title II also allows the government to effectively indemnify an air carrier for terrorism acts during that 180-day period which result in third-party loss liability above $100 million. Any liability above this amount will be assumed by the U.S. Government, and no punitive damages against the airline or the government can be awarded under a cause of action arising out of the terrorist act.

Title IV of the Stabilization Act entitled, "Victim Compensation," established a compensation program for victims of the September 11, 2001 events that protects the airlines by limiting their liability to the limits of the air carrier's liability coverage while providing compensation to victims. Recognizing the unique nature of the September 11 events and the potential for protracted legal battles, Title IV allows for an expedient method for compensating affected third parties. Victims or their families may seek compensation from the government fund or they may sue the airlines (United or American), but not both. The amount of compensation to victims is determined by a Special Master based on economic and non-economic losses, but will not include punitive damages. Applicants for compensation from the fund are promised a decision within 120 days, as opposed to the expected much longer time involved in a lawsuit (the 1993 World Trade Center bombing lawsuits still have not been settled). Also, unlike lawsuits, applicants would not have to prove fault, which would be required for a lawsuit. The U.S. District Court for the Southern District of New York will have exclusive jurisdiction over lawsuits against the airlines. Air carrier liability is limited to the limits of the liability coverage maintained by the air carrier. Title IV of the Stabilization Act effectively indemnifies the affected airlines for liability beyond their insurance coverage for the events of September 11, and provides budget authority to pay claims in advance of appropriations acts. It has been estimated that claims against the airlines from the September 11 events could be as much as $18 billion without this indemnification (WSJ 2001b).

The British Government announced on September 21, 2001, that it would indemnify its airlines from war and terrorism liabilities above $50 million, and would waive payment for coverage for 30 days. The German government also announced its intention to assist German airlines with interim insurance coverage (WP 2001a). The French government announced the establishment of a $378 million emergency fund to assist French airlines, to be provided equally by the government and a $2 passenger ticket tax (WP 2001d).

The immediate reaction of the aviation insurance industry to the events of September 11, 2001, was to exercise its 1-week notification provision to inform airlines that the war risk or terrorism clauses of their insurance coverage would be cancelled, with a replacement of a maximum of only $50 million, as compared to the $1.5 billion estimated to be in effect for large airlines on September 11, 2001. As Congress passed the Stabilization Act and it was signed into law, insurers raised the available capacity for war risk or terrorism insurance to $1 billion, but at significantly higher premiums (WSJ 2001a). It was estimated that the new coverage premiums for terrorism/war risk would cost airlines a cumulative total of another $1.5 to $3 billion per year (WSJ 2001b).

Another effect of September 11 on the insurance industry is that commercial property, liability, and workmen's compensation insurance premiums have been increasing by as much as 50 to 100 percent. Reinsurers are expected to realize very large losses from claims arising out of the September 11 events, and have expressed unwillingness to cover war risk or terrorism in a wide range of insurance markets. Such exclusions have appeared for years in the launch liability insurance certificates supplied by launch licensees to the FAA as evidence of financial responsibility.

The ability of primary insurers to spread their risk with the reinsurance market is limited such that insurers must retain the risk and would therefore agree to provide insurance only at vastly increased premiums, if at all. Even auto, homeowner, and small business insurance is expected to be affected by larger premiums (WP 2001b). Commercial property owners in the Washington, D.C., metropolitan area have experienced insurance policy premium increases of 25 to 35 percent, with terrorism specifically excluded from these new policies (FT 2002). Premiums for property and casualty insurance increased by an average of 2 percent in 1999 and 4.5 percent in 2000. The lack of terrorism coverage in future insurance policies may affect the availability of capital for new commercial development loans in urban areas such as Washington, D.C. (WP 2001e).

It has been estimated that the cost to the insurance industry of the September 11 terrorist attacks will be in the range of $30 to $50 billion, which the insurance industry will be able to pay, but will result in the industry avoiding future exposure for insurance coverage for acts of terrorism or war. The insurance industry has proposed that the Federal Government create an insurance company that would pool premiums for future terrorist attacks and would be modeled after a similar system in the United Kingdom. Each voluntary insurer would keep 5 percent of premiums and accept 5 percent of the risk, but the Federal Government would, in effect, act as a reinsurer to cover losses in excess of the pool's capacity. A common reinsurance pool of $5 to 10 billion would be created from excess insurance premiums and would be available to pay claims for terrorist or war claims; but above this pool, the Federal Government (i.e., taxpayers) would be expected to pay for damages. The pool would exist for a six-year period (WP 2001b).

The Administration's response to this proposal by the insurance industry has been to propose another model in which no insurance pool is used, but the government splits the risk of terrorist events with the insurance industry. In this model, usual insurance practices would be followed by the industry in insuring against damages from terrorism, but the government would pay between 80 and 90 percent of the cost of damages on a sliding scale that changes over a 3-year period, while the insurance industry assumes the remaining liability. Total liability would be capped at $100 billion, and the plan would expire after 3 years. This model, unlike the pool proposal, minimizes government involvement in the insurance industry (WP 2001c, WP 2001d, WSJ 2001c). State insurance regulators supported the Federal Government's plan in a meeting of the National Association of Insurance Commissioners on October 15, 2001. They opposed the insurance industry's proposed "pool" plan on the grounds that it would introduce "a whole new bureaucracy," whereas the Administration's plan provides a short-term bolstering of the insurance industry. Insurers have expressed concerns about the government's proposal for risk sharing of terrorist liability because it does not assure enough market stability and places too much of the risk on insurers (WP 2001f).

On November 1, 2001, two different insurance industry aid package bills were introduced separately in the House and Senate. Neither plan will help pay for insurance losses arising from the September 11 terrorist attacks, but both would assist insurance companies in the event of future terrorist attacks. The Senate bill would obligate the Federal Government for 90 percent of all terrorist attack claims above $10 billion for two years, followed by insurance company obligations increasing to $20 billion in the third and final year of the bill. The House bill would obligate the government for 90 percent of claims above $100 million up to the first $20 billion. Above $20 billion, the government would be compensated by the insurance industry through insurance bill surcharges, and tax-deferred reserves could be used to pay for terrorist attack claims (WP 2001g). The White House has stated that it supports the Senate Banking Committee bill, which provides 80 percent compensation by the government with no requirement for insurers or policyholders to reimburse the government (WP 2001h). The House passed its version of an insurance industry terrorism aid bill by a vote of 227 to 193 on November 29, 2001(WP 2001j). There has been no final congressional action as of February 2002.

A Lloyds' of London newsletter featuring an article on opportunities or insurers to make money from the September 11 events has prompted critics of the insurance industry to state that the industry is taking advantage of the situation, putting pressure on the government for financial support, and is actually in excellent financial health. Although the property and casualty insurance industry paid out $27.2 billion last year, it made $27 billion above that due to investment income. In the past, insurance policies included acts of terrorism without any additional charges, but this is expected to change to protect the insurance companies. The insurance industry is estimated to have a current surplus of about $300 billion, but does not want to risk it on terrorist attack claims without additional premiums to cover the added risk. Like all industries, insurance companies seek to provide a reasonable rate of return on investment (WP 2001i).

The post September 11, 2001 impact on aviation as a whole is readily apparent. However, it is important to note that there has been some convolution of information regarding insurance issues since September 11, 2001. While it is true that liability rates have increased significantly this year, these increases cannot be entirely attributed to the events of September 11, 2001. December 2001 increases in the range of 40 percent to 60 percent were expected based on general liability renewals of July 2001 and because of previous undercharging in the commercial insurance market. Further, care should be taken when considering literature reviews as many reports intermixed strict liability aviation issues with specific aviation war-risk issues, which have been treated quite differently since September 11, 2001.

Representatives of aerospace insurance brokers and underwriters in the commercial space transportation launch liability insurance market were contacted in the late January to early February 2002 timeframe to ascertain the effects of September 11 on the commercial space transportation insurance market (Marsh 2002, RUA 2002, USAIG 2002, WC 2002). Although launch insurance premiums were already increasing by about 25 percent to 35 percent due to an insurance market correction prior to September 11, 2001, the effects of the terrorist attacks was to greatly exacerbate the increases in premium. Premium increases are now estimated to vary from 50 percent to 400 percent depending on the loss record of the insured and the risk aversion of specific underwriters and reinsurers. The maximum available capacity for launch liability insurance has decreased from a pre-September 11 estimate of $1 to $1.5 billion down to $500 million in February 2002. These effects reflect the fact that some insurance companies have dropped out of the aerospace insurance underwriting market and the decreased number of reinsurance companies willing to participate in the aerospace business.

The reluctance of some underwriters and reinsurers to provide coverage for the aerospace market, including the commercial space launch area, reflects a re-evaluation of the perceived risks in this business area because of September 11, even though war-risk coverage may be excluded from launch liability coverage.[1] Such risk averse behavior is also expected to affect the ability of RLVs, relatively new and unproven designs, to attract insurance at reasonable premiums at this time. The reduction in the number of willing reinsurers, coupled with their risk-based increases in premium to the underwriters, is a principal driving force for the large increases in premium charged by the underwriters. This "hard" market with increasing premiums was estimated to continue for at least the next two years until the rates of return associated with higher premiums attract new investors into the underwriting and reinsurance business for aerospace insurance. The resumption of a space launch insurance market with relatively constant and reliable premiums along with increasing capacity at some future time is predicated on no large losses in the overall space launch and satellite business or any repeat, in magnitude of losses, of the events of September 11, 2001.

The significance of the terrorist attacks on September 11 to launch liability management and the aforementioned government response in relation to this study on commercial space transportation liability risk-sharing can be summarized as follows:

[1] The FAA has not issued a finding or determination that such an exclusion is considered "usual" for launch liability coverage.

- When a terrorist attack using civil aircraft resulted in unprecedented fatalities and casualties in the United States, the Federal Government intervened by quickly passing a law to limit and indemnify airline liability above existing insurance coverage.

- The federal government role in liability risk-sharing with the commercial airline industry represents a deviation from prior practice in this industry, which had always been completely responsible for its own insurance and liability.

- Insurance industry reaction to the terrorist attack, by dramatically raising premiums and reducing available capacity, and possibly withdrawing from providing terrorism/war risk coverage, may result in the Federal Government's continuing involvement in subsidizing or indemnifying industries against acts of terrorism.

Some additional questions raised by the events of September 11 include:

- Will the drawdown on insurance capacity be short term, with adjustment over time, or does September 11 represent a structural change in the capacity of the industry?

- If conventional third-party space transportation liability insurance is less available (supply and/or cost), then alternative approaches as discussed in Chapter 9 of this study, such as tax subsidies or greater reliance on the launch industry itself to set up funds in combination with insurance at MPL levels, may be called for.

- How *comparable* is the third-party risk associated with September 11 to the third-party risk associated with space transportation activities? In other words, how vulnerable is space transportation to terrorist threat and should such threat be regarded as maximum possible, not probable, loss as long as sufficient security against acts of terrorism or sabotage can be maintained? In this regard, it is noteworthy that war-risk exclusions have appeared on launch liability insurance certificates submitted by launch licensees as evidence of financial responsibility, although the FAA has not issued a finding or determination that such an exclusion is considered "usual."

- Despite the events of September 11, the role of government indemnification is still a fundamental public policy question. It pertains to desirability of underwriting launch as a public good; market failure elsewhere in providing compensation to third parties and the need to assure victim compensation as part of social policy; and whether launch activities represent an appropriate use of government indemnification provisions compared with other private activities and facilities that involve potential catastrophic liability.

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