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PRELIMINARY REGULATORY EVALUATION, INITIAL REGULATORY FLEXIBILITY DETERMINATION, TRADE IMPACT ASSESSMENT, AND UNFUNDED MANDATES ASSESSMENT

Commercial Space Transportation Reusable Launch Vehicles and Reentry Licensing Regulations

Notice of Proposed Rulemaking (14 CFR Parts 400, 401, 404, 405, 406, 413, 415, 431, 433, and 435)

**OFFICE OF AVIATION POLICY AND PLANS,
OPERATIONS REGULATORY ANALYSIS BRANCH, APO-310**

**Reviewed and Edited by
Archie Muckle, Jr.**

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LIST OF ABBREVIATIONS

14 CFR	Title 14, Code of Federal Regulations
AST	FAA Office of the Associate Administrator for Commercial Space Transportation
COMET	Commercial Experiment Transporter
DOD	U.S. Department of Defense
DOS	U.S. Department of State
DOT	U.S. Department of Transportation
E_c	Expected average number of casualties
ELV	Expendable Launch Vehicle
FAA	Federal Aviation Administration
FSS	Flight safety system
FY	Fiscal Year
LASD	FAA Licensing and Safety Division
LEO	Low-Earth Orbit
LV	Launch vehicle
METEOR	Multiple Experiment to Earth Orbit and Return
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
OCST	DOT Office of Commercial Space Transportation
RFA	Regulatory Flexibility Act of 1980
RLV	Reusable Launch Vehicle
RV	Reentry Vehicle
SSDD	FAA Space Systems Development Division

EXECUTIVE SUMMARY

This report presents an evaluation of the effects of revisions to Title 14, Code of Federal Regulations, Parts 400,401, 404, 405, 406, 413, 4 15, and the effects of the addition of Parts 43 1, 433, and 435. It presents an analysis of the expected impacts of these revisions and additions, focusing on the primary direct costs that would be incurred by the commercial space transportation industry to comply with the proposed rule, and the costs borne by the Federal Aviation Administration (FAA) to administer its requirements. It also presents estimates of the safety benefits that would be realized by the general public should industry be required to comply with the proposed rule.

The proposed rule is consistent with the FAA's authority to regulate commercial space reentry operations enacted on October 28, 1998. This authority, as exercised in the form of the proposed regulation, would protect public health and safety and the safety of property as the commercial space transportation industry matures technologically. The proposed rule would complement existing regulations that focus on the launch phase only of commercial space transportation vehicles.

The proposed rule is expected to impose a total estimated cost of $113 million (undiscounted 1997 dollars; $65 million discounted) on the commercial space transportation industry and the FAA over the 15-year period from 2000 to 2014. Industry would incur approximately 27 percent of these total costs, or $30 million, complying with the regulatory requirements. The FAA would spend approximately 73 percent of the total estimated cost, or $83 million, administering the proposed rule. There may be other additional direct impacts attributable to the proposed rule that are not identified and measured in this report for which the FAA solicits information,

The proposed rule is expected to generate safety benefits of approximately $119 million (undiscounted 1997 dollars; $66 million discounted), based on a range from $22 million to $217 million, (undiscounted 1997 dollars; $12 million to $121 million discounted) over the 15-year period. These benefits would take the form of enhanced safety, principally by ensuring that the expected average number of casualties from commercial space transportation reentry missions

would not exceed 30 per one million reentry missions for the general public, and one casualty per million reentry missions for the public adjacent to reentry sites.

The proposed rule would not have a significant impact on a substantial number of small entities currently engaged in or attempting to enter the commercial space transportation industry.

The proposed rule would not affect trade opportunities for U.S. firms doing business abroad or for foreign firms doing business in the United States.

The proposed rule is not likely to uniquely affect or impose a significant cost on small governments covered by those requirements under the Unfunded Mandates Act of 1995.

1.0 BACKGROUND AND REPORT INTRODUCTION

1.1 Regulatory Background

The Commercial Space Launch Act of 1984, as amended and codified in 49, United States Code 70101-70119 (1994) Subtitle IX, chapter 701, Commercial Space Launch Activities, authorizes the U.S. Secretary of Transportation to regulate domestic commercial space launch operations to protect (1) public health and safety, (2) property, (3) the environment, (4) national security, and (5) foreign policy. The Act and its amendments also charge the U.S. Department of Transportation (DOT) with promoting and facilitating private sector involvement in and expansion of this emerging industry.

During the two-year period immediately following establishment of the Act, there was little injection of private funds to bolster the commercial launch industry. Launch services provided by the National Aeronautics and Space Administration (NASA) Space Transportation System (that is, the Space Shuttle) and Arianespace, a European launch operator, were more advantageous financially than establishing private facilities for launching commercial payloads. Following the Space Shuttle Challenger disaster in 1986, however, the Federal Government ended its role as principal launcher of commercial payloads and established new polices to promote the commercial launch industry.

A DOT objective is to maintain a regulatory environment consistent with this burgeoning industry by fostering technological advancement without presenting unacceptable risks to the general public. The DOT Office of Commercial Space Transportation (OCST) published licensing regulations for commercial space launches in April 1988. To date, there have been 108 licensed launches.[1] In 1992 OCST established policy and associated criteria for ensuring that commercial space reentry missions can be conducted safely.[2]

[1] Extracted from Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation Internet Website Home Page (http:/ast.faa.gov/licensing/lic_issued/lic_issu.cfm), February 22, 1999, Active *Launch Licenses*.

[2] The Federal Register, Volume 57, Number 57 (Tuesday, March 24, 1992), Volume 57, Number 226 (Monday, November 23, 1992), and Volume 60, Number 148 (Wednesday, August 2, 1995) describe the

On November 15, 1995, overall responsibility for implementing the Act was delegated by the Secretary of Transportation to the Federal Aviation Administration (FAA) Administrator; OCST was moved intact and became the Office of the Associate Administrator for Commercial Space Transportation (AST). In recent years, AST has addressed issues important to commercialization of the space transportation industry, including licensing requirements for launches from Federal Government launch ranges and financial responsibility requirements for all licensed launch activities

1.2 Problem Statement

Congress enacted the Commercial Space Act of 1998 on October 28, 1998, giving the FAA authority to regulate commercial space reentry operations. Consistent with this authority and its mission, the FAA is proposing a rule that would protect public health and safety and the safety of property amidst a maturing commercial space transportation industry. As proposed, the rule would codify and supplement the existing 1992 safety policies governing the conduct of commercial space reentry missions initially established by OCST for a specific case, and make it applicable industry-wide. Furthermore, it would complement existing regulations that focus on the launch phase only of commercial space transportation vehicles. The proposed rule is expected to create impacts that require identification, evaluation, and to the extent practicable, measurement. Furthermore, the impacts attributable to the proposed rule are expected to be muted due to the pre-existing 1992 policy.

1.3 Scope and Limits

This regulatory evaluation identities the expected economic impacts of proposed revisions and additions to commercial space transportation licensing regulations that affect reentry missions, including launch, reentry, and operation of a reentry site. Where possible, the magnitude of these impacts is estimated.' The evaluation concentrates on

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criteria that formed the basis for Department of Transportation's treatment of petitions by commercial entities to conduct reentry missions.

[3] The principal requirements evaluated are the proposed additions of Commercial Space Transportation Licensing Regulations, Title 14, Code of Federal Regulations, Part 431, Launch and Reentry of a Reusable Launch Vehicle, Part 433, License. To Operate a Reentry Site, and Part 435, Reentry of a Reentry Vehicle

the principal regulatory requirements and addresses the primary direct costs and benefits attributable to the proposed rule that would be incurred by the commercial space transportation industry, the FAA, and the general public. Also included in this report are preliminary determinations of the impacts that the proposed rule would have on (1) small entities, (2) international trade, and (3) State, local, and tribal governments.

Other Than a Reusable Launch Vehicle. Proposed revisions to Parts 400, 401, 404, 405, 406, 413, and 415 do not impact the Federal Aviation Administration, the commercial space transportation industry, or public health and safety, and the safety of property. Similarly, Sections 431.21 and .51, 433.1, .5, and .9, and 435.1, 3, .7, .9, .11, .13, .15, .21, and .41 415 do not impact the Federal Aviation Administration, the commercial space transportation industry, or public health and safety, and the safety of property.

2.0 INDUSTRY PROFILE

2.1 Market Overview

2.1.1 Commercial Launch Operators

The nation's commercial space transportation industry is experiencing growth, as evidenced by the dramatic increase in demand for private sector launches over the past 10 years. Thirty-seven domestic licensed commercial launches (eight failures and 29 successes) were conducted during the first five years (1989 through 1993) of private sector launch under the Commercial Space Act of 1998. During the past five years (that is, 1994 through present) there have been 71 launches (four failures, 67 successes), an increase of approximately 109 percent.[4] Since enactment of launch licensing regulations, ten companies have been licensed to conduct launch activities. Three of these ten companies continue to maintain active licenses and account for 70 percent of all licensed launch activities to date, as many entities have either merged with or been acquired by other commercial space launch companies.'. Table 2-l summarizes the status of all commercial space transportation launch licensees.

Currently, commercial operators licensed to launch space vehicles rely on support from Federal Government employees and contractors operating U.S. Department of Defense (DOD) ranges and civilian government facilities, such as NASA facilities, to launch expendable launch vehicles (ELVs). However, there are commercial and State-sponsored entities that have obtained licenses to operate non-Federal launch sites. The status of licenses for all site operators is summarized in Table 2-2.

[4] Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation Internet Website Home Page (http:/ast.faa.gov/launch_info/launch/histroy.cfm), February 22, 1999, *Historical Launch Activity*.

[5] Extracted from Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation Internet Website Home Page (http:/ast.faa.gov/licensing/lic_issued/lic_issu.cfm), February 22, 1999, Active *Launch Licenses*; and supplemented with information from discussions with Carl Rappaport, Office of the Associate Administrator for Commercial Space Transportation, Space Systems Development Division, August 12, 1998.

TABLE 2-1. Status of Commel al Space Transportatic Launch Licenses

Commercial Organization Name	Number of Launches	License status	Expiration Date
McDonnell Douglas	37	Active"	May 1, 1999 January 2, 2000
Lockheed Martin Corporation	26	Active[b]	May 31, 1999 December 3 1, 1999
Orbital Sciences Corporation	13	Active'	March 18, 1999 March 18, 1999 March 13, 2000 September 2, 2000
Genera1 Dynamics	9	Acquired	y Martin Marrietta
EER Systems	6	No active	icense
Martin Marrietta	12	Merged with Lockheed Corporation	
Space Services of America. Inc.		Merged with EER Systems	
American Rocket	1	No longer in commercial space launch business	
Space Data	1	Merged with Orbital Sciences Corporation	
Conatec	0	No longer in commercial space launch business	
Total	108	8 (Active Licenses)	

Source: Federal Aviation Administrati Associate Administrator for Commercial Space Transportation Internet Web Site Home Page (http://ast.faa.gov/), and interviews with key Federal Aviation Administration personnel listed in Table A-1 in the Appendix.

[a, b] Two distinct licenses reflecting different mission operating characteristics.

[c] Four distinct licenses reflecting different mission operating characteristics.

TABLE 2-2. Private and State-Sponsored Launch Site Operator Licenses

Organization Name	Launch Site Name	Launch Site Location	Status of License
Spaceport Systems International	The California Spaceport	Vandenberg Air Force Base, California (Federal Government range)	Issued September 19, 1996 Expires September 19, 2001
Spaceport Florida Flight Authority	Spaceport Florida Authority	Cape Canaveral, Florida (Federal Government range)	Issued May 22, 1997 Expires May 22, 2002
Virginia Commercial Space Flight Authority	Virginia Commercial Space Flight Center	Wallops Island. Virginia (Federal Government range)	Issued December 19, 1997 Expires December 19, 2002
Alaska Aerospace Development Corporation	Kodiak Launch Complex	Kodiak Island, Alaska (not a Federal Government range)	Issued September 24, 1998 Expires September 24, 2003

Source: Federal Aviation Administration Associate Administrator for Commercial Space Transportation Internet Web Site Home Page (http://ast.faa.gov/), February 22, 1999.

2.1.2 Reusable Launch Vehicles

In addition to increases in the frequency of annual launches and the emergence of private sector launch site operators, the variety of commercial launch programs and associated vehicles is expanding. Just as the United States space program matured from single-use rockets to repeated-use space transportation vehicles (for example, the Space Shuttle is a partially reusable launch vehicle), the commercial space transportation industry also is advancing technologically. Driven by high launch costs and market demand for lower-priced space transportation services, commercial entities are studying a variety of repetitive use launch vehicle (LV) concepts and alternative designs — commonly referred to as reusable launch vehicles (RLVs) — to supplement and eventually replace ELVs. The levels of LV reuse being considered range from full reusability to partial reusability, wherein components from at least one stage of a LV are recoverable for future use. The development cost to bring a RLV to the market — which include research, design,

construction, test, and evaluation — generally are very high and can range from $150 million to over $500 million.[6]

Currently, there are nine known entities at varying stages of development focused on establishing RLV programs. These organizations, listed in Table 2–3, are confronting the technological challenges and inherent safety risks that present strong barriers to both entering the industry and sustaining an economically viable business. Although detailed information is not readily available, with the exception of Lockheed Martin Corporation, the majority of these entities are relatively small, having fewer than 100 employees. The smallest, David L. Burkhead, is a single proprietor. While the commercial space transportation industry is capable of meeting anticipated launch demand with the current supply of launch sites and ELVs, customers want lower-priced services — RLVs have the potential of fulfilling this need.

[6] Development of the Kelly Space and Technology Astroliner vehicle is expected to cost $150 million while the Kistler Aerospace Corporation K–1 is estimated to cost $500 million, as reported in Associate Administrator for Commercial Space Transportation, January 1998, *Reusable Launch Vehicle Programs and Concepts,* Federal Aviation Administration, pp. 11 and 13, respectively.

TABLE 2-3. Commercial Reusable Launch Vehicle Development Entities

Commercial Organization Name	Program Name	Technical Status	Funding Status and Source
Advent Launch Services	**Heavy Lift Launch System**	**Concept**	**Unknown**
David L. Burkhead	Spacecub	Concept	Unknown
Kelly Space and Technology	Astroliner	Under Development	Secured $3 million in private funding towards its $450 million goal
	Express	Under Development	Seeking funding
	Spirit	Under Development	Secured private funding
Kistler Aerospace Corporation	K-1	Under Development	Secured $250 million in private funding towards its $750 million goal
Lockheed Martin Corporation	VentureStar	Under Development	May be funded by Lockheed-Martin Corporation
Pioneer Rocketplane	Pathfinder	Under Development	Secured $3.5 million in funding towards its $250 million goal
Rotary Rocket Company	Roton-C	Under Development	Secured $6 million from private sector sources
Third Millennium Aerospace	SpaceVan/Bantam Van	Concept	Unknown
Vela Technology Development	Space Cruiser System	Under Development	Unknown

Source: Associate Administrator for Commercial Space Transportation, January 1998, *Reusable Launch Vehicle Programs and Concepts*, Federal Aviation Administration, and *Space News*, March 23-29, 1998; "Wall Street Warms Up to Rocket Firms."

2.1.3 Reentry Vehicles

The ability to return space transportation hardware to Earth for reuse, either in part or whole, would help to lower the relatively steep costs associated with this industry that are currently reflected in the high price of space transportation services. RV technology is not limited to the LV itself, as the space transportation industry has, for a variety of reasons, developed satellite payloads that, although launched using ELVs, can return to Earth as payload RVs for some form of reuse. For example, payloads used in experimentation may require direct examination on Earth to benefit from the effort, and related equipment may have salvage value that can be returned to service after refurbishment. While this helps to reduce the costs of doing business, the ability to reuse

LVs offers additional cost savings that can significantly aid industry in lowering prices. Although all commercial RLVs are still under development and some remain in the conceptual and preliminary design phases, the need to reduce the costs of space transportation services remains. In the interim — until RLVs are commercially available — the industry is expected to continue to demand that payloads and related hardware be returned to Earth for reuse.

Barriers to entering the commercial space transportation industry and maintaining an economically viable business are significant, as financing reentry mission programs and the advanced technology associated with RLVs is not accomplished easily.[7] In light of the high development costs mentioned previously (that is, $150 million to over $500 million) and the desire to expedite commercialization of RLVs in order to help lower prices for space transportation services, the FAA is working diligently to keep pace with this evolving industry; FAA intervention is proceeding by maintaining a regulatory environment that continues to protect public safety without creating barriers to industrial growth.

2.2 Reentry Mission Projections

Estimates of the expected number of future commercial reentry missions (including launches and reentries of RLVs and payload RVs) must take into consideration the uncertainty in the rate of technological advancement, market demand conditions, and foreign competition as this industry continues to mature and respond to pressures to minimize costs. The Commercial Space Transportation Advisory Committee projects an average of 33 payloads annually would be launched to geosynchronous orbit over the next 12 years.[8] The FAA forecasts that there would be 34 launches to low-earth orbit (LEO) during this same period.[9] All of these estimates for annual launch demand may

[7] In addition to high economic and technological risks are long payback periods.
[8] Commercial Space Transportation Advisory Committee, May 1998, *Commercial Spacecraft Mission Model Update*, Federal Aviation Administration, Associate Administrator for Commercial Space Transportation.
[9] Federal Aviation Administration, May 1998, *LEO Commercial Market Projections*, Associate Administrator for Commercial Space Transportation.

not be for reentry missions or involve RLVs. This is because there is uncertainty regarding the rate at which RLVs would be substituted for ELVs. Conversely, the availability of RLVs may result in an increase in the number of reentry mission launches, pending RLV costs and the responsiveness of demand to market prices for such services." Additionally, several entities, such as Advent Launch Systems, are proposing using RLVs for suborbital and orbital launches for recreational purposes." Collectively, mission model projections, expected rate of industry maturation, anticipated market conditions, and expert opinion suggest that over the 15-year period, beginning 2000 and ending 2014, the commercial space transportation industry may be able to supply a total of 524 reentry mission launches, with most launches occurring in the later years as shown in Figure 2–1.[12] The shape of the curve in this figure is based on the assumption that in the first half of the 15-year period the number of reentry missions is expected to increase dramatically as firms enter the market. Toward the end of the period the rate of increase in the number of missions is expected to slow down as market demand reaches a steady state or equilibrium. Furthermore, the FAA projects that five commercial entities would be conducting these missions over the 15-year period 2000 to 2014.[13] The FAA invites comments on the merits of this assumption and any potential impacts related thereto.

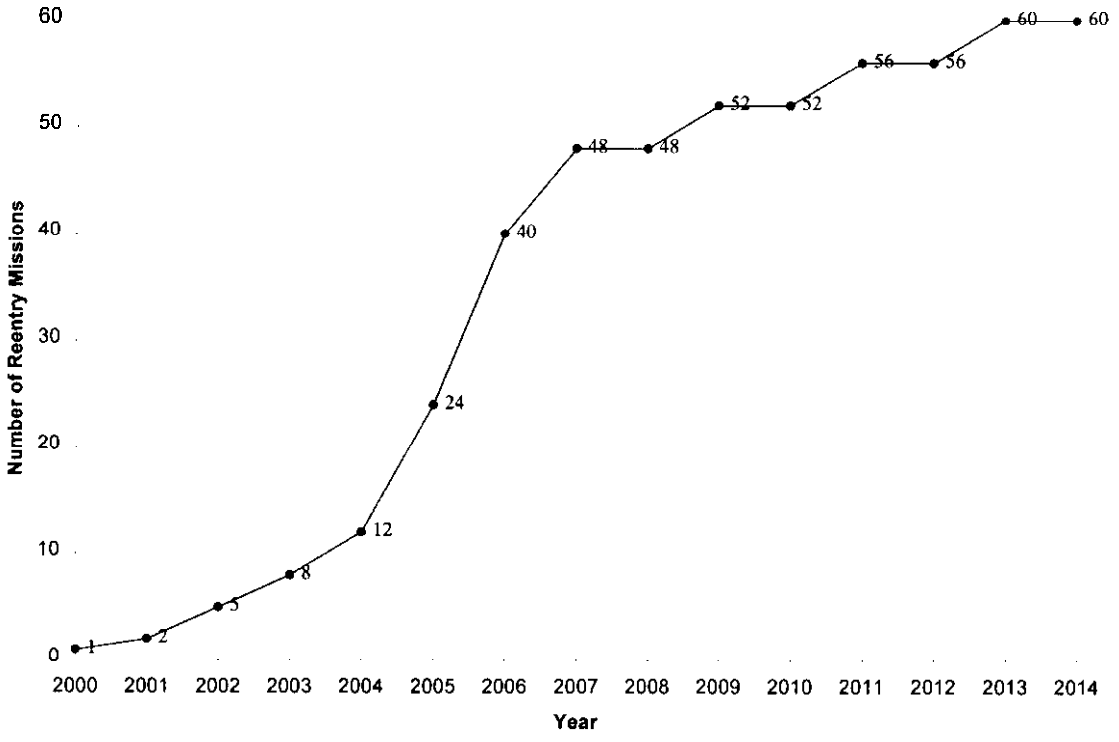
[10] Kelly Space and Technology expects that launch prices for its Astroliner RLV will be less than $2000 per pound for a low earth orbit, as reported in Associate Administrator for Commercial Space Transportation, January 1998, *Reusable Launch Vehicle Programs and Concepts,* Federal Aviation Administration, p. 11.

[11] Information extracted from Space Frontier Foundation, August 13, 1998,"The New Commercial Space Companies" and supplemented with information obtained from technical discussions with Brett Alexander, Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation, Space Systems Development Division, September 2, 1998.

[12] Information provided by Brett Alexander, Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation, Space Systems Development Division, August 13, 1998. No estimate is provided as to how the number of projected reentry missions will be split between RLVs and RVs launched using ELVs.

[13] Information provided by Brett Alexander, Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation, Space Systems Development Division, August 13, 1998.

FIGURE 2-l. Distribution of Expected Reentry Vehicle Missions



Source: Developed with information provided by Brett Alexander, Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation, Space Systems Development Division, August 13, 1998.

3.0 REQUIREMENTS OF THE PROPOSED RULE

3.1 Historical Perspective

The licensing of private sector interests in conducting space transportation activities that include reentry operations has not been previously addressed explicitly by formal Federal Government regulations. However, in 1992 the OCST, predecessor to the AST, evaluated the Commercial Experiment Transporter (COMET) Program (developed by Westinghouse Electric Corporation and Space Industries , Inc.) request for permission to conduct a reentry mission. Although OCST did not have explicit regulatory authority to license a commercial reentry operation, it performed this function under its payload determination authority associated with its launch license evaluation responsibilities. In accordance with its statutory mandate to protect public safety, OCST developed a process and associated performance-based criteria for evaluating the COMET reentry mission. The COMET Program was discontinued in May 1994 without performing its reentry mission. In 1995 NASA initiated a restart of the program; EER Corporation assumed development of the RV and renamed it the Multiple Experiment to Earth Orbit and Return (METEOR) Program. The OCST, and eventually AST, continued to assume responsibility for evaluating the request for permission to conduct a reentry mission under its payload determination authority, and reentry mission approval was subsequently granted to the METEOR Program. Unfortunately, the LV failed and consequently the METEOR Program did not perform the planned reentry mission. Since this time there have been no requests for permission to reenter a commercial vehicle or payload.

3.2 The Proposed Requirements

The proposed revisions to commercial space transportation licensing regulations for reentry operations incorporate much from the OCST and AST experience with evaluating the COMET/METEOR programs, as well as relevant considerations contained in current regulations governing launch licensing. The principal proposed revisions (hereafter referred to as the proposed rule) contain provisions for (I) two types of licenses for RLV missions — mission-specific and operator license, (2) operation of a reentry site, and (3)

two types of licenses for reentry of a RV other than a RLV — reentry-specific and reentry operator license. A RLV mission-specific license pertains to a single model or RLV type, and authorizes a specified number of RLV missions. A RLV operator license pertains to missions involving a "designated family of RLVs" to a designated site that adheres to certain operational parameters, such as payload and trajectory.'" Similarly, a non-RLV reentry-specific license pertains to one model or type of RV, while a reentry operator license for non-RLVs authorizes reentry of a designated family of RVs to a designated site that adheres to certain operational parameters, such as payload and trajectory[15]. Operational restrictions on a reentry site pertain to its use for RLVs or RVs. This section presents a brief discussion of the principal relevant components of the proposed rule — 14 CFR Part 431, Part 433, and Part 435.

3.2.1 Proposed Part 431, Launch and Reentry of a Reusable Launch Vehicle

Subpart B — Policy Review and Approval

Subpart B of the proposed rule defines the responsibilities of the FAA for issuing policy approval to a RLV mission license applicant, summarizes the application requirements subject to policy review, and addresses denial of policy approval.[16] In general, policy approval would be denied if "..the proposed mission presents any issues, other than those issues addressed in the safety review [in Subpart C] that would adversely affect U.S. national security or foreign policy interests, would jeopardize public health and safety or the safety of property, or would not be consistent with international obligations of the United States."" The results of this determination would be formally transmitted to the applicant in writing. The FAA would be responsible for responding to appeals and reacting to revised applications.

[14] Federal Aviation Administration, January 27, 1999, *Revision of Commercial Space Transportation Licensing Regulations,* Notice of Proposed Rulemaking (Draft), p.111-112..
[15] Ibid., p.141.
[16] There is no distinction made between a RLV mission or RLV operator license with regard to this requirement, as it applies to both types.
[17] Federal Aviation Administration, January 27, 1999, *Revision of Commercial Space Transportation Licensing Regulations,* Notice of Proposed Rulemaking (Draft).

Subpart C — Safetv Review and Approval

Subpart C contains the principal requirements of the proposed rule that would have a direct impact on the FAA, the commercial space transportation industry, and the general public. Specifically, the proposed rule would require the FAA to perform a safety review of a RLV mission application and notify an applicant in writing of any issues raised during the review that would impede issuance of safety approval. The review includes a technical assessment to determine if the applicant is "..capable of launching a RLV and payload, from a designated launch site, and reentering the RLV and payload, if any, to a designated reentry site, or otherwise landing the RLV and payload, if any, on Earth without jeopardizing public health and safety and the safety of property."" Accordingly, this subpart contains requirements designed to ensure that the expected average casualty risk (E,) to the public for any RLV mission will not exceed 30 casualties in every one million RLV missions (which translates to 30×10^{-6}), and for persons within a 100-mile distance from the border of the area adjacent to and surrounding the designated reentry site and contingency abort locations, the expected average casualty risk will not exceed one casualty in every one million RLV missions (which translates to 1×10^{-6}).[19] Successful applicants for RLV mission licenses would be required to establish an organizational infrastructure, including a safety organization and independent safety official, to support and approve internal safety and readiness reviews, review risk and systems safety engineering analyses, monitor personnel compliance with an applicant's safety policies and procedures, conduct operational rehearsals, and demonstrate that the overall RLV mission program can achieve a margin of safety consistent with the required expected casualty risk criterion, and reenter to Earth a RLV in a manner commensurate with stipulated safety goals. Industry would have to demonstrate that personnel having direct control over the RLV mission adhere to specified work and rest standards, that the mission plan possesses the necessary procedures and contingency, communication, and emergency response plans, and that personnel must be able to perform the planned

[18] Ibid., p.116-117
[19] Ibid., p. 119.

mission and respond to, investigate, and report accidents and unplanned events and incidents to the FAA.

Subpart D — Payload Reentry Review and Determination

Subpart D focuses on the responsibilities of the FAA to determine if reentry of a payload presents any issues that would adversely affect U.S. national security or foreign policy interests, would jeopardize public health and safety or the safety of property, or would not be consistent with international obligations of the United States.[20] In conducting a payload review, the FAA would consult with the DOD, DOS, and other Federal Government organizations, such as NASA, before advising an applicant in writing as to the results of its review. Applicants are notified in writing of issues raised during the review that would impede a favorable determination so that they may respond, as appropriate. Commercial entities applying for a license would be required to provide the FAA with certain information, such as the presence of hazardous substances and the explosive potential of payload materials, in order to perform its payload review.

Subpart E — Post-Licensing Reauirements

This subpart of the proposed rule contains the requirement that licensees must reapply to the FAA for modification of the principal license if the planned RLV mission and its safety-related procedures differ from the initial license. Any changes that could have an impact on public health and safety can trigger the need to request a modification approval. This requirement would cause a commercial space transportation entity to submit an application for license modification and cause the FAA to review and approve such modification requests. Modifications requiring FAA approval include revised reentry plans and procedures, altered payload, alternate vehicle design or type of RLV, modified reentry site, modified trajectory, and altered safety system and policy. Proposed Subpart E also requires that a RLV licensee provide AST with certain launch, flight path, reentry, and payload information at 60- and 15-day intervals prior to each planned

[20] Ibid., p. 130.

mission, maintain all records pertaining to the reentry mission for a period of three years, and make these records available to the FAA upon request.

Subpart F — Environmental Review

This proposed subpart addresses the FAA's responsibility to analyze reentry operations for environmental impacts. Accordingly, an applicant must furnish the FAA with information that would permit this analysis in accordance with the requirements contained in the National Environmental Policy Act as codified in 42 U.S.C. 4321, related regulations, and FAA procedures and policies.

3.2.2 Proposed Part 433, License to Operate a Reentry Site[21]

This subpart addresses the FAA's authority to issue a license to operate a reentry site, provided that the applicant demonstrates that operation is consistent with safety requirements. Also addressed is the FAA's responsibility to analyze reentry site operations for environmental impacts. Accordingly, an applicant must furnish the FAA with information that would permit this analysis in accordance with the requirements contained in the National Environmental Policy Act as codified in 42 U.S.C. 4321, related regulations, and FAA procedures and policies.

3.2.3 Proposed Part 435, Reentry of a Reentry Vehicle other than a Reusable Launch Vehicle

Subpart B — Policy Review and Approval

The requirements for policy review for both types of non-RLV reentry licenses, as they relate to the reentry phase of a mission, are identical to those for RLVs discussed previously in Section 3.2.1, for Subpart B (and are not repeated here).

[21] Due to the uniqueness of commercial space transportation entities, Part 433.3, Issuance of a License to Operate a Reentry Site, does not contain discrete requirements that can be evaluated for purposes of deriving compliance and administrative costs, and associated safety benefits.

Subpart C — Safety Review and Approval

The requirements for safety review and approval for both types of non-RLV reentry licenses, as they relate to the reentry phase of a mission, are identical to those for RLVs discussed previously in Section 3.2.1, for Subpart C (and are not repeated here).

Subpart D — Payload Reentry Review and Determination

The requirements for payload determination for both types of non-RLV reentry licenses, as they relate to the reentry phase of a mission, are identical to those for RLVs discussed previously in Section 3.2.1, for Subpart D (and are not repeated here).

Subpart E — Post-Licensing Requirements

The post-licensing requirements for both types of non-RLV reentry licenses, as they relate to the reentry phase of a mission, are identical to those for RLVs discussed previously in Section 3.2.1, for Subpart E (and are not repeated here).

Subpart F — Environmental Review

The requirements for environmental review for both types of non-RLV reentry licenses, as they relate to the reentry phase of a mission, are identical to those for RLVs discussed previously in Section 3.2.1, for Subpart E (and are not repeated here).

4.0 IMPACT OF PROPOSED REVISION OF COMMERCIAL SPACE TRANSPORTATION LICENSING REGULATIONS

4.1 Overview of Analytical Approach

This section presents an evaluation of the impacts of the principal parts of the proposed rule on the commercial space transportation industry, the Federal Government, and the general public; it estimates the total incremental costs and benefits of the proposed rule. This is accomplished by comparing operations under the proposed rule with current practice, commonly referred to as the baseline. Quantifying the primary impacts of the proposed rule in dollars yields costs -the out-of-pocket expenditures incurred by the commercial space transportation industry in complying with its requirements and the expenses borne by the FAA from administering the proposed rule — and benefits — the dollar value of fatalities, injuries, and property damage prevented or mitigated. Cost savings to the FAA or the commercial space transportation industry directly attributable to the proposed rule are also captured in this process, as appropriate.'*

4.1.1 Identification of Baseline

The proposed rule implements certain policies developed by AST in 1992 with respect to public safety for the first commercial space reentry operation. However, the safety criteria proposed in this rulemaking use different measures that better reflect current agency and range safety practices. The 1992 policy established safety criteria pertaining to a unique and specific request to conduct a first-of-a-kind payload reentry mission; that is, the COMET, later renamed METEOR, reentry vehicle. Accordingly, a comprehensive regulatory (benefit-cost) analysis was not required. Therefore, the baseline case used for this analysis views the proposed rule as a new requirement imposed on an emerging segment of the commercial space transportation industry that plans to operate reusable launch vehicles (RLVs) or conduct reentry operations with reentry vehicles (RVs).

[22] Information is requested by the FAA on other costs attributable to the proposed rule not captured in this evaluation. For example, certain proposed requirements may have secondary impacts that would change operations, consequently causing commercial transportation entities to incur additional costs or reduce expenses.

Doing so implies that, but for imposition of safety requirements by the agency, some compliance costs would not have been incurred by entities planning to conduct RLV missions (launch and reentry) and RV operations that are associated with launches from Federal ranges. (Regulatory costs and benefits associated with launches from Federal ranges are assessed as part of a separate rulemaking on launch licensing requirements for launches from Federal ranges.)

4.1.2 Incremental Impact Analysis

Incremental impact analysis, within the context of this study, focuses on determining the difference between all relevant FAA and commercial space transportation industry actions under the baseline and under the proposed rule. As noted in Section 4.1 .1 above, the incremental effects of the proposed rule are identified and measured relative to common commercial space transportation practice only (that is, the baseline case). Accordingly, if the proposed rule creates an environment that departs from this baseline, then the cost to the commercial space transportation industry to comply with it, the cost to the FAA to administer it, and the impacts on safety are identified and estimated in dollars to the extent practicable.

4.2 Impact of the Proposed Rule on Commercial Space Transportation Entities

4.2.1 Current Commercial Space Transportation Industry Practice

The COMET/METEOR experiences demonstrated that commercial space transportation entities could develop reentry programs capable of minimizing unplanned events and mitigating safety risks during reentry missions. Many of DOT's performance-based requirements for reentry mission approval contained in the 1992 policy were already being addressed voluntarily by the applicants as a matter of standard operating procedure and good business practice. For example, since the Challenger disaster, industry has emphasized rigorous quality assurance programs and associated safety organizations with the authority to take the necessary actions to avoid risk to public health and safety and the safety of property. These practices continue to evolve today, as commercial space transportation entities and the FAA maintain frequent communication to ensure that

technological advances are consistent with emerging safety considerations, and Federal government intervention creates an environment that helps facilitate industry maturation.

4.2.2 Incremental Effects on Commercial Space Transportation Entities

The historical evidence of COMET/METEOR was supplemented with data from interviews with FAA (that is, AST) staff and commercial space transportation industry experts to identify the incremental effects of the proposed rule relative to the baseline.[23] Collectively this information supports the assertion that the principal requirements contained in the proposed rule would pose additional impacts on commercial space transportation entities.

A prudent commercial entity is not likely to jeopardize the success of a mission and risk future business by discounting important engineering techniques and related operating practices. Accordingly, industry is expected to behave rationally and develop reentry mission programs that maximize inherent system reliability in order to minimize the risk of mission failure. In so doing, these entities are also taking many of the necessary precautions to prevent or minimize any adverse impacts on safety and health. Consequently, many of the technical requirements contained within the proposed rule are already being addressed voluntarily by industry (to varying degrees) as a matter of standard operating procedure and good business practice, and therefore expenditures to achieve compliance are minimized.[24] Additionally, based on past licensing experience and practices, the FAA expects to work closely with reentry license applicants during the

[23] Specific documents referring to COMET and METEOR contained in the List of References at the end of this report, such as U.S. Department of Transportation, August 4, 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review*, Office of Commercial Space Transportation, Licensing and Safety Division provide ample evidence of the actions taken by OCST. This evidence was supplemented with information obtained from interviews with key FAA personnel identified in Table A-1 in the Appendix to this report that, as part of their responsibility as AST personnel, maintain frequent communication with representatives from the commercial space transportation industry. Additional information was obtained from The Aerospace Corporation personnel also identified in Table A-1.

[24] Interviews with Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation personnel: Ronald Gress and Carole Flores, Licensing and Safety Division; Charles Larsen, Space Systems Development Division, August 12, 1998.

pre-application consultation period to facilitate the licensing process and help keep associated costs to a minimum.[25]

The principal sections of the proposed rule have a wide spectrum of effects on commercial space transportation entities, Impacts range from no measurable effect, as is the case for Sections 43 1.75 and .79 (which are equivalent to current practice), to commercial space transportation entities incurring costs implementing additional safety-related activities to comply with major requirements, such as those contained in Sections 43 1.33 and .35. This comparative incremental impact analysis is summarized in Table 4-1 below. The FAA invites comments on the validity of this assertion and any potential impacts related thereto.

[25] Ibid

TABLE 4-1. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed by the Commercial Space Transportation Reentry Licensees

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
43 1.25 Application for Policy Review	Provide written information identifying RLV model, type, configuration, ownership, reentry sites, trajectories, and planned events,	Documentation is already generated and available to submit to the Federal Aviation Administration.	Administrative burden of providing to the Federal Aviation Administration information documenting the overall reentry program consistent with application guidance."
43 1.33: Safety Organization	Describe safety organization, including lines of communication and designated independent safety official to assume responsibility for safety and performing rehearsals and readiness reviews,	Roles and responsibilities defined for the safety organization currently being performed voluntarily.	Administrative burden of providing to the Federal Aviation Administration reentry safety organization and reentry personnel roles in application materials, formal identification of an independent safety official and associated responsibilities."

[a] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, January *4, 1991. Information Required for OCST to Review Commercial Reentry* (Interim), Office of Commercial Space Transportation, Licensing and Safety Division; and U.S. Department of Transportation, November 15, 1993, *Strategic Plan for Operations Review of the COMET Reentry Vehicle*, Revision 1.0, Office of Commercial Space Transportation, Licensing and Safety Division, p. 2.

[b] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, January 4, 1991, *Information Required for OCST to Review Commercial Reentry* (Interim), Office of Commercial Space Transportation, Licensing and Safety Division, p.7; U.S. Department of Transportation, November 15, 1993, *Strategic Plan for Operations Review of the COMET Reentry Vehicle*, Revision 1.0, Office of Commercial Space Transportation, Licensing and Safety Division, p. G-4; and U.S. Department of Transportation, August *4,* 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review.* Office of Commercial Space Transportation, Licensing and Safety Division, p. 22.

TABLE 4-1. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed by the Commercial Space Transportation Reentry Licensee (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
13 1.35: Acceptable vlission Risk	Perform a risk analysis; expected average number of casualties to the general public is not to exceed 30 per million reentry missions (E, $\leq$ 30 x lo"); expected average number of casualties to the public adjacent to reentry site is not to exceed one per million reentry missions (E, $\leq 1 \times 10^{-6}$).	Risk analyses are performed and documented, although the level of rigor applied is less than that required to achieve the criterion for expected average number of casualties to the general public per the proposed rule.	Perform more rigorous risk analyses; validate analyses; and establish that expected average number of casualties to the general public will not exceed 30 per million reentry missions (E, $\leq 30 \times 10^{-6}$) and expected average number of casualties to the public adjacent to reentry site is not to exceed one per million reentry missions (E, $\leq$ 1 x 10")
13 1.37: Mission Readiness	Submit procedures verifying mission readiness in key areas, including personnel; RLV; payload; safety-critical systems; launch site and related equipment and property; reentry flight and recovery; mission rules, constraints, and contingency abort plans; dress rehearsals; and licensee currency.	Documentation is already generated and available to submit to the Federal Aviation Administration.	Administrative burden of providing to the Federal Aviation Administration information documenting the overall reentry program consistent with application guidance."

TABLE 4-1. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed hv the Commercial Space Transportation Reentry Licensees (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
431.39: Mission Rules, Procedures, and Contingency Plans	Written mission rules, procedures, and contingency plans compiled and approved by safety official; personnel complete current checklists.	Rules, procedures, and contingency plans compiled, documented, and approved.	Administrative burden of interfacing and exchanging materials periodically with the Federal Aviation Administration in order to provide sufficient written information to adequately document the reentry mission program; and responding to compliance monitoring.[c]
431.41: Communications Plan	Documented communication networks, procedures, and protocols concurred with by site operator and provided to all site personnel.	Communication networks, procedures, and protocols documented.	Administrative burden of interfacing and exchanging materials with the Federal Aviation Administration periodically in order to provide sufficient written information to adequately document the communications plan.[c]

[c] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, August 4, 1999, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review*, Office of Commercial Space Transportation, Licensing and Safety Division, p. 22.

TABLE 4-l. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed by the Commercial Space Transportation Reentry Licensees (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
·31.43:)perational Requirements and Restrictions	Submit procedures to ensure conformance with public risk criteria, the system safety process, monitoring of safety-critical systems, and human activation of safety systems. Identify suitable abort sites for RLV contingency abort, RLVs must be operated in a manner such that the expected average number of casualties to the general public does not exceed 30 per million reentry mission launches ($E_c \leq 30 \times 10^{-6}$). Restricted from substantial dwell time over populated areas; monitor safety-critical reentry systems during launch and reentry; must have a flight safety system; command-activated fail-safe reentry; avoid physical contact with other space vehicles; do not generate debris; perform collision avoidance analysis; 3 sigma dispersion reentry sites; crew work and rest limitations.	Monitoring, flight safety systems, and suitable abort sites determined is currently being performed voluntarily. Monitor safety-critical reentry systems during launch and reentry; must have a flight safety system; command-activated fail-safe reentry; avoid physical contact with other space vehicles.	Operate a RLV in a manner such that the expected average number of casualties to the general public does not exceed 30 per million reentry missions ($E_c \leq 30 \times 10^{-6}$). Stringent flight path parameters to achieve an expected average number of casualties to the general public not to exceed 30 per million reentry missions ($E_c \leq 1 \times 10^{-6}$); implement crew work and rest hour limitations based on NASA Goddard Wallops Flight Facility Code 800 requirements and maintain associated records to administer requirement; and responding to compliance monitoring.[d]

[d] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, August 4, 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review.* Office of Commercial Space Transportation, Licensing and Safety Division, p. 24; and National Transportation Safety Board, July 26, 1993, *Special Investigation Report, Commercial Space Launch Incident,* NTSB/SIR-93/02, PB93-917003, Washington, D.C., pp. 31-32; and Range Safety Office, Patrick Air Force Base, *Eastern and Western Range 127-1,* October 31, 1997.

TABLE 4-1. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed by the Commercial Space Transportation Reentry Licensees (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
431.45: Mishap Investigation and Emergency Response Plan	Plan and procedures for investigating, reporting, and responding to reentry emergencies and timely interface with the Federal Aviation Administration Operations Center	Emergency plans are developed.	Incorporating interface with the Federal Aviation Administration Operations Center into the plan; preparing for, accommodating, and reacting to compliance monitoring activities; and administrative burden of interfacing and exchanging materials periodically with the Federal Aviation.[e]
431.57: Information Requirements for Payload Review	Provide payload characteristics, including explosive potential and securing methods	Payload characteristics are documented.	Administrative burden of providing the Federal Aviation Administration with sufficient documentation on the reentry mission.[f]
431.73: Continuing Accuracy, Application for Modification	Submit application pending nature of modifications.	Modifications are generally documented.	Conditional requirement, pending whether modifications are made. Administrative burden of providing the Federal Aviation Administration with sufficient documentation on modifications.[g]

[e] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, August 4, 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review.* Office of Commercial Space Transportation, Licensing and Safety Division, p. 3.

[f] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, *August 4. 1995, Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review*, Office of Commercial Space Transportation, Licensing and Safety Division, p. 24; and U.S. Department of Transportation, November 15, 1993, *Strategic Plan for Operations Review, of the COMET Reentry Vehicle*, Revision 1.0, Office of Commercial Space Transportation, Licensing and Safety Division, p. 2.

[g] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, August 4, 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review,*, Office of Commercial Space Transportation, Licensing and Safety Division, p. 22.

TABLE 4-1. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed bv the Commercial Space Transportation Reentrv Licensees (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline and Proposed Rule That Impact Industry
43 1.75 : Agreement with Federal Range	Secure formal agreement with Federal range.	This is standard operating procedure.	None, except for providing the Federal Aviation Administration with sufficient documentation on agreement secured with a Federal range. [h]
43 1.77: Records	Retain records pertaining to missions for a three-year period. Records related to an unplanned event shall be preserved for at least three years and not destroyed until advised by the FAA.	This is standard operating procedure. Records are maintained for a three-year period.	None, except for responding to requests from the Federal Aviation Administration for information, or maintaining data beyond a three-year period in the case of an unplanned event.
413 1.79: Reporting Requirements	Reporting to AST at 60- and 15-day intervals prior to reentry; reporting to the FAA unplanned events	Reporting unplanned events.	Minimal administrative burden of reporting to AST at 60- and 15-day intervals prior to reentry.
4131.93: Environmental Information	Provide information to permit FAA review of environmental impacts	None, although this is a requirement under the National environmental Policy Act.	Prepare and submit to the Federal Aviation Administration an environmental assessment.'

[h] U.S. Department of Transportation, August 4,1995, *Payload Determination Evaluation for rhe METEOR Reentry Vehicle, Vehicl'e Safety Assessment and Operations Review.* Office of Commercial Space Transportation, Licensing and Safety Division, p. 22.
Federal Register, August 2, 1995, p. 39479.

[i] Applicants are expected to be required to follow guidance similar to that contained in U.S. Department of Transportation, August 1995, *Environmental Assessment for EER Systems Corporation's METEOR l'ehicle and Payload,* Office of Commercial Space Transportation; U.S. Department of Transportation, January 4,1991, *Information Required for OCST to Review Commercial Reentry* (Interim), Office of Commercial Space Transportation, Licensing and Safety Division; and U.S. Department of Transportation, August 4,1995, Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review, Office of Commercial Space Transportation, Licensing and Safety Division.

TABLE 4-l. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Compliance Actions Performed by the Commercial Space Transportation Reentry Licensees (Continued)

Section of Proposed Rule	Summary of Proposed Rule-Required Actions	Comparable Baseline Actions Performed by Commercial Space Transportation Entities	Principal Difference Between Baseline anb Proposed Rule That Impact Industry
4133.7 Environmental	Provide information to permit FAA review of environmental impacts	None, although this is a requirement under the National environmental Policv Act.	Prepare and submit to the Federal Aviation Administration an environmental assessment.'
4135.23: Policy Review	Same requirements as 43 1.25 listed above	Same as response to Section 43 1.25 listed above	Same as response to Section 43 1.25 listed above
4135.33: Safety Review	Same requirements as Sections 431.33, .37, .39, .41, .43, and .45 listed above.	Same as response to Sections 431.33, .35, .37, .39, .41, .43, and .45 listed above.	Same as response to Sections 43 1.33, .35, .37, .39, .41, .43, and .45 listed above.
4135.35 Acceptable Reentry Risk	Same requirements as paragraphs (a) and (b) of Section 43 1.35. This pertains to the expected average number of casualties to the public (E,) of 30 x 10^{-6} and 1 x 10^{-6} as listed above for 431.35.	Same as response to Section 43 1.35 listed above.	Same as response to Section 43 1.35 listed above.
4135.43: Payload Review	Same requirements as Section 431.57 listed above.	Same as response to Section 43 1.57 listed above.	Same as response to Section 431.57 listed above.
435.51:Post-Licensing Requirements (General)	Same requirements as Sections 43 1.73, .75, .77. and .79 listed above.	Same as response to Sections 431.73, .75, .77, and .79 listed above.	Same as response to Sections 431.73, .75, .77, and .79 listed above.
4135.61: I3nvironmental Review (General)	Same requirements as Section 43 1.93 listed above.	Same as response to Section 431.93 listed above.	Same as response to Section 43 1.93 listed above.

4.2.3 Incremental Cost Impact on Commercial Space Transportation Entities

As summarized in Table 4-1 above, 21 principal sections of the proposed rule contain requirements that collectively arc expected to create incremental costs to the commercial space transportation industry. Many of the reentry requirements contained in Part 43 1 for RLVs are also common to Part 435 pertaining to reentry of non-RLVs. Therefore, these requirements are addressed collectively to the extent practicable.[26] Derivation of the incremental compliance cost estimates is summarized in Table 4-2. Following this table is a discussion of the rationale for establishing the incremental cost impact of these requirements to a commercial space transportation entity.

[26] The significant technological differences between ELV-launched RVs and RLVs is likely to create a compliance cost differential between the type of reentry mission performed by commercial space transportation entities. However, these differences are not addressed in terms of discrete compliance cost estimates for RLVs and RVs. This is because sufficient information is not readily available upon which to base an estimate as to how the 524 reentry missions projected in Figure 2-1 would be divided between RLV and RV mission types. However, once RLV technology is proven, it is likely to replace ELVs as the LV for RV payloads. Accordingly, most of the 524 projected reentry missions may be required to comply with the RLV-related requirements being proposed. Therefore, this regulatory analysis uses a worst case approach from a compliance cost standpoint (that is, RLV compliance costs will prevail), rather than developing discrete compliance cost estimates for RLV and non-RLV reentry missions.

TABLE 4-2. Commercial Space Transportation Entity Compliance Cost"
(In 1997 Dollars)

Section of Proposed Rule	First Year Costs for a Single Entity Approved for Reentry Operations(Year 2000 Only)			Recurring Costs for a Single Entity Approved for Reentry Operations (Years 2001-2014)			First Year and Recurring Costs for a Single Entity Approved for Reentry Operations, 2000-2014		
	Technical	Administrative	Total	Technical	Administrative	Total	Technical	Administrative	Total"
431.25: Policy Review[b]	$0	$395	**$395**	$0	$0	$0	$0	$395	**$395**
431.33: Safety Organization'	$103,081	$5,154	**$108,235**	$103,081	$5,154	$108,235	$1,546,215	$77,310	**$1,623,525**
431.35: Acceptable Reentry Risk[d]	$721,567	$36,078	**$757,645**	$0	$3,608	**$3,608**	$721,567	$86,590	**$808,157**
431.37: Mission Readiness'		$3,951	**$3,951**	$0	$0	**$0**		$3,951	**$3,951,**

Source: The Aerospace Corporation, Gwynne Gurevich; and Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation personnel: Ronald Gress, Licensing and Safety Division, Charles Larsen (Space Systems Development Division).

Note: All cost estimates for personnel hours are based on a conservative value for annual salary of $83,500 provided by The Aerospace Corporation. Applying a fringe benefit factor of 23.45% (see Appendix A, Tables A-2 and A-4) yields $103,081, which is the estimated cost to a commercial space transportation entity for one professional staff.

[a] These costs are independent of the frequency of reentry mission events.

[b] Dividing $103,081 by 2087 hours per year and multiplying the result by eight hours yields $395 in administrative costs.

[c] Technical cost is estimated at 1.0 staff; administrative cost is estimated at 5 percent of technical cost.

[d] Technical cost is estimated at 7 staff; administrative first year cost is 5 percent of technical cost; recurring administrative cost is estimated at .5 percent of technical first year cost.

[e] Dividing $103,081 by 2087 hours per year and multiplying the result by 80 hours yields $3951 in administrative costs.

TABLE 4-2. Commercial Space Transportation Entity Compliance Cost (Continued)
(In 1997 Dollars)

Section of Proposed Rule	First Year Costs for a Single Entity Approved for Reentry Operations(Year 2000 Only)			Recurring Costs for a Single Entity Approved for Reentry Operations (Years 2001-2014)			First Year and Recurring Costs for a Single Entity Approved for Reentry Operations, 2000-2014		
	Technical	Administrative	Total	Technical	Administrative	Total	Technical	Administrative	Total"
431.39: Mission Rules, Procedures, Contingency Plans, and Checklists[f]	$51,541	$2,577	$54,118	$0	$2,577	$2,577	$51,541	$38,655	**$90,19**
431.41: Communications Plan[f]	$51,541	$2,511	$54,118	$0	$2,577	$2,577	$51,541	$38,655	**$90,19**
431.43: Operational Requirements and Restrictions[g]	$1,649,296	**$82,465**	**$1,731,761**	$103,081	$5,154	$108,235	$3,092,430	$154,621	**$3,247,05**
431.45: Mishap Investigation and Emergency Response Plan[h]	$103,081	$5,154	**$108,235**	$25,770)	$5.1541	**$30,924**	$463.8611	$77.3101	$541.171
431.57: Information Requirements for Payload Review[b]	$0	$395	$395	$0	$0	$0	$0	$395	**$39**
431.73: Continuing Accuracy, Application for Modification[i]	$31,611	$1,581	$33,192	$0	$0	$0	$31,611	$1,581	**$33,19**
431.75: Agreement with Federal Range[j]	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$(**
431.77: Records[b]	$0	$395	$395	$0	$395	$395	$0	$5,925	**$5,92**

[f] Technical cost is estimated at 0.5 staff; all administrative costs are estimated at 5 percent of technical first year cost.
[g] Technical first year cost is estimated at 16 staff; administrative first year costs estimated at 5 percent of technical first year cost; recurring technical cost is estimated at 1 staff; recurring administrative cost is estimated at 5 percent of recurring technical cost.
[h] Technical first year cost is estimated at 1 .0 staff; recurring technical cost is estimated at 0.25 staff; all administrative cost are estimated at 5 percent of technical first year cost.
[i] Dividing $103.08 I by 2087 hours per year and multiplying the result by 640 hours yields technical cost; administrative cost is estimated at 5 percent of technical costs.
[j] No incremental cost impact.

TABLE 4-2. Commercial Space Transportation Entity Compliance Cost (Continued)

(In 1997 Dollars)

Section of Proposed Rule	First Year Costs for a Single Entity Approved for Reentry Operations(Year 2000 Only)			Recurring Costs for a Single Entity Approved for Reentry Operations (Years 2001-2014)			First Year and Recurring Costs for a Single Entity Approved for Reentry Operations, 2000-2014		
	Technical	Administrative	Total	Technical	Administrative	Total	Technical	Administrative	Total"
131.79: Reporting Requirements[j]	$0	$0	$0	$0	$0	$0	$0	$0	$0
131.93: Environmental nformation[k]	$257,703	$12,885	$270,588	$0	$0	$0	$257,703	$12,885	$270,588'
133.7: Environmental'	$154,622	$7,731	$162,353	$0	$0	$0	$154,622	$7,731	$162,353~
135.23: Policy Review	Incremental compliance costs reflected in Section 431.25 above.								
135.33:Safety Review	Incremental compliance costs reflected in Sections 431.33, .37, .39, .41, .43, and .45 above.								
135.35: Acceptable Reentry Risk for a Reentry Vehicle-	Incremental compliance costs reflected in Section 431.35 above.								
135.43: Payload Reentry Review	Incremental compliance costs reflected in Section 431.57 above.								
135.5 1: Post-Licensing Requirements (General)	Incremental compliance costs reflected in Sections 431.73, .75, .77, and .79 above.								
135.6 1: Environmental Review 'General)	Incremental compliance costs for this section are reflected in Section 43 1.93 costs above.								
Total	$3,124,043	$161,338	$3,285,381	$231,932	$24,619	$256,551	$6,371,091	$506,004	$6,877,095

[k] Technical fixed cost is estimated at 2.5 staff; administrative costs are estimated at 5 percent of technical fixed costs.

[l] Technical fixed cost is estimated at 1 .5 staff; administrative costs are estimated at 5 percent of technical fixed costs.

[m] The time-phasing of firms entering the industry is not considered in total compliance cost figures in this table (that is, all firms are assumed to enter into the industry in the year 2000. However, time-phasing is considered when calculating compliance cost streams within this evaluation, as presented in Table A-4 in the Appendix to this report.

Section 43 1.25 Application Requirements for Policy Review, and Section 435.23:Policy Review Requirements and Procedures

This proposed requirement -to provide specific information to the FAA -presents an administrative paperwork burden to a commercial entity. The cost impact of packaging and submitting the requisite information to the FAA in a prescribed format, such as completing a specific application, is based on a eight hour level of effort. This task would be performed by an individual whose annual cost to a commercial entity is conservatively estimated to be approximately $103,000. The result is a paperwork cost to a commercial entity of approximately $400 (undiscounted 1997 dollars) per application submittal." Over the 15-year period five such submittals are expected collectively from the commercial space transportation industry, resulting in a total cost of $2,000 (undiscounted 1997 dollars) to industry.

[27] See Table 4-2 for derivation of the estimate for this compliance cost

Section 43 1.33: Requirements for Safety Organization, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

Under the baseline, a safety organization with clearly defined roles, responsibilities, authorities, and lines of communication is consistent with the findings and recommendations of the Rodgers Commission and National Transportation Safety Board reports.** However, the proposed requirement to ". . .designate a qualified safety official.. to monitor independently compliance. .with. [all] safety policies and procedures" is not necessarily customary and usual practice. Inclusion of this proposed requirement suggests that it is a refinement to industry baseline practices designed to mitigate safety risks to the public. For example, to be " responsible for the conduct of all.. .mission activities.. ." implies a degree of comprehensiveness that may not be common practice in industry. Because the safety official must be independent, the function cannot be assigned as a collateral duty to an individual with line responsibility for reentry operations. Furthermore, the magnitude of responsibilities of the safety official suggest that the level of effort required to perform this function would exceed part-time employment This also supports the notion that the independent safety official function cannot be successfully performed as a collateral duty. Accordingly, this proposed requirement would result in a commercial space transportation entity hiring a person to fulfill the safety official role. The annual cost to a commercial entity to support a person in this position would be approximately $103,000, supplemented with additional administrative costs. Accordingly, a single commercial space transportation entity would incur incremental compliance costs of approximately $1.6 million (undiscounted 1997 dollars) for the 15- year period from 2000 to 2014.[29] Industry would incur a total cost of $8 million (undiscounted 1997 dollars)."'

[28] These reports are referenced in Federal Aviation Administration, January 27, 1999, *Revision of Commercial Space Transportation Licensing Regulations,* Notice of Proposed Rulemaking (Draft). For specific recommendations see Rogers, William P. et. al., June 6, 1986, *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, Presidential Commission, Washington, D.C., p. 199, and National Transportation Safety Board, July 26, 1993, *Special Investigation Report, Commercial Space Launch Incident*, NTSB/SIR-93/02, PB93-917003, Washington, D.C., pp. 36 and 52.

[29] A conservative estimate of annual salary of $83,500 for this position is used provided by The Aerospace Corporation. Applying a fringe benefit factor of 23.45% yields $103,081, which is the estimated cost to a commercial space transportation entity to employ this individual. See Table 4-2 for derivation of compliance costs, as well as Appendix A, Tables A-2 and A-4.

[30] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report.

Section 431.35: Acceptable Reusable Launch Vehicle Mission Risk, and Section 435.35: Acceptable Reentry Risk for Reentry of a Reentry Vehicle

Commercial space transportation entities would incur additional costs performing risk analyses of vehicle and payload reentry, and assessing the probabilities and consequences of all reentry hazards, events, and system failures that place the public at risk. Additionally, commercial entities will expend effort preparing documentation and establishing an associated document control system for drawings and schematics that will be acceptable to the FAA, and fulfill the level of rigor implied by the requirements contained in the proposed rule. The cost impact to a commercial entity attributable to this requirement would be approximately $757,000 in the first year of operation, with recurring costs of $3,600 annually, for a total of $808,000 (undiscounted 1997 dollars) for the 15-year period from 2000 to 2014.[31] The total cost to industry would be approximately $4 million (undiscounted 1997 dollars) for the 15-year period."

Section 431.37: Mission Readiness, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

This requirement — to provide specific procedures to the FAA that verify mission readiness — presents an administrative paperwork burden to a commercial entity. The cost impact of packaging and submitting the requisite information to the FAA in a format that may be easily reviewed by a knowledgeable individual is based on a 80 hour level of effort. This task would be performed by an individual whose annual cost to a commercial entity is conservatively estimated to be approximately $103,000. The result is a paperwork cost to a commercial entity of approximately $4,000 (undiscounted 1997 dollars) per application submittal." Over the 15-year

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Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

[31] See Table 4-2 for derivation of the estimate for this compliance cost.

[32] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

[33] Using a conservative estimate for annual salary of $83,500 provided by The Aerospace Corporation, and applying a fringe benefit factor of 23.45% yields $103,081, which is the estimated cost to a commercial space transportation entity to employ this individual. (See Appendix A, Tables A-2 and A-4). Dividing this number by 2087 hours per year and multiplying the result by 80 hours yields approximately $4,000. (See Federal Aviation Administration,

period five such submittals are expected collectively from the commercial space transportation industry, resulting in a total cost of $20,000 (undiscounted 1997 dollars).'"

Section 43 1.39: Requirements for Mission Rules, Procedures, Contingency Plans, and Checklists, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

Commercial space transportation entities are generally expected to fulfill this requirement as part of their standard operating procedures. However, it is anticipated that some additional effort will be expended to conform to FAA format requirements. Furthermore, commercial entities would expend effort exchanging documents with the FAA periodically, and preparing for, accommodating, and reacting to FAA inspection and monitoring activities. Accordingly, the incremental cost impacts will be incurred initially during the application phase and throughout the operating lifetime of commercial operations as an entity interfaces with the FAA, as required, to accommodate compliance monitoring activities. The cost impact to a single commercial space transportation entity to comply with is this requirement is approximately $54,000 in the first year of operation with $2,600 annually of recurring costs, or $90,000 (undiscounted 1997 dollars) for the 15-year period from 2000 to 2014.[35] Industry as a whole would incur $450,000 over the 15-year period.[36]

Section 43 1.41: Requirements for Communications Plan, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

Commercial space transportation entities are expected to have in place communications plans that are consistent with much of the regulatory requirement as a matter of standard business

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January 1998, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, Office of Aviation Policy and Plans, p. 4-21.) Calculations are summarized in Table A-5 in the Appendix to this report.

[34] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

[35] See Table 4-2 for derivation of the estimate for this compliance cost.

[36] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

practice. However, they are expected to incur incremental costs from initial compliance with the requirement, and annual recurring costs from interfacing and exchanging documents with the FAA periodically, and preparing for, accommodating, and reacting to FAA inspection and compliance monitoring activities. Accordingly, a commercial entity would incur an incremental compliance costs of approximately $90,000 (undiscounted 1997 dollars) for the 15-year period from 2000 to 2014.[37] Industry as a whole would incur $450,000 (undiscounted 1997 dollars) over the 15-year period.'*

Section 43 1.43: Reusable Launch Vehicle Mission Operational Requirements and Restrictions, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

Commercial space transportation entities would expend an additional levels of effort to comply with the reentry vehicle flight path requirements during nominal and nonnominal operations, specifically as it pertains to minimizing dwell time over populated areas during all segments of a reentry phase, and performing a collision avoidance analysis during launch windows to maintain adequate separation from orbiting objects.

The proposed work and rest requirements would also burden commercial space transportation entities. For example, an individual having direct control over reentry or involved in decisions affecting reentry operations is restricted to 60 hours over a seven-day period. Further, the proposed rule reduces the maximum permissible hours worked per shift, limits the maximum number of consecutive workdays, and specifies the minimum rest required between five consecutive 12-hour work shifts. This is summarized below in Table 4-3.

[37] See Table 4-2 for derivation of the estimate for this compliance cost.

[38] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

TABLE 4-3. Proposed Work and Rest Requirements

	Maximum Hours Over Seven Day Period	Maximum Hours Per Shift	Maximum Consecutive Work Days	Minimum Rest After Five Consecutive Shifts of Twelve Hours
Proposed Rule	60 Hours	12 Hours	14 Days	48 Hours

Source: Federal Aviation Administration, January 27, 1999, Revision of Commercial Space Transportation Licensing Regulations. Notice of Proposed Rulemaking (Draft).

Currently it is common practice among commercial space transportation entities to follow NASA work and rest standards for launches. Ordinarily launch mission operations personnel work less than the maximum currently permissible, such as a 40-hour work week comprised of five eight-hour shifts. Hence, the 72-hour work week is generally an extreme condition that occurs infrequently. Furthermore, industry is voluntarily supplementing NASA work and rest standards with additional provisions limiting the maximum work shift to 12 hours and including a mandatory rest period of at least 8 hours between these extended-hour shifts.[39] These practices, which are consistent with proposed requirements, are expected to continue for reentry operations.[40]

The duration of a reentry operation is likely to determine the extent that the proposed work and rest requirements would have on commercial space transportation entities. However, this impact would occur under the extreme or limiting conditions only. Under such conditions, commercial entities would have to revisit their duty rosters and make scheduling adjustments that may cause them to add one additional reentry operations personnel.

Generally, commercial space transportation entities currently conducting ELV programs either avoid the limiting conditions or have sufficient numbers of similarly trained back-up personnel to accommodate such restrictions without impacting mission schedules.[41] However, given the

[39] National Transportation Safety Board, July 26, 1993, *Special Investigation Report, Commercial Space Launch Incident*, NTSB/SIR-93/02, PB93-917003, Washington, D.C., p. 32.

[40] Interviews with key AST personnel identified in Table A-1 in the Appendix to this report indicate that it is not uncommon for commercial space transportation entities to supplement NASA duty time standards with more limiting requirements for launch activities. It is expected that this practice would continue for reusable launch vehicles and reentry operations in general.

[41] Interviews with key AST personnel identified in Table A-1 in the Appendix to this report (principally Charles Larsen on November 20, 1998) indicate that large as well as small launch organizations have ample personnel to cover extend work shifts. In some cases, individuals working on the planning for launch and reentry operations for

relatively small size of the entities comprising the emerging reentry segment of the commercial space transportation industry, staff augmentation of at least one is likely. This task would be performed by an individual whose annual cost to a commercial entity is conservatively estimated to be approximately $103,000. Additionally, the FAA anticipates that additional costs will be incurred for recordkeeping to ensure compliance with required work and rest standards, and preparing for, accommodating, and reacting to FAA inspection and monitoring activities.

Hence, the incremental cost to a single commercial entity to comply with the proposed requirement would be approximately $1.7 million in the first year of operation, followed by annual recurring costs of $107,000 attributable to the proposed work and rest requirement, for a total of $3.2 million (undiscounted 1997 dollars) for the 15-year period from 2000 to 2014.[42] The total cost to industry for the 15-year period would be $16 million (undiscounted 1997 dollars).[43]

Section 43 1.45: Requirements for Mishap Investigation and Emergency Response Plan, and Similar Requirements Contained in Section 435.33: Safety Review Requirements and Procedures

Commercial entities are expected to have prepared emergency response plans that are consistent with much of the regulatory requirement as a matter of standard business practice. However, the FAA anticipates that these plans would require additional annual maintenance (for example, periodic training drills and annual exercises) to comply with certain elements of the proposed rule. For example, entities are likely to incur additional costs to establish and demonstrate their ability to successfully respond to accidents occurring in remote areas having sparse populations (where overflight may be permitted, provided the E_c does not exceed 30×10^{-6}). Furthermore, additional annual maintenance costs are expected to arise from preparing for, accommodating, and reacting to FAA inspection and monitoring activities. Accordingly, a commercial space transportation entity would incur incremental costs of $108,000 initially and $3 1,000 annually of

subsequent missions may be used to support a current mission in order to avoid encroaching on work and rest limits.

[42] See Table 4-2 for derivation of the estimate for this compliance cost.

[43] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

recurring costs to comply with the requirement, or approximately $542,000 (undiscounted 1997 dollars) for the 15-year period.[44] Industry would incur total compliance costs of approximately $2.7 million (undiscounted 1997 dollars) for the 15-year period."[45]

Section 43 1.57: Information Requirements for Payload Reentry Reviews, and Similar Requirements Contained in Section 435.43: Payload Reentry Review Requirements and Procedures

The requirement to provide specific payload information to the FAA presents an administrative paperwork burden to a commercial entity. The cost impact of packaging and submitting the requisite data to the FAA in a prescribed format is based a eight hour level of effort. This task would be performed by an individual whose annual cost to a commercial entity is conservatively estimated to be approximately $103,000. The result is a minimal paperwork cost to a commercial entity of approximately $400 per application submittal.[46] Over the 15-year period five such submittals are expected collectively from the commercial space transportation industry, resulting in a total cost of $2000 (undiscounted 1997 dollars).

Section 43 1.73: Requirements for Modification of a License, and Similar Requirements Contained in Section 435.51: Post Licensing Requirements -Reentry License Terms and Conditions (General)

Depending on the nature of modifications to an existing license, this requirement may or may not impact a commercial space transportation entity. For instance, trivial changes to reentry missions that do not impact public health and safety and the safety of property the would cause a commercial space transportation entity to expend a negligible level of effort advising the FAA. In contrast, changes made to a reentry mission that materially affect mission rules, plans, and contingency procedures, would cause an entity to expend considerable effort responding to this requirement. Conditional upon these latter types of changes, it is assumed that, on average, a

[44] See Table 4-2 for derivation of the estimate for this compliance cost.
[45] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.
[46] See Table 4-2 for derivation of the estimate for this compliance cost.

commercial space transportation entity would incur incremental compliance costs of approximately $33,000 (undiscounted 1997 dollars) per modification application.[47]

Section 43 1.75: Requirements for Securing Agreement with Federal Range, and Similar Requirements Contained in Section 435.5 1: Post Licensing Requirements — Reentry License Terms and Conditions (General)

It is customary and usual practice for commercial space transportation entities launching ELVs from Federal ranges to enter into formal agreements prior to using such facilities. Commercial entities planning to use these same facilities for reentry missions are expected to act in similar fashion. While the proposed requirement may cause an applicant to enter into an agreement sooner, it has no impact on commercial entities other than the negligible level of effort expended (that is, less than one hour) to advise the FAA of its existence. Therefore, the incremental cost to industry to comply with this requirement would be zero.

Section 43 1.77: Requirements for Records, and Similar Requirements Contained in Section 435.51: Post Licensing Requirements-Reentry License Terms and Conditions (General)

It is generally accepted practice among all commercial concerns to maintain business operations records for some period of time, often more than three years.[48] Furthermore, the availability and capability of electronic storage systems renders records retention a manageable task. Accordingly, the proposed three-year requirement to maintain records for FAA review, upon request, would not impact commercial space transportation entities. From a worst case perspective, this evaluation assumes the FAA would exercise its record request authority. As a result, the impact to a commercial entity is the effort expended duplicating these records, which is not expected to exceed eight person-hours. Assuming one request annually for records duplication, the cost to a commercial entity would be approximately $400 annually or $6,000

[47] See Table 4-2 for derivation of the estimate for this compliance cost.

[48] To be consistent with or respond to any provision of the U.S. Internal Revenue Code, businesses must keep records from three to seven years, and in some instances indefinitely (U.S. Department of the Treasury, February 1998, p. 14). Commercial entities in the business of providing services generally maintain meticulous records for insurance purposes in order to address liability claims. Therefore, it is not unreasonable to assume that commercial space transportation entities would maintain their reentry operations records for a period at least equivalent to the shortest period (that is, three years) stipulated by the U.S. Internal Revenue Service.

(undiscounted 1997 dollars) for the 15-year period.[49] Total costs to industry would be $30,000 (undiscounted 1997 dollars) for the 15-year period.[50]

Section 43 1.79: Reporting Requirements, and Similar Requirements Contained in Section 435.51: Post Licensing Requirements — Reentry License Terms and Conditions (General)

The information to be supplied by the licensee per this proposed requirement is similar to that supplied previously to the FAA during the application process in accordance with Section 43 1.57. The burden placed on the licensee is to duplicate data supplied previously to ensure that the required payload and reentry information will be available to the FAA no later than 60 and 15 days prior to conducting a licensed reentry, as appropriate. This responsibility is not expected to impact commercial space transportation entities, as it involves the conveyance of previously supplied information and generates a negligible level of effort (that is, less than one hour). Therefore, the incremental cost to industry to comply with this requirement would be zero.

Section 43 1.93: Requirements for Environmental Information, and Similar Requirements Contained in Section 435.61: Environmental Review (General)

Absent the proposed rule, it is possible that a commercial space transportation entity may be required to address the environmental effects of its operations in accordance with environmental regulations issued by state governments in addition to National Environmental Policy Act (NEPA) requirements. Apart from this occurrence, commercial entities planning to conduct reentry missions would be required to submit an assessment to the FAA of the environmental impacts of its activities. This would cause a commercial entity to incur incremental compliance

[49] Using a conservative estimate for annual salary of $83,500 provided by The Aerospace Corporation, and applying a fringe benefit factor of 23.45% yields $103,081, which is the estimated cost to a commercial space transportation entity to employ this individual. (See Appendix A, Tables A-2 and A-4). Dividing this number by 2087 hours per year and multiplying the result by eight hours yields $395.14. (See Federal Aviation Administration, January 1998, *Economic Analysis of Investment and Regulatory Decisions Revised Guide*, Office of Aviation Policy and Plans, p. 4-21.) Calculations are summarized in Tables A-5 and A-6 in the Appendix to this report.

[50] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

costs of $271,000 (undiscounted 1997 dollars).[51] Over the 15-year period, industry as a whole would incur compliance costs of $1.4 million (undiscounted 1997 dollars).[52]

Section 433.7: Environmental Information

A commercial entity applying for a license to operate a reentry site, regardless of whether they are independent of those organizations applying for licenses to conduct a RLV or non-RLV reentry mission, must submit to the FAA information to permit an analysis of the environmental impacts of its activities. Because reentry sites are not as complex as the vehicles that will be using them (that is, RLVs and RVs), the level of effort required to assemble this information would be relatively less. Accordingly, this requirement would cause a commercial entity to incur incremental compliance costs of $162,000 (undiscounted 1997 dollars)." Industry would incur total compliance costs of approximately $800,000 (undiscounted 1997 dollars) over the 15-year period.[54]

In summary, as shown in Table 4-2, a single space transportation entity initiating operations in the year 2000 is estimated to incur approximately $7 million (undiscounted 1997 dollars) for the 1 S-year period from 2000 to 2014 to comply with the principal requirements contained in Sections 43 1,433, and 435 of the proposed rule. Based on a projected industry population of five entities over the 15-year period from 2000 to 2014, and assuming that all entities initiate activities in the year 2000, total industry compliance cost would be approximately $35 million (undiscounted 1997 dollars) for the 15-year period (that is $7 million x 5 entities = $35 million). However, because the five entities will enter the industry at different times over the 15-year

[51] See Table 4-2 for derivation of the estimate for this compliance cost.
[52] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.
[53] See Table 4-2 for derivation of the estimate for this compliance cost. For purposes of this regulatory analysis, the projected number of entities receiving a reentry site operator license over the 15-year period is presumed to be equivalent to the number of commercial space transportation entities performing reentry missions (that is, five).
[54] Calculated by multiplying the five entities projected to comprise the industry by the 15-year cost to comply with the requirement. Accordingly, it assumes that all entities begin activities in the year 2000 and does not consider the time-phasing used to develop the projection presented in Figure 2-1 and Table A-4 in the Appendix to this report. Therefore, the industry cost for this particular requirement is overstated. However, the total compliance cost to

period, recurring costs will not be incurred for the entire 15-year period by all five entities. This time-phasing of firms entering the industry is considered in calculating industry total compliance cost, which is estimated to be $30 million (undiscounted 1997 dollars).[55] A total compliance cost stream is presented in Table A-4 in the Appendix to this report. Accordingly, on average, each entity will incur approximately $6 million to comply with the principal requirements of the proposed rule (that is, $30 million ÷ 5 entities = $6 million).

4.3 Impact of the Proposed Rule on the Federal Aviation Administration

4.3.1 Current Federal Aviation Administration Practice

Fifteen principal sections of the proposed rule contain requirements that impact the FAA. Each of these proposed regulatory requirements is compared with the baseline to identify the incremental cost to the FAA. While it may be necessary for the FAA to confer with other Federal Government organizations in performing its responsibilities under the proposed rule, such as NASA and the Departments of Defense and State, the cost to these other agencies is minimal. This is because their involvement is assumed to include only coordination of administrative information, cursory reviews of application materials, and limited consultation on technical matters.'" Therefore, the incremental analysis associated with administering the requirements of the proposed rule pertains to the effects on the FAA only

A request for a reentry license today would be processed by the FAA's Licensing and Safety Division (LASD). LASD would exercise the function inherited from OCST that was performed

industry for the overall proposed rule is based on the projected time-phasing of commercial entities initiating operations.

[55] All five entities are not projected to enter into the industry in the year 2000. Rather, one will enter in the year 2000, two in the year 2001, one in 2006, and one in 2009 for a total of five entities. This is shown in Table A-4 in the Appendix to this report. The time phasing of the number of projected entities entering the industry impact when compliance costs begin to incur, which determines the total compliance costs borne by industry. For purposes of this regulatory analysis, the number of entities receiving a reentry site operator license over the 15-year period is projected to be equivalent to the number of commercial space transportation entities performing reentry missions (that is, five).

[56] The Federal Aviation Administration is expected to use consultants from private industry to evaluate applications, as was done for the COMET and METEOR programs, according to information extracted from interviews with key AST personnel (see Table A-1 in the Appendix) and Federal Aviation Administration, 1998, "AST-200 FY 2000 Budget Estimates (Working Papers), Associate Administrator for Commercial Space Transportation, Licensing and Safety Division.

on the COMET/METEOR requests for permission to conduct a reentry mission.[57] Hence, the proposed rule formally extends the LASD responsibilities and duties to licensing reentry operations.

Currently, upon receipt of a launch-related licensee application, the FAA has 180 days (or 6 months) in which to evaluate the application and make a decision to approve or disapprove the request. Formal evaluation of an application, however, may be preceded by a voluntary pre-application consultation process that can involve a substantial amount of interface between the FAA and the applicant. During the consultation period, an applicant may submit to the FAA a draft application for review and comment. Pending the results of the consultation review, additional drafts may be prepared and submitted to the FAA for further assessment. This iterative process enables an applicant to prepare and submit a final license application for evaluation that is less likely to require modification and create costly delays during the formal 180-day evaluation period. Hence, by the time an application is presented to the FAA for evaluation, most if not all problems, concerns, and issues have been identified and resolved.

4.3.2 Incremental Effects on the Federal Aviation Administration

The process and requirements used by the OCST in evaluating the COMET/METEOR programs were reviewed and supplemented by interviews with key AST personnel to identify the impact of the proposed rule on the FAA. Many of the principal actions required of the FAA under the proposed rule would have been performed (by the FAA) for the COMET/METEOR program.[58] Therefore, the level of effort expended to administer the proposed rule for a single applicant would be comparable to the actions taken to apply the 1992 policy, augmented with the additional duties associated with other requirements not reflected in the reentry policy established for COMET/METEOR.

[57] The FAA Licensing and Safety Division (LASD) currently is responsible for (1) evaluating launch license applications, (2) recommending approval or disapproval, and (3) monitoring licensee compliance with the license requirements; Federal Aviation Administration, March 11, 1998, *Licensing and Safety Division Order No. 001, Launch Licensing and Compliance Monitoring Process and Procedures*, Associate Administrator for Commercial Space Transportation, Licensing and Safety Division.

[58] The referenced document (U.S. Department of Transportation, November 15, 1993) entitled, *Strategic Plan for Operations Review of the COMET Reentry Vehicle* succinctly describes the process followed to evaluate the operations of the COMET Freeflyer reentry vehicle proposed by Space Industries, Inc.

To the extent that the proposed rule injects a level of formality into the reentry licensing process, it may improve the efficiency with which the FAA performs this function through standardization and consistency (discussed in Section 4.5). This could result in cost savings. However, these cost savings may be completely eroded by the proposed rule itself, as creating a regulation to institutionalize and formalize past policy may introduce additional administrative costs. It is assumed that these situations, should they arise, would have off-setting results.

The principal sections of the proposed rule — Parts 43 1,433, and 435 -would cause the FAA to incur additional costs administering their respective requirements. This analysis is summarized in Table 4-4 below. The FAA invites comments on the validity of these assertions and any potential impacts related thereto.

TABLE 4-4. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Administrative Functions Performed hv the Federal Aviation Administration

Section of Proposed Rule	Summary of Proposed rule-Required Actions	Comparable Actions Performed by OCST and AST	Difference Between Baseline and Proposed Rule That Impact FAA
43 1.23: Policy Review	Coordinate policy review, focusing on national security, foreign policy interests, public health and safety, and property; coordinate with other government agencies; notify applicant in writing.	None.	Administrative burden of coordinating activities with DOS, DOD, and NASA and notifying applicants in writing of issues, concerns, and approvals.
43 1.27: Denial of Policy Approval	Notify applicant in writing.	None.	Administrative burden of notifying applicants in writing of denial of policy approval.
43 1.3 1: General (Safety Review)	Conduct general safety review focusing on public health and safety and property; notify applicant in writing.	None.	Perform technical review of operations vehicle safety assessment.[a, b].
43 1.47: Denial of Safety Approval	Notify applicant in writing.	None.	Administrative burden of notifying applicants in writing of denial of safety approval.

Source: Interviews with key AST personnel identified in Table A-1 in the Appendix to this report.

[a] Activities to be performed are expected to be similar to those contained in U.S. Department of Transportation, November 15, 1993, *Strategic Plan for Operations Review of the COMET Reentry Vehicle*, Revision 1.0, Office of Commercial Space Transportation. Licensing and Safety Division.

[b] Activities to be performed are expected to be similar to those contained in U.S. Department of Transportation, December 6, 1994, *Space Industries, Incorporated COMET Freeflyer, Vehicle Safety Assessment,* Office of Commercial Space Transportation, Licensing and Safety Division.

TABLE 4-4. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Administrative Functions Performed by the Federal Aviation Administration (Continued)

Section of Proposed Rule	Summary of Proposed rule-Required Actions	Comparable Actions Performed by OCST and AST	Difference Between Baseline and Proposed Rule That Impact FAA
43 1.55: Payload Review	Perform and coordinate payload review and notify applicant of issues impeding favorable determination.	None.	Perform payload determination evaluation.[c, d]
43 1.59: Issuance of Payload Determination	Notify applicant in writing.	None.	Administrative burden of notifying applicants in writing of payload determination.
43 1.73: Application for Modification of a License	Perform policy and safety reviews.	None.	As required, perform policy and safety reviews on mission changes."
43 1.83: Compliance Monitoring	Review documentation and observe activities of licensee, contractors, and subcontractors associated with the RLV mission.	None.	Site visits to relevant facilities to review material and observe operations
43 1.9 1: General Environmental Review	Perform environmental impact assessment.	None.	Perform environmental assessment.[c, e]

Source: Interviews with key AST personnel identified in Table A-1 in the Appendix to this report.

[c] Activities to be performed are expected to be similar to those contained in Jackson, Stewart, August 4, 1995, Memorandum to Ronald K. Gress; EER systems Corporation METEOR Payload Determination Application, " U.S. Department of Transportation, Office of Commercial Space Transportation

[d] Activities to be performed are expected to be similar to those contained in U.S. Department of Transportation, August 4, 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment and Operations Review,* Office of Commercial Space Transportation, Licensing and Safety Division.

[e] Activities to be performed are expected to be similar to those contained in U.S. Department of Transportation, August 1995, *Environmental Assessment for EER Systems Corporation 's METEOR Vehicle and Payload,* Office of Commercial Space Transportation.

TABLE 4-4. Impact of Revision of Commercial Space Transportation Licensing Regulations on the Administrative Functions Performed by the Federal Aviation Administration (Continued)

Section of Proposed Rule	Summary of Proposed rule-Required Actions	Comparable Actions Performed by OCST and AST	Difference Between Baseline and Proposed rule That Impact FAA
433.3: Operation of a Reentry Site	Conduct general review focusing on issues jeopardizing public health and safety, property, national security, and international obligations. It includes a review of environmental information.	None.	Review of reentry site operator application.
435.23: Policy Review	Same requirements as Sections 43 1.23 and .27 listed above.	Same as response to Sections 43 1.23 and .27 listed above.	Same as response to Sections 43 1.23 and .27 listed above.
435.3 1: Safety Review and Approval (General)	Same requirements as Sections 43 1.3 1 and .47 listed above.	Same as response to Sections 43 1.3 1 and .47 listed above.	Same as response to Sections 43 1.3 1 and .47 listed above.
435. 43: Payload Reentry Review	Same requirements as Sections 43 1.55 and .59 listed above.	Same as response to Sections 43 1.55 and .59 listed above.	Same as response to Sections 431.55 and .59 listed above.
435.51: Post-Licensing Requirements	Same requirements as Sections 43 1.73 and .83 listed above.	Same as response to Sections 43 1.73 and .83 listed above.	Same as response to Sections 43 1.73 and .83 listed above.
435.61 Environmental Review (General)	Same requirement as Section 43 1.9 1 listed above.	Same as response to Section 43 1.91 listed above.	Same as response to Section 43 1.9 1 listed above.

4.3.3 Incremental Cost Impact on the Federal Aviation Administration

As summarized in Table 4-4 above, 15 principal sections of the proposed rule contain requirements that collectively are expected to create incremental administrative costs to the FAA. The rationale for establishing the incremental cost impact of these requirements is provided below. Following the discussion of each principal section of the proposed rule — 43 1, 433, and 435 — derivation of the incremental compliance cost estimates is summarized in a tabular format

Section 43 1.23: Application Requirements for Policy Review, and Similar Requirements Contained in Section 435.23: Policy Review Requirements and Procedures

The FAA would be required to expend additional person-hours to review applications and consult with other Federal government organizations. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.27: Requirements for Denial of Policy Approval, and Similar Requirements Contained in Section 435.23: Policy Review Requirements and Procedures

The FAA would be required to expend additional person-hours to inform applicants, in writing, of issues raised during the policy review that resulted in denying approval. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.3 1: Requirements for General Safety Review, and Similar Requirements Contained in Section 435.3 1: Safety Review and Approval for Reentry of Reentry Vehicle (General)

The FAA would be required to expend additional person-hours to conduct a thorough review of an application in order to determine whether an applicant is capable of performing a reentry mission in a manner consistent with the requirements contained in the proposed rule. The review will focus on program infrastructure, technical and operational characteristics of the vehicle, mission plan, and payload. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.47: Requirements for Denial of Safety Approval, and Similar Requirements Contained in Section 435.3 1: Safety Review and Approval for Reentry of Reentry Vehicle (General)

The FAA would be required to incur additional costs to inform applicants, in writing, of the basis for denying approval to their reentry application. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.55: Requirements for Payload Review, and Similar Requirements Contained in Section 435.43: Payload Reentry Review Requirements and Procedures

The FAA would be required to expend additional person-hours to conduct a review of the payload to ensure it is consistent with the requirements in the proposed rule. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.59: Requirements for Issuance of Payload Determination, and Similar Requirements Contained in Section 435.43: Payload Reentry Review Requirements and Procedures

The FAA would be required to incur additional costs to inform applicants, in writing, of its payload determination. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.73: Continuing Accuracy of License Application; Application for Modification of a License, and Similar Requirements Contained in Section 435.51: Post-Licensing Requirements — Reentry License Terms and Conditions (General)

The FAA would be required to incur additional costs to review applications to modify licenses and to inform applicants, in writing, of its decision to approve or deny the request. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.83: Compliance Monitoring, and Similar Requirements Contained in Section 435.5 1: Post-Licensing Requirements — Reentry License Terms and Conditions (General)

The FAA would be required to incur additional costs to gain access to the facilities of the licensee, or its contractors and subcontractors, in order to review information and observe mission-related activities. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5 below.

Section 43 1.91: Environmental Review (General), and Similar Requirements Contained in Section 435.61: environmental Review (General)

The FAA would be required to incur additional costs to analyze the environmental impacts associated with operation of the subject reentry vehicle. The analysis will be based on information supplied by the applicant and performed by the FAA in accordance with the requirements of the National Environmental Policy Act, the Council on Environmental Quality

Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, and FAA Procedures for Considering Environmental Impacts. The estimated cost to the FAA to administer this requirement is addressed in Table 4-5.

The FAA experience evaluating an application to conduct a reentry mission is limited to the COMET and METEOR programs, as no other requests have been presented since. As was mentioned previously, much of the proposed rule is a codification of the 1992 safety policies established to ensure that COMET/METEOR reentry missions would not jeopardize public health and safety and the safety of property. Consequently, this experience provides a partial basis for establishing the costs to the FAA for administering the proposed rule. Using this past experience, AST expects that the costs to be incurred performing its reentry licensing pre-application consultation, application evaluation, and compliance monitoring duties in the near term to be higher than that incurred for COMET/METEOR for a single application.'" The extent to which such costs would be higher than that incurred for COMET/METEOR is unknown since there is no history of U.S. commercial reentry activity. The assessment of higher application costs, however, is largely due to the expectation that the inherently more complex RLV programs will dominate reentry missions in the future; and initially these will require greater evaluative effort on the part of FAA personnel until they have developed experience in this area. While AST budget estimates for fiscal year 2000 reflect additional funding needed to exercise its reentry mission approval function, this need cannot be attributed to the proposed rule per se, but rather to the complexity associated with the advancing technology being evaluated, and the limited experience base resident at the FAA in the immediate and near term.

Because discrete time allocation is not documented within the FAA, it is not possible to readily develop a method for allocating budgetary administrative cost estimates to each regulatory section of the proposed rule based on the COMET/METEOR experience. Regardless, AST fiscal year 2000 budget estimates of the cost to perform its pre-application consultation and application evaluation licensing responsibilities may be correlated collectively to Sections 431.23, 431.27, 431.31, 431.47, 431.55, 431.59, and 431.91; 433.9; and 435.23, 435.31, 435.43, and 435.61 of the

[59] Federal Aviation Administration, 1998, "AST-200 FY 2000 Budget Estimates (Working Papers), Associate Administrator for Commercial Space Transportation, Licensing and Safety Division.

proposed regulation.[60] Therefore, using information provided by FAA technical personnel, FAA can be expected to spend $2.5 million — an amount equivalent to that expended for COMET/METEOR-to administer these requirements for a single application.[61]

The costs that would be incurred by the FAA to perform its compliance monitoring responsibilities corresponding to Sections 43 1.73, 43 1.83, and 435.5 1 can vary widely, as the spectrum of changes to reentry program operations can range from trivial to major. Although information upon which to base a robust estimate of compliance monitoring costs is limited, consistency suggests that it would be equivalent to that incurred for COMET/METEOR, which is estimated to be 20 percent of pre-application consultation and application evaluation costs, or approximately $503,000.[62] The pre-application process enables commercial space transportation entities and the FAA to determine the potential for reentry license approval prior to the formal evaluation. For entities taking full advantage of the pre-application consultation, the possibility of application approval may be very high, given that the FAA consultation encourages formal submittal. In situations where the consultation process results in a less than favorable assessment of the application, or firms do not take full advantage of the benefits of pre-application consultation, the risk of denial may have a higher probability, and may be determined with less expenditure by the FAA. Accordingly, pre-application consultation and application evaluation costs borne by the FAA associated with applicants denied and reconsidered for reentry licenses are estimated to be 10 percent of pre-application consultation and application evaluation costs for those applicants who are approved, or $252,000. The incremental cost to the FAA to administer the proposed rule per applicant are summarized in Table 4-5.

[60] The incremental costs to the FAA to evaluate applications for a license to operate a reentry site are included among the costs to evaluate a RLV and RV mission application. This assumption simplifies estimating the unique costs that may be associated with evaluating applications submitted by commercial entities that are operating the reentry site only, and are independent of the organizations owning the vehicle and using the reentry site to conduct the reentry mission.

[61] Federal Aviation Administration Office of the Associate Administrator for Commercial Space Transportation, "AST-200 FY 2000 Budget Estimates" (supplied by Ronald Gress, Federal Aviation Administration Licensing and Safety Division). Although not addressed in this analysis, it is not unreasonable to expect some FAA costs to decrease over time due to experience (that is, the learning curve effect), thereby reflecting increased efficiency.

[62] Interviews with Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation personnel: Ronald Gress, Licensing and Safety Division.

TABLE 4-5. Incremental Cost to the Federal Aviation Administration per Applicant to Administer the Principal Revisions to Parts 431,433, and 435 of the Proposed Rule (1997 Dollars)

	Sections 431.23, .27, .31, .47, .55, .59, and .91; 433.9; and 435.23, .31, .43, and .61		Sections 431.73 and .83, and 436.51
	Pre-Application Consultation	Application Evaluation	Compliance Monitoring
Applications Approved: Own Staff Full-time Equivalents (FTE)	$966,890" (10 FTEs @ $96,689 each per annum)		$193,378
Contractor Personnel	$1,550,000		$3 10,000
Total	$2,5 16,890		$503,378
Review of Application Denials and Reconsideration Process : Own Staff Full-time Equivalents (FTE)	$96,689 (1 FTE @ $96,689 per annum)		Not Applicable
Contractor Personnel	$155,000		Not Applicable
Total	$25 1,689		***

Source: Federal Aviation Administration Office of the Associate Administrator for Commercial Space Transportation, "AST-200 FY 2000 Budget Estimates."

[a] Cost to the Federal Aviation Administration for Federal government full-time equivalent staff is derived by increasing the 1997 Federal government pay of 73,000 for GS-14 Step 5 white-collar (non-postal) workers in the Washington, D.C. by 32.45 percent to account for fringe benefits. This results in an annual cost of $96,689 per worker. See Table A-3 in the Appendix to this report for breakdown of fringe benefit components.

Based on projections of the level of application activity over the 15-year period from 2000 to 2014, the FAA is expected to spend approximately $83 million in administering the safety requirements of Parts 431,433, and 435. Approximately 94 percent (or $78 million) of the cost by the FAA to administer these Parts would be incurred to approve the projected reentry license applications and modifications to be evaluated over the 15-year period. Approximately 6 percent (or $5 million) of the cost to administer Parts 43 1,433, and 435 would be expended on the review of application denials and reconsideration process. This is summarized in Table 4-6

TABLE 4-6. Incremental Cost to the Federal Aviation Administration to Administer the Principal Revisions to Parts 431 and 435 of the Proposed Rule (in 1997 Dollars - Undiscounted)

Applications Approved				Review of Application Denials and Reconsideration Process	
Number of New Requests	Pre-Application and Application Evaluation cost	Number of Modifications Evaluated*	Compliance Monitoring cost	Pre-Application and Application Evaluation cost	Total Administrative cost
5	$12,584,450	129	$64,935,762	$5,285,469	$82,805,681

[a] Only entities with existing (that is, approved) licenses apply for modifications, which can be either approved or denied. Accordingly, entries under this column include all applications from approved licensees for modification that are evaluated by the FAA and either approved or denied.

4.4 Safety Benefits

4.4.1 Accident Types

Many types of unplanned events can occur during a reentry mission, given the spectrum of payloads, vehicle designs, and mission paths. For purposes of this analysis, this spectrum is represented by two categories of unplanned event, hereafter referred to as accidents: (1) an airborne break-up, explosion, or collision, and (2) a ground point-of-impact crash. Under each accident category — airborne or ground — the population of the area surrounding the accident scene or accident zone can be (1) none, (2) sparse (i.e. rural), or (3) dense (that is, urban). Accordingly, this results in the six accident types presented in Table 4-7.

TABLE 4-7. Accident Types

Population	Airborne Explosion	Ground Point-of-Impact Crash
None	Accident Type I	Accident Type IV
Rural	Accident Type II	Accident Type V
Urban	Accident Type III	Accident Type VI

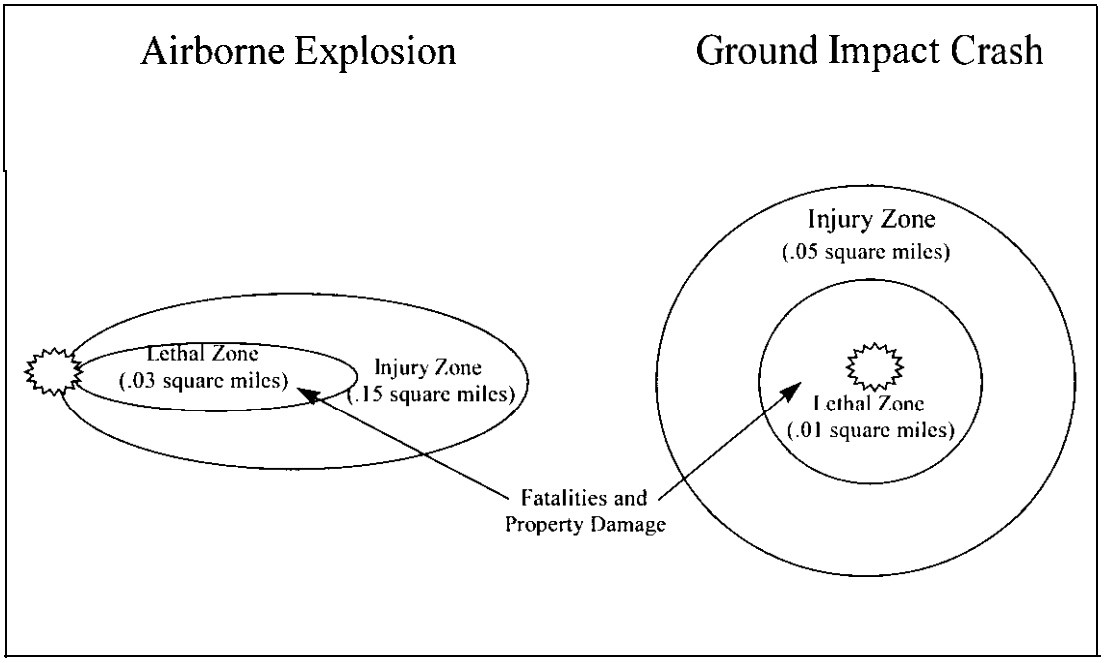
4.4.2 Accident Consequences

To arrive at accident consequences, the accident scenes or zones for airborne and ground accidents are characterized in terms of fatalities, injuries, and property damage.[63] Space vehicle type, velocity, trajectory, weather, payload, presence of hazardous materials, and other factors that would contribute to generating a complicated and large spectrum of accident consequences is avoided, resulting in a relatively simple and conservative approach to accident consequence determination. Fixed wing aircraft and launch vehicle accident data are used to derive the accident consequence zones for airborne and ground accidents illustrated in Figure 4-1.[64] The area of these zones (measured in square miles) is multiplied by population and housing density statistics (also measured in square miles) for rural and urban land areas to calculate the number of fatalities, injuries, and property damaged in the associated lethal and injury zones.[65] Dollar values are assigned to fatalities, injuries, and property damage to quantify accident consequences (that is, accident costs) for each accident type.[66] For example, the area of the lethal zone for an airborne explosion is .03 square miles (from Figure 4-l below). Multiplying this value by the population density for a rural area, which is 18 people per square mile (from Table A-7 in the Appendix to this report), results in a population density of .54 for a rural area corresponding to a Type II accident. Multiplying .54 by $2,700,000, which is a minimum value assigned to a statistical fatality avoided for comparison purposes (from Table A-8 in the Appendix to this report) results in the cost of fatalities associated with a Type II accident, or $1,458,000. Multiplying the area of the lethal zone (that is, .03 square miles) by the residential housing density for a rural area, which is 8 units (from Table A-7), results in a housing density of .24 for a rural area corresponding to a Type II accident. Multiplying .24 by $56,250, which is the value of rural property damage (from Table A-8 in the Appendix to this report) results in the cost of property damage associated with a Type II accident, or $13,500. Multiplying the area of the injury zone (that is, .15 square miles from Figure 4-l) by the by the population density for a rural

[63] Debris fields established on the basis of industry expert opinion and fixed-wing aircraft and launch vehicle airborne and ground accident information, collectively supplied by Gwynne Gurevich, The Aerospace Corporation, June 1998.
[64] The Aerospace Corporation, Gwynne Gurevich, June 1998.
[65] Residential housing units is used as a proxy for property damage.

area, which is 18 people per square mile (from Table A-7 in the Appendix to this report), results in a population density of 2.7 for a rural area corresponding to a Type II accident. Multiplying 2.7 by $280,150, which is the average value of an injury (from Table A-8 in the Appendix to this report) results in the cost of injuries associated with a Type II accident, or $756,405. Summing all accident costs (that is fatalities, injuries, and property damage) results in a cost estimate for a Type II accident of $2,227,905 (undiscounted 1997 dollars). This process is repeated for all cells in Table 4-8 below to quantify accident consequences by accident type.

FIGURE 4-l. Accident Category Lethal and Injury Zones



Source: Based on expert opinion and relevant information provided by Gwynne Gurevich, The Aerospace Corporation, June 1998.

[66] Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, Federal Aviation Administration, Office of Policy and Plans, June 1998.

TABLE 4-8. Accident Consequences Per Reentry Mission
(Value in 1997 Dollars)

Accident Type	Fatalities		Injuries		Property Damage		Total Value
	Number	Value	Number	Value	Number	Value	
Airborne Explosion							
I. Nonpopulated	0	$0	0	$0	**0**	0	**$0**
II. Rural Population	0.54	$1,458,000	2.7	$756,405	0.24	$13,500	**$2,227,905**
III. Dense Population	64.5	$174.150.000	322.5	$90.348.375	26.28	$2,956,500	**$267,454,875**
Ground Impact							
IV. Nonpopulated	0	$0	0	$0	**0**	**0**	**$0**
V. Rural Population	0.18	$486,000	2.7	$756,405	0.08	$4,500	**$1,246,905**
VI. Dense Population	21.5	$58,050,000	107.5	$30,116,125	8.76	$985,500	**$89,151,625**
Total	86.72	**$234,144,000**	435.4	**$121,977,310**	35.36	**$3,960,000**	**$360,081,310**

4.4.3 Baseline Accident Probabilities and Expected Costs of an Accident

One of the more difficult areas to ascertain is the probability of a LV or RV accident in the absence of government regulation, as this information is needed to calculate the expected value of an accident under the baseline in order to estimate the incremental safety benefits of the proposed rule. While the expectation of prudent and rational judgment on the part of commercial space transportation entities suggests that accident probabilities will be low (that is, close to or equivalent to the expected casualty rate in the proposed rule), experience suggests otherwise, as evidenced by the recent Titan IV and Delta III accidents. Accordingly, given past experience and uncertainty regarding future reentry mission performance, it is appropriate to consider a range of accident probabilities. In this analysis, reentry mission accident probability may range from .3 (or 300,000 accidents per million missions) to .03 (or 30,000 accidents per million missions).[67]

Accident rates are not constant, as they are expected to vary among LV and RV designs and mission conditions. Furthermore, accident rates are expected to improve over time as the industry matures; and RLV programs in particular will experience reliability growth over the next 15-years. In the absence of intervention by Federal government in the form of regulatory requirements, the FAA believes that this industry would be able to reduce the probability of a LV, RV, or RLV accident from a probability of .3 to a probability of .05).[68] Consequently, a range of reliability growth and improved accident prababilities are considered in this analysis over the 15-year period from 2000 to 2014. For example, accident probabilities can range from .3 to.03 for the period 2000 to 2004, and can be expected to improve over time, from 10 to .01 for the period 2005 to 2009, and from .05 to .005 for years 2009 to 2004.[69]

[67] Based on the probability of success for new generation ELVs, which is 0.7; The Aerospace Corporation, Gwynne Gurevich, June 1998. Hence, 1.0 - 0.7 = 0.3, which is taken as the (worst case) probability of a reentry mission accident.

[68] Based on expert industry opinion, the commercial space transportation industry may be able to reduce the probability of an accident by as much as 80 to 85 percent in year 15, The Aerospace Corporation, June 1998.

[69] Uncertainty regarding the extent to which industry has already implemented appropriate technology and safety practices, or the rate at which they will improve the safety of their operations over time warrants using a range of probability values. The values used are based on information provided by The Aerospace Corporation, Gwynne Gurevich, June 1998.

The spectrum of accident probabilities used in this analysis is summarized in Table 4-9. Accident probabilities are assigned to each of the six accident types on the basis of landmass. (The assignment process used is described in the Appendix to this report.) Each accident probability is multiplied by accident consequences in Table 4-8 (that is, accident costs) to calculate the expected value for each accident type in the absence of regulatory requirements — the baseline case. These calculations are summarized in Table 4-10. For example, using the lower and upper probability values for the years 2000 to 2004 for a Type II accident, .00488 and .04877 are multiplied by the total value of a Type II accident from Table 4-8, or $2,227,905, to arrive at the lower and upper bound expected value of a Type II accident under the baseline —$10,872 and $108,655 (undiscounted 1997 dollars). This process is repeated for all cells in Table 4-9 below to derive the lower and upper bound expected values for all accident types under the baseline over the 15-year period from 2000 to 2014 shown in Table 4-10.

TABLE 4-9. Baseline Accident Probability Profile[a]

Accident Type[b]	Years 2000 to 2004 Accident Probability		Years 2005 to 2009 Accident Probability		Years 2010 to 2014 Accident Probability	
	Lower Probability	Upper Probability	Lower Probability	Upper Probability	Lower Probability	Upper Probability
I	0.00975	0.09754	0.00329	0.03292	0.00165	0.01646
II	0.00488	0.04877	0.00165	0.01646	0.00082	0.00823
III	0.00037	0.00369	0.00012	0.00122	0.00006	0.00062
IV	0.00975	0.09754	0.00329	0.03292	0.00165	0.01646
V	0.00488	0.04877	0.00165	0.01646	0.00082	0.00823
VI	0.00037	0.00369	0.00012	0.00122	0.00006	0.00062
Total	0.03000	0.30000	0.01012	0.10120	0.00506	0.05062

[a] Total probabilities based on information pertaining to ELV and RV experience and engineering estimates developed by Gwynne Gurevich, The Aerospace Corporation, June 1998. Probabilities pertain to reentry missions and launches from Federal ranges.

[b] Due to uncertainty, the probability of airborne and ground impact accidents are given equal weight

TABLE 4-10. Accident Consequences Per Reentry Mission Under Current Industry Practice — Baseline Case (in 1997 Dollars)

Accident Type	Accident Prevention					
	2000-2004		2005-2009		2010-2014	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Airborne Explosion						
I. Nonpopulated	$0	$0	$0	$0	$0	$0
II. Rural Population	$10,872	$108,655	$3,676	$36,671	$1,827	$18,336
III. Urban Population	$98,958	$986,908	$32,095	$326,295	$16,047	$165,822
Ground Impact						
IV. Nonpopulated	$0	$0	$0	$0	$0	$0
V. Rural Population	$6,085	$60,812	$2,057	$20,524	$1,022	$10,262
VI. Urban Population	$32,986	$328,969	$10,698	$108,765	$5,349	$55,274
Total Costs	$148,901	$1,485,344	$48,526	$492,255	$24,246	$249,694

4.4.4 Accident Prevention and Damage Limitation Effects

The 21 principal sections of the proposed rule impacting commercial space transportation entities — Sections 431.25, .33, .35, .37, .39, .41, .43, .45, .57, .73, .75, .77, .79, and .93; Section 433.9; and Sections 435.23, .33, .35, .43, .51, and .61 -are expected to have positive impacts on the safety of reentry missions. These positive safety impacts include accident prevention and damage limitation effects. The accident prevention effect of the proposed rule is the reduction in the probability of an accident. The damage limitation effect of the proposed rule is the reduction in accident severity if an accident occurs. Incremental accident prevention benefits are calculated by determining the difference between the expected value of an accident (that is, the product of the probability of an occurrence and the dollar cost of an accident) under the baseline and under the proposed rule. Similarly, damage limitation benefits are calculated by determining the difference in the dollar value of an accident under the baseline and under the proposed rule.

Assigning discrete accident prevention effects to each of the relevant 21 principal sections is not possible, as information is not available to support estimating their relative contribution to achieving the expected average number of casualties per event criterion for public and reentry site risk. However, it is possible to assign accident prevention effects to Sections 431.25, .33,

.35, .37, .39, .41, .43, .57, .73, .75, .77, .79, and .93; Section 433.9; and Sections 435.23, .33, .35, .43, .51, and .61 collectively-that is, together these sections reduce the probability of an accident under the baseline case and contribute to meeting the expected public casualty risk criterion, Furthermore, it is expected that Section 43 1.45 would yield damage limitation effects. This is summarized in Table 4-11.

TABLE 4-11. Benefit Effects of Principal Requirements from Parts 431,433, and 435 of the Proposed Rule

Section of Proposed Rule		Benefit iffects: Accident Prevention	Damage Limitation
§ 43 1.25	Policy Review	Collectively these Sections of the proposed rule would reduce the probability of Accident Types I, 11, III, IV, V and VI to the expected average number of casualties for public and reentry site risk — 30 x 10^{-6} and 1 x 10” respectively.	Collectively these Sections do not have damage limitation effects — they have accident prevention effects.
§ 431.33	Safety Organization		
§ 431.35	Mission Risk		
§ 431.37	Mission Readiness		
§ 431.39	Rules and Plans		
§ 431.41	Communications		
§ 431.43	Requirements		
§ 431.57	Payload Review		
§ 431.73	Modification		
§ 43 1.75	Range Agreement		
§ 43 1.77	Records		
§ 431.79	Reporting		
§ 43 1.93	Environmental		
‘$433.9	Environmental		
§ 435.23	Policy Review		
§ 435.33	Safety review		
§ 435.35	Reentry Risk		
§ 435.43	Payload Review		
§ 435.51	Post-Licensing		
§ 435.61	Environmental		
§ 43 1.45	Mishap Investigation and Emergency Response Plan	Does not reduce accident probability, but does reduce accident costs, given an accident.	Reduces accident costs by 50 percent for all accident types.

4.4.5 Accident Probabilities and Expected Costs Under the Proposed Rule

Collectively, the probability for each accident type under the proposed rule must sum to the public risk criteria (that is, the probability for each accident type contributes to the overall criteria for public casualty risk, $E_c \leq 30 \times 10^{-6}$.[70, 71] Accident probabilities are assigned to each of the six accident types on the basis of land mass as was done for the baseline. (The assignment process used is identical to that applied for the baseline as is described in the Appendix to this report.). The results of this process is presented below in Table 4-12.

Estimates for the expected value for each accident type under the proposed rule are calculated in much the same way as was done for the baseline case. The probability of each accident type in Table 4-12 is multiplied by the accident consequence values (that is the cost of an accident) presented in Table 4-8. For example, the expected value of a Type II accident under the proposed rule for public risk is calculated by multiplying $2,227,905, the cost of a Type II accident from Table 4-8, by the accident probability of a Type II accident occurring for the general public found in Table 4-12, or 0.000004. The result is an expected value of a general public Type II accident of nine dollars (that is, $2,227,905 x 0.000004 = $9). This calculation is summarized in Table 4-12 below. This process is repeated for all relevant cells in Table 4-12 below to derive expected values for all accident types under the proposed rule over the 15-year period from 2000 to 2014.

[70] The general public risk criteria (that is, $E_c \leq 30 \times 10^{-6}$) is a mathematical approximation to the probability of an accident = .00003. Thus, the risk criterion casualty rate of .00003 approximates the probability of an accident, for the purpose of this evaluation. The basis for this assessment of approximating the expected casualty rate for the general public as an accident probability is based on information contained in the report entitled, " the, *Casualty-Expectancy Computations in DAMP*, Research Triangle Institute September 30, 1995 (RTI/5180/60-41F), p. 5.

[71] Accident probabilities and expected costs for reentry site risk (that is, $E_c \leq 1 \times 10^{-6}$) under the proposed rule are not addressed quantitatively in this evaluation for several reasons. Most importantly, uncertainty concerning reentry operations precludes partitioning the probability of an accident between launch and reentry phases of a mission. Furthermore, absent the proposed rule, reentry sites are expected to be situated in remote locations, including oceans (where there is no population). Consequently, expected reentry site accident costs with or without the proposed rule (that is, the dollar value of fatalities, injuries, and property damage), is likely to be negligible or even zero.

TABLE 4-12. Accident Consequences Per Reentry Mission to the General Public — Proposed Rule
(Value in 1997 Dollars)

Accident Type	Accident Values	General Public Risk Probability (30×10^{-6})[a]	Expected Value[b]
I	$0	0.000008	$0
II	$2,227,905	0.000004	$9
III	$267,454,875	0.000003	$802
IV	$0	0.000008	$0
V	$1,246,905	0.000004	$5
VI	$89,151,625	0.000003	$267
Total	$360,081,310	0.00003	$1,084

[a] The general public risk criteria (that is, $E_c = 30 \times 10^{-6}$) is a mathematical approximation to the probability of an accident.
[b] Calculated by multiplying accident values by the probability of an accident.

4.4.6 Incremental Safety Benefits

The incremental safety benefits attributable to the proposed rule may be viewed as accident costs avoided. They are calculated as the difference between the expected value of an accident under the baseline (from Table 4-I 0) and under the proposed rule for general public risk (from Table 4-12). These calculations are summarized in Table 4-13 for a single reentry mission. For example, for the period 2000 to 2004 the expected value of a Type II accident to the genera1 public under the proposed rule is $9 (from Table 4-12). The difference between $9 and the lower bound expected value of a Type II accident under the baseline (from Table 4-10) is $10, 863 (that is, $10,872 - 9 = $10,863) and the difference between $9 and the upper bound expected value of a Type II accident under the baseline (from Table 4-10) is $108,646 (that is, $108,655 - $9 = $108, 646).[72]

[72] Although not addressed quantitatively in this evaluation, there may be some incremental safety benefits resulting from the proposed reentry site risk criteria also. However, because reentry sites are generally expected to be located in remote areas absent the proposed rule, reentry site accidents would result in few (if any) casualties (that is, fatalities and injuries) and little or no property damage. For example, if oceans were used as reentry sites absent the proposed rule, then the incremental safety benefits attributable to the proposed rule would be zero.

TABLE 4-13. Incremental Safety Benefits Per Reentry Mission"
(in 1997 Dollars)

Accident Type	Accident Prevention						Damage Limitation'
	2000-2004		2005-2009		2010-2014		2000-2014
	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	
Airborne Explosion							
INonpopulated	$0	$0	$0	$0	$0	$0	$0
II. Rural Population	$10,863	$108,646	$3,676	$36,662	$1,827	$18,327	$5
III. Urban Population	$98,156	$986,270	$32,095	$325,493	$16,047	$165,020	$401
Ground Impact							
IV. Nonpopulated	$0	$0	$0	$0	$0	$0	$0
V. Rural Population	$6,080	$60,807	$2,057	$20,519	$1,022	$10,257	$3
VI. Urban Population	$32,719	$328,757	$10,698	$108,498	$5,349	$55,007	$134
Total Accident Prevention Benefits	$147,818	$1,484,479	$48,526	$491,172	$24,246	$248,611	$542
Total Accident Prevention and Damage Limitation Benefits	$148,360	$1,485,021	$49,067	$491,714	$24,787	$249,153	***

a Does not include the relatively small, but positive in nental safety ben :s directly attributable to the reentry site criteria, $E_c \leq 1 \times 10^{-6}$.

b Estimated as 50 percent of the expected value of a general public accident under the proposed rule. For example, using a Type II accident, this would be 50 percent of $9 (from Table 4-12) or approximately $5.

Safety benefits -accident costs avoided-are realized as missions are performed (without incident). Therefore, the number of (completed) reentry missions projected over the 15-year period (presented in TableA-12 in the Appendix to this report) is multiplied by incremental safety benefits per reentry mission (that is, the data in Table 4-13) to estimate total incremental safety benefits over the period 2000 to 2014. Using a range of accident probabilities and associated safety benefits, the total safety benefit that would result from the proposed rule is estimated to range from $22 to $2 17 million (undiscounted 1997 dollars). To account for the uncertainty in reentry mission performance over the 15-year period, the Midpoint safety benefit value is used to quantify the expected impact of the proposed rule, or $119 million (undiscounted 1997 dollars)."

Estimates of the collective accident prevention and damage limitation effects of the regulatory sections must be tempered, however, as industry may be compliant with some aspects of the proposed technical requirements voluntarily as a result of industry standard operating practices. This supports using a range of reentry mission accident probabilities, as current industry practices consistent with requirements contained in the proposed rule may result in accident prevention effects that otherwise would be attributable solely to the regulation, thereby over-estimating the incremental benefits of the proposed rule.

4.5 Secondary Benefits from the Proposed Rule

The proposed rule offers a variety of secondary impacts that would benefit both the FAA and the commercial space transportation industry that are not readily quantified. Formalizing licensing responsibilities for reentry operations (by establishing a specific regulation) would emphasize LASD duties and FAA expectations. It would also better define the licensing process relative to the ad hoc approach implemented for COMET and METEOR.[74] This would afford applicants with clearly defined direction, possibly helping to facilitate the iterative pre-application

[73] This number is the midpoint between $22 million and $217 million (undiscounted 1997 dollars) for the period 2000 to 2014.

[74] By its ad hoc nature (that is, there was no discrete regulation) the licensing approach implemented for COMET and METEOR did not jeopardize public health and safety, or the safety of property. The process was established

consultation process. As the number of requests for launch licensing increases, formality would also help ensure consistency in implementing the licensing process. This could lead to cost savings to the FAA as a result of economies of scale from repetitive operations. These cost savings would spill over to commercial space transportation entities by reducing the turnaround time between application submittal and licensing approval. Additionally, consistent application of the licensing process would help commercial space transportation entities gain familiarity with its requirements, leading to proficiency in their ability to interact with the process and the FAA. This in turn would lead to industry cost savings, possibly due to less rework or paperwork avoided.

A formalized licensing process for reentry operations will enhance communications between the FAA and the commercial space transportation industry in terms of frequency and efficiency of information exchange. In so doing, it would instill a regulatory climate that will promote and foster growth and technological advancement in this maturing industry, while protecting public health and safety, and the safety of property. The FAA invites comments on the validity of this assertion and any potential impacts related thereto.

4.6 Summary of Incremental Costs and Safety Benefits

The proposed rule is estimated to result in incremental costs totaling approximately $113 million (undiscounted 1997 dollars) over the 15-year period from 2000 to 2014. Commercial space transportation industry compliance costs would account for almost 27 percent of this amount, or $30 million (undiscounted 1997 dollars) over the 15-year period. The costs to the FAA for administering the proposed rule would account for approximately 73 percent of total incremental costs, or $83 million (undiscounted 1997 dollars) over the 15-year period. The general public would realize incremental safety benefits of approximately $119 million (undiscounted 1997 dollars).[75] These results are summarized in Table 4-14.

for a single case, and accordingly was not necessarily the most efficient approach to regulating commercial reentry operations.

[75] Based on a range from $22 million to $217 million (undiscounted 1997 dollars) over the 15-year period 2000 to 2014 — $119 million (undiscounted 1997 dollars) is the midpoint of this range. This value is used to account for the uncertainty of reentry mission performance over the 15-year period.

TABLE 4-14. Summary of Total Costs and Benefits

Category	Undiscounted[a]	Discounted[b]
Commercial Space Transportation Industry Compliance Costs	$30,024,108	$19,856,923
Federal Aviation Administration Administrative Costs	$82,805,681	$45,448,078
Total Costs	**$112,829,789**	**$65,305,001**
Accident Costs Avoided: Lower Bound (Safety Benefits)	$21,595,917	$12,054,543
Accident Costs Avoided: Upper Bound (Safety Benefits)	$216,583,155	$120,852,982
Accident Costs Avoided: Midpoint (Safety Benefits)	**$119,089,536**	**$66,453,763**

[a] In 1997 dollars.
[b] Discounted at seven percent over a 15-year period from 2000 to 2014.

5.0 **CONCLUSION**

Based on the assumptions and data used herein, the proposed rule would impose incremental costs on the commercial space transportation industry and the FAA to respectively comply and administer its requirements. The costs borne by industry would comprise approximately 27 percent of all incremental costs attributable to the proposed rule.[76] The general public would realize additional safety benefits attributable to accident costs avoided. Additionally, the proposed rule would yield noteworthy secondary benefits that should improve the quality of the regulatory process while maintaining an environment that facilitates the maturation of this developing industry. The FAA solicits information pertaining to any additional direct impacts attributable to the proposed rule that are not identified and measured in this report.

[76] This is based on the undiscounted incremental compliance and implementation costs from Table 4-14.

6.0 INITIAL REGULATORY FLEXIBILITY DETERMINATION INITIAL REGULATORY FLEXIBILITY DETERMINATION

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities (i.e., small business and small not-for-profit government jurisdictions) are not unnecessarily and disproportionately burdened by Federal Government regulations. The RFA, which was amended in March 1996, requires that whenever an agency publishes a general notice of proposed rulemaking, an initial regulatory flexibility analysis be performed if the proposed rule would have a significant economic impact on a substantial number of small entities. The regulatory flexibility analysis must: (I) identify the economic impact on small entities and (2) consider alternatives that may lessen those impacts.

The Small Business Administration has defined small business entities relating to space vehicles (Standard Industrial Codes 3761, 3764, and 3769) as entities comprising fewer than 1,000 employees. The FAA has determined that the proposed rule would impact five small businesses, imposing on an entity average compliance costs of approximately $6 million over the 15-year period (in 1997 dollars).

The annualized compliance cost to each small business is approximately $700,000 (in 1997 dollars). Ordinarily, this section of the evaluation would be based on typical financial data (for example, annual net income or losses) as a means to determine any of the commercial space transportation small entities significantly impacted by the proposed rule. However, the traditional use of such financial data for these small entities cannot be employed since RLV operators (including a number of RV operators) represent relative new companies and they have no revenue history. In fact, these small operators are in the process of raising funds to finance their new ventures. Due to the lack of data on the financial characteristics of these small RLV operators, this evaluation is using the 1998 average revenue received per launch for ELV operators. The revenue that RLV operators would obtain from their customers is expected to be similar to the revenue that established ELV operators currently receive from their customers. Revenue data based on ELV operators' experience would be used for the purpose of assessing the extent to which compliance with the proposed rule would impose significant economic

impacts on each of the five potentially impacted small RLV operators. This assessment would be done by comparing the annualized cost of compliance to the annual average revenue expected to be received by each of the five small RLV operators over the next 15 years. While the long-term revenues of RLV operators are expected to exceed those of ELV operators, which would be due to inherent lower operating costs, for the purpose of this evaluation they are assumed to be nearly the same over the 1 S-year period. For this reason, the average revenue of about $50 million generated by each ELV launch in 1998 will be used as a indicator of what RLV operators would be expected to generate per RLV mission in future years. This assessment is based primarily on information received for orbital launch events for ELV operators from the FAA's Office of Commercial Space Transportation Report entitled, "Commercial Space Transportation: 1998 Year In Review", Table l and the Appendix (January 1999).

Each of the five potentially impacted small RLV entities is expected to average about seven missions per year over the next I5 years. Using $50 million as an average expected revenue per mission, each entity would be expected to receive about $350 million in revenue ($50m x 7 missions annually) for all missions annually. The FAA has determined that none of the five small entities would incur a significant economic impact, since the average annualized cost of compliance ($700,000) would be only 0.2 percent of the anticipated average annual revenues of $350 for missions conducted annually.

The FAA certifies that the proposed rule would not impose a significant economic impact on a substantial number of small businesses. Therefore, a regulatory flexibility analysis is not required. Furthermore, the proposed rule is not likely to cause small business failures or adversely impact their competitive position relative to larger businesses. However, the FAA requests comments on the validity of the assertions herein and additional information on the financial characteristics of these small business.

6.2 Conclusion

The proposed rule would not impose a significant economic impact on a substantial number of small businesses. Therefore a regulatory flexibility analysis is not required. Furthermore, the proposed rule is not likely to cause small business failures, or weaken their competitive position

relative to larger businesses, The limited amount of financial information on these small entities precludes a more thorough financial analysis. Therefore, the FAA requests comments on the validity of the assertions herein and additional information on the financial characteristics of these and any other emerging small business.

7.0 INTERNATIONAL TRADE IMPACT ASSESSMENT

The proposed rule contains revisions to commercial space transportation licensing regulations that would not constitute a barrier to international trade, including the export of domestic goods and services out of the United States. The proposed rule would equally affect domestic and foreign organizations conducting commercial space transportation operations within the United States, The proposed rule is not expected to place domestic firms at a disadvantage with respect to foreign interests competing for similar business in international markets. Therefore, based on the evaluation and impacts reported herein, the proposed rule is not expected to affect trade opportunities for U.S. firms doing business abroad or for foreign firms doing business in the United States. The FAA invites comments on the validity of this assertion and any potential impacts related thereto.

8.0 UNFUNDED MANDATES REFORM ACT ASSESSMENT

Title II of the Unfunded Mandates Reform Act of 1995, enacted as Public Law 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any 1 year. Section 204(a) of the Act, Title 2 of the United States Code 1534(a), requires the Federal agency to develop an effectiveness process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate." A significant intergovernmental mandate under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any 1 year. Section 203 of the Act, Title 2 of the United States Code 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any and for a meaningful and timely opportunity to provide input in the development of regulatory proposed rules.

Based on the evaluation and impacts reported herein, the proposed rule is not expected to meet the $100 million per year cost threshold. Consequently, it would not impose a significant cost or uniquely affect small governments. Therefore, the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply to the proposed regulation.

APPENDIX

TABLE A-l. Interviews Pr iding Key Technical Information

Interviewee	Affiliation	Specific Areas of Providing Technical Assistance and Related Information
Ronald K. Gress	Federal Aviation Administration (FAA), Office of the Associate Administrator for Commercial Space Transportation (AST), Licensing and Safety Division (LASD)	• Administrative and compliance costs • Budget Estimates • Market profile
Stewart Jackson	FAA, AST, Space Systems Development Division (SSDD)	• Regulatory background • Administrative and compliance costs • Market profile
Brett Alexander	FAA, AST, SSDD	• Regulatory background • Market profile • License activity projections
Carole Flores	FAA, AST, LASD	• Regulatory background • FAA administrative costs • Market profile
Gwynne Gurevich	The Aerospace Corporation Los Angeles, California	• Market Profile • Industry compliance costs
Charles Larsen	FAA, AST, SSDD	• Industry compliance costs
Pat Martin	FAA, AST, LASD	• FAA licensing process
Ruben Mitchel*	FAA, AST, SSDD	• FAA personnel costs
Carl Rappaport*	FAA, AST, SSDD	• Regulatory background • Market profile

* rmer Department of Transportation, Office of Commercial Space Transportation personnel currently working in the Federal Aviation Administration, Office of the Associa Administrator for Commercial Space Transportation; this is a direct result of the 1995 reorganization at the Department of Transportation which transferred, intact, the Office of Commercial Space Transportation to the Federal Aviation Administration, resulting in the formation of the Office of the Associate Administrator for Commercial Space Transportation.

TABLE A-2. Public and Private Sector Fringe Benefit Factors

Category	Government Factor	Commercial Factor
Retirement and Disability	23.7%	10.3%
Health and Life Insurance	5.60%	7.10%
Medicare	1.45%	1.45%
Miscellaneous	1.70%	4.60%
Total Fringe Benefit	32.45%	23.45%

Source: Federal Aviation Administration, January, 1998, p. 4-22.

TABLE A-3. Federal Aviation Administration Personnel Costs

Salary	Fringe Benefit Factor	Costs to Federal Aviation Administration	
		Annual Salary	Hourly Wage
$73,000	32.45%	$96,689	$46.33

Source: Cost to the Federal Aviation Administration for Federal government full-time equivalent staff is derived by increasing the 1997 Federal government pay of 73,000 for GS-14 Step 5 white-collar (non-postal) workers in the Washington, D.C. by 32.45 percent to account for fringe benefits. This results in an annual cost of $96,689 per worker. Dividing this amount by 2087 yields an hourly rate of $46.33.

TABLE A-4. Commercial Space Transportation Industry Incremental Costs to Comply with the Principal Requirements of Parts 431.433, and 435 of the Proposed Rule (in 1997 Dollars)

Year	Discount Factor	Projected Industry Population	First Year Costs (2000 Only) Undiscounted	Recurring Costs (2001-2014) Undiscounted	Total Costs UnDiscounted	Total Costs Discounted
2000	1.0700	1	$3,285,381	$0	$3,285,381	$3,070,450
2001	1.1449	3	$6,570,762	$256,551	$6,827,313	$5,963,240
2002	1.2250	3	$0	$769.653	$769.653	$628.266
2003	1.3108	3	$0	$769,653	$769,653	$587,165
2004	1.4026	3	$0	$769,653	$769,653	$548,752
2005	1.5007	3	$0	$769,653	$769,653	$512,852
2006	1.6058	4	$3,285,381	$769,653	$4,055,034	$2,525,271
2007	1.7182	4	$0	$1,026,204	$1,026,204	$597,260
2008	1.8385	4	$0	$1,026,204	$1,026,204	$558,187
2009	1.9672	5	$3,285,381	$1,026,204	$4,311,585	$2,191,791
2010	2.1049	5	$0	$1,282,755	$1,282,755	$609,428
2011	2.2522	5	$0	$1,282,755	$1,282,755	$569,559
2012	2.4098	5	$0	$1,282,755	$1,282,755	$532,298
2013	2.5785	5	$0	$1,282,755	$1,282,755	$497,475
2014	2.7590	5	$0	$1,282,755	$1,282,755	$464,929
Total	***	***	$16,426,905	$13,597,203	$30,024,108	$19,856,923

TABLE A-5. Commercial Space Transoortation Personnel Cost

Annual Salary	Fringe Benefit Factor	Cost to Space Transportation Entities		
		Annual	Hourly[a]	Eight-Hours
$83,500	1.2345	$103,081	$49.39	$395[b]

Source: Commercial space transportation entity personnel costs based on information supplied by The Aerospace Corporation, Los Angeles, California.

a Hourly costs calculated by dividing annual cost by 2087 hours per year. (See Federal Aviation Administration, January 1998, *Economic Analysis of Investment and Regulatory Decisions Revised Guide*, Office of Aviation Policy and Plans, p. 4-21.).

b The actual cost is $395.12 is rounded to the nearest dollar.

TABLE A-6. Federal Aviation Administration Incremental Costs to Administer the Principal Requirements of Parts 431,433, and 435 of the Proposed Rule

Year	License Modifications Reviewed	Consultation and Evaluation costs		Compliance	Total Costs	
		Applicants Approved	Applicants Denied	Monitoring costs	Undiscounted	Discounted
2000	0	$2.516.890	$0	$0	$2.516.890	$2.352.234
2001	0	$5,033,780	$0	$0	$5,033,780	$4,396,698
2002	2	$0	$0	$1,006,756	$1,006,756	$821,813
2003	4	$0	$0	$2,013,512	$2,013,512	$1,536,099
2004	4	$0	$0	$2,013,512	$2,013,512	$1,435,606
2005	7	$0	$251,689	$3,523,646	$3,775,335	$2,515,665
2006	11	$2,516,890	$251,689	$5,537,158	$8,305,737	$5,172,396
2007	13	$0	$503,378	$6,543,914	$7,047,292	$4,101,588
2008	14	$0	$251,689	$7,047,292	$7,298,981	$3,970,162
2009	13	$2,516,890	$503,378	$6,543,914	$9,564,182	$4,861,945
2010	13	$0	$503,378	$6,543,914	$7,047,292	$3,348,118
2011	12	$0	$755,067	$6,040,536	$6,795,603	$3,017,329
2012	12	$0	$755,067	$6,040,536	$6,795,603	$2,819,934
2013	12	$0	$755,067	$6,040,536	$6,795,603	$2,635,452
2014	12	$0	$755,067	$6,040,536	$6,795,603	$2,463,039
Total	129	$12.584.450	$5.285.469	$64.935.762	$82.805.681	$45.448.078

TABLE A-7. Demographic Data

	Land Area (Square Miles)	Population (Per Square Mile)	Residential Housing Units (Per Square Mile)
Rural	3,449,000	18	8
Urban	87,000	2,150	836

Source: Statistical Abstract of the United States (1992; 1997), U.S. Department of Commerce.

TABLE A-S. Accident Consequence Values
(In 1997 Dollars)

	Injury			Property Damage	
Fatality	**Serious**	**Minor**	**Average**	**Urban**	**Rural**
$2.700.000	$521,800	$38,500	$280,150	$112,500	$56.250

Source: "Economic Values for Evaluation of Federal Aviationministration.Investment.and Regulatory Programs," U.S. Department of TransportationFederal Aviation Administration, Office of Aviation Policy, Plans; and Statistical Abstract of the United States (1992;1997), U.S. Department of Commerce.

Assignment of Accident Type Probabilities

The process of assigning accident probability among the various accident types is accomplished using proportional analysis based on land mass. This process, described below, is applied to allocating the probability of an accident to the six accident types under the baseline (see Table 4-10) and under the rule (see Table 4-13). The process is described using an example case.

Example: The probability of an accident under the baseline for the period 2000 to 2004 is estimated to be .30, which corresponds to an accident regardless of where (that is, rural or urban) and how (that is, airborne or ground). The task is to allocate this probability among the six accident types, which, when summed, equal .30. Using proportional analysis, the probability of .30 is allocated on the basis of urban land mass as follows:

$$.3/3{,}536{,}000 = X/87{,}000$$

Where 3,536,000 is the total land mass of the United Sates in square miles, and 87,000 square miles is the urban land mass. Solving for X in the above equation results in .00738. This is the probability of an urban accident-accident types III and VI. Therefore, this probability is split between each, resulting in a probability of .00369 each for accident types III and VI as shown in Table A-9, a truncated version of Table 4-9. Subtracting .00738 from .30 leaves .29262 in probability value to be allocated among the remaining four accident types (that is, I, 11, IV, and V).

Absent information as to the likelihood of an accident over a rural populated area relative to a non-populated area, it is necessary to make an assumption regarding the probability of these occurrences. Given this uncertainty, and the expectation that reentry mission flight paths will avoid populated areas in order to ensure satisfying the E_c criteria, it is reasonable to assume that the probability of an accident over a nonpopulated area is twice as great as an accident over a rural populated area. Accordingly, the probability of Types II and V (rural populated) accidents are half that of Types I and IV (nonpopulated) accidents. Further, the probability of a Type I accident is equivalent to a Type IV, as both occur in nonpopulated areas. Similarly, the

probability of a Type 11 accident is equivalent to a Type V, as both occur in rural populated areas. Hence, the following algebraic equation can be established:

$$2X+2(.5X)= .29262$$

Where X = a Type I or IV accident, and .5X pertains to an Accident Type II or V. Solving for X results in .09754, the probability assigned to both a Type I and Type IV accident. Half of this value, .04877, is assigned to Accident Types II and V.

This process is repeated to complete the accident probability profiles for the upper bound baseline. Dividing these probability values by 10 yields the lower bound probabilities. The same process is used to allocate the accident probability of .00003 (30 x 10" or 3×10^{-5}) under the proposed rule.

TABLE A-9. Baseline Accident Probabilitv Profile — Upper Bound

Accident Type	Years 2000 to 2004	Years 2005 to2009	Years 2010 to 2014
I	0.09754	0.03292	0.01646
II	0.04877	0.01646	0.00823
III	0.00369	0.00122	0.00062
IV	0.09754	0.03292	0.01646
V	0.04877	0.01646	0.00823
VI	0.00369	0.00122	0.00062
Total	0.30000	0.10120	0.05062

Probability of Accident and Expected Average Number of Casualties

The proposed criteria for limiting public risk from reentry operations is expected casualty risk (E,), which is the collective risk to a population measured as the expected average number of casualties per reentry operation of a reentry vehicle. The proposed limit for this measure is 30×10^{-6}. Mathematically, it is the sum, over all possible events, of the product of the probability of the event and its consequences. In this evaluation an accident refers to casualties, which includes fatalities, injuries, and property damage, and numerically E_c approximates the probability of an accident. In certain situations, the two measures may be identical. More specifically, the

probability of an accident and the expected average number of casualties are approximately equal numerically when the probability of a single accident is much greater than the probability of multiple casualties. Therefore, 30×10^{-6} is used as the maximum permissible probability of an accident under the proposed rule. A in-depth discussion and mathematical proof of this concept are presented in a study by Research Triangle Institute (beginning on page 5) entitled, *Casualty-Expectancy Computations* in *DAMP*, September 30, 1995 (report number RTIA 180/60-4 1 F).

TABLE A-10. Projected Reentry Mission License and Launch Activity

Period	Year	New Licenses Approved	Modifications Approved	Modifications Denied	New License Applications Denied	Total Applications Reviewed	Cumulative Licenses	Completed Reentry Missions
1	2000	1	0	0	0	1	1	1
2	2001	2	0	0	0	2	3	2
3	2002	0	2	0	0	2	3	5
4	2003	0	4	0	0	4	3	8
5	2004	0	3	1	0	4	3	12
6	2005	0	6	1	1	8	3	24
7	2006	1	10	1	1	13	4	40
8	2007	0	12	1	2	15	4	48
9	2008	0	12	2	1	15	4	48
10	2009	1	12	1	2	16	5	52
11	2010	0	12	1	2	15	5	52
12	2011	0	12	0	3	15	5	56
13	2012	0	12	0	3	15	5	56
14	2013	0	12	0	3	15	5	60
15	2014	0	12	0	3	15	5	60
Total	***	5	121	8	21	155	***	524

Source: Federal Aviation Administration, Office of the Associate Administrator for Space Transportation, Space Systems Development Division, Brett Alexander, August 13, 1998.

TABLE A-l 1. Undiscounted and Discounted Incremental Safety Benefits
(In 1997 Dollars)

Year	Undiscounted Benefits		Discounted Benefits		Present Value Factor
	Lower Bound	Upper Bound	Lower Bound	Upper Bound	
2000	$148,360	$1,485,021	$138,654	$1,387,870	1.0700
2001	$296,720	$2,970,042	$259,167	$2,594,149	1.1449
2002	$741,800	$7,425,104	$605,530	$6,061,097	1.2250
2003	$1,186,880	$11,880,166	$905,465	$9,063,322	1.3108
2004	$1,780,320	$17,820,250	$1,269,343	$12,705,592	1.4026
2005	$1,177,618	$11,801,124	$784,697	$7,863,587	1.5007
2006	$1,962,697	$19,668,540	$1,222,269	$12,248,578	1.6058
2007	$2,355,236	$23,602,248	$1,370,769	$13,736,723	1.7182
200s	$2,355,236	$23,602,248	$1,281,092	$12,838,059	1.8385
2009	$2,551,506	$25,569,102	$1,297,056	$12,998,035	1.9672
2010	$1,288,931	$12,955,930	$612,362	$6,155,269	2.1049
2011	$1,388,079	$13,952,540	$616,324	$6,195,095	2.2522
2012	$1,388,079	$13,952,540	$576,004	$5,789,808	2.4098
2013	$1,487,228	$14,949,150	$576,773	$5,797,538	2.5785
2014	$1,487,228	$14,949,150	$539.040	$5.418.260	2.7590
Total	$21,595,917	$216,583,155	$12,054,543	$120,852,982	***

LIST OF REFERENCES

Associate Administrator for Commercial Space Transportation, January 1998, *Reusable Launch Vehicle Programs and Concepts,* Federal Aviation Administration.

Associate Administrator for Commercial Space Transportation, May 12, 1998, Commercial Space *Launch Fact Sheet,* Internet Home Page, Federal Aviation Administration.

Boddie, Sharon, August 4, 1995, Memorandum to Ronald K. Gress, "Action: METEOR Environmental Assessment, " U.S. Department of Transportation, Office of Commercial Space Transportation.

Commercial Space Transportation Advisory Committee, May 1998, *Commercial Spacecraft Mission Model Update,* Federal Aviation Administration, Associate Administrator for Commercial Space Transportation.

Federal Aviation Administration, 1998, "AST-200 FY 2000 Budget Estimates (Working Papers), Associate Administrator for Commercial Space Transportation, Licensing and Safety Division.

Federal Aviation Administration, January 1998, Economic *Analysis of Investment and Regulatory Decisions -Revised Guide,* Office of Aviation Policy and Plans.

Federal Aviation Administration, March 11, *1998, Licensing and Safety Division Order No. 001, Launch Licensing and Compliance Monitoring Process and Procedures,* Associate Administrator for Commercial Space Transportation, Licensing and Safety Division.

Federal Aviation Administration, April *13, 1998, Commercial Space Launch History,* Internet Home Page, Office of the Associate Administrator for Commercial Space Transportation.

Federal Aviation Administration, May 1998, *LEO Commercial Market Projections,* Associate Administrator for Commercial Space Transportation.

Federal Aviation Administration, June *1998, Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs,* Office of Aviation Policy and Plans.

Federal Aviation Administration, January *27, 1999, Revision of Commercial Space Transportation Licensing Regulations,* Notice of Proposed Rulemaking (Draft).

Federal Aviation Administration, September 21, 1998, *Interim Guidelinesfor Reusable*

LIST OF REFERENCES

Launch Vehicles (Draft).
Federal Aviation Administration, October 16, 1998, *Interim Guidelines for Reusable Launch Vehicles* (Draft).

Federal Register, March 24, 1992,, Volume 57, Number 57.

Federal Register, November 23, 1992, Volume 57, Number 226.

Federal Register, August 2, 1995, Volume 60, Number 148.

Federal Register, July 25, 1996, Volume 61, Number 144.

Federal Register, March 19, 1997, Volume 62, Number 53.

Gress, Ronald K., July 26, 1995, Memorandum to Frank C. Weaver, "EER Systems Corporation Petition for Waiver of Criterion 1 of OCST Vehicle Safety Approval Criteria for METEOR Reentry Vehicle System,." U.S. Department of Transportation, Office of Commercial Space Transportation.

Jackson, Stewart. August 4, 1995, Memorandum to Ronald K. Gress; "EER systems Corporation METEOR Payload Determination Application, " U.S. Department of Transportation, Office of Commercial Space Transportation.

Jackson, Stewart, June *26,* 1998, *Commercial Reentry: Safety Implications and Regulatory* Issues, Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation

Journal of Spacecraft and Rockets, September-October, 1994, Commercial *Experiment Transporter- COMET,* Volume 3 1, Number 3.

National Transportation Safety Board, July 26, 1993, *Special Investigation Report, Commercial Space Launch Incident,* NTSBISIR-93102, PB93-917003, Washington, D.C.

Phaneuf Associates, Incorporated, March *6, 1998, Reentry Regulations, Regulatory Issues and Options Paper,* Washington, D.C..

Range Safety Office, Patrick Air Force Base, *Eastern and Western Range* 127-1, October 31, 1997.

Rogers, William P. et. al., June *6,* 1986, *Report of the Presidential Commission on the Space Shuttle Challenger Accident,* Presidential Commission, Washington, D.C.

LIST OF REFERENCES

Research Triangle Institute, *Casualty-Expectancy Computation in DAMP,* September 30, 1995 (RTI/5180/60-41F).
Scott, William B., June 15, 1998, "Airline Ops Offer Paradigm for Reducing Spacelift Costs," *Aviation Week & Space Technology.*

Space Frontier Foundation, August 13, 1998,"The New Commercial Space Companies."

Space News, March 23-29, 1998; "Wall Street Warms Up to Rocket Firms."

The Aerospace Corporation, undated, *Risks to Population from Uncontrolled Reentry and Breakup of a Winged Vehicle,* Los Angeles, California.

The MITRE Corporation, September *1994, COMET Safety Approval Process External Review* (Final Report).

U.S. Department of Commerce, *1992, 1997, Statistical Abstract of the United States*, Bureau of the Census, Economics and Statistics Administration.

U.S. Department of Transportation, September *18,* 1990, *Information Required for OCST to Review Commercial Reentry* (Interim), Office of Commercial Space Transportation, Licensing and Safety Division.

U.S. Department of Transportation, January *4, 1991, Information Required for OCST to Review Commercial Reentry* (Interim), Office of Commercial Space Transportation, Licensing and Safety Division.

U.S. Department of Transportation, November *15,* 1993, *Strategic Plan for Operations Review of the COMET Reentry Vehicle,* Revision 1 .0, Office of Commercial Space Transportation, Licensing and Safety Division..

U.S. Department of Transportation, August *1994, Risk Sensitivity Assessment of Flight Termination Systems on Reentry Vehicles* (Final Report), Office of Commercial Space Transportation.

U.S. Department of Transportation, December *6, 1994, Space Industries, Incorporated COMET Freeflyer*, *Vehicle Safety Assessment,* Office of Commercial Space Transportation, Licensing and Safety Division.

U.S. Department of Transportation, July 12, 1995, *Analysis of EER's Petition to Waive OCST Safety Criterion 1 for Commercial Reentry Vehicles* (Draft), Office of Commercial Space Transportation, Licensing and Safety Division.

LIST OF REFERENCES

U.S. Department of Transportation, August 1995, *Environmental Assessment for EER Systems Corporation's METEOR Vehicle and Payload,* Office of Commercial Space Transportation.

U.S. Department of Transportation, August *4,* 1995, *Payload Determination Evaluation for the METEOR Reentry Vehicle, Vehicle Safety Assessment und Operations Review,* Office of Commercial Space Transportation, Licensing and Safety Division.

U.S. Department of the Treasury, February *1998, Starting a Business and Keeping Records,* Publication 583.