Federal Aviation Administration

Department of Transportation
Federal Aviation Administration
Office of Commercial Space Transportation

Final Programmatic Environmental Impact Statement for Horizontal Launch and Reentry of Reentry Vehicles

December 2005

Final Programmatic Environmental Impact Statement for Horizontal Launch and Reentry of Reentry Vehicles

LEAD AGENCY: The Federal Aviation Administration Office of Commercial Space Transportation was the lead agency for developing this Programmatic Environmental Impact Statement (PEIS) under the National Environmental Policy Act of 1969.

TITLE OF PROPOSED ACTION: Licensing the Launch of Horizontal Launch and Reentry of Reentry Vehicles.

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DESIGNATION OF STATEMENT: Final Programmatic Environmental Impact Statement

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: Under the proposed action, the FAA would license the launch of horizontally launched vehicles and the reentry of reentry vehicles (RVs). The FAA has evaluated three horizontal launch vehicle (LV) design concepts and reentry with both powered and unpowered landing. This PEIS assesses the potential programmatic environmental effects of licensing horizontal launches and reentries of RVs, as well as the licensing of launch facilities that would support horizontal launches and reentries. The information in the PEIS is not intended to address all site-specific launch issues. This PEIS will be used to tier subsequent environmental analyses for site-specific launches, reentries, or the operation of a launch or reentry site. To facilitate these site-specific environmental analyses the FAA has provided guidance throughout the PEIS in various sections and technical appendices. This PEIS is intended to update and replace the 1992 *Final PEIS for Commercial Reentry Vehicles* and to complement the 2001 *PEIS for Licensing Launches*.

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Final Programmatic Environmental Impact Statement Approval

After careful and thorough consideration of the facts contained herein and following consideration of the views of those Federal agencies having jurisdiction by law or special expertise with respect to the environmental impacts described, the undersigned finds that the proposed Federal action is consistent with existing national environmental policies and objectives as set forth in section 101(a) of the National Environmental Policy Act of 1969.

Approving FAA Official: ______________________

Date: 12/1/05

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ACRONYMS AND ABBREVIATIONS

Al_2O_3	Aluminum Oxide (alumina or particulate matter)
Ar	Argon
ARTCC	Air Route Traffic Control Center
AST	Office of Commercial Space Transportation
ATNS	Air Traffic Noise Screening
BLM	Bureau of Land Management
BMP	Best Management Practice
BOA	Broad Ocean Area
^oC	Degrees Celsius
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CAC	Clean Air Corridor
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CH_4	Methane
Cl	Atomic Chlorine
CNS/ATM	Communication, Navigation, Surveillance/Air Traffic Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRV	Commercial Reentry Vehicle
dB	Decibel
dBA	A-weighted decibel
DoD	Department of Defense
DOI	Department of Interior
DOT	Department of Transportation
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ESA	Endangered Species Act
^oF	Degrees Fahrenheit
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FL	Flight Level
FPPA	Farmland Protection Policy Act
FR	Federal Register
FRP	Fiber Reinforced Plastics
GEO	Geosynchronous Earth Orbit
GTO	Geosynchronous Transfer Orbit

H	Atomic Hydrogen
H_2	Molecular Hydrogen
H_2O	Water
HAP	Hazardous Air Pollutant
HCl	Hydrogen Chloride
He	Helium
HNM	Heliport Noise Model
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
INM	Integrated Noise Model
^oK	Degrees Kelvin
LEO	Low Earth Orbit
LH_2	Liquefied Hydrogen
LOX	Liquid Oxygen
LV	Launch Vehicle
MEO	Medium Earth Orbit
MMH	Monomethylhydrazine
MOA	Military Operations Area
MSL	Mean Sea Level
MTR	Military Training Route
N	Atomic Nitrogren
N_2	Molecular Nitrogen
N_2O_4	Nitrogen Tetroxide
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NH_3	Ammonia
NHPA	National Historic Preservation Act
NIRS	Noise Integrated Routing System
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOTAM	Notice to Airmen
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRI	Nationwide Rivers Inventory
O^+	Atomic Oxygen ion
O_2	Molecular Oxygen
O_3	Ozone
ODS	Ozone-Depleting Substance
OPA	Oil Pollution Act

OSHA	Occupational Safety and Health Administration
OTR	Ozone Transport Region
Pb	Lead
PEIS	Programmatic Environmental Impact Statement
PEIS LL	Programmatic Environmental Impact Statement for Licensing Launches[1]
PM	Particulate Matter
PM_{10}	Particulate Matter with diameter 10 microns or less
$PM_{2.5}$	Particulate Matter with diameter 2.5 microns or less
ppm	parts per million
psf	pounds per square foot
RCRA	Resource Conservation and Recovery Act
RISO	Rocket Impact on Stratospheric Ozone
RLV	Reusable Launch Vehicle
RP1	Rocket Propellant 1 or kerosene
RV	Reentry Vehicle
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
SPCC	Spill Prevention, Control, and Countermeasure
SWPPP	Storm Water Pollution Prevention Plan
TCP	Traditional Cultural Property
TRACON	Terminal Radar Approach Control
$\mu g/m^3$	Micrograms per cubic meter
U.S.	United States
USACE	United States Army Corps of Engineers
USAF	United States Air Force
U.S.C.	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet
UVB	Ultraviolet Radiation Band "B"
VFR	Visual Flight Rules
VOC	Volatile Organic Compound
VRM	Visual Resource Management
WRAP	Western Regional Air Partnership
WSR	Wild and Scenic Rivers

[1] Federal Aviation Administration, 2001. Programmatic Environmental Impact Statement for Licensing Launches. May 24. Accessed at http://ast.faa.gov/lrra/comp_coop.htm on May 26, 2005.

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EXECUTIVE SUMMARY

The Federal Aviation Administration's (FAA's) Office of Commercial Space Transportation (AST) is responsible for licensing launches of launch vehicles (LVs), reentries of reentry vehicles (RVs), and the operation of facilities that support these activities.[2] Issuing a license for one of these activities is considered a Federal action and is subject to review as required by the National Environmental Policy Act (NEPA) of 1969, as amended, 42 United States Code (U.S.C.) 4321 *et seq*. This Programmatic Environmental Impact Statement (PEIS) evaluates the potential environmental consequences of licensing horizontal launches, reentries, and the operation of facilities associated with those activities. This PEIS is intended to be used to tier subsequent environmental analyses for site-specific launches, reentries, or the operation of a launch or reentry site. Licensing these activities would allow the space launch industry to meet demand for existing services and expand into new markets. Over the past few years, the commercial space industry has developed vehicles that launch and land horizontally from and on conventional runways. These vehicles could carry human passengers (i.e., spaceflight participants), cargo, or satellites.

This PEIS covers licensed launches from both existing government launch and reentry facilities and nonfederal launch and reentry sites in the United States (U.S.) and abroad. This PEIS assesses the potential programmatic environmental effects of licensing horizontal launches of LVs, reentries of RVs, as well as licensing the operation of facilities that support these activities. The operation, maintenance, repair, and decommissioning of payloads are outside the scope of this PEIS. The scope of the analyses contained in this PEIS is limited to the assessment of environmental consequences associated with the proposed action and alternatives at a programmatic level. The information in this PEIS is not intended to address all site-specific impacts. Any required site-specific environmental documentation would be developed as needed and tiered from this and other programmatic analyses as appropriate. Localized effects and the cumulative impact of these localized effects at an individual launch site can only be appropriately analyzed during the environmental review phase of the FAA's license application review process. Licensees are expected to comply with all applicable Federal, state, and local laws and regulations and international treaties. To facilitate the site-specific environmental analyses that would be required, the FAA has provided guidance throughout this PEIS in various sections and in technical appendices.

ES.1 Proposed Action and Alternatives Including the No Action Alternative

This PEIS analyzes the environmental impacts of the proposed action, three alternatives, and the no action alternative, as presented below.

- **Proposed Action** – The FAA would review applications and issue commercial licenses for: launches of horizontal LVs (1,279 horizontally launched LVs between 2005 and 2015 with a maximum of 154 launches per year), reentries of RVs with both powered and unpowered

[2] Launch vehicles (LVs) in this Programmatic Environmental Impact Statement are comprised of both expendable launch vehicles (ELVs) that have stages or components that are not intended for recovery or reuse, and reusable launch vehicles (RLVs) that have stages or components that can return to Earth and be recovered and reused.

landings (51 reentries between 2005 and 2015 with a maximum of 15 reentries per year), and the operation of facilities that support these activities.

- **Alternative 1** – Same as proposed action except that all reentries of RVs would have unpowered landings.
- **Alternative 2** – Same as proposed action except that all reentries of RVs would have powered landings.
- **Alternative 3** – Same as proposed action except that FAA would only license horizontal launches of LVs that ignite their rocket motors at or above 914 meters (3,000 feet).[3]
- **No Action Alterative** – The FAA would not issue commercial licenses for horizontal launches of LVs, reentry of RVs, or the operation of facilities that support these activities.

The proposed action and alternatives considered in this PEIS include three horizontal launch vehicle (LV) concepts, which include existing and conceptual designs. These LVs would typically range from 9 to 21 meters (30 to 70 feet) in length and weigh 1,300 to 4,500 kilograms (2,866 to 9,921 pounds) unfueled. The LV concepts, which are categorized by launch method, would use the following design configurations to meet operational goals.

- **Concept 1 vehicles** – These vehicles use jet powered take off with subsequent rocket engine ignition and powered horizontal landing.
- **Concept 2 vehicles** – These vehicles use rocket powered take off and flight and non-powered horizontal landing.
- **Concept 3 vehicles** – These vehicles are carried aloft by assist aircraft with subsequent rocket engine ignition and non-powered horizontal landing.

LVs may be launched on orbital or suborbital trajectories. Vehicles launched on suborbital trajectories would not reach orbit. Launches of LVs on suborbital trajectories would not require a reentry license. Vehicles launched on orbital trajectories would reach Earth orbit and would reenter the Earth's atmosphere. Launches of LVs on orbital trajectories that reenter would require a reentry license.

This PEIS analyzes environmental impacts by examining the following activities associated with the horizontal launch of an LV.

- Launch facility preparation
- Preparation of the LV
- Pre-flight ground operations
- Horizontal take off, flight, and/or launch
- Deployment of payload (if applicable) and/or attainment of intended altitude

This PEIS also assesses the impacts associated with the reentry of an RV, including

- Establishment of a reentry trajectory from Earth orbit or outer space,
- Reentry into the Earth's atmosphere,

[3] The altitude of 914 meters (3,000 feet) is generally accepted as the altitude of the mixing height. The mixing height is the level below which contributions of emissions can impact ambient air quality.

- Powered or unpowered landing, and
- Recovery of the RV from the surface of the Earth.

ES.2 Potential Impacts

Various environmental criteria were used to determine the overall environmental impact of the proposed action. Although the significance of most environmental consequences will need to be determined in a site-specific NEPA analysis that tiers from this PEIS, three resource areas may be affected on a programmatic level, these include: atmosphere, orbital debris, and socioeconomic impacts. This PEIS analyzes impacts on the atmosphere including: ambient air quality, acid rain, ozone depletion, and global warming. Impacts related to orbital debris include de-orbiting material as well as collisions in space with other man-made objects. Impacts associated with socioeconomics include the effects on the commercial launch industry and the national economy with respect to the global market; however, local socioeconomic impacts associated with developing a launch or reentry facility would be addressed in a site-specific NEPA analysis. The analysis contained in this PEIS is not site-specific; any required site-specific environmental documentation would be developed as needed and tiered from this and other NEPA analyses as appropriate.

Exhibit ES-1, Summary of Impacts by Alternative, lists the impacts by resource associated with the proposed action, alternative 1, alternative 2, alternative 3, and the no action alternative.

Exhibit ES-1. Summary of Impacts by Alternative

Resource Area	Proposed Action Impacts	Alternative 1 Impacts	Alternative 2 Impacts	Alternative 3 Impacts	No Action Impacts	Specific Regulatory Agency Consultation[4]
Atmosphere						
Troposphere	❍	❍	❍	❍	Δ	State environmental agency and Environmental Protection Agency
Stratosphere	❍	❍	❍	❍	Δ	
Mesosphere	❍	❍	❍	❍	Δ	
Ionosphere	❍	❍	❍	-	Δ	
Airspace[5]	❍	❍	❍	❍	Δ	FAA safety review and approval process
Biological Resources						
Vegetation[6]	❍	❍	❍	❍	Δ	N/A
Wildlife[5]	❍	❍	❍	❍	Δ	N/A
Threatened and Endangered Species[5]	❍	❍	❍	❍	Δ	U.S. Fish and Wildlife Service; National Marine Fisheries Service
Cultural Resources[7]	❍	❍	❍	❍	Δ	State Historic Preservation Officer; Tribal Historic Preservation Officer; National Register of Historic Places
Geology and Soils[6]	❍	❍	❍	❍	Δ	
Hazardous Materials and Waste[5]	❍	❍	❍	❍	Δ	N/A

Δ No change - No Impact ❍ Negligible Impact M Moderate Impact S Significant Impact

[4] See Appendix D for a detailed summary of the requirements for regulatory processes including information on agency consultation.
[5] The FAA license application process would minimize the potential impacts of the affected resource area, e.g., the Safety Review and Approval Process would address airspace.
[6] Potential impacts associated with the resource would be evaluated in a site-specific NEPA analysis.
[7] Launch or reentry activities would not result in a significant impact on the resource. The development of a new or modification of an existing launch or reentry facility would be analyzed in a site-specific NEPA analysis.

Exhibit ES-1. Summary of Impacts by Alternative

Resource Area	Proposed Action Impacts	Alternative 1 Impacts	Alternative 2 Impacts	Alternative 3 Impacts	No Action Impacts	Specific Regulatory Agency Consultation[4]
Health and Safety[4]	❍	❍	❍	❍	Δ	FAA Licensing and Safety Division Mission and Safety Review
Land Use						
Land Use[6]	❍	❍	❍	❍	Δ	U.S. Department of Agriculture Natural Resources Conservation Service
Section 4(f) Resources	❍	❍	❍	❍	Δ	Secretaries of the Interior, Housing and Urban Development, and Agriculture; state agencies
Socioeconomics						
Socioeconomics[5]	M	M	M	M	M	N/A
Environmental Justice[5]	❍	❍	❍	❍	Δ	N/A
Visual Resources and Aesthetics[6]	❍	❍	❍	❍	Δ	Appropriate Federal, state, and local agencies
Water Resources						
Freshwater and Marine Systems[6]	❍	❍	❍	❍	Δ	Local water agency (if a National Pollutant Discharge Elimination System permit or a Storm Water Pollution Prevention Plan is necessary)
Wetlands[6]	❍	❍	❍	❍	Δ	Army Corps of Engineers
Floodplains[6]	❍	❍	❍	❍	Δ	Federal Emergency Management Agency, Executive Order 11988
Ground Water[6]	❍	❍	❍	❍	Δ	N/A

Δ No change - No Impact ❍ Negligible Impact M Moderate Impact S Significant Impact

As shown in Exhibit ES-1, implementation of the proposed action or any of the alternatives other than the no action alternative would result in (1) impacts that would be negligible, (2) impacts that would be addressed through the completion of the FAA licensing process, (3) impacts that would require the completion of a site-specific NEPA analysis, and/or (4) impacts that would be negligible for horizontal launch or reentry activities, but would require the completion of site-specific NEPA analysis for the development or modification of a launch or reentry facility. The analysis contained in this PEIS concluded that the implementation of the proposed action or any of the alternatives other than the no action alternative would result in negligible impacts on all aspects of the atmosphere and on orbital debris. By adhering to the FAA licensing and review process, impacts on airspace and public health and safety would not be significant. Because this is a programmatic review, site-specific NEPA analysis would be required to evaluate the impacts on or associated with noise, vegetation, wildlife, threatened or endangered species, local socioeconomics, environmental justice, and hazardous waste. For licensing horizontal launch or reentry activities, the analysis contained in this PEIS found that the impacts on geology and soils, fresh water or marine systems, wetlands, floodplains, ground water, aesthetics and visual resources, section 4(f) resources, land use, or cultural resources would not be significant; however, these determinations depend on site-specific characteristics as well. The licensing of a launch or reentry site involving new construction or modification of existing infrastructure would require evaluation in a site-specific NEPA analysis.

Except for alternative 2, implementation of the proposed action would result in slightly greater environmental impacts than the overall impacts associated with the alternatives and no action alternative. Under alternative 2 it was assumed that all reentries would have powered landings; therefore, the environmental impacts of implementing alternative 2 would be slightly greater than those from the proposed action. However all impacts associated with the proposed action and the alternatives were found to be negligible. In terms of socioeconomics, the proposed action would result in the greatest beneficial impact as it would not restrict the innovation and development of the U.S. commercial space industry through restrictive licensing. Implementing the proposed action would not limit or restrict the growth of the U.S. space industry, while implementation of one of the alternatives could limit U.S. commercial launch and reentry vehicle development and growth, and implementation of the no action alternative could severely limit and restrict the growth of the U.S. commercial space launch industry.

1 INTRODUCTION AND PURPOSE AND NEED

The National Environmental Policy Act (NEPA) of 1969 as amended (42 United States Code [U.S.C.] 4321, *et seq.*), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] 1500-1508), Federal Aviation Administration (FAA) Order 1050.1 E, *Environmental Impacts: Policies and Procedures*, and Presidential Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions* (whose implementation is guided by NEPA and CEQ implementing regulations), direct FAA lead agency officials to consider the environmental consequences when planning for, authorizing, and approving Federal actions. When the FAA Office of Commercial Space Transportation (AST) issues a license, it is considered a Federal action and is subject to review as required by NEPA. The seven types of licenses issued by AST are detailed in Section 1.2.2. Accordingly, the FAA prepared this Programmatic Environmental Impact Statement (PEIS) to evaluate the potential environmental impacts of activities associated with licensing launches of horizontal launch vehicles (LVs), reentry of reentry vehicles (RVs), and operation of facilities supporting these activities[8]. The analysis in this document can be used to tier subsequent environmental analyses for specific launches or reentries or for the operation of a launch or reentry site.

1.1 Background

Under 49 U.S.C. Subtitle IX, Chapter 701, *Commercial Space Launch Activities* (formerly the *Commercial Space Launch Act*), the Department of Transportation (DOT) designated an office within the office of the Secretary of Transportation, as the lead agency to carry out responsibilities for United States (U.S.) commercial launch activities. This office had responsibilities to

- License and regulate all U.S. commercial launch activities to ensure that they are conducted safely and responsibly, and
- Promote, encourage, and facilitate the growth of the U.S. commercial space transportation industry.

In November 1995, this office was transferred to the FAA and was redesignated as the Office of Commercial Space Transportation with the office designation AST. Congress enlarged the FAA's role in October 1998 to include the licensing of reentries and reentry sites.

The FAA is given the responsibility to

- Regulate the commercial space transportation industry, only to the extent necessary, to ensure compliance with U.S. international obligations and to protect the public health and safety, safety of property, and national security and foreign policy interest of the U.S.;

[8] For purposes of this document, LV means both expendable and reusable launch vehicles (RLVs) that can be launched into orbital or suborbital trajectories. Reentry vehicle means a vehicle designed to return from Earth orbit or outer space to Earth, or an RLV designed to return from Earth orbit or outer space to Earth, substantially intact. 49 U.S.C. § 70101 These vehicles reenter Earth's atmosphere from Earth orbit or outer space. In this document reentry vehicles consist of RVs launched both vertically and horizontally.

- Encourage, facilitate, and promote commercial space launches and reentries by the private sector;
- Recommend appropriate changes in Federal statutes, treaties, regulations, policies, plans, and procedures; and
- Facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

In fulfilling its responsibilities since 1989, the FAA has licensed more than 100 launches and has issued licenses for the operation of several launch sites including: California Spaceport at Vandenberg Air Force Base, California; Spaceport Florida at Cape Canaveral Air Force Station, Florida; Mid-Atlantic Regional Spaceport at Wallops Island, Virginia; Kodiak Launch Complex on Kodiak Island, Alaska; and Mojave Airport in Mojave, California.

In the past few years, the commercial space industry has expressed heightened interest in commercial development of space, including LVs that launch horizontally and RVs. Twenty-six private organizations formally entered a competition for the Ansari X Prize[9]. Of the 26 private organizations that competed for the X Prize, nine were developing vehicles that launch and land horizontally on conventional runways. The LVs that competed for the Ansari X Prize were suborbital vehicles[10]; however, many of the companies developing X Prize vehicles are proposing to continue to build on the LV platform to develop vehicles that would use orbital trajectories and would require a reentry license from the FAA. These vehicles would include manned and unmanned flights and could carry passengers (i.e., spaceflight participants) or other payloads[11] into orbit. On October 4, 2004, SpaceShipOne, built by Scaled Composites, became the first private manned spacecraft to exceed an altitude of 100 kilometers twice in as many weeks, claiming the $10,000,000 Ansari X-Prize.

The Federal government, primarily the National Aeronautics and Space Administration (NASA) and U.S. Air Force (USAF), has previously conducted horizontal LV and RV projects. As identified in *Commercial Space Launch Activities* (49 U.S.C., Subtitle IX, Chapter 701), the development of such vehicles and associated services by the commercial space transportation industry is in the national and economic interest of the U.S. To ensure that launch services provided by private U.S. enterprises are consistent with the national security and foreign policy interests of the U.S. and do not jeopardize public safety and the safety of property, the FAA is authorized to regulate and license the U.S. commercial space transportation industry.

This authority extends to the proposed action considered in this PEIS, licensing horizontal vehicle launches and reentry of RVs, which is considered a Federal action subject to the requirements of NEPA. As such, NEPA requires that Federal agencies consider the impacts of their activities on the human environment. FAA Order 1050.1 E describes the FAA's procedures

[9] The Ansari X Prize, a St. Louis based non-profit foundation, offered a $10 million prize to the first team to launch a vehicle capable of carrying three people (or one person and ballast weight for two others) on a suborbital trajectory to a 100-kilometer (62-mile) altitude and repeats the flight within two weeks in the same vehicle.

[10] Suborbital vehicle is defined as "a vehicle, rocket-propelled in whole or in part, intended for flight on a suborbital trajectory, and the thrust of which is greater than its lift for the majority of the rocket-powered portion of its ascent." Suborbital trajectory is defined as "the intentional flight path of a launch vehicle, reentry vehicle, or any portion thereof whose vacuum instantaneous impact point does not leave the surface of the Earth."

[11] For purposes of this document, the payload is the item that an aircraft or rocket carries over and above what is necessary for the operation of the vehicle in flight and could include spaceflight participants, cargo, or satellites.

for implementing NEPA and includes thresholds for determining the level (significance) of an impact. Specifically, this Order requires that FAA decision-makers facilitate public involvement by including consideration of the effects of the proposed action and alternatives; avoidance or minimization of adverse effects attributable to the proposed action; restoration and enhancement of resources; and environmental quality of the nation. This PEIS evaluates the potential programmatic environmental consequences of licensing horizontal launches and reentries of RVs, as well as the operation of facilities where these activities would occur. This PEIS identifies the environmental considerations that a subsequent site-specific analysis would consider in accordance with NEPA.

1.2 FAA Licensing Program

The following provides a general description of the license application process for a launch or reentry and a description of the types of licenses issued by the FAA. A more detailed description of FAA's licensing program can be found in Appendix A.

FAA License Application Process

Three steps comprise the FAA launch or reentry licensing process; detailed descriptions of each of the following key components are presented in Appendix A, FAA Licensing Program.

1. Pre-Application Consultation
2. Application Evaluation, including
   - Policy Review and Approval
   - Safety Review and Approval
   - Payload Review and Determination
   - Financial Responsibility Determination
   - Environmental Review
3. Compliance Monitoring

During the Pre-Application Consultation and Application Evaluation periods, the FAA works with the applicant to ensure that sufficient information is supplied from the applicant to the FAA to support a review of the proposed action. The Policy Review and Approval process determines whether the information in the license application presents any issues affecting U.S. national security or foreign policy interests, or international obligations of the U.S. The Safety Review and Approval process determines whether a license applicant or payload owner or operator has obtained all required licenses, authorizations, and permits. During the Payload Review and Determination process, the FAA reviews a payload proposed for launch to determine whether a license applicant or payload owner or operator has obtained all required licenses, authorization, and permits, unless the payload is exempt from review. The Financial Responsibility Determination process ensures that all commercial licensees demonstrate financial responsibility to compensate for the maximum probable loss resulting from claims by a third party for death, bodily injury, or property damage or loss resulting from an activity carried out under the license; and the U.S. Government against a person for damage or loss to government property resulting from an activity carried out under the license. The Environmental Review component of the licensing process ensures that potentially significant environmental impacts of licensed launch activities on the natural and human environment are fully considered in decision making. An applicant must provide information sufficient to enable the FAA to comply with all the requirements of such standards. Compliance Monitoring ensures that a licensee complies with the terms and conditions set forth in the license issued by the FAA. Compliance Monitoring also involves oversight conducted by the FAA during licensed launch activities. All of these processes, except for Compliance Monitoring, are completed prior to the FAA issuing a license to an applicant. All FAA safety analyses and requirements are included in the terms and conditions of the license.

1.2.2 FAA Licenses

The FAA issues seven types of licenses for activities associated with launch, reentry, or operation of a facility where such activities would occur.

Launch Site Operator License – "A license to operate a launch site authorizes a licensee to operate a launch site in accordance with the representations contained in the licensee's application, with terms and conditions contained in any license order accompanying the license, and subject to the licensee's compliance with 49 U.S.C subtitle IX, ch.701 and this chapter. 14 CFR 420.41(a) A license to operate a launch site authorizes a licensee to offer its launch site to a launch operator for each launch point for the type and any weight class of LV identified in the license application and upon which the licensing determination is based. 14 CFR 420.41(b) Issuance of a license to operate a launch site does not relieve a licensee of its obligation to comply with any other laws or regulations; nor does it confer any proprietary, property, or exclusive right in the use of airspace or outer space. 14 CFR 420.41(c) A license to operate a launch site remains in effect for five years from the date of issuance unless surrendered, suspended, or revoked before the expiration of the term and is renewable upon application by the licensee." 14 CFR 420.43

Reusable Launch Vehicle (RLV) Mission-Specific License – "A mission-specific license authorizing an RLV mission authorizes a licensee to launch and reenter, or otherwise land, one model or type of RLV from a launch site approved for the mission to a reentry site or other location approved for the mission. A mission–specific license authorizing an RLV mission may authorize more than one RLV mission and identifies each flight of an RLV authorized under the license. A licensee's authorization to conduct RLV missions terminates upon completion of all activities authorized by the license or the expiration date stated in the reentry license whichever comes first." 14 CFR 431.3(a)

RLV Mission Operator License – "An operator license for RLV missions authorizes a licensee to launch and reenter, or otherwise land, any of a designated family of RLVs within authorized parameters, including launch sites and trajectories, transporting specified classes of payloads to any reentry site or other location designated in the license. An operator license for RLV missions is valid for a two-year renewable term." 14 CFR 431.3(b)

Reentry-Specific License – "A reentry-specific license authorizes a licensee to reenter one model or type of RV, other than an RLV, to a reentry site or other location approved for the reentry. A reentry-specific license may authorize more than one reentry and identifies each reentry authorized under the license. A licensee's authorization to reenter terminates upon completion of all activities authorized by the license or the expiration date stated in the reentry license, whichever occurs first.” 14 CFR 435.3(a)

Reentry Operator License – “A reentry operator license authorizes a licensee to reenter any of a designated family of RVs, other than an RLV, within authorized parameters, including trajectories, transporting specified classes of payloads to any reentry site designated in the license. A reentry operator license is valid for a two-year renewable term.” 14 CFR 435.3(b)

Launch-Specific License – “A launch-specific license authorizes a licensee to conduct one or more launches, having the same launch parameters, of one type of LV from one launch site. The license identifies, by name or mission, each launch authorized under the license. A licensee’s authorization to launch terminates upon completion of all launches authorized by the license or the expiration date stated in the license, whichever occurs first.” 14 CFR 415.3(a)

Launch Operator License – “A launch operator license authorizes a licensee to conduct launches from one launch site, within a range of launch parameters, of LVs from the same family of vehicles transporting specified classes of payloads. A launch operator license remains in effect for five years from the date of issuance.” 14 CFR 415.3(b)

1.3 Purpose and Need

The ***purpose*** of the proposed action is to facilitate the issuance of licenses for horizontal vehicle launches, reentry of RVs, and the operation of facilities where such actions would occur. By facilitating the issuance of licenses, the FAA would assist the space launch industry in meeting the demand for services (e.g., demand for delivering satellites to orbit) and expanding into new markets (e.g., space tourism). The FAA, in fulfilling its mission, has developed a licensing program designed to regulate and promote the growth of the U.S. commercial space industry. To further enhance this, the FAA wants to facilitate the issuance of licenses for the launch of new and emerging vehicles to meet the increased demand for space-based missions and the expansion into new commercial space markets.

The ***need*** for the action proposed by the FAA is to promote the growth of the U.S. commercial space transportation industry while protecting public health and safety, the safety of property, and ensuring that the launch services provided by private U.S. enterprises are consistent with national security and foreign policy interests of the U.S.

1.4 Scope of this PEIS

This PEIS considers the programmatic environmental impacts of the proposed action (i.e., licensing horizontal vehicle launches, reentry of RVs, and the operation of facilities where such actions would occur) and its alternatives, including the no action alternative. For the purposes of this PEIS, the FAA reviewed the programmatic impacts of licensing all types of horizontally launched LVs, RVs, and the operation of facilities where such actions would occur versus licensing only certain subsets of these activities. The activities considered in this PEIS could occur at any location that falls under the licensing authority of the FAA or other appropriate Federal launch and reentry facilities. These launch and reentry facilities may be located in the U.S. or abroad. The operation of launch facilities located outside of the U.S. would not be licensed by AST. As the designated authority for regulating the U.S. commercial space transportation industry and issuing licenses for launches, reentries, and the operation of launch sites, the FAA is the lead agency preparing this PEIS. No other agency has been designated or requested to act as a cooperating or co-lead agency for the development of this PEIS.

The FAA has estimated that there would be 1,279 U.S. commercial horizontal vehicle launches between 2005 and 2015. Of these, 97 percent (1,242) U.S. commercial horizontal launches are expected to use suborbital trajectories. The remaining 3 percent (37) U.S. commercial horizontal launches are expected to reach orbit and subsequently reenter the Earth's atmosphere during their descent. Note that the horizontal launches considered in this analysis include launches of both reusable and expendable vehicles; however, very few expendable launches were included in the analysis. In addition, 14 U.S. commercial vertical launches of RVs are expected to reach orbit and reenter Earth's atmosphere. Therefore, there would be a total of 51 U.S. commercial reentries of RVs from 2005 through 2015. These estimates, along with the pre- and post-flight activities associated with launch and reentry, provide the basis for the description of the proposed action and the analysis of environmental impacts. The horizontal launch of an LV includes

- Launch site preparation,
- Preparation of the LV,
- Pre-flight ground operations,
- Horizontal take off, flight, and/or launch, and
- Deployment of payload (if applicable) and/or attainment of intended altitude.

The downrange deposition of any components (e.g., stages, inter-stage material or expended debris such as bolts) associated with the LV was also evaluated. The reentry of an RV includes

- Establishment of a reentry trajectory from Earth orbit or outer space,
- Reentry into the Earth's atmosphere,
- Powered or unpowered landing, and
- Recovery of the RV from the surface of the Earth.

The scope of this PEIS addresses the delivery of a payload to Earth orbit but does not address the operation, maintenance, repair, or decommissioning of such payload, which are outside of the FAA's regulatory purview. However, because orbital and reentering debris that could be associated with the activities addressed in the proposed action have the potential to impact the human environment, this PEIS considers the impact of such debris. The scope of this PEIS does not include any construction activities at a launch or a reentry site. Construction activities (e.g., repair or modification of existing infrastructure or development of new infrastructure) would be addressed in separate site-specific environmental documentation tiered from this PEIS and other NEPA analyses as appropriate. Because the FAA does not license "amateur rocket activities"[12] conducted at private sites, such activities are not considered in this PEIS.

[12] "Amateur rocket activities" are defined in 14 CFR 401.5 as "launch activities conducted at private sites involving rockets powered by a motor or motors having a total impulse of 200,000 pound-seconds or less and a total burning or operating time of less than 15 seconds, and a rocket having a ballistic coefficient, i.e., gross weight in pounds

Based on the activities associated with licensing horizontal vehicle launches, reentry of RVs, and the operation of facilities where such actions would occur, the FAA determined which resource areas could be affected by the proposed action and alternatives (see Section 3, Affected Environment). This programmatic review allows the FAA to present a description of the unique environmental resources that would be affected by an alternative regardless of the specific geographic area. Furthermore, this allows the FAA to describe the affected environment in sufficient detail to understand the effects of each alternative on a particular resource area, as presented in Section 4, Environmental Consequences. For example, each layer of the atmosphere is described in sufficient detail to define the impacts of up to 154 horizontal vehicle launches per year and a maximum of 15 reentries of RVs per year on each layer, while regional air quality standards (National Ambient Air Quality Standards [NAAQS]) are described in sufficient detail to allow for a bounding analysis that would specify the number of launches or reentries that would exceed regulated NAAQS standards. Specific localized effects and the cumulative impacts of localized effects of a launch or a reentry at a specific launch or reentry site would be analyzed in a separate NEPA document that would tier from this PEIS.

1.4.1 Tiering from this PEIS

Programmatic documents, within the context of NEPA, involve an analysis of an agency's programs (e.g., licensing programs), activities, or policies that occur on a broad or national level. Tiering in such cases is appropriate when it helps the lead agency focus on the issues that are ready for decision and exclude from consideration issues already decided or not yet ready for analysis. Programmatic analyses can be tiered from to create subsequent environmental analyses (i.e., a supplemental environmental impact statement [EIS], a new EIS, a supplemental environmental assessment [EA], or a new EA). These tiered analyses narrow the scope of an activity to a site-specific or project-specific action. Tiering is designed to avoid repetition in documents and delays in site-specific analyses when program-level statements have already been conducted. The CEQ regulations for implementing NEPA (40 CFR 1502.20 and 1508.28) state that when a PEIS has been prepared, a subsequent environmental analysis needs only to summarize the issues discussed in a PEIS, incorporate discussions from the PEIS by reference, and concentrate on the issues specific to the subsequent action. A tiered document cannot lead to a change in scope or in the environmental findings of the broader document; such a change would result in the preparation of a new PEIS, EIS, or EA and subsequent environmental analyses.

A site-specific document tiering from this PEIS would address future activities that would fall within the scope of this PEIS would focus on the unique environmental resources that would be affected. Once a specific vehicle and site have been selected, the subsequent tiered document could follow the format of the affected environment presented in this PEIS. The analysis in the tiered document would be more narrowly focused than the PEIS given the site-specific nature of the action. Where appropriate, documents that would tier from this PEIS would reference the analysis and findings presented in this PEIS. For example, so long as the activities of the tiered document are within the scope of this PEIS, the analysis of such impacts would simply cite the

divided by frontal area of rocket vehicle--less than 12 pounds per square inch." [Note: The definition of amateur rocket activities is proposed to be revised by FAA.]

findings contained in this PEIS and incorporate the conclusions regarding significance of impacts.

1.4.2 Related Documentation

This PEIS updates and replaces the 1992 PEIS for Commercial Reentry Vehicles (PEIS CRV)[13] by analyzing the impacts associated with the reentry of RVs (with powered and unpowered landings) using current reentry estimates and RV technology, and complements the 2001 PEIS for Licensing Launches (PEIS LL)[14] by analyzing the impacts associated with horizontal vehicle launches. The PEIS CRV presented a programmatic review of the impacts associated with licensing reentry of RVs including the use of supplemental deceleration systems (e.g., parachutes and retro thrusts). The PEIS LL presented a programmatic review of the impacts associated with licensing launches of LVs from ground-, air-, and sea-based launch platforms for a variety of propulsion systems (i.e., liquid, solid, and hybrid rocket motors). This approach seeks to encompass all reasonably foreseeable launch and reentry activities that would fall under the licensing authority of the FAA. The PEIS LL is incorporated by reference in this PEIS. Exhibit 1-1 presents a comparison of the scope of the PEIS CRV, PEIS LL, and this PEIS.

[13] Available at: http://ast.faa.gov/lrra/environmental/envc/PEISRV5-28-92.pdf
[14] Available at: http://ast.faa.gov/lrra/comp_coop.htm

Exhibit 1-1. Comparison of Scope of the PEIS LL, the PEIS CRV, and this PEIS

Document	PEIS LL	PEIS CRV	Current PEIS
Date Finalized	May 2001	May 1992	November 2005
Proposed Action	To issue licenses for launches of vertical LVs. The PEIS addressed the impacts from ignition, liftoff, ascent through the atmosphere to orbit and payload separation, and cited the 1992 PEIS CRV in assessing the impacts associated with RVs	To issue licenses for reentries of RVs, which included both powered and unpowered landing of unmanned RVs. Manned RVs were not included in the proposed action. The PEIS CRV only addressed reentry specific licenses and reentry operator licenses	To issue licenses for launches of horizontal LVs, as well as reentries with powered and unpowered landings for manned and unmanned RVs. This PEIS addresses horizontally launched LVs and replaces the PEIS CRV for all types of RVs
Alternatives to Proposed Action	Considered More Environmentally-Friendly Propellant Combinations Alternative and No Action Alternative	Considered No Action Alternative	Considers Licensing Orbital RVs Reentries with Unpowered Landings Only, Licensing Orbital RVs Reentries with Powered Landings Only, Licensing Horizontal Launches of LVs Where Rocket Ignition Occurs at or Above 914 meters (3,000 feet), and No Action Alternative
Launch Operations	Considered vertically launched vehicles	Assumed that RVs would have been launched on vertically launched expendable LVs but did not analyze these impacts	Addresses horizontally launched vehicles
Reentry Operations	Did not consider reentry/landing operations	Considered reentries with powered and unpowered landings of unmanned RVs	Considers reentries with powered and unpowered landings of vertical and horizontal RVs

Exhibit 1-1. Comparison of Scope of the PEIS LL, the PEIS CRV, and this PEIS

Document	PEIS LL	PEIS CRV	Current PEIS
Basis for Analysis	The PEIS LL used the following LVs as representative vehicles: Taurus, Athena, Titan II, Delta II, Delta III, Delta IV, Zenit-3SL, Titan IV, and Atlas V	The PEIS CRV evaluated the effects of unmanned RVs that would be launched from expendable LVs and indicated that the size of such vehicles ranges from 170 to 6,970 kilograms (between 0.2 and 8.2 percent of the weight of the Space Shuttle [85,000 kilograms])	This PEIS used the following to define representative vehicles: X-Prize Entrants and the vehicles and technologies presented in 2004 U.S. Commercial Space Transportation Developments and Concepts: Vehicles, Technologies, and Spaceports
U.S. Licensed Launch Manifest Estimates	Assumed 72 small, 22 medium, 75 intermediate, and 92 high capacity launches between 2000 and 2010	None	Assumed 485 Concept 1, 566 Concept 2, and 228 Concept 3 launches between 2005 and 2015
U.S. Licensed Reentry Manifest Estimates	None	Assumed up to 7 reentries per year from 1993-1999 and 20 to 30 reentries per year from 2000-2005	Assumed 37 horizontal and 14 vertical reentries between 2005 and 2015

1.5 Summary of the Public Involvement Process

In accordance with the CEQ NEPA implementing regulations for public involvement (40 CFR 1506.6) and FAA Order 1050.1 E, the FAA has provided opportunities and means for public involvement during the preparation of this PEIS. Public participation in the NEPA process not only provides for and encourages open communication between the FAA and the public, but also promotes better decision-making. Throughout the preparation of the PEIS, including the scoping process and public comment period on the Draft PEIS, the FAA sought substantive input from a variety of sources concerning the issues that should be addressed. The FAA continues to encourage the public to submit comments throughout the entire PEIS development process.

Scoping for the development of this PEIS began with the publication of the Notice of Intent (NOI) in the *Federal Register* (68 FR 50210) on August 20, 2003. See Appendix B, Public Involvement Material, for a copy of the NOI. During scoping, the FAA invited the participation of Federal, state, and local agencies, Native American tribes, environmental groups, organizations, citizens, and other interested parties to assist in determining the scope and significant issues to be evaluated in this PEIS. The FAA provided the public, organizations, and agencies with an opportunity to request a public scoping meeting; however, no interest or request for a public scoping meeting was received by FAA and no such meeting was sponsored by the FAA. On October 16, 2003, the FAA published a notice of extension in the *Federal Register* (68 FR 59676), which extended the scoping period from September 26, 2003 to October 31, 2003. The extension was provided to allow the public sufficient opportunity to explore alternatives and raise issues pertinent to the scope of the PEIS. The FAA developed a website to provide information on the PEIS and solicit public comments during scoping. The FAA also established phone and fax lines, an e-mail address, and a U.S. Postal Service address for submittal of public comments and questions. Appendix B, Public Involvement Material, provides copies of the public notices, announcements, and a summary of the comments received during the public scoping period.

The public comment period for the Draft PEIS began with the publication of the Notice of Availability (NOA), published in the *Federal Register* by the Environmental Protection Agency (EPA) on July 29, 2005. The NOA announced the availability of the Draft PEIS, initiated the 45 day public comment period for the NEPA process, and requested comments on the Draft PEIS. The FAA also published a NOA in the *Federal Register* on July 29, 2005, which provided information on the proposed action and alternatives and provided contact information for submitting comments to the FAA. See Appendix B for a copy of the NOA. A downloadable version of the Draft PEIS was available on the FAA PEIS website and hardcopies of the document were sent to persons on the distribution list. The only comments on the Draft PEIS received during the comment period were from XCOR Aerospace and the EPA. The EPA's letter indicated a lack of objection to the proposed action. The responses to XCOR Aerospace's comments and a copy of the EPA comment letter are provided in Appendix B. The public involvement process will conclude when the FAA issues a Record of Decision (ROD) no sooner than 30 days after the release of the Final PEIS.

1.6 Outline of the PEIS

- Section 2 provides a description of the proposed action encompassing the various vehicle concepts that are analyzed in this document, the no action alternative, and alternatives considered but removed from detailed analysis.

- Section 3 describes the potentially affected environment in terms of resource areas including atmosphere, air quality, airspace, orbital debris, noise, geology and soils, surface water, wetlands, floodplains, terrestrial and aquatic plants and animals, threatened and endangered species, socioeconomics, environmental justice, public health and safety, transportation and infrastructure, and cultural resources.

- Section 4 describes the potential direct and indirect environmental consequences associated with the proposed action and the alternatives on the resources presented in Section 3.0.

- Section 5 describes the potential cumulative environmental consequences associated with the proposed action and other Federal and non-Federal activities.

- Section 6 discusses the mitigation measures associated with the potential environmental consequences.

- Sections 7 and 8 discuss the irreversible and irretrievable commitment of resources (including short-term use versus long-term productivity) and present the preparers of the PEIS, respectively.

- Section 9 presents the references.

- Section 10 is a glossary of terms used in this document.

- Several appendices provide technical support and detailed information related to this document, and include

    - Appendix A – FAA Licensing Program
    - Appendix B – Public Involvement Materials
    - Appendix C – Applicable Legal Requirements, including those for each individual resource area
    - Appendix D – Regulatory Process Description, which provides more detail and guidance for applicants who are completing site-specific environmental analyses
    - Appendix E – Potential Accident Scenarios
    - Appendix F – Emissions Associated with the Proposed Action and Alternatives and Other Space Launch Activities
    - Appendix G – Distribution List, which includes all parties that are included in mail-outs related to the PEIS and its development

2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The commercial space launch industry strives to develop safe and affordable access to space and promote new commercial development of space (e.g., space tourism). In the past few years, the commercial space launch industry has expressed heightened interest in conducting launches of horizontal vehicles and reentries of RVs. The new horizontal LV technologies (i.e., new propulsion systems and propellants) are being developed to provide affordable access to space. In addition to the new horizontal LV technologies, the commercial space launch industry is continuing to develop new RV technologies with reentries using both powered and unpowered landings.

In accordance with its responsibilities under Title 49, U.S.C., Subtitle IX, Sections 70101-70121 (formerly the *Commercial Space Launch Act*), the FAA regulates the commercial space launch industry by licensing launches and reentries occurring in the U.S. and those conducted by U.S. citizens outside of the U.S., and issuing launch site operator licenses. The FAA developed the alternatives considered in this PEIS based on the activities that it has the regulatory authority to license and the types of horizontal LVs and RVs that currently exist or are under development. The FAA defined the proposed action in terms of the activities associated with horizontal vehicle launches, followed by a detailed discussion of the concepts and propellants used by LVs, and the estimated launch manifest by year. The reentry of an RV is described using the same information (i.e., activities, concepts, and estimated reentry manifest), while the description of the alternatives considered in detail focuses on the differences between each alternative and the proposed action.

The following is a list of potential alternatives including (1) the proposed action, (2) the no action alternative, (3) alternatives carried forward for analysis, and (4) alternatives not analyzed further in the PEIS. These alternatives allow the FAA to present the environmental impacts of the proposed action and alternatives in comparative form, defining the issues and providing a basis for options considered by decision makers.

2.1 Proposed Action

Under the proposed action, the FAA would license horizontal vehicle launches, reentries of RVs using powered and unpowered landings, and the operation of facilities that would support such actions. The activities associated with horizontal vehicle launches and reentry of RVs are presented separately, and the impact analysis in Section 4 discusses the potential impacts considering the activities both as individual events and as part of a single mission. Some horizontal LVs would be launched into suborbital trajectories and would not reach orbit. Rather the vehicles would reach apogee (i.e., the highest point in the vehicle's flight) and would return to land at a designated location. Some horizontal LVs would be launched into orbital trajectories and would reach Earth orbit or outer space. These vehicles would reenter Earth's atmosphere to return to Earth. After reentry, these vehicles would land at designated locations. In addition, some RVs would be transported into orbit by vertical LVs, as considered in the PEIS LL, and would reenter the Earth's atmosphere and land at designated locations.

The proposed action for a single mission considered in this PEIS could include launch only, reentry only, or launch and reentry. The activities associated with a horizontal LV landing, after it had returned from a suborbital trajectory, would be the same as landing a horizontal LV that had reentered and landed from an orbital trajectory; therefore, these activities are described only once as part of the discussion on reentry.

2.1.1 Horizontal Launch

Current horizontal launch technology can be used to launch payloads, including spaceflight participants or cargo, into suborbital trajectories; however, future horizontal LVs would be used to transport spaceflight participants into orbit and carry larger payloads into both Low Earth Orbit (LEO)[15] and Geosynchronous Earth Orbit (GEO)[16]. The use of horizontal LVs to transport payloads into LEO and GEO is reasonably foreseeable within the timeframe of this PEIS and is considered in this document.

2.1.1.1 Activities Associated with Horizontal Launch

For purposes of this analysis, the FAA identified the following as activities typically associated with horizontal launch.

- Launch facility preparation
- Preparation of the LV
- Pre-flight ground operations
- Horizontal take off, flight, and/or launch
- Deployment of payload (if applicable) and/or attainment of the intended altitude

Preparing the facility for a horizontal launch would include ensuring that the necessary safety advisories have been issued and that procedures and plans are in place to safely conduct the proposed activities. The preparation of the LV would typically begin with the arrival of the LV and its associated payload at a launch site. The preparation of the LV would include vehicle and payload assembly. The pre-flight ground operations would include fueling and final preparations for horizontal launch. The LV would initiate its formal launch sequence (ignition of its propulsion system) when all preparation and pre-flight operations are completed. After ignition of the rocket engines, the LV would continue along its flight path until it reaches its desired altitude or orbit. The activities associated with reentry (for those vehicles that reach orbit) are described in Section 2.1.2.1 of this document. The activities associated with landing a horizontal LV from a suborbital trajectory are the same as the latter stages of landing a horizontal LV from an orbital trajectory and are therefore also described in Section 2.1.2.1 of this document.

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[15] Objects in LEO follow a path between the Earth's atmosphere and the bottom of the Van Allen belts, from an altitude of 161 to 1,609 kilometers (100 to 1,000 miles). The Van Allen belts are zones of intense radiation trapped in the Earth's magnetosphere (a region dominated by the Earth's magnetic field that traps charged particles).

[16] GEO is an orbit at 35,888 kilometers (22,300 miles) altitude that is synchronized with the Earth's rotation.

2.1.1.2 LV Concepts for Horizontal Launch

This PEIS considered three horizontal LV concepts, which include existing and conceptual LV designs. These LVs would typically range from 9 to 21 meters (30 to 70 feet) in length and weigh 1,300 to 4,500 kilograms (2,866 to 9,921 pounds) unfueled. The LV concepts, which are categorized by launch method, would use the following design configurations to meet operational goals.

- **Concept 1 vehicles** – These vehicles use jet-powered take off with subsequent rocket engine ignition and powered horizontal landing.
- **Concept 2 vehicles** – These vehicles use rocket-powered take off and flight and non-powered horizontal landing.
- **Concept 3 vehicles** – These vehicles are carried aloft by assist aircraft with subsequent rocket engine ignition and non-powered horizontal landing.

Concept 1

Concept 1 LVs would take off under jet power from conventional runways and would ignite rocket engines at a specified altitude. At a designated launch altitude, jet engines would be shut down and rocket engines would be ignited. If a suborbital trajectory is planned, the LV would climb until propellants are consumed or rocket engines are shut down. The vehicle would then glide unpowered along a parabolic trajectory until reaching apogee. If an orbital trajectory were planned, the LV would climb until reaching the designated orbit. When appropriate, the rocket motors would be fired to move the LV from Earth orbit or outer space to a trajectory that would allow the vehicle to reenter Earth's atmosphere. The LV would then descend. During descent, jet engines would be restarted at a specified altitude and the vehicle would fly to a powered, horizontal landing at a designated location. Exhibit 2-1 depicts a typical Concept 1 LV.

Exhibit 2-1. Typical Concept 1 LV

Concept 2

Concept 2 vehicles would involve horizontal LVs taking off under rocket power from conventional runways. The rocket motors would use rocket propellants including liquid oxygen (LOX) and either kerosene or alcohol. After take off, the LV would follow a steep ascent trajectory. If a suborbital trajectory is planned, the LV would climb until propellants are consumed or rocket engines are shut down. The vehicle would then glide unpowered along a parabolic trajectory until reaching apogee. If an orbital trajectory is planned, the LV would climb until reaching the designated orbit. When appropriate, the motors would be fired to move the LV from Earth orbit or outer space to a trajectory that would allow the vehicle to reenter Earth's atmosphere. The vehicle would glide to a horizontal landing at a designated location. Exhibit 2-2 depicts a typical Concept 2 LV.

Exhibit 2-2. Typical Concept 2 LV

Concept 3

Vehicles included in Concept 3 are comprised of an assist aircraft and an LV. The assist aircraft could be a carrier or a tow aircraft and could range in size from a modified commercial Boeing 747 jumbo jet to a fixed wing aircraft with a 25-meter (82-foot) wingspan. The sizes of Concept 3 LVs could vary from 9 to 46 meters (30 to 150 feet) in length. If a carrier aircraft were used, the LV would be attached to the top of the carrier aircraft, or mated to the underside of the carrier aircraft. If a tow aircraft were used, the LV would be tethered to the back of the tow aircraft. The assist aircraft would have jet engines. The assist aircraft and the LV would take off horizontally from a conventional runway. The assist aircraft would carry or tow the LV to the designated launch release altitude. The LV would be released from the assist aircraft. Rocket engines on the LV would be fired as the assist aircraft pulls away. The assist aircraft would make a powered horizontal landing on the designated runway after releasing the LV. If a suborbital trajectory were planned, the LV would climb until propellants are consumed or rocket engines are shut down. The vehicle would then glide unpowered along a parabolic trajectory until reaching apogee. If an orbital trajectory were planned, the LV would climb until reaching the designated orbit. When appropriate, the motors would be fired to move the LV from Earth orbit or outer space to a trajectory that would allow the vehicle to reenter Earth's atmosphere. The LV would glide to a horizontal landing at a designated location. Exhibit 2-3 depicts typical Concept 3 LVs.

Exhibit 2-3. Typical Concept 3 LVs

At this time a vehicle concept similar to that described in Concept 3, but which would perform a powered decent through the Earth's atmosphere, is not reasonably foreseeable. However, should a vehicle matching this description or a vehicle not yet appropriately described be developed, the FAA would prepare a supplement to this PEIS, as appropriate.

2.1.1.3 Propellants for Horizontal Launch

Representative propellants proposed for horizontally launched LVs include

- Jet fuel used in conventional and modified jet engines,
- Hydrocarbon fuel (e.g., Rocket Propellant-1 [RP-1] or kerosene) plus an oxidizer such as LOX,
- Cryogenic propellants (e.g., LOX/liquefied hydrogen [LH_2], where the fuel and oxidizer are maintained at very low temperatures),
- Solid propellant (e.g., polybutadiene matrix with acrylonitrile, ammonium perchlorate[17] oxidizer, and powdered aluminum),
- Concentrated hydrogen peroxide, which can be used as a monopropellant or as an oxidizer in combination with kerosene or alcohol-based fuels[18], or
- Hybrid propulsion systems, consisting of a combination of liquid and solid propellants.

Impacts from specific LV propellant combinations would be considered in future tiered analyses. Exhibit 2-4 shows the types of propellants that may be used by each of the horizontal LV concepts discussed in this PEIS.

[17] The FAA is aware of the recent scientific debate concerning the health issues associated with perchlorate exposure. It should be noted that although the EPA has not established a Federal drinking water standard for perchlorate, it has established an official reference dose of 0.0007 milligram per kilogram per day based on the 2005 report *Health Implications of Perchlorate Ingestion,* which was prepared by the National Research Council of the National Academy of Science.

[18] None of the LV concepts being considered in this PEIS included the use of hydrogen peroxide propellants. If horizontally launched LVs using hydrogen peroxide are proposed in the future they would need to be analyzed in additional analyses.

Exhibit 2-4. Propellant Systems Proposed for Use in Horizontal LV Concepts

Horizontal LV Concept	Propellant			
	Hydrocarbon	Cryogenic	Solid	Hybrid
Concept 1	X	X		
Concept 2	X	X		
Concept 3			X	X

2.1.1.4 Launch Manifest for Horizontal Launch

The FAA estimates that the total number of U.S. licensed launches (vertically and horizontally launched LVs) between 2005 and 2015 would be 2,760. Horizontal launches would comprise a portion of all FAA licensed launches. It is anticipated that between 2005 and 2015 a total of 1,279 FAA licensed horizontal launches would be conducted. Exhibit 2-5 shows the number of launches of each horizontal LV concept that are estimated to occur in each year.

Exhibit 2-5. Estimated Horizontal U.S. Licensed Launches for 2005-2015

Horizontal LV Concept	Estimated Number of Horizontal U.S. Launches											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	**Total**
Concept 1	0	10	50	50	50	75	50	50	50	50	50	485
Concept 2	5	30	34	55	52	55	60	65	65	70	75	566
Concept 3	7	8	11	16	24	22	28	27	29	27	29	228
Total	12	48	95	121	126	152	138	142	144	147	154	1,279

2.1.2 Reentry

The commercial space launch industry is developing new vehicles and technologies, which would launch into orbit, reenter Earth's atmosphere, and land on the surface of the Earth. RVs would include both powered and unpowered landings of vehicles that are manned and unmanned. Reentry vehicle concepts with powered landing rely on the use of a propulsion system to control the rate and direction of descent and may use equipment, including a flexible aero-shield or a steerable parachute, to reduce the descent rate. Reentry vehicles with unpowered landings use air resistance coupled with parachute or parafoil systems to control the rate and direction of descent.

2.1.2.1 Activities Associated with Reentry

For purposes of this analysis, the FAA identified the following as activities typically associated with reentry

- Activities performed while in Earth orbit or in outer space to establish a reentry trajectory;
- Reentry of the RV and the use of various equipment and systems to control descent of RVs with unpowered landings on the Earth's surface, or the use of propulsion systems to control descent of RVs with powered landings on the Earth's surface; and
- Recovery of the RV from the Earth's surface.

Reentry begins when the propulsion system of an RV in Earth orbit or outer space is fired and the RV moves into a trajectory that allows the vehicle to reenter Earth's atmosphere. Upon reentry, the RV would be oriented to slow the rate of descent and dissipate the heat generated during reentry. Reentry vehicles could have powered or unpowered landings. The recovery of the RV from the Earth's surface may include the use of recovery equipment including ships, fixed and rotary wing aircraft, and overland vehicles, or no recovery may be required if the RV lands on a runway.

2.1.2.2 RV Concepts

RVs range from 9 to 46 meters (30 to 150 feet) in length and weigh 1,300 to 10,000 kilograms (2,866 to 22,046 pounds) unfueled. In this PEIS, RVs with both unpowered and powered landings are considered. For an RV with unpowered landing, once the RV enters Earth's atmosphere, the RV would glide, deploy a parachute or parafoil, and descend to the Earth's surface. For an RV with powered landing, once the RV enters the Earth's atmosphere, a propulsion system would be used to control descent and direct the RV to the appropriate landing site.

RVs using powered or unpowered landing methods could be oriented vertically or horizontally during reentry and subsequent landing. The design and size of the RV dictates whether landing would be powered or unpowered. Exhibit 2-6 shows the types of landing methods associated with vertically or horizontally oriented RVs.

Exhibit 2-6. Characterization of RVs Landings

RV Orientation	Unpowered Landing			Powered Landing	
	Parachute	Glide	Parafoil	Jet Engine	Rocket Motor
Horizontal		X	X	X	X
Vertical	X				X

Disk or aircraft shaped RVs tend to be oriented horizontally and would land using either powered or unpowered methods. The smaller RVs using aircraft designs tend to land using unpowered methods and would glide to the Earth's surface, while larger RVs with aircraft designs would tend to land using powered methods. Missile shaped RVs tend to be oriented vertically and would land using either powered or unpowered methods.

Some RVs would land using a combination of unpowered and powered methods; a rocket engine would be fired to slow initial descent, then a parachute would be deployed, and finally when the RV is close to the Earth's surface, rocket engines would be fired for final touch down. For purposes of this analysis, the propellants used by an RV during powered landing were assumed to be the same as those used during launch.

2.1.2.3 Propellants for RVs

A variety of propellants may be used to move the RV into a reentry trajectory; however, these propellants would be used while the RV is in orbit or in outer space and their use would not affect the natural or human environment. Therefore, the use of these propellants while in orbit or in outer space is not discussed further in this PEIS. Ground level impacts associated with fueling the RV with these propellants are considered as appropriate in this PEIS.

RVs that have unpowered landing (horizontal or vertical) would not use propellants during landing operations. RVs that have powered landing (horizontal or vertical) could use several types of propellants. These propellants could include

- Jet fuel used in conventional and modified jet engines;
- Hydrocarbon fuel (e.g., RP-1 or kerosene plus an oxidizer such as LOX);
- Cryogenic propellants (e.g., LOX/LH_2, where the fuel and oxidizer are maintained at very low temperatures);
- Solid propellants (e.g., polybutadiene matrix with acrylonitrile, ammonium perchlorate oxidizer, and powdered aluminum);
- Concentrated hydrogen peroxide, which can be used as a monopropellant or as an oxidizer in combination with kerosene or alcohol based fuels; or
- Hybrid propulsion systems, consisting of a combination of liquid and solid propellants.

2.1.2.4 Reentry Manifest

It is estimated that between 2005 and 2015 a total of 51 FAA licensed reentries would be conducted. Exhibit 2-7 shows the number of reentries for each RV type that are estimated to occur in each year.

Exhibit 2-7. Estimated Number of U.S. Licensed Reentries of RVs per Year

RV Type	Number of FAA Licensed Reentries											Total
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Horizontal	0	0	0	0	1	1	2	5	7	9	12	**37**
Vertical	0	0	0	0	0	1	2	2	3	3	3	**14**
Total	0	0	0	0	1	2	4	7	10	12	15	**51**

2.2 Alternatives to the Proposed Action

The following alternatives to the proposed action present three options and approaches considered by the FAA for the licensing of LVs launched on orbital trajectories based upon their powered or unpowered landing and the altitude of rocket ignition. Evaluating these alternatives fosters better decision making because it gives the FAA the ability to define the environmental issues associated with launch licensing activities and to evaluate potential impacts in a comparative form. These alternatives have been retained for further analysis and are evaluated in detail in this PEIS.

2.2.1 License Orbital LVs Using Unpowered Landings Only (Alternative 1)

Alternative 1 would consider licensing only launches of orbital LVs for which unpowered landing is planned. For the purpose of this alternative, the FAA assumed that all licensed reentries would have unpowered landings (51 reentries from 2005 to 2015). The remaining activities as presented in the proposed action would remain the same.

2.2.2 License Orbital LVs Using Powered Landings Only (Alternative 2)

Alternative 2 would consider licensing only launches of orbital LVs for which powered landing is planned. For the purpose of this alternative, the FAA assumed that all licensed reentries would have powered landings (51 reentries from 2005 to 2015). The remaining activities as presented in the proposed action would remain the same.

2.2.3 License Horizontal Launches of LVs Where Full Rocket Engine Ignition Occurs at or above 914 meters (3,000 feet) (Alternative 3)

Alternative 3 would license horizontally launched LVs including LVs that do not produce rocket emissions below 914 meters (3,000 feet), for a total of 713 launches from 2005 to 2015 (See Exhibit 2-8).[19] For the purpose of this alternative, 25 landings would be jet powered and 26 would be rocket powered. Under this alternative, all Concept 2 vehicles presented in the proposed action would not be licensed, and the remaining activities would be the same as those described in the proposed action.

Exhibit 2-8. Estimated Horizontal U.S. Licensed Launches for 2005-2015 Under Alternative 3

Horizontal LV Concept	Estimated Number of Horizontal U.S. Launches										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concept 1	0	10	50	50	50	75	50	50	50	50	50
Concept 3	7	8	11	16	24	22	28	27	29	27	29
Total	7	18	61	66	74	97	78	77	79	77	79

2.3 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of launch facilities for such activities; therefore, all U.S. licensed launches would be vertical launches as described in the PEIS LL.

Not licensing the activities described in the proposed action would result in adverse minor impacts on the socioeconomic setting of local communities where one of the major employers or economic growth opportunities is the commercial horizontal launch industry. Under this alternative, horizontal LVs and RVs could be designed and constructed in the U.S., but there would be no licenses issued for launches of these vehicles. This could slow the expansion and reduce the competitiveness of the U.S. horizontal launch and reentry industry, as it would have to rely on foreign markets as outlets for further developing and commercializing the technology.

[19] The altitude of 914 meters (3,000 feet) is generally accepted as the altitude of the mixing height. The mixing height is the level below which contributions of emissions can impact ambient air quality.

2.4 Alternatives Removed from Further Analysis

The FAA considered the following alternative to the proposed action, but for the reasons cited below, did not analyze the alternative in detail.

Licensing Horizontal LVs Using Aerial Fueling

Horizontal LVs using aerial fueling would take off under jet engine power from a conventional runway. At a designated altitude (typically between 6,100 and 15,240 meters [20,000 and 50,000 feet] above mean sea level [MSL]), a tanker airplane would transfer liquid propellants to the LV. The tanker airplane would disengage after the propellants are transferred and the LV would ignite its rocket engines once the tanker airplane cleared the area. If a suborbital trajectory were planned, the LV would climb until propellants are consumed or rocket engines are shut down. The vehicle would then glide unpowered along a parabolic trajectory until reaching apogee. If an orbital trajectory is planned, the LV would climb until reaching the designated orbit. When appropriate, the rocket motors would be fired to move the LV from Earth orbit or outer space to a trajectory that would allow the vehicle to reenter the Earth's atmosphere. The LV would then descend. During descent, jet engines would be restarted at a specified altitude and the vehicle would fly to a powered, horizontal landing at a designated location. Exhibit 2-9 shows a graphic of a typical flight profile for horizontal LVs using aerial fueling.

Exhibit 2-9. Typical Horizontal LV Using Aerial Fueling

Although LVs based on this concept have been proposed, they are in a less mature stage of development than the three vehicle concepts described in Section 2.1.1.2. Their production and launch are not reasonably foreseeable within the timeframe of this PEIS, and therefore they are not analyzed in this document. If in the future these designs become ready for analysis, it may be possible to tier from this PEIS for subsequent analyses.

3 AFFECTED ENVIRONMENT

3.1 Introduction

In accordance with NEPA (40 CFR 1502.15), the FAA defined the geographic area that may be affected by one or more of the alternatives under consideration (see Section 2) as the launch and reentry locations, both in the U.S. and abroad, that would fall under the licensing authority of the FAA. The geographic area of the affected environment includes the atmosphere and the broad ocean area (BOA) that are environmental resources outside of the jurisdiction of any nation. Within the geographic area of the affected environment, the FAA reviewed the environmental resources, both natural and man-made, that would be affected by one or more of the alternatives under consideration. For each environmental resource that may be affected, this PEIS presents

- A definition and a description of the baseline conditions of the environmental resource, and
- The regulatory setting and standards protecting the environmental resource.

By presenting the definition and description of the baseline condition of each environmental resource, as well as the regulatory setting and standards, this section provides the basis for the evaluation and comparison of impacts on each environmental resource by alternative, which is presented in Section 4, Environmental Consequences. Additionally, the environmental resources presented and analyzed in this PEIS serve as a roadmap for future actions that fall within the scope of and would tier from this PEIS by presenting a comprehensive description of the environmental resources that may be affected (Section 3) and providing a methodology for the impact assessment and significance determinations (see Section 4).

The affected environment consists of both natural and manmade environmental resources that collectively comprise the human environment. Naturally occurring environmental resources include each layer of the atmosphere, biological resources, geology and soils, and water resources. Manmade environmental resources include airspace, hazardous materials and waste, land use, Section 4(f) Resources, noise, orbital debris, public health and safety, socioeconomics (including utilities), and environmental justice. Visual and aesthetic resources as well as cultural resources consist of both natural and manmade elements. The following subsections present the definition, the regulatory setting, and the baseline conditions for each environmental resource. To further define the existing conditions related to an environmental resource, a summary of the applicable laws and regulations that protect the resource and agency consultation procedures are presented in Appendix C, which provides relevant information for future documents that would tier from this PEIS. As with the framework of the PEIS, the applicable regulations are presented within the context of resource areas.

3.2 Environmental Resource Areas

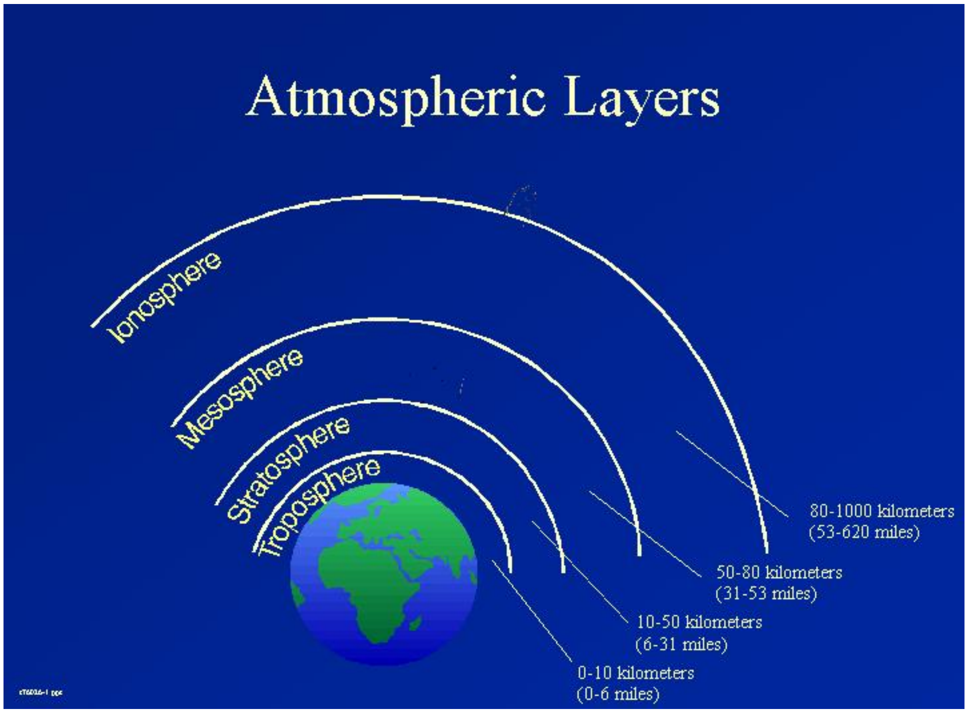
The following sections discuss the resource areas commonly considered in NEPA analyses. Orbital debris has been included in the discussion because FAA's licensing activities address launches and reentries, both of which could contribute to orbital debris under nominal and accident conditions of the launch or reentry.

3.2.1 Atmosphere

3.2.1.1 Definition and Description

The Earth's atmosphere consists of four main layers (i.e., troposphere, stratosphere, mesosphere, and ionosphere) that are separated by narrow transition zones. Each layer is characterized by altitude, temperature, structure, density, composition, and degree of ionization (i.e., the positive or negative electric charge associated with each layer). Exhibit 3-1 shows the altitude ranges associated with the atmospheric layers.

Exhibit 3-1. Altitude Range for Atmospheric Layers



Source: ICF Kaiser for Beal Aerospace, 1998

More than 99 percent of the total atmospheric mass is concentrated within 40 kilometers (25 miles) of the Earth's surface. The upper boundary at which gases disperse into space lies at an altitude of approximately 1,000 kilometers (621 miles) above sea level. (NASA, 2003) The higher layers of the atmosphere, which consist of the mesosphere and ionosphere, differ significantly in composition from the lower regions and also contain a significant proportion of ionized (electrically charged) gas atoms and molecules. (Space Science Division, Naval Research Laboratory, 2003) The following subsections describe each layer of the atmosphere in terms of approximate altitude, temperature, air density, and air composition.

Troposphere

The troposphere is the lowest level of the atmosphere extending from the Earth's surface to approximately 8 to 16 kilometers (5 to 10 miles) in height. The thickness of the troposphere varies based on its location over the Earth, roughly 8 kilometers (5 miles) thick at the poles, and approximately 16 kilometers (10 miles) thick at the equator. The temperature in the troposphere generally drops as altitude increases at an average of 6 degrees Celsius (°C) per kilometer, or 43 degrees Fahrenheit (°F). (NASA, 2003) The upper boundary of the troposphere is the tropopause, which is represented by an area of stable temperatures. (Manchester Metropolitan University, 2000) While not the largest area of the atmosphere, the troposphere is the densest layer and contains up to 75 percent of the atmosphere's mass. The gas composition of the troposphere is made up mainly of molecular nitrogen (N_2), which constitutes 78 percent, and molecular oxygen (O_2), which constitutes 21 percent. Other trace gases such as argon (Ar), carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (NO_2), water (H_2O), and ozone (O_3) are present in the troposphere. (Manchester Metropolitan University, 2000) Due to the Earth's rotation and the available moisture in the troposphere, this is the layer of the atmosphere where weather phenomena occur and climate patterns are experienced.

For the purposes of this PEIS, the discussion of air quality within the troposphere presents the conditions that occur at or below 914 meters (3,000 feet) above ground surface. The altitude of 914 meters (3,000 feet) above ground surface is appropriate for evaluating air quality impacts in the troposphere because the Federal government (EPA) uses that altitude to assess contributions of emissions to the ambient air quality and for the *de minimis* calculations under the Clean Air Act (CAA). (EPA, 1992) The following subsections present a discussion of the pollutants regulated under the CAA (ambient air quality standards for criteria pollutants, air toxics [hazardous air pollutants (HAPs)], and regional haze).

Criteria Pollutants

The primary Federal legislation that addresses air quality is the CAA of 1970 (as amended in 1977 and 1990). The purpose of the CAA is to preserve air quality and to protect public health and welfare. Under the authority of the CAA and amendments, EPA established a set of NAAQS for "criteria" pollutants: carbon monoxide (CO), NO_2, O_3, particulate matter with diameter 10 microns or less (PM_{10}) and 2.5 microns or less ($PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb). The NAAQS established "Primary" standards to protect public health and "Secondary" standards at levels designed to protect the public welfare by accounting for the effects of air pollution on vegetation, soil, materials, visibility, and other aspects of the general welfare. The CAA granted California the authority to set its own Ambient Air Quality Standards (CAAQS) if they are more stringent than the prevailing national standards. The California Clean Air Act of 1988 provides the state with a comprehensive framework for air quality planning regulation. As of 1990, other states became eligible to adopt the California program as their own, but are otherwise prohibited from setting their own emission standards. Federal agencies are required to meet the CAAQS for actions that occur in California or in other states that have adopted the CAAQS, in the same way they are required to meet the NAAQS.

The concentrations of criteria air pollutants are used to determine ambient air quality in the U.S., which are compared against the maximum allowable airborne concentrations specific in the NAAQS for the criteria pollutants. The criteria pollutants are described below.

- **O_3** is a photochemical oxidant and the major component of smog. O_3 is not emitted directly into the air, but formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOCs) and nitrogen oxides (NO_X) in the presence of sunlight. Heavy-duty diesel vehicles (large trucks and buses) are a major source of NO_X emissions. Exposure to O_3 for several hours at relatively low concentrations has been found to significantly reduce lung function and induce respiratory inflammation in normal, healthy people during exercise.

- **CO** is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. Motor vehicles (primarily automobiles) are the largest source of CO emissions nationally. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease.

- **NO_2** is a brownish, highly reactive gas, caused largely by oxidation of the primary air pollutant nitric oxide (NO). NO_2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides (NO_2 and NO) are an important precursor both to O_3 and acid rain and may affect both terrestrial and aquatic ecosystems.

- **SO_2** results largely from stationary sources. High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular disease. SO_2 also is a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, and historic buildings and statues.

- **Particulate Matter (PM)** includes dust, dirt, soot, smoke, and liquid droplets directly emitted into the air, as well as particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO_2 and VOCs. Heavy-duty diesel vehicles (large trucks and buses) are a major source of PM emissions. Exposure to high concentrations of PM can affect breathing and respiratory symptoms, aggravate existing respiratory and cardiovascular disease, alter the body's defense systems against foreign materials, damage lung tissue, and cause carcinogenesis and premature death.

- **Pb** exposure can occur through multiple pathways, including inhalation of air and ingestion of lead in food, water, soil, or dust. Excessive lead exposure can cause seizures, mental retardation, and/or behavioral disorders, and even low doses of lead can lead to central nervous system damage. Because of the prohibition of lead as an additive in liquid fuels, transportation sources are no longer a major source of lead pollution.

Exhibit 3-2 provides the Federal and California Primary and Secondary ambient air quality standards.

Exhibit 3-2. Federal and State Primary and Secondary Ambient Air Quality Standards

Parameter	Standard	National Ambient Air Quality Standard	California Ambient Air Quality Standards	Average Period
Ozone[a]	Primary and Secondary Primary	0.12 ppm (235 μg/m^3) 0.08 ppm (150 μg/m^3)	0.09 ppm (180 μg/m^3) 0.070 ppm (137 μg/m^3)[d]	1-hour average 8-hour average
Particulate matter (PM_{10})	Primary and Secondary Primary and Secondary	150 μg/m^3 50[a] μg/m^3	50 μg/m^3 20[b] μg/m^3	24-hour average Annual average
Fine particulate matter ($PM_{2.5}$)[b]	Primary Primary	65 μg/m^3 15 μg/m^3	— 12 μg/m^3	24-hour average Annual average
Nitrogen dioxide	Primary and Secondary	— 0.053[a] ppm (100 μg/m^3)	0.25 ppm (470 μg/m^3) —	1-hour average Annual average
Sulfur dioxide	—	—	0.25 ppm (655 μg/m^3)	1-hour average
	Secondary	0.50 ppm (1,300 μg/m^3)	—	3-hour average
	Primary	0.14 ppm (365 μg/m^3)	0.04 ppm (105 μg/m^3)	24-hour average
	Primary	0.03 ppm (80 μg/m^3)	—	Annual average
Carbon monoxide	Primary and Secondary	35 ppm (40 mg/m^3)	20 ppm (23 mg/m^3)	1-hour average
	Primary and Secondary	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	8-hour average
Lead	Primary and Secondary	1.5 μg/m^3 —	— 1.5 μg/m^3	3-month average 30-day average
Sulfates	—	—	25 μg/m^3	24-hour average

Exhibit 3-2. Federal and State Primary and Secondary Ambient Air Quality Standards

Parameter	Standard	National Ambient Air Quality Standard	California Ambient Air Quality Standards	Average Period
Hydrogen sulfide	—	—	0.03 ppm (42 $\mu g/m^3$)	1-hour average
Vinyl Chloride	—	—	0.01 ppm (26 $\mu g/m^3$)	24-hour average
Visibility Reducing Particles	—	—	0.23 per kilometer[c]	8-hour average

ppm = Parts per million
$\mu g/m^3$ = Micrograms per cubic meter
— = No standard has been established, or the standard is measured in different units.

[a] The revised ozone standard of 0.08 parts per million (ppm) for an 8-hour averaging period and the standard for $PM_{2.5}$ became effective in September 1997. However, legal challenges have delayed EPA's designation of the attainment or nonattainment areas. On April 15, 2004, EPA designated the counties or partial counties that are in nonattainment for the 8-hour ozone standard. The national 1-hour standard will be revoked one year after the initial designations. Designations for the $PM_{2.5}$ standards became effective April 5, 2005 (U.S. EPA, 2005).

[b] The national standard is an annual arithmetic mean, and the California standard is an annual geometric mean.

[c] This is the extinction coefficient due to particles when relative humidity is less than 70 percent.

[d] This concentration was approved by the California Air Resources Board on April 28, 2005 and is expected to become effective in early 2006. (CARB, 2005) – California Air Resources Board (CARB), Ambient Air Quality Standards Chart (Federal and California), May 6, 2005. Available at: http://www.arb.ca.gov/aqs/aaqs2.pdf

Sources of air pollutants include stationary sources (e.g., industrial facilities, refineries, power plants, launch pads), area sources (which are a collective representation of sources not specifically identified), mobile sources (e.g., motor vehicles, ships, aircraft, off-road engines, mobile platforms), and biogenic (natural) sources (e.g., forest fires, volcanoes).

The size and topography of the air basin, as well as the prevailing meteorological conditions, determine how air pollutants are dispersed. Air currents carry secondary pollution from one region to another, often increasing the background levels of air pollutants for the recipient regions. Such conditions are addressed in the CAA Section 184, which defines an Ozone Transport Region (OTR) that includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington D.C. The emission standards are more protective in OTRs. An example of secondary pollution would be the long distance transport of NO_X and VOCs, which react in the presence of sunlight to form ozone, from one region to another where it would degrade the air quality.

The CAA (42 U.S.C. 7401) requires the adoption of NAAQS to protect the public health, safety, and welfare from known or anticipated effects of criteria air pollutants. According to EPA guidelines, an area with air quality better than the NAAQS is designated as being in attainment, while areas that currently have or have had worse air quality are classified as nonattainment or maintenance areas, respectively. Pollutants in an area may be designated as unclassified when data is lacking for EPA to form a basis of attainment status. Air quality monitors are used to determine compliance with the NAAQS and to evaluate the impact of pollution control strategies. EPA uses the monitoring results to designate areas into the following categories.

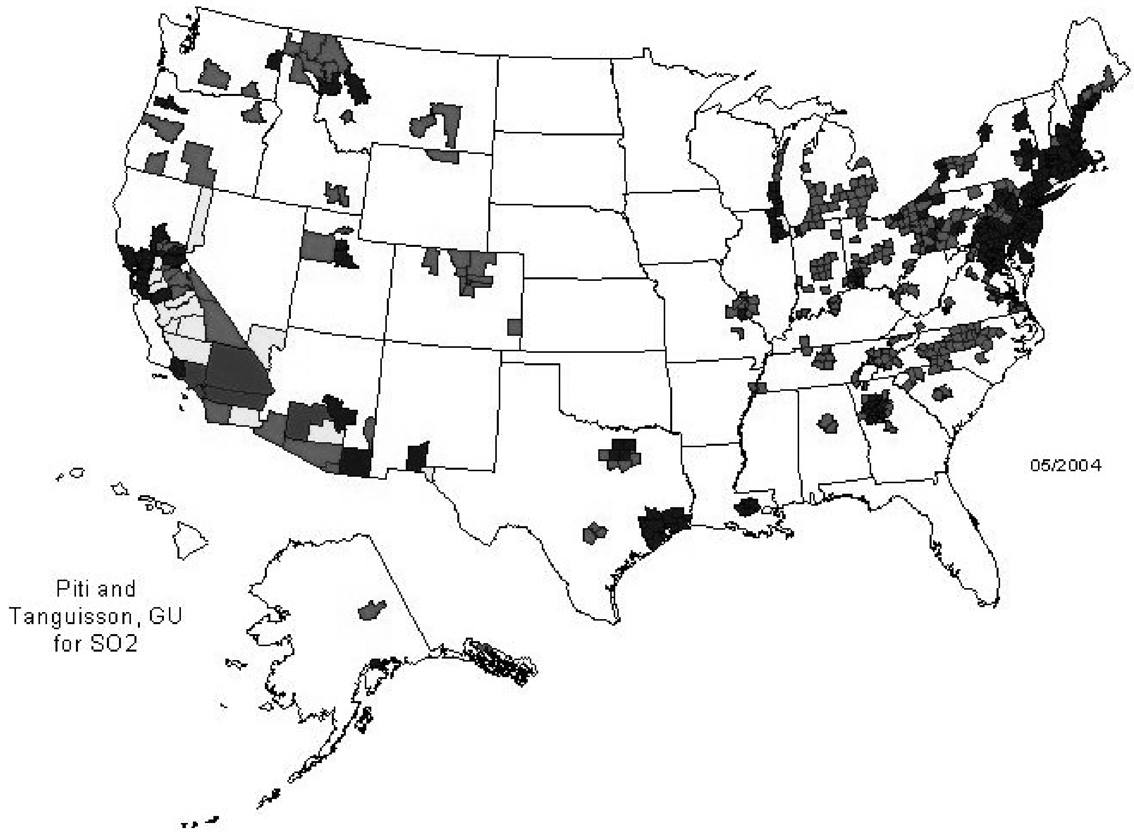
- **Nonattainment Areas** – Locations where measured concentrations exceed the NAAQS. Areas designated as nonattainment for ozone are classified as marginal, moderate, serious, severe, extreme, or Section 185A (previously called transitional). Areas designated as nonattainment for PM or CO are classified as moderate or serious.
- **Maintenance Areas** – Previously designated nonattainment areas that have been redesignated because they have demonstrated compliance with the NAAQS for a period of time.
- **Attainment Areas** – The areas of the country in which ambient pollutant concentrations have always been in compliance with the NAAQS, or have been redesignated after a number of years as a maintenance area.
- **Unclassifiable** – Areas where no ambient monitoring record exists. Most of the areas are rural, remote areas and are assumed to be in attainment.

The present locations of non-attainment areas in the U.S. are indicated in Exhibit 3-3.

The official list of nonattainment areas and a description of their boundaries can be found in the Code of Federal Regulations (40 CFR Part 81) and pertinent Federal Register notices. EPA maintains an unofficial list on the Internet at http://www.epa.gov/oar/oaqps/greenbk/. As of February 2004, there were 68 nonattainment and 69 maintenance areas for ozone, 59 nonattainment and 24 maintenance areas for PM_{10}, 39 nonattainment and zero maintenance areas for $PM_{2.5}$, 11 nonattainment and 65 maintenance areas for CO, 22 nonattainment and 30 maintenance areas for SO_2, eight maintenance areas for Pb, zero nonattainment areas for NO_2, and one maintenance area for NO_2.

For areas that are designated nonattainment, the CAA establishes levels and timetables for each region to achieve attainment of the NAAQS. States must prepare a State Implementation Plan (SIP), which documents how the region will reach its attainment levels by the required date. The SIP includes inventories of emissions within the area and establishes emissions budgets that are designed to bring the area into compliance with the NAAQS. In maintenance areas, the SIP documents how the state intends to maintain compliance with NAAQS.

Exhibit 3-3. Location of Nonattainment Areas for Criteria Pollutants, January 2004



Note: Map is shaded by county to indicate the number of criteria pollutants for which the county is in non-attainment. However, the purpose of this exhibit is to generally illustrate the location of nonattainment areas in the U.S. Source: EPA, 2003b

Air Toxics

In addition to the NAAQS, the CAA also authorizes EPA to regulate emissions of HAPs, also known as toxic air pollutants or air toxics. HAPs are pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. EPA is required to control 188 HAPs; a complete list of these HAPs can be found at http://www.epa.gov/ttn/atw/orig189.html. Two HAPs, hydrogen chloride (HCl) and atomic chlorine (Cl), are sometimes components of rocket engine emissions, depending on the propellant type.

Regional Haze

Under the regional haze rule (64 FR 35714, dated July 1, 1999), states are required to develop SIPs to address visibility at designated mandatory Class I areas, including 156 designated national parks, wilderness areas, and wildlife refuges. General features of the regional haze rule are that all states are required to prepare an emissions inventory of all haze related pollutants (i.e., VOCs, NO_X, SO_2, PM_{10}, $PM_{2.5}$, and ammonia [NH_3]) from all sources in all constituent counties. Most states will develop their regional haze SIP in conjunction with their $PM_{2.5}$ SIP over the next several years. Five states in the Western Regional Air Partnership (WRAP) however, have elected to submit regional haze SIPs under the provisions of Section 309 of the regional haze rule, which includes a clean air corridor (CAC) that extends from Nevada and Utah to Oregon and Idaho. Those preliminary regional haze SIPs were submitted in December 2003. The areas that have opted to implement the Section 309 regional haze SIP option are the states of Arizona, New Mexico, Wyoming, Utah, and Oregon.

Stratosphere

The stratosphere is the second major layer of the atmosphere and occupies the region from 10 to 50 kilometers (6 to 31 miles) above the Earth's surface. The stratosphere also contains the area known as the ozone layer, which is located between 20 to 30 kilometers (12 to 19 miles) above the planet's surface. Ozone plays the major role in regulating the thermal regime of the stratosphere, as H_2O content within the layer is very low. Temperature increases with ozone concentration, as solar energy is converted to kinetic energy when ozone molecules absorb ultraviolet (UV) radiation, resulting in heating of the stratosphere. (NASA, 2003) Air temperature in the stratosphere remains relatively constant up to an altitude of 25 kilometers (16 miles), where it then gradually increases to a temperature of 220 degrees Kelvin (°K) (-53°C) at the lower boundary of the stratopause. (NASA, 2003) The rise in temperature is a result of the layer's absorption of UV radiation that is emitted by the sun.

The stratosphere contains 90 percent of the atmospheric O_3 and acts as a UV radiation shield for the plants and animals on the surface of the Earth. Ozone is made up of three oxygen molecules and is generated by the action of sunlight causing an oxygen molecule (O_2) to combine with an atom of oxygen. The total amount of O_3 in the stratosphere remains relatively constant, but varies in concentration by time and place depending on sunspot activity, season, and latitude. However, O_3 concentrations in the stratosphere have been on a long-term, global downward trend. This downward trend is due to ozone-depleting substances (ODS) such as chlorofluorocarbons (CFCs) and halons, which were formerly used as refrigerants, solvents, and fire extinguishing agents. (EPA, 2004) When these substances reach the stratosphere, UV radiation breaks up the molecules, releasing chlorine and bromine atoms that destroy O_3. One chlorine atom can destroy over 100,000 ozone molecules. Decreasing O_3 levels reduce the effectiveness of the UV shield, and allow more Ultraviolet Radiation Band B (UVB) radiation to reach the Earth's surface. Because UVB radiation is known to be particularly damaging to cellular nucleic acids, this raises the risk of human health problems and biological damage. (NASA, 2003) Aluminum oxide particulates (Al_2O_3) and soot aerosols related to volcanism and wildfires may also provide reaction surfaces for the destruction of O_3. NO_2 also functions as a catalyst for the destruction of O_3 in the stratosphere.

The release of ODS has resulted in an annual ozone hole over Antarctica since the 1980s. In the worst years, the O_3 concentration can be decreased by 60 percent, allowing twice the amount of normal UVB radiation to reach the Earth's surface. (U.S. EPA, 2004) O_3 depletion has become a global issue and has been observed over North America, South America, Europe, Asia, Africa, and Australia. (U.S. EPA, 2004) In response to the decreasing O_3 levels, the U.S. placed a ban on CFC use in aerosol sprays in the 1970s, and in 1994, the U.S. and other developed countries halted all production of halons. Additionally, the U.S. and other developed countries ended the production of CFCs in 1996. In addition the U.S., under the CAA, regulates CO, NO_X, VOCs, and SO_2 because of their role in influencing the formation and destruction of both tropospheric (ground-level) and stratospheric (upper atmosphere) ozone in addition to other ground level air quality issues (see Section 3.1.2).

Global Warming

Global warming refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. Atmospheric gases affect the Earth's surface temperature by absorbing solar radiation that is reflected by the Earth's surface back into space. The concentration of these gases, known as "greenhouse gases," is increasing as a result of human activities. (U.S. EPA Office of Atmospheric Programs, 2001) CO_2 is the most significant greenhouse gas resulting from human activity, which represented approximately 84 percent of total greenhouse gas emissions in 2001.

The largest source of CO_2, and of overall greenhouse gas emissions, is fossil fuel combustion, both from stationary (power plants, industry and manufacturing processes) and mobile sources (automobiles, trucks, construction equipment, lawn mowers). Electric power generation – utilities and non-utilities combined – accounted for the largest source of U.S. greenhouse gas emissions in 2001, closely followed by transportation sources and industrial processes. On an annual basis, the overall consumption of fossil fuels in the U.S., and therefore emissions from the combustion of those fuels, generally fluctuates in response to changes in general economic conditions, energy prices, weather (temperature extremes during winters and summers), and the availability/acceptance of non-fossil fuel alternatives. (U.S. EPA Office of Atmospheric Programs, 2001)

Ozone Depletion

Ozone present in the atmosphere shields the Earth from harmful levels of UV radiation by absorbing part of the UV rays emitted by the sun. Excess levels of UV radiation can result in adverse human health effects ranging from sunburn to skin cancer and immune deficiencies. Most of the UV-shielding ozone layer over the Earth's surface is contained within the stratosphere. (Note that this protective ozone is different from ground-level or tropospheric ozone, which can result in harmful effects to humans and the environment via direct exposure.) Stratospheric ozone can be destroyed through chemical and photochemical reactions. As a result, the presence of pollutants that are key components of these reactions (especially chlorine) can result in ozone depletion. PM may affect stratospheric ozone; however, the exact impact of PM on ozone depletion is unclear.

Mesosphere

The mesosphere is located between 50 and 80 kilometers (31 to 50 miles) above the Earth's surface. The mesosphere is the coldest layer of the atmosphere with the temperature decreasing as the altitude increases. The coldest temperatures at the mesopause (the upper boundary of the mesosphere) can reach -100°C (170°K). (Manchester Metropolitan University, 2000) In the mesosphere objects entering the Earth's atmosphere begin to heat up due to friction with air molecules. (Chabrillat, 2004) O_3 and H_2O are found in negligible concentrations in this layer. The air composition in this layer is made up of lighter gases that are stratified according to their molecular weight due to gravitational separation. (NASA, 2003) Because air thickness is negligible, objects tend to move at high speeds and molecular friction typically causes meteors or space debris to burn up prior to impacting the Earth's surface.

Ionosphere

The ionosphere (also known as the thermosphere) is located above the mesosphere and begins between 85 and 105 kilometers (53 and 65 miles) above the Earth's surface and is considered to extend upwards to 2,000 kilometers (1,243 miles), although it has no well-defined upper boundary. (Lutgens, 1995) The ionosphere accounts for only a fraction of the atmosphere's mass as gas molecules are extremely sparse in this layer. This portion of the atmosphere is known as the ionosphere because radiation causes the scattered gas molecules in this layer to become electrically charged (i.e., they become ions). This layer of the atmosphere is also known as the thermosphere because solar activity, which releases very short-wavelength solar energy, can raise the temperature of the gas molecules to more than 2,000°C (3,632°F). (Lutgens, 1995) While temperatures would seem extreme on a measured scale, heat sensation in the thermosphere is actually relative to the collision of sparse gas molecules with a foreign body. Therefore, a satellite orbiting the Earth in the thermosphere would achieve a temperature based on the amount of solar radiation it absorbs, and not the temperature of the surrounding air. (Lutgens, 1995)

The ionosphere is of practical importance because it is what enables long-distance radio communications on Earth, as the radio waves reflect off the ionosphere. Shorter wavelength radio waves can penetrate the ionosphere, and are used in satellite communications. The upper regions of the ionosphere are also of practical importance because, although the atmospheric density is very low compared to that in the lower atmosphere, it still acts to slow down artificial satellites and limit the length of time a satellite can stay in low-altitude orbits around Earth. (Space Science Division, Naval Research Laboratory, 2003)

The ionosphere is noted for its concentration of ions and free electrons. Gases such as helium (He), Ar, O, O_2, CO_2, atomic nitrogen (N), NO, and N_2 absorb solar radiation passing through the ionosphere and are split into ions and free electrons. (University of Leicester, 2004) The level of ionization depends on sunspot activity, season, geographic location, and the gas being ionized. (National Oceanic and Atmospheric Administration [NOAA], 2004a) As a general rule, ionization increases in the sunlit atmosphere while decreasing in the shadowed atmosphere. The ionosphere is a dynamic system and is influenced by parameters such as acoustic motions of the atmosphere, electromagnetic emissions, and variations in geomagnetic field. (NOAA, 2004)

Beyond the ionosphere, the exosphere starts and continues until it merges with interplanetary gases, or space. The exosphere is considered to be beyond the Earth's atmosphere. In this region, atomic hydrogen (H) and He are the prime components and are only present at extremely low densities. (NASA, 1995)

3.2.1.2 Regulatory Setting

The FAA has the authority to regulate the commercial space activities performed by U.S. citizens and corporations as defined at 49 U.S.C., Subtitle IX, Chapter 701, *Commercial Space Launch Activities*. The FAA regulates commercial space activities by issuing licenses when it determines that an applicant's launch or reentry proposal or proposal to operate a launch site will not jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the U.S. FAA does not license launches performed by and for U.S. government agencies.

FAA reviews a payload proposed for launch to determine whether a license applicant or payload owner or operator has obtained all required licenses, authorization, and permits, unless the payload is exempt from review. The FAA does not review payloads that are subject to regulation by the Federal Communications Commission (FCC) or the Department of Commerce, NOAA; or owned or operated by the U.S. Government. In addition, three international treaties and conventions related to operations and activities in the various layers of the atmosphere and exosphere exist.

- Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967
- Convention on International Liability for Damage Caused by Space Objects, 1972
- Convention on Registration of Objects Launched into Outer Space, 1976

The regulatory setting for the portion of the troposphere regulated under the CAA is presented below.

Criteria Pollutants

A Federal agency cannot support an action (e.g., fund, license) unless the activity will conform to the most recent EPA-approved SIP for the region. The SIP accounts for all the emissions within the federally approved air quality management area that affect ground level air quality. Emissions (e.g., from commercial aircraft or LVs) that occur 914 meters (3,000 feet) above ground level or higher have been found not to affect ground level air quality and are not included in the EPA-approved SIP for the any federally approved air quality management area. Federal agencies whose actions cause emissions of criteria pollutants are required to review those emissions against

- Established *de minimis* levels specified in the regulations. Exhibit 3-4 shows the *de minimis* threshold levels of various nonattainment areas.
- Ten percent of the air quality control area's emissions inventory for any criteria pollutant, as specified in the EPA-approved SIP.

Exhibit 3-4. General Conformity *De Minimis* Levels

Area Designation[a]		Pollutant	*De Minimis* Level in tons per year (metric tons per year)
Ozone	Extreme Nonattainment	NO_X or VOC	10 (9)
	Severe Nonattainment	NO_X or VOC	25 (22)
	Serious Nonattainment	NO_X or VOC	50 (45)
	Other Nonattainment, within OTR	NO_X	100 (90)
	Other Nonattainment, within OTR	VOC	50 (45)
	Other Nonattainment, outside OTR	NO_X or VOC	100 (90)
	Maintenance	NO_X	100 (90)
	Maintenance, within OTR	VOC	50 (45)
	Maintenance, outside OTR	VOC	100 (90)
PM_{10}	Serious Nonattainment	PM_{10}	70 (63)
	Moderate Nonattainment	PM_{10}	100 (90)
	Maintenance	PM_{10}	100 (90)
CO	Nonattainment or Maintenance	CO	100 (90)
SO_2	Nonattainment or Maintenance	SO_2	100 (90)
NO_2	Nonattainment or Maintenance	NO_2	100 (90)
Pb	Nonattainment or Maintenance	Pb	25 (22)

[a] No *de minimis* level has been established for $PM_{2.5}$ yet.

Source: EPA regulations 40 CFR 93.153(b)

Should the Federal action exceed a *de minimis* threshold or be greater than 10 percent of air quality control area's emissions inventory for any criteria pollutant, a general conformity determination is completed in accordance with the CAA. A conformity analysis may involve performing air quality modeling and implementing measures to mitigate air quality impacts.

Air Toxics

Under Title V of the CAA, operators of launch or reentry facilities that emit any of the regulated 188 air toxics from regulated sources would be required to obtain any necessary permits from EPA. Emissions sources covered by the CAA would include pre- and post-launch activities, such as support vehicle and fueling operations. The emissions of a LV or RV during flight do not fall under the regulatory authority of EPA. Under Title V of the CAA, facilities must obtain permits to release regulated air pollutants, including criteria pollutants and toxic air pollutants.

Regional Haze

Under the regional haze rule (64 FR 35714, dated July 1, 1999), states are required to prepare an emissions inventory of all haze related pollutants (i.e., VOC, NO_X, SO_2, PM_{10}, $PM_{2.5}$, and NH_3) from all sources in all constituent counties. Should the emission of haze related pollutants exceed the levels of a SIP, then measures would be implemented to reduce the emission of the haze related pollutant.

Climate Change

No specific regulatory standards for climate change exist. Various international treaties and agreements have been developed but the U.S. is not party to such agreements.

3.2.2 Airspace

3.2.2.1 Definition and Description

Airspace refers to the space that lies above a nation and comes under its jurisdiction. Airspace is a finite resource that can be defined vertically and horizontally, as well as temporally. Time is an important factor in airspace management and air traffic control. The FAA has established various airspace designations to protect aircraft while operating near and between airports and while operating in airspace identified for defense-related purposes. Flight rules and air traffic control procedures govern safe operations in each type of designated airspace. Military operations follow specific procedures to maximize flight safety for both military and civil aircraft.

The types of airspace are defined by the complexity or density of aircraft movements, the nature of operations conducted within the airspace, the level of safety required, and the national and public interest in the airspace. The classes of airspace are controlled, uncontrolled, special use, and other airspace, as defined in Exhibit 3-5.

Exhibit 3-5. Definitions of Airspace Categories

Category	Definition	Examples
Controlled Airspace	Airspace used by aircraft operating under Instrument Flight Rules (IFR) that require different levels of air traffic service	Altitudes above Flight Level (FL) 180 (5,500 meters [18,000 feet] above MSL) Airport Traffic Areas, Airport Terminal Control Areas, Jet Routes, Victor Routes
Uncontrolled Airspace	Airspace primarily used by general aviation aircraft operating under Visual Flight Rules (VFR)	As high as 4,420 meters (14,500 feet) above MSL
Special Use Airspace	Airspace within which specific activities must be confined or access limitations are placed on non-participating aircraft	Restricted Areas Military Operations Areas (MOA)
Other Airspace	Airspace not included under controlled, uncontrolled, or special use categories	Military Training Routes (MTR)

Controlled Airspace. Controlled Airspace covers airspace used by aircraft operating under IFR that require different levels of air traffic service. As shown in Exhibit 3-5, examples of controlled airspace include the altitudes above FL180 (approximately 5,500 meters [18,000 feet]) above MSL, some Airport Traffic Areas, and Airport Terminal Control Areas. General controlled airspace includes the established Federal airways system, which consists of the high altitude (Jet Routes) system flown above FL180, and the low altitude structure (Victor Routes) flown below FL180.

Controlled airspace has numerous designations from Class A to Class G depending upon the degree of airspace control required to maintain flight safety. Airspace in North America contains "North American Coastal Routes," which are numerically coded routes preplanned over existing airways and route systems to and from specific coastal fixes. North American Routes consist of

- **Common Route/Portion.** That segment of a North American Route between the inland navigation facility and the coastal fix.
- **Noncommon Route/Portion.** That segment of a North American Route between the inland navigation facility and a designated North American terminal.
- **Inland Navigation Facility.** A navigation aid on a North American Route at which the common route and/or the noncommon route begin or end.
- **Coastal Fix.** A navigation aid or intersection where an aircraft transitions between the domestic route structure and the oceanic route structure.

During peak air travel times in the U.S., about 5,000 airplanes are in the sky every hour. This translates to approximately 50,000 aircraft operating in U.S. skies each day. The U.S. airspace is divided into 21 zones (centers), and each zone is divided into sectors. Also within each zone are portions of airspace, about 81 kilometers (50 miles) in diameter, called Terminal Radar Approach Control (TRACON) airspaces. Multiple airports exist within each TRACON airspace and each airport has its own airspace with an 8-kilometer (5-mile) radius.

Uncontrolled Airspace. Uncontrolled Airspace is primarily used by general aviation aircraft operating under VFR and generally refers to airspace not otherwise designated and operations below 366 meters (1,200 feet) above ground level. Uncontrolled airspace is not subject to the strict conditions of flight required by those aircraft using controlled airspace and can extend as high as 4,420 meters (14,500 feet) above MSL.

Special Use Airspace. Special Use Airspace is airspace within which specific activities must be confined or for other reasons, access limitations are imposed upon non-participating aircraft. The types of Special Use Airspace are

- **Alert Areas.** Alert areas are airspace in which a high volume of pilot training activities or unusual aerial activity takes place. The activities within alert areas are not considered hazardous to aircraft and are conducted in accordance with FAA regulations. Both participating and transiting aircraft are responsible for collision avoidance. (FAA, 2004)

- **Restricted Areas.** Restricted areas contain airspace identified by an area on the surface of the Earth within which the flight of aircraft, while not wholly prohibited, is subject to restriction. Activities within these areas are confined to permitted activities and limitations are imposed upon all other aircraft operations. Restricted areas generally are used to contain hazardous military activities. The term "hazardous" implies, but is not limited to, weapons deployment (these areas also are referred to as controlled firing areas and may be either live or inert), aircraft testing, and other activities that would be inconsistent or dangerous with the presence of non-participating aircraft.

- **MOAs.** MOAs include airspace designated for non-hazardous military activities and are established outside of controlled airspace below FL180. Typical activities that occur in MOAs include military pilot training, aerobatics, and combat tactics training. When MOAs are in use, non-participating aircraft flying under IFR clearances are directed by air traffic control to avoid the MOA. However, even when a MOA is in use, entry into the area by VFR aircraft is not prohibited, and flight by non-participating aircraft can occur on a see-and-avoid basis.

- **Prohibited Areas.** Prohibited areas include airspace where no aircraft may be operated without the permission of the using agency. This airspace is established for security and other national welfare reasons. (FAA, 2004)

- **Warning Areas.** Warning areas include airspace that may contain hazards to non-participating aircraft in international airspace. Warning areas are established beyond the 22-kilometer (12-nautical-mile) limit. Although the activities conducted within warning areas may be as hazardous as those in restricted areas, warning areas cannot be legally designated as restricted areas because they are over international waters. By Presidential Proclamation No. 5928, December 27, 1988 (issued in 1989), the U.S. territorial limit was extended from 5.6 to 22 kilometers (3 to 12 nautical miles). Special Federal Aviation Regulation 53 establishes certain regulatory warning areas within the new (5.6- to 22-kilometer [3- to 12-nautical-mile]) territorial airspace to allow continuation of military activities while further regulatory requirements are determined.

Other Airspace. Other Airspace includes MTRs. They are low altitude, high-speed routes established by the FAA as airspace for special use by the military services. Routes may be established as IFR Routes or VFR Routes. MTRs are depicted on aeronautical charts and detailed descriptions are provided in the Department of Defense (DoD) Flight Information Publication AP/1B.

En route airways and jet routes are air corridors used by commercial and private aircraft. These corridors are generated based on the prevailing jet stream and their positions vary. The airways are identified by a "V" and a number designation and apply to altitudes up to 5.5 kilometers (18,000 feet). Jet routes are identified by a "J" and a number designation and apply to altitudes over 5.5 kilometers (18,000 feet).

Airspace over the BOA is governed by the procedures of the International Civil Aviation Organization (ICAO), outlined in ICAO Document 444, *Rules of the Air and Air Traffic Services*. The FAA acts as the U.S. agent for aeronautical information to the ICAO. Document 444 is the equivalent of the domestic manual for air traffic control, FAA Handbook 7110.65, Air Traffic Control.

3.2.2.2 Regulatory Setting

All alterations and temporary closures of existing airspace are processed through the FAA. The FAA reviews and approves all such modifications. Use of restricted airspace and warning areas requires the issuance of a Notice to Airmen (NOTAM), which provides notice to all aircraft of the restricted or warning area via air traffic control. The FAA is the designated agency that coordinates the airspace activities with the ICAO.

International airspace is regulated by the ICAO, outlined in ICAO Document 444, *Rules of the Air and Air Traffic Services*, which includes airspace beyond the 22-kilometer (12-nautical mile) limit. The FAA defines the ICAO as a "specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transport." (FAA, 2004b) To accomplish these objectives, the ICAO's main activities include standardization of international standards, recommended practices, and procedures; development of communication, navigation, surveillance/air traffic management (CNS/ATM) systems; regional planning of air navigation facilities and services; facilitating international standards on customs and immigration; and technical assistance. (ICAO, 2004) Currently, 188 countries are members of the ICAO. Regions that make up international airspace include the African-Indian Ocean Region, Caribbean Region, Europe Region, Middle East/Asia Region, North American Region, North Atlantic Region, Pacific Region, and South American Region. (FAA, 2004a)

3.2.3 Biological Resources

3.2.3.1 Definition and Description

Biological resources include terrestrial and aquatic plants and animals and the various ecosystems that they inhabit. Plants range from single-celled algae and plankton to more complex multicellular angiosperms (flowering plants) and gymnosperms (non-flowering seed plants). Animals include single-cell protozoa up through multicellular aquatic and terrestrial organisms.

Terrestrial Plants and Animals

Terrestrial plants are located throughout most of the world. Plants tend to be limited by temperature and will not grow at high latitudes or altitudes due to the cold climates. Terrestrial plants tend to have growing cycles in temperate climates, resting dormant in the winter and then flowering in the spring. Deciduous plants lose their foliage in the fall. Conifers (evergreens) do not lose their foliage during the winter season, though they do not grow or flower in the winter. In tropical climates plants may grow all year round, though they tend to flower at specific times of the year. Currently, a total of 746 species of plants are listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS) and are afforded protection under the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 *et seq*.). (USFWS, 2004)

Terrestrial wildlife inhabits all the contents on Earth. Characteristics that are common to the more advanced animals (e.g., reptiles, mammals, birds) include migratory patterns, specific breeding areas and times, foraging areas and specific ranges of distribution. Such animals tend to establish home ranges and distribution patterns based on quality of the available habitat and its ability to support a particular population size. Scarce resources and/or low quality or degraded habitat tend to preclude wildlife habitation or cause existing wildlife to abandon such areas. However, a host of wildlife species typically referred to as “pests” are able to thrive in low quality or degraded habitats. Currently, a total of 519 species of plants are listed as threatened or endangered by the USFWS and are afforded protection under the ESA. (USFWS, 2004)

Aquatic Plants and Animals

Aquatic plants tend to be located close to shorelines and are limited in depth by light penetration (photic zone) and in range by water temperature. Located in the region between uplands and the open water are a host of terrestrial plants that have become tolerant to living in seasonally or permanently wet conditions. Cordgrasses and mangroves are examples of terrestrial plants that have adapted to have their bases and roots submerged in saltwater, while their leaves are always in the open air. These plants expel excess salt through special pores, which allow them to live in the salt water. The plants’ root systems help to hold mud together, which would otherwise be washed away with the tides. The mud creates a habitat specific to wetland areas and is required for a number of species to live in during varying parts of their life cycle. Algae belong to the kingdom Protista and are eukaryotes, which carry out photosynthesis and may be unicellular or multicellular. Algae are found throughout the ocean within the water depth to which light penetrates (photic zone).

Aquatic wildlife includes fish, crustaceans (shrimp, lobsters, crabs), bivalves (clams) as well as various birds (gulls, pelicans, penguins, puffins), and marine mammals (whales, walruses, seals). Aquatic birds are differentiated from the terrestrial ones in that they tend to spend the majority of their time living and feeding in aquatic environments, though they still lay their eggs on the land. Aquatic birds are found all over the world. Aquatic mammals include animals that spend part of their time on land and sea like seals, sea lions, walruses, and sea otters, and those that spend their entire life in the ocean like dolphins, whales, and manatees. Marine mammals are found all over the world’s oceans. Marine reptiles are similar to their terrestrial counterparts except that they live primarily, and in some cases entirely, at sea. Examples would include sea turtles, sea snakes, and marine iguana. Marine reptiles are again limited in their range due to the inability to regulate their own body temperature. Fish are located throughout all aquatic ecosystems. Fish spend their entire lives at sea, and breathe oxygen through the use of gills that remove oxygen from water as it passes over the gills. As with the terrestrial animals, seasonal habits, migration patterns, and breeding times are species-specific.

3.2.3.2 Regulatory Setting

The ESA is the primary law that addresses biological resources, (see Appendix C, Applicable Legal Requirements, for additional information). The USFWS administers the ESA, which states that all Federal departments and agencies shall seek to conserve endangered and threatened species. Included with the protection of the animals themselves is a concern for their critical habitat. Critical habitat is defined as specific area within the geographical area occupied by a species at the time it is listed and includes areas that are essential to conservation of the species. State-listed threatened and endangered species are afforded protection in accordance with state-specific regulations.

Other Federal regulations designed to protect the nation's biological resources include

- *The Fish and Wildlife Coordination Act* of 1958 (16 U.S.C. 661 *et seq.*) promotes the conservation of non-game fish and wildlife and their habitats to all Federal departments and agencies.

- *The Migratory Bird Treaty Act* of 1918, as amended (16 U.S.C. 703-712), protects migratory birds by prohibiting actions such as hunting, capturing, or killing the listed species or their nests and eggs.

- *The Bald and Golden Eagle Protection Act* (16 U.S.C. 668 *et seq.*) specifically protects the two species from unauthorized capture, purchase, transportation, etc. of the birds, their nests, or their eggs. Any action that might disturb the eagles would require notification of the USFWS for appropriate mitigation measures.

- *The Marine Mammal Protection Act* of 1972 was most recently reauthorized in 1994. The purpose of the Act is to protect marine mammals from human activities. The Act established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, and on the importing of marine mammals and marine mammal products into the U.S.

- *The Magnuson-Stevens Fishery Conservation and Management Act* of 1976 governs the conservation and management of ocean fishing. The Act establishes exclusive U.S. management authority over all fishing within the exclusive economic zone (EEZ), all anadromous fish throughout their migratory range (except when in a foreign nation's waters), and all fish on the Continental Shelf. Each individual site may be subject to further state and local regulations.

3.2.4 Cultural Resources

3.2.4.1 Definition and Description

Cultural resources includes prehistoric and historic structures, artifacts, or archaeological sites. Cultural resources also include underwater sites, burial sites, and Native American/Hawaiian religious sites. Historic properties are defined as artifacts, archaeological sites, standing structures, or other historic resources listed, or potentially eligible for listing, on the National Register of Historic Places (National Register). Paleontological resources are fossil remains of prehistoric plant and animal species and may include shells, bones, leaves, and pollens.

3.2.4.2 Regulatory Setting

Section 101(b)(4) of NEPA established a Federal policy for the conservation of historic and cultural, as well as the natural, aspects of the nation's heritage. Regulations implementing NEPA stipulate that Federal agencies must consider the consequences of their undertakings on cultural resources that are included or eligible for inclusion on the National Register. (40 CFR Part 1502.16[g]) The terminology… "eligible for inclusion in the National Register" includes all properties that meet the specifications set forth in Department of Interior (DOI) regulations at 36

CFR 60.4. These guidelines are promulgated under Section 106 of the National Historic Preservation Act (NHPA) in 16 U.S.C. 470 *et seq.* Requirements of Section 106 include

- The identification of significant historic properties or sites of cultural significance that may be adversely impacted by a proposed action or undertaking,
- Consultation with the applicable State and/or Tribal Historic Preservation Officer, and as necessary, the Advisory Council on Historic Preservation, and
- The development of mitigation measures.

In addition to 36 CFR 60.4, numerous other parts under 36 CFR should be addressed:

- Part 60 – National Register
- Part 61 – State and local preservation programs
- Part 62.1 – National natural landmarks
- Part 63 – National Register
- Part 65 and 65.1 – National Historic Landmarks
- Part 68 – Standards
- Part 73 – World Heritage Program
- Part 78 – Waiver of Federal agency section 110 responsibilities
- Part 79 – Curation
- Part 800 – Consultation (as revised; 65 FR 77697)

In addition to compliance with Section 106, a site-specific analysis should also consider EO 13287, Preserving America. EO 13287 provides government directives for the goals of the protection, enhancement, and contemporary use of federally owned historic properties by promoting intergovernmental cooperation and partnerships for the preservation and use of such resources. EO 13287 states… “Agencies shall maximize efforts to integrate the policies, procedures, and practices of the NHPA and this order into their program activities in order to efficiently and effectively advance historic preservation objectives in the pursuit of their missions.”

A Traditional Cultural Property (TCP) is defined by the National Park Service (NPS) as a property or place that is eligible for inclusion on the National Register because of its association with cultural practices and beliefs that are (1) rooted in the history of a community, and (2) important to maintaining the continuity of that community’s traditional beliefs and practices.

EO 13007 defines an Indian Sacred Site as “any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion; provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site.” (61 FR 26771) Under EO 13007, Federal agencies, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, must: (1) accommodate access to and ceremonial use of Indian Sacred Sites by Indian religious practitioners, and (2) avoid adversely affecting the physical integrity of such sacred sites.

Additional statutes, regulations, and other requirements should be considered per FAA Order 1050E.

- Executive Order 11593, Protection and Enhancement of the Cultural Environment (36 FR 8921)
- Antiquities Act of 1906 (16 U.S.C. 431-433) – codified at 43 CFR part 3 as the Preservation of American Antiquities
- Archaeological and Historic Preservation Act of 1974 (16 U.S.C. 469-469c)
- Guidelines for Archeology and Historic Preservation: Standards and Guidelines (48 FR 44716)
- Standards for the Treatment of Historic Properties under the National Park Service (36 CFR part 68)
- Protection of Archeological Resources (43 CFR part 7), including part 7.7, Notification to Indian tribes of possible harm to, or destruction of, sites on public lands having religious or cultural importance
- Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001) – codified at 43 CFR part 10
- Protection and Custody of Archaeological Resources, under Indians, Heritage Preservation (25 CFR part 262 and 25 CFR part 262.8); also Notice to Indian tribes of possible harm to cultural or religious sites under part 262.7
- American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996)
- Department of Transportation Act (49 U.S.C. 303)
- Public Building Cooperative Use Act of 1976 (40 U.S.C. 601 *et seq.*) and codifications at 41 CFR parts 101-17 through 101-19
- Executive Order 13006, Locating Federal Facilities on Historic Properties in Our Nation's Central Cities (61 FR 26071)
- Executive Order 13175, Consultation and Coordination with Indian Tribal Governments (65 FR 67249)
- Presidential Memorandum of April 29, 1994, Government-to-Government Relations with Native American Tribal Governments
- Executive Order 11593, Protection and Enhancement of the Cultural Environment (36 FR 8921)

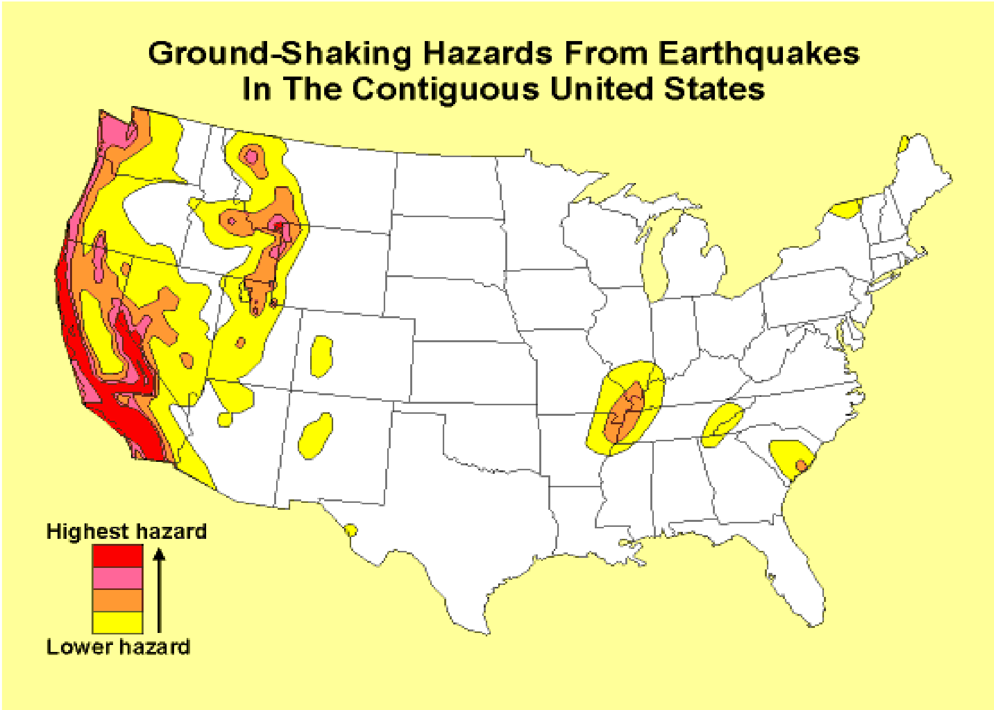
3.2.5 Geology and Soils

3.2.5.1 Definition and Description

Geology

Geology and soils are those Earth resources that may be described in terms of landforms, geology, and soil conditions. The makeup of geology and soils within a given physiographic region influences the occurrence of vegetation types, the presence of mineral or energy resources, the presence of ground water resources, and the potential for seismicity and associated risks such as earthquakes and landslides. Exhibit 3-6 shows the geographic distribution for earthquakes in the continental U.S.

Exhibit 3-6. Geographic Distribution for Earthquakes in the Continental U.S.



Source: USGS, 2002

Geology is the study of the composition and configuration of the Earth's surface and subsurface features. The general shape and arrangement of a land surface, including its height and the position of its natural and man-made features, is referred to as topography. The topography of the land surface affects the general direction of surface water and ground water flow. Ground water is stored and transmitted underground in aquifers that supply lakes and rivers and is often used for human purposes, such as drinking water and irrigation for crops.

Soils

Soil is defined as the surface layer of the Earth, composed of minerals and fine rock material disintegrated by geological processes and humus, the organic remains of decomposed vegetation. Soils and sediments are typically described in terms of their composition, slope, and physical characteristics. Differences among soil types in terms of their structure, organic and chemical properties, elasticity, strength, shrink-swell potential, and erosion potentially affect their ability to support or sustain agricultural, structural, filtration, and natural detoxification purposes. The U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) has classified over 20,000 types of soils in the U.S., including areas classified as prime and unique farmlands. Information pertaining to a given area's soil types is typically available from county soil surveys. The three principal types of soil are clay, sand, and loam. Factors determining the nature of soil are vegetation type, climate, parent rock material, elevation, and the geological age of the developing soil. Soil and sediment characteristics vary significantly depending upon their physical location and can be compounded by environmental factors. For example, some soils in the U.S. are naturally more acidic than others in the country. However, soils such as those in New England have been impacted from transboundary air emissions of NO_X, SO_2, and other pollutants that emanate from the Midwest and Ohio Valley and are deposited into the regional soils. (Driscoll, 2001)

3.2.5.2 Regulatory Setting

Geology

No specific regulatory standards pertain to geology other than best management practices (BMPs) and building codes that must be adhered to within seismic zones. However, no activities associated with the proposed action would involve ground altering, subsurface disturbances, or the implementation of any structures.

Soils

While the USDA has designated specific soils as prime and unique farmlands, no additional regulations govern soils. State-implemented BMPs are in place to control erosion and prevent runoff and stream sedimentation. Activities associated with the proposed action that could affect soils are consistent with pre- and post-launch emissions (e.g., HCl, SO_2, and NO_X) and impacts to air quality.

3.2.6 Hazardous Materials and Waste

3.2.6.1 Definition and Description

Hazardous materials and hazardous waste are defined by a number of U.S. regulatory agencies. In general, hazardous materials and hazardous waste include substances that, because of their quantity, concentration, or physical, chemical, or infectious characteristics, may present substantial danger to the public health, welfare, or the environment when released. EPA regulates hazardous chemicals, substances, and wastes under the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the Toxic Substances Control Act. Underground storage tanks (USTs) containing regulated substances, including petroleum products and those hazardous substances included in CERCLA are subject to the requirements of RCRA Subtitle I. Tanks used to store hazardous wastes are regulated under RCRA's hazardous waste regulations. Currently, 28 states have approved UST programs, meaning owners and operators are subject to Federal and state requirements. No single comprehensive regulation governs aboveground storage tanks. Federal laws that regulate aboveground storage tanks include the CWA, the Oil Pollution Act (OPA), the CAA, and RCRA. The specific regulatory requirements depend on the substances contained in the tanks. Also, many states have stringent requirements for aboveground storage tanks.

In addition, the Occupational Safety and Health Administration (OSHA) has definitions and workplace safety-related requirements and thresholds for listed "hazardous and toxic substances," (OSHA, 2004), and DOT has definitions and requirements for the safe transport of "hazardous materials." (U.S. DOT, 1997)

Hazardous Materials Management. Hazardous materials management is the responsibility of the cognizant authority that is operating facilities and installations. Maintenance and flight support operations at various locations may require the use of products containing hazardous materials, including paints, solvents, oils, lubricants, acids, batteries, fuels, surface coatings, and cleaning compounds. These products would be used and stored at appropriate locations throughout each site, but would be primarily associated with industrial and maintenance activities. Site-specific plans would outline the strategies and procedures for storing, handling, and transporting hazardous materials in addition to responding to on-site or off-site spills.

Hazardous Waste Management. Federal and state regulations require that hazardous waste be handled, stored, transported, disposed of, or recycled in compliance with applicable regulations. Aircraft and vehicle maintenance, fuel storage and dispensing, and facility and grounds maintenance activities are activities that could generate hazardous wastes. The sources of hazardous waste include waste fuel, waste oils, spent solvents, paint waste, and used batteries. Site-specific procedures and plans would outline the steps for appropriate management of hazardous wastes, such as satellite accumulation points and properly labeled DOT-approved containers. Wastes may be disposed of using designated hazardous waste accumulation facilities or private hazardous waste contractors, as needed.

3.2.6.2 Regulatory Setting

EPA enforces RCRA and CFR Title 40 §§ 260 through 272, which provide requirements for the generation, storage, transportation, treatment, and disposal of hazardous waste. EPA and various states have regulations regarding the operation and maintenance of USTs and aboveground storage tanks.

3.2.7 Health and Safety

3.2.7.1 Definition and Description

Health and safety includes consideration of any activities, occurrences, or operations that have the potential to affect the well being, safety, or health of workers or members of the general public. Overall public health and safety is controlled by a host of legislation that regulates transportation of hazardous cargo, provides for the protection of workers in the work place, protects the public from exposure to hazardous materials, and provides for emergency preparedness.

The primary objective of the FAA's commercial space transportation licensing program is to ensure public health and safety through the licensing of commercial space launches and reentries, and the operation of launch facilities. Protection of public health and safety and the safety of property is the objective of FAA's licensing and compliance monitoring/safety inspection processes. As detailed in Section 1.2.1, the components of the FAA licensing process include a pre-licensing consultation period and an application evaluation period that consists of a policy review, payload review, safety evaluation, financial responsibility determination, and an environmental review. The FAA issues a license when it determines that an applicant's launch or reentry activities or proposal to operate a launch facility will not jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the U.S. The FAA does not license launches performed by, or with substantive involvement of, U.S. government agencies.

3.2.7.2 Regulatory Setting

OSHA regulations and NASA Safety Program requirements are applicable as well as the FAA regulations at 14 CFR Parts 400-450. DoD Range Safety Standards (Range Commanders Council Standard 321-02) apply to such activities occurring at DoD facilities.

3.2.8 Land Use

3.2.8.1 Definition and Description

Land Use

EPA defines land use as… "the way land is developed and used in terms of the kinds of anthropogenic activities that occur (e.g., agriculture, residential areas, industrial areas)." (EPA, 2003) Humans develop land for a variety of purposes that can include economic production, natural resource protection, or institutional uses. Land use in the U.S. is typically regulated in some manner by land use plans, policies, or ordinances that stipulate the permissible uses within an area. Such land classification types can include agricultural, forestry, urban, inland water bodies, and other categories. Land use classifications are then often sub-classified for more specific purposes such as low-density residential or light industrial uses.

Regulations regarding land use can occur on a local, state, or Federal level to manage military installations, or to protect sensitive areas such as historic properties, prime or unique farmlands, national parks, wildlife refuges, or other areas that are afforded special status. However, land use planning and regulations that designate acreages or parcels for residential, commercial, or industrial uses generally occur at the local and municipal level. Additionally, lands categorized as "public use" may also carry special use designations, for which management guidance is provided. The Federal land management agencies (Forest Service, Bureau of Land Management [BLM], USFWS, and NPS) have a variety of land management plans (e.g., the Forest Service develops Forest Management Plans). "Public use" land use designations can include

- Controlled use or wilderness areas,
- Limited use areas that are designed to protect sensitive natural, physical, biological, or cultural resource values,
- Low intensity areas, which are designed to control multiple uses of resources so that no sensitive values are diminished,
- Moderate use areas that provide a controlled balance between higher intensity land uses and resource protection, and
- Intensive use areas, which are designed to accommodate the concentrated use of land and resources to meet human needs.

Section 4(f) Resources

The Federal statute that governs impacts on any publicly owned land is commonly known as the DOT Act, section 4(f) provisions, although it was recodified and renumbered as section 303(c) of 49 U.S.C. This order continues to refer to section 4(f) because it would create needless confusion to do otherwise; the policies section 4(f) engendered are widely referred to as "section 4(f)" matters. Appendix A of FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures*, summarizes the following about Section 4(f) of the DOT Act:

> The Secretary of Transportation will not approve any program or project that requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance or land from an historic site of national, state, or local significance as determined by the officials having jurisdiction thereof, unless no feasible and prudent alternative exists to the use of such land and such program, and the project includes all possible planning to minimize harm resulting from the use.

3.2.8.2 Regulatory Setting

Land Use

Land use management practices are subject to mandates of the controlling agency, while non-Federal lands are often subject to the collective guidance and regulations of local, county, and state entities. Land use management and planning approaches are intricate processes that seek to provide protection of resource values that may be present on-site as well as off-site in the surrounding community.

The Farmland Protection Policy Act (FPPA) (7 U.S.C. 4201-4209) requires the cooperation of Federal agencies to minimize their contribution to the unnecessary and irreversible conversion of farmland to non-agricultural uses and to be compatible with state and local government, and private programs and policies to protect farmland. The USDA National Conservation Resource Service (NRCS) classifies farmland as prime farmland, unique farmland, and land of statewide or local importance. (USDA, 2004) Farmland subject to the FPPA requirements does not have to be currently used for farming. It can be forest land, pastureland, cropland, or other land, but not water or developed urban land. NRCS uses a land evaluation and site assessment system to establish a farmland conversion impact rating score on proposed sites of federally funded and assisted projects. (USDA, 2004) Based on this score, if the potential adverse impacts on the farmland exceed the recommended allowable level, then the project sponsor must consider alternative sites or implement measures to minimize impacts. (USDA, 2004)

Section 4(f) Resources

The FAA shall not approve any program or project which requires the use of any section 4(f) resource, including publicly owned land from a public park, recreation area, wildlife or waterfowl refuge of national, state, or local significance as determined by the Federal, state, or local officials having jurisdiction thereof, or any land from an historic site of national, state, or local significance as so determined by such officials unless (1) no feasible and prudent alternative exists to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreation areas, wildlife and waterfowl refuge, or historic sites resulting from such use. In carrying out the national policy, the FAA shall cooperate and consult with the Secretaries of the Interiors, Housing and Urban Development, and Agriculture, and with the states regarding potential impacts on such resources.

3.2.9 Noise

3.1.9.1 Definition and Description

The FAA defines noise as sound that is unwanted and that disturbs routine activities and peace and quiet and can cause annoyance. Three characteristics are used to measure noise: amplitude, frequency, and duration. Amplitude is the intensity of the noise and is described in units called decibels (dB). Frequency measures the number of wavelengths that are received over a period of time. High frequency noises have a high number of wavelengths per time period, and low frequency noises have fewer wavelengths per time period. Examples of high frequency noises are those from jet engines or train whistles. Low frequency noises can be sonic booms and blast noises. Duration is simply the length of time over which the noise continues. Common metrics for quantifying noise include A-weighted decibel levels (dBA), which are specific to the sensitivity of the human ear, as well as community and day-night noise levels, which are averaged noise levels over a particular period of time. Exhibit 3-7 presents some common noise sources and their decibel levels (in dBA) along with typical noise sources and their associated noise levels associated with launch and reentry activities.

Exhibit 3-7. Comparison of Noise Levels from Common Noise Sources

dBA	Overall Level	Outdoor Noise Level	Indoor Noise Level
120	Uncomfortably Loud	Military jet aircraft take off from aircraft carrier at 15 meters (50 feet)	Oxygen torch
110	Very Loud	Turbo fan aircraft at take off at 61 meters (200 feet)	Rock band
100		Boeing 707 or DC-8 aircraft at one nautical mile, Jet flyover at 305 meters (1,000 feet), Bell J-2A helicopter at 30 meters (100 feet)	-
90	Moderately Loud	Boeing 737 or DC-9 aircraft at 2 kilometers (one nautical mile), power lawnmower, Motorcycle at 8 meters (25 feet)	Newspaper press

Exhibit 3-7. Comparison of Noise Levels from Common Noise Sources

dBA	Overall Level	Outdoor Noise Level	Indoor Noise Level
80		Propeller plane flyover at 305 meters (1,000 feet), Diesel truck at 64 kilometers per hour (40 miles per hour) at 15 meters (50 feet)	Blender, Garbage disposal
70		High urban ambient sound, Passenger car 105 kilometers per hour (65 miles per hour) at 8 meters (25 feet)	Radio, TV, vacuum cleaner
60	Quiet	Air conditioning unit at 30 meters (100 feet)	Dishwasher at 3 meters (10 feet), Conversation
50		Large transformers at 30 meters (100 feet)	Dishwasher in next room
40	Just audible	Lowest levels of urban ambient sound	Small theater Large conference room
10		-	Broadcast and recording studio
0	Threshold of Hearing	-	-

Source: Modified from FAA, 2001

Engine Noise

Noise associated with rocket engines is produced when the propellant is consumed and exhausted into the atmosphere. During take off, the noise from rocket engines on vertically launched LVs has been measured at 80 to 120 dBA at a distance of 4.8 kilometers (3 miles) from the launch pad. Noise associated with LVs and RVs in motion is governed by the combustion process, dynamics of the exiting gases, and flight parameters. As the vehicle ascends, two principles combine to reduce the ground noise levels: (1) separation distance increases; and (2) the air becomes thinner and therefore less capable of transmitting noise. As an RV descends, the reverse occurs, the separation distance decreases and the air becomes denser and therefore more capable of transmitting noise. However, the speed of the RV begins to decrease as it approaches the surface of the Earth, dropping below supersonic speeds.

Sonic Boom

Sonic booms occur when an LV, RV, or jet aircraft exceeds the speed of sound (Mach 1). At sea level in the standard atmosphere, the speed of sound is 340,294 meters per second (1,116 feet per second). (NASA, 2003) Normally, as the vehicle travels through the air, the air is displaced to make room for the vehicle, and the air returns as the vehicle passes. When traveling below the speed of sound, a pressure wave precedes the vehicle and initiates displacement; however, when the vehicle exceeds the speed of sound, the pressure wave cannot keep up and, as a result, the parting of air from the vehicle is abrupt. This creates a shock wave at the front of the vehicle when the air is displaced and also at the rear of the vehicle as the air returns to the unoccupied space. The shockwave resulting from supersonic flight creates a sonic boom. Sonic booms are produced without warning. (UGA/Media, 2004)

Sonic booms create pressure waves or shock waves that are measured in overpressures (Newtons per square meter [pounds per square foot]). Overpressures are highest in intensity directly over the flight path of the vehicle, and the intensity of the sonic boom decreases with increasing lateral distance from the flight path. The lateral distance at which the sonic boom no longer reaches the ground is called the lateral cutoff distance. The intensity and the duration of the sonic boom depend on the size of the vehicle and how the vehicle is operated. The larger the vehicle, the higher the intensity and the longer the duration of the sonic boom. Larger vehicles displace more air molecules, thus creating a more intense sonic boom.

The duration of a sonic boom is brief. A fighter plane-sized vehicle can create a sonic boom lasting 100 milliseconds while a space shuttle sized-vehicle can create a sonic boom lasting 500 milliseconds. (UGA/Media, 2004) In general, the lower the altitude at which the vehicle is operated, the more intense the sonic boom is at ground level. Intensity also increases during flight maneuvers such as diving, accelerating, and turning. Intensity levels can decrease with an increase in altitude. However, the increase in altitude increases the area exposed to the sonic boom. For every 305 meters (1,000 feet) of altitude, the ground width of the boom increases 1.6 kilometers (one mile). For example, a sonic boom generated at 9,146 meters (30,000 feet) would create a boom exposure width of 48 kilometers (30 miles). Conversely, the boom intensity can decrease from the use of some flight maneuvers, such as climbing and decelerating. (UGA/Media, 2004)

Depending on the vehicle altitude, a sonic boom will typically reach the ground in 2 to 60 seconds after the vehicle flies overhead. However, in some instances, the sonic boom does not reach the ground even though the vehicle is flying at supersonic speeds. The speed of sound is a function of temperature. (UGA/Media, 2004) An increase or decrease in temperature corresponds to an increase or decrease in sonic speed. At ground level if the temperature is 14°C (58°F), the speed of sound is 1,210 kilometers (750 miles) per hour. At an altitude of 9,146 meters (30,000 feet) the temperature is approximately 45°C (113°F) with a corresponding speed of sound at 1,081 kilometers (670 miles) per hour. (UGA/Media, 2004) The temperature gradient between the altitudes tends to refract shock waves upward. Therefore, for a sonic boom to reach the ground, the speed of a vehicle at altitude must be equal to or greater than the speed of sound on the ground or, in this example, equal to or greater than 1,210 kilometers (750 miles) per hour. (UGA/Media, 2004)

3.1.9.2 Regulatory Setting

Noise is primarily regulated through local noise ordinances, which are designed to protect noise sensitive areas (e.g., residential population centers and schools). Federally regulated noise standards are designed to protect worker safety, and various commercial standards address commercial aircraft noise.

The OSHA regulation 1910.95 establishes a maximum noise level of 90 dBA for a continuous eight-hour exposure during a working day and higher levels for shorter exposure time in the workplace. The EPA has recommended an average equivalent noise level of 70 dBA for continuous 24-hour exposure to noise to protect hearing. (FAA, 1985) Noise also may be impulsive in nature. Under OSHA regulation 1910.95, exposure to impulse noise should not exceed 140 dBA. The 140 dBA threshold should be considered advisory rather than mandatory. The FAA regulates the noise associated with commercial aircraft at 14 CFR Part 36.

3.1.10 Orbital Debris

3.1.10.1 Definition and Description

Orbital debris can be described as man-made material in the Earth's orbit that is no longer serving any function, such as outdated satellites or expended portions of spacecraft. Some objects do not remain in orbit, but gradually descend back into the Earth's atmosphere. This is because orbiting objects lose energy through friction with the upper reaches of the atmosphere, which is progressively thinner at higher altitudes. Over time, the object falls into progressively lower orbits and eventually falls toward the Earth. Orbital debris in LEO can take several years to return to Earth, while objects at higher altitudes can stay in orbit for hundreds or possibly thousands of years. (The Aerospace Corporation, 2005) As an object's orbital trajectory draws closer to Earth, it speeds up and outpaces objects in higher orbits. Once the object enters the measurable atmosphere, drag associated with the density of the lower atmosphere will slow it down rapidly, causing it to burn up or deorbit and fall to the surface of the Earth.

NASA has determined that a significant amount of debris does not survive the severe heating that occurs during reentry. (NASA, 2003) Components that do survive are most likely to fall into the oceans, other water bodies, or onto sparsely populated regions, because these types of areas cover the majority of the surface of the Earth. While scientists can predict to some extent the approximate time an object may reenter the Earth's atmosphere, determining the footprint of the area likely to be impacted by the debris is extremely difficult. During the past 40 years, an average of one catalogued piece of debris fell back to Earth each day. To date, no serious injury or significant property damage caused by reentering debris has been confirmed. (The Aerospace Corporation, 2005)

Orbital debris that remains in orbit could create hazards to orbiting spacecraft, to astronauts or cosmonauts engaged in extra-vehicular space activities. NASA has defined three types of orbital debris

- Objects larger than 10 centimeters (3.9 inches) in diameter, commonly referred to as **large objects**, which are routinely detected, tracked, and catalogued;
- Objects between one and 10 centimeters (0.4 and 3.9 inches) in diameter, commonly referred to as **risk objects**, which cannot be tracked and catalogued; and
- Objects smaller than one centimeter (0.4 inch) in diameter commonly referred to as **small debris** or in some sizes, **microdebris**.

The interaction among these three classes of debris combined with their long residual times in orbit creates concern that there may be collisions producing additional debris fragments. If more pieces of debris are created, the total debris population would grow, thereby increasing the potential for debris reentry into Earth's atmosphere. Debris in each of the three classes can be divided into four types depending on their source.

- ***Solid rocket motor ejecta*** is typically less than 0.01 centimeter (0.004 inch) in diameter and results from the ejection of thousands of kilograms of Al_2O_3 dust from solid rocket motors into the orbital environment. (FAA, 2001) Solid rocket motors may release larger chunks of unburned solid propellant or slag. However, solid rocket motor particles typically decay very rapidly, or are dispersed by solar radiation pressure. (FAA, 2001)

- ***Operational debris*** is composed of inactive payloads and objects released during satellite delivery or satellite operations, including lens caps, separation and packing devices, spin-up mechanisms, empty propellant tanks, spent and intact vehicle bodies, payload shrouds, and a few objects thrown away or dropped during manned activities.

- ***Fragmentation debris*** results from collisions or explosions of objects in space.

- ***Deterioration debris*** consists of very small debris particles created by the gradual disintegration of the spacecraft surface as a result of exposure to the space environment and includes paint flaking and plastic and metal erosion.

According to the NASA Orbital Debris Program Office, approximately 11,000 objects larger than 10 centimeters (3.9 inches) are known to exist, more than 100,000 particles between one and 10 centimeters (0.4 to 3.9 inches) in diameter exist, and tens of millions of particles smaller than one centimeter (0.4 inch) exist. Debris of sizes between 0.01 and one centimeter (0.004 and 0.4 inch) can produce serious damage depending upon system vulnerability and defensive design provision. (FAA, 2001) On average, debris of one millimeter (0.04 inch) is capable of perforating current U.S. space suits. Objects larger than one centimeter (0.4 inch) can produce catastrophic damage. While it is currently practical to shield against debris particles up to one centimeter (0.4 inch) in diameter (a mass of one gram [0.05 ounce]), for larger debris, current shielding concepts become impractical. (NASA, 2003)

Orbital debris generated by LVs and RVs also contributes to the larger problem of objects in space, which includes radio-frequency interference and interference with scientific observations in all parts of the spectrum. For example, emissions at radio frequencies often interfere with radio astronomy observations. (NASA, 2003)

3.1.10.2 Regulatory Setting

As identified in Section 3.1.1, Atmosphere, one international treaty addresses orbital debris and the liability associated with it, the *Convention on International Liability for Damage Caused by Space Objects*, dated 1972. In addition to the international treaty, NASA and the USAF Space Command monitor orbiting space objects.

3.1.11 Socioeconomics

3.1.11.1 Definition and Description

Socioeconomics

Socioeconomics include the social and economic indicators that are specific to the human environment. Social indicators include statistical data related to population distributions, ethnicity, home ownership, education levels, and the availability of medical care, fire and rescue services, educational facilities, and other public amenities such as libraries or recreational opportunities. Economic indicators are used to assess the economic health of the nation or a community, as well as to make forecasts concerning future economic conditions. Key economic indicators include employment trends and unemployment rates, income levels, retail sales, industry, factory, and agricultural activities, and home purchases or sales.

Collectively, social and economic indicators are often referred to as socioeconomics. Much of the information that assists in evaluating the socioeconomic status of a given population is available from the U.S. Census Bureau on a national, state, or regional level. Site-specific socioeconomic data are available from the U.S. Census Bureau on a county, census block, and census tract level as well. More detailed information regarding a community's educational institutions, fire and rescue or medical services, and local employment information is typically available from state or county governmental offices such as local Chambers of Commerce.

The population of the U.S. is approximately 290 million, with the majority of the population centers concentrated on the eastern and western coasts and in major metropolitan areas. Public services, including medical, police, and fire services, are more densely located in metropolitan areas as compared to rural areas. In addition, metropolitan areas tend to have more established infrastructure to provide utility services (i.e., water, electricity, natural gas, and phone) and waste collection services (i.e., solid waste and waste water disposal) than are available in rural areas.

To compare and track the various economic generators, the U.S., Canada, and Mexico have developed the North American Industry Classification System (NAICS), which has replaced the U.S. Standard Industrial Classification (SIC) system. The NAICS helps track the changing economy and provides new comparability in statistics about business activity across North America. NAICS code 3364 (Aerospace Product and Parts Manufacturing), and sub-code 33641 (Aerospace Product and Parts Manufacturing) represent the aerospace industry, which falls under NAICS code 336 (Transportation Equipment Manufacturing). The Aerospace Product and Parts Manufacturing industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing complete aircraft, missiles, or space vehicles; (2) manufacturing aerospace engines, propulsion units, auxiliary equipment or parts; (3) developing and making prototypes of aerospace products; (4) aircraft conversion (i.e., major modifications to systems); and (5) complete aircraft or propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications). (U.S. Census Bureau, 2004)

In 2002, the annual payroll[20] for all reported NAICS codes was approximately $3.5 trillion. The annual payroll for manufacturing, which includes transportation equipment manufacturing, was approximately $568 billion, and the annual payroll for NAICS code 336 *Transportation Equipment Manufacturing* was approximately $80 billion, or two percent of the total annual payroll, and 14 percent of transportation equipment manufacturing, respectively. Note, some industries' annual payroll information was incomplete and others were not reported at all, so the values presented are conservative values that inflate the actual percentages of the aerospace industry on the overall annual payroll. (U.S. Census Bureau, 2004)

Environmental Justice

Environmental justice (EO 12898) is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of an adverse impact resulting from a major Federal action. Meaningful involvement means that potentially affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that would affect their environment or health; the public's contribution can influence the regulatory agency's decision; the concerns of all participants involved would be considered in the decision-making process; and the decision-makers would seek out and facilitate the involvement of those potentially affected.

Environmental justice concerns include consideration of the race, ethnicity, and poverty status of populations near the site of a proposed action. The CEQ defined "minority" to consist of the following groups: Black/African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaska Native, and Hispanic populations (regardless of race). The Interagency Federal Working Group on Environmental Justice guidance states that a "minority population" may be present in an area if the minority population percentage in the area of interest is "meaningfully greater" than the minority population in the general population. The CEQ defined "low-income populations" as those identified with the annual statistical poverty thresholds from the U.S. Census Bureau. The accepted rationale in determining what constitutes a low-income population is similar to minority populations, in that when the low-income population percentage within the area of interest is "meaningfully greater" than the low-income population in the general population, the community in question is considered to be low-income.

3.1.11.2 Regulatory Setting

Socioeconomics

Socioeconomic conditions are regulated through a host of Federal programs that provide for equal opportunity, anti-discrimination, and accessibility, as well as state and local ordinances.

[20] Payroll includes all forms of compensation, such as salaries, wages, commissions, dismissal pay, bonuses, vacation allowances, sick- leave pay, and employee contributions to qualified pension plans paid during the year to all employees.

Environmental Justice

Through EO 12898, all Federal actions or actions funded with Federal monies that may result in significant adverse effect must be evaluated for the potential of such significant impacts on disproportionately affected minority or low-income populations. In keeping with EO 12898, the FAA encourages public participation regarding proposed actions that have the potential to adversely affect minority or low-income populations to foster better decision-making practices.

3.1.12 Visual and Aesthetic Resources

3.1.12.1 Definition and Description

Visual and aesthetic resources refer to natural or developed landscapes that provide information for an individual to develop their perceptions of the area. Landforms, surface water, vegetation, viewpoints or viewsheds, open space, transportation structures, and man-made features are fundamental characteristics of an area that define the visual environment and form the overall impression that an observer receives of an area. The value of a given area's visual resources is typically dependent on how harmoniously the area is mixed with surrounding visual elements. The visual character of an area can be defined by the presence of visual resource elements and the relationship between those elements. The size, type, gradient, scale, and continuity of landforms, structures, land use patterns, and vegetation are all contributing factors to an area's visual character and how it is perceived.

The existing visual resources within an area as well as changes to visual elements are often influenced by social considerations, including the public value placed on the area, public awareness of the area, and community concern for the visual resources within the area. However, one individual's perception of the quality or value of visual resources within an area can vary significantly from another's observation. This is due to viewer sensitivity, which is based on factors that include a person's background (e.g., urban versus rural upbringing), what they expect to find visibly pleasurable, and what types of activities they may participate in. Additionally, different types of settings can be more or less susceptible to perceived changes depending upon the visual elements that are present. Areas with significant open spaces (e.g., coastlines, prairies, etc.) are usually more sensitive to perceived changes than areas such as an industrial complex or cityscape, because the changes are often more readily apparent in undeveloped or natural settings.

3.1.12.2 Regulatory Setting

Though dependent on physical location, many environments within the U.S. include regions of rich aesthetic and visual resources as well as designated and undesignated areas of great natural beauty and scenic diversity. Visual and aesthetic resources commonly fall under several different formal designations including national forest; national monument; national, state, or county parks; national wildlife refuges; wilderness areas; wild and scenic rivers; national trails; privately-owned land; and historic places and districts. Various roads also may be designated as scenic byways due to their scenic, historic, and cultural qualities.

Visual resources in areas surrounding certain selected rivers are protected under The Wild and Scenic Rivers (WSR) Act [P.L. 90-542, as amended] [16 U.S.C. 1271-1287]. Agencies are required, as part of their standard environmental review processes, to consult with the NPS and other Federal and state agencies having jurisdiction, prior to taking any actions which could effectively foreclose or downgrade wild, scenic, or recreational river status of rivers in the WSR System, study rivers, river segments in the Nationwide Rivers Inventory (NRI), or rivers or river segments otherwise eligible under section 5(d) for inclusion in the WSR System but not on the NRI or under study (FAA Order 1050.1 E Appendix A). (National WSR System, 2004)

The BLM's Visual Resource Management (VRM) system ensures that the scenic values of public lands are considered before allowing uses that may have negative visual impacts. This two-part system (1) inventories the scenic values of an area and assigns certain management objectives, and (2) evaluates proposed activities to determine if they conform to the area's management objectives, or if the proposed action requires adjustment. (BLM, 2004)

3.1.13 Water Resources

Water resources include both freshwater and marine systems, wetlands, floodplains, and ground water. The marine systems include the BOA (essentially open ocean) that is not under the direct jurisdiction of any single nation.

3.1.13.1 Definition and Description

Freshwater Systems

Freshwater environments, also known as interior water systems, consist of rivers and streams (lotic systems) and lakes and ponds (lentic systems). Rivers and streams include natural and man-made bodies of moving water. Streams originate from lakes or from ground water seeps and join with other streams, or tributaries to form a main channel or river. Rivers empty into large water bodies such as oceans and lakes and are fed by tributaries. Depending upon their regularity of flow, streams are described as (1) ephemeral, which only exist for a short time during rain events, (2) intermittent, which flow seasonally depending on rainfall patterns and snowmelt, and (3) perennial, which maintain a constant flow.

The physical characteristics of a lotic system often determine the biological characteristics of the system. Slow moving systems often have higher biological productivity. Because of the slow water movement, more organic material is able to settle out of the water column to be used by primary and secondary consumers. In fast moving systems, the organic material is washed downstream before it can be utilized. Slow moving systems often have more productive vegetative communities. Suspended solids in the water column settle out in low energy systems and allow for greater light penetration to promote higher photosynthesis rates. Fast moving, turbulent systems stir up sediment and suspended solids and restrict light penetration. In addition, slow moving systems allow vegetation to root along the shorelines. This vegetation can be a food source and a habitat for other organisms.

Lakes are large, deep freshwater bodies that can be large enough to have surface waves and tides. Lakes are often closely associated with rivers. Rivers often flow into and/or out of lakes. Lakes have a stratified temperature regime from surface to bottom. The temperature differences between the layers cause water column stability. This stability restricts oxygen movement to bottom layers and nutrient and food movement to upper layers. In the spring and fall, water column stability deteriorates and results in uniform mixing. This is often referred to as lake turnover. (EPA, 2004) Ponds are smaller versions of lakes and can support rooted plants in all areas of the pond. The water temperatures are relatively uniform from top to bottom and are based on the ambient air temperature. In cold climates, an entire pond can freeze solid.

Marine Systems

Including coasts along the Atlantic Ocean, Pacific Ocean, Gulf of Alaska, Bering Sea, Arctic Ocean, and Gulf of Mexico, the U.S. has more than 153,226 kilometers (95,000 miles) of coastline. Just as other countries with coastlines, the U.S. has an established EEZ that defines its coastal environments from an economic, political, and regulatory perspective. While the host country does not have complete sovereignty over their EEZ regarding maritime or air traffic, the host country does maintain sovereign rights over resources within the zone (e.g., fishing, mineral resources, and marine protection).

Created in 1983 by presidential proclamation, the U.S. EEZ extends out from the coast to a distance of 370 kilometers (200 nautical miles). Within the EEZ are two smaller zones, the territorial and the contiguous zone. The territorial zone extends 22 kilometers (12 nautical miles) from the coastline and is included in the sovereign territory of the host country. The contiguous zone extends an additional 22 kilometers (12 nautical miles) out from the territorial zone border. Within this zone, the host country has rights to control immigration, customs, sanitary, and pollution regulations. (Environmental Health Center, 1998) The areas within the U.S. EEZ are rich in natural resources such as seafood, oil and mineral deposits, and wilderness and recreational areas.

More than 10,521,830 hectares (26,000,000 acres) of wetlands are located along the coasts of the Atlantic Ocean, Pacific Ocean, and Gulf of Mexico. This includes salt marshes and coastal freshwater wetlands. Estuaries dominate the coastal wetlands. Estuaries are defined as tidally influenced, brackish water wetlands. Estuaries provide protection to inland areas from the physical forces of coastal waves and wind, nursery and nesting areas for a variety of fish and waterfowl, and filtration of water for sediment, nutrients, and other pollutants. Over 75 percent of U.S. commercial fish and shellfish and 80 to 90 percent of U.S. recreational fish are dependent on estuaries during mating, birthing, or maturation. (Environmental Health Center, 1998) According to EPA, the coastal wetlands along the Gulf of Mexico alone provide habitat for 75 percent of the migrating waterfowl in the U.S.

The BOA is defined as the open water areas of the Pacific and Atlantic Oceans outside of the EEZ, located 322 kilometers (200 miles) offshore. The BOA is outside of the jurisdiction of any individual nation. The marine environment supports a wealth of diverse organisms and it is estimated that 80 percent of all life on the planet is located within its oceans. (Natural History, 2003) Additionally, ocean waters have the capacity to produce carbon and absorb large amounts of CO_2 that result from fossil fuel burning activities. Ocean movement is primarily influenced by wind, though tides that are a result of the gravitational pull of the sun and moon and seismic activity are also factors. The majority of the Earth's geologic activity occurs within the ocean, particularly the Pacific Ocean. (Marine Biology, 2004) Volcanic eruptions and lava flows continually add to the ocean crust, and large chains of undersea trenches and mountain ranges such as the Monterey Bay Submarine Canyon and the Mid-Ocean Ridge are present.

Oceans are constantly in motion as a result of both horizontal and vertical currents. Horizontal ocean currents are a result of wind-based currents that occur due to solar energy and uneven heating of the Earth's surface. Wind-based currents primarily affect surface waters; however, their impact can be measured down to 200 meters (656 feet) in depth. Frictional forces between the water molecules drag deeper waters along but at reduced energy levels. In addition, the Earth's rotation tends to deflect the water movements with increasing depth. Some surficial currents are seasonal in nature, while others move in patterns that are almost unchanged throughout the year. Because of the wind-influenced surficial ocean currents, ocean circulation and the general circulation patterns of the atmosphere are related. Currents that have the potential to affect the U.S. include the Gulf Stream, the California, and Labrador currents. (Naval Meteorology and Oceanography Command, 2004)

Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. (Cowardin, 1979) Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands are found from the tundra to the tropics and on every continent except Antarctica. For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." (40 CFR 230.3(t))

The Cowardin classification system has five wetland systems, eight subsystems, and 11 classes of wetlands. The term "system" refers here to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. Exhibit 3-8 presents a description of the wetland systems.

Exhibit 3-8. Wetlands Systems

System	Description
Marine	The Marine System consists of the open ocean overlying the continental shelf and its associated high-energy coastline. Marine habitats are exposed to the waves and currents of the open ocean and the water regimes are determined primarily by the ebb and flow of oceanic tides. Salinities exceed 30 percent, with little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater inflow, and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind and waves are also considered part of the Marine System because they generally support typical marine biota.
Estuarine	The Estuarine System consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low-energy coastlines an appreciable dilution of sea water exists. Offshore areas with typical estuarine plants and animals, such as red mangroves (*Rhizophora mangle*) and eastern oysters (*Crassostrea virginica*), are also included in the Estuarine System.
Riverine	The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 percent. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water."
Lacustrine	The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent areal coverage; and (3) total area exceeds 8 hectares (20 acres). Similar wetland and deepwater habitats totaling less than 8 hectares (20 acres) are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 meters (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 percent.
Palustrine	The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 percent. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 hectares (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 meters (6.6 feet) at low water; and (4) salinity due to ocean-derived salts less than 0.5 percent.

Wetlands are capable of a wide variety of ecological functions that provide significant biological, economic, and societal values. The functionality of a wetland depends upon its physical location (e.g., freshwater or coastal environments), the hydrological regime, surrounding topography, precipitation, climate, soils, and available nutrients. Some of the most important wetland functions include

- Critical habitats that provide food, shelter, nesting, and breeding/spawning grounds,
- Decomposition of organic material that incorporates nutrients back into the food web,
- Natural flood storage capabilities, and
- The improvement of water quality.

By providing a mix of terrestrial and aquatic environments, wetlands maintain a unique habitat on which numerous species including invertebrates and microorganisms are dependent. According to data from the NRCS, wetlands in the U.S. support about 5,000 plant species, 190 species of amphibians, and a third of all native bird species. Coastal wetlands are an integral part of the life cycle for many marine organisms; they are the nursery and spawning grounds for 60 to 90 percent of U.S. commercial fish catches. (USDA, 2004)

Floodplains

Floodplains consist of the low-lying areas adjacent to rivers and streams that are subject to natural inundations typically associated with precipitation. The most common regulatory definition concerning such an area is the 100-year floodplain or Special Flood Hazard Area (SFHA), which has been established for most U.S. rivers and streams by the Federal Emergency Management Agency (FEMA). By FEMA standards, a 100-year flood is a flood that has a one percent chance of being reached or exceeded in any given year. In some cases FEMA has also designated floodways. Floodways are areas likely to experience the deepest and fastest flowing floodwaters. The risk and severity of a flood depends on several factors that include the size of the watershed, surrounding topography, stream bank elevation, annual rainfall or snowfall, and the presence of upstream water bodies, dams, or other hydraulic modifications.

Floodplains serve a critical role in floodwater attenuation, water quality, and ground water recharge. Floodplains naturally slow storm water velocities and accommodate peak flows, allowing for organic waste and sediment removal. Natural vegetation present within the floodplain serves as a buffer for excessive nutrient loads, assists in stabilizing water temperatures, and filters other contaminants, thus improving water quality. Floodplains also provide habitat for a wide diversity of plant and animal life whose presence is directly related to the health of a given ecosystem. Many fish, bird, and other wildlife species are dependent upon floodplains as spawning or nesting areas. Streams and their associated floodplains also provide sources of potable water derived from either surface water or ground water recharge. Additionally, floodplains characteristically maintain nutrient rich soils that support agricultural uses which in turn provide economic benefits. Lastly, floodplains provide a wealth of aesthetic and recreational opportunities that not only provide economic, but social value as well.

Ground Water

Ground water is defined as water, both fresh and saline, that is stored below the Earth's surface in pores, cracks, and crevices below the water table. Typical forms of ground water include aquifers and aquifer sources, such as springs and wells. The U.S. Geological Survey (USGS) defines an aquifer as "a formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs." (USGS, 2004) Surface water from precipitation or that resides in wetlands, ponds, lakes, or rivers may enter an aquifer through percolation through soils. Areas that provide source water to the aquifers are known as recharge zones. Water that moves into the ground first enters a belt of soil moisture that is known as the zone of aeration or the unsaturated zone. Once soils and plants have removed what water they need, surplus water can then move through an intermediate belt and into the ground water's zone of saturation. (Allan, 1995)

The occurrence of ground water is dependent upon a given area's geology, soils, topography, and climatic regimes. Thus, the amount of ground water present throughout the U.S. is not evenly distributed and the depth to ground water can be close to the surface or lie several hundred feet below. (USGS, 1999)

Ground water is critical because aquifers serve as a major source of drinking water in the U.S., as well as sources of irrigation for agriculture, industrial, and mining activities. Accessed via drilled wells, artesian wells, and springs, ground water typically tends to be acceptable for human consumption. This is because ground water is less susceptible to contamination by pollutants associated with human activity than surface water. The soils and rocks associated with aquifers act as a filtration system for most biological contaminants, though high bacterial concentrations can exist in some cases, especially where the ground water table is shallow. (USGS, 1999) Additionally, minerals and organic constituents are present in ground water. These are harmless in most cases, but in rare cases can be harmful or even toxic. (USGS, 1999)

According to the USGS, factors such as population growth, technology that allows for more rapid ground water removal rate, and added industrial and agricultural demands have had an impact on ground water supplies. Human activity contributes to ground water degradation through the use of pesticides, herbicides, and fertilizers, which can percolate through soils and into aquifers. Additional human stressors include leaking sewage and septic systems, petroleum product or chemical spills, and landfill leachates. (USGS, 1999) Because most ground water recharge occurs at a very slow rate, growing water demands and contamination can pose significant issues. Recharge rates may not be able to keep up with increasing water demands, and diminishing ground water resources in some areas (e.g., the Midwest). The overuse of shallow coastal aquifers can result in saltwater intrusion that renders the ground water unusable. Another issue is that ground water contamination is extremely difficult to detect, and recognition of contamination may not occur until an aquifer's water quality has been compromised.

3.1.13.2 Regulatory Setting

The following subsections present a description of the regulatory setting associated with freshwater and marine systems, wetlands, floodplains, and ground water (see Appendix C, Applicable Legal Requirements, for additional information).

Freshwater Systems

The CWA establishes water pollution control standards and programs with the objective of restoring and maintaining the chemical, physical, and biological integrity of U.S. water resources. The Act provides for the elimination of the discharge of pollutants into navigable waters and for water quality goals to protect fish and wildlife. The Act specifies (1) that actions must comply with Federal and state water quality criteria; (2) regulations for issuing permits under the National Pollutant Discharge Elimination System (NPDES) for storm water discharge be established by EPA; and (3) that states assess non-point source water pollution problems and develop pollution management plans.

Water quality and the consumption and diversion of water are regulated by a number of Federal and state agencies in the U.S. The EPA has the primary authority for implementing and enforcing the CWA. (33 U.S.C. 1251) The EPA, along with state agencies to which EPA has delegated some of its authority, issues permits under the CWA to maintain and restore the quality of our nation's water resources. The Act requires permits for activities that result in the discharge of pollutants to water resources or the placement of fill material in waters of the U.S.

Storm Water Pollution Prevention Plans (SWPPPs) are typically prepared and permitted under the NPDES program to ensure construction activities do not lead to unacceptable levels of erosion and water pollution. Other regulations relevant to the protection of freshwater systems include the Safe Drinking Water Act (SDWA) and EO 11988 (Floodplain Management).

Marine Systems

Under the Oceans Act of 2000, the U.S. established a commission to make recommendations for a coordinated and comprehensive national ocean policy. Within the contiguous zone, which extends 44 kilometers (24 nautical miles) from the coastline, the U.S has rights to control immigration, customs, sanitary, and pollution regulations. Also, the BOA is subject to EO 12114, Environmental Effects Abroad of Major Federal Actions, which requires consideration of proposed Federal actions or programs for their potential to affect the environment.

Wetlands

Wetlands are regulated under the CWA and the River and Harbors Act, and individual states, EPA, and the U.S. Army Corps of Engineers (USACE) implement the various regulations. The regulations primarily regulate discharges into "waters of the United States," of which wetlands are considered to be waters of the U.S. The USACE issues permits for discharges into wetlands, with oversight by EPA; however, a few states have assumed permitting authority (Michigan and New Jersey). Also, individual states may regulate activities that involve wetlands under Section 401 of the CWA.

Floodplains

To reduce risks to human life and lessen property damages, FEMA established the National Flood Insurance Program (NFIP) and creates maps that identify flood hazard areas. The most commonly used flood hazard-mapping tool is the Flood Insurance Rate Map, which identifies the boundaries of the 100-year floodplain or SFHA. Development, including federally funded or federally assisted projects that occur within the floodplain must comply with local floodplain management ordinances, which are based on NFIP requirements. Areas that are designated as floodways should remain free from all development or activities that could serve as an obstruction to floodwaters. Additionally, mandatory flood insurance requirements apply to structures located within the floodplain that are eligible for insurance through a community's participation in the NFIP.

EO 11988, Floodplain Management, mandates that Federal agencies avoid construction or management practices that would adversely affect floodplains unless that agency finds that (1) no practical alternative exists, and (2) the proposed action has been designed or modified to minimize harm to or within the floodplain. EO 11988 further tasks all Federal agencies to reduce the risk of flood loss; minimize the impact of floods on human safety, health and welfare; and restore and preserve the natural and beneficial values served by floodplains in carrying out the agency's responsibilities. Federal agency activities subject to compliance with this Order include: (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Ground Water

Ground water that is used as drinking water is regulated by EPA under the SDWA. The SWDA allows EPA to set maximum contaminant levels standards for the drinking water, allows individual states to establish wellhead protection areas, and allows EPA to regulate and permit underground injection wells. In addition to the SDWA, EPA also regulates USTs (40 CFR Part 280), which allows individual states to develop UST programs. Such programs are used to monitor USTs, prevent or detect leaks early, and prevent aquifer degradation.

4 ENVIRONMENTAL CONSEQUENCES

Introduction

This section of the PEIS describes the potential environmental consequences associated with each alternative.

- **Proposed Action** – The FAA would review applications and issue commercial licenses for: launches of horizontal LVs (1,279 horizontally launched LVs between 2005 and 2015 with a maximum of 154 launches per year), reentries of RVs with both powered and unpowered landings (51 reentries between 2005 and 2015 with a maximum of 15 reentries per year), and the operation of facilities that support these activities.
- **Alternative 1** – Same as proposed action except that all reentries of RVs would have unpowered landings.
- **Alternative 2** – Same as proposed action except that all reentries of RVs would have powered landings.
- **Alternative 3** – Same as proposed action except that FAA would only license horizontal launches of LVs that ignite their rocket motors at or above 914 meters (3,000 feet).
- **No Action Alterative** – The FAA would not issue commercial licenses for horizontal launches of LVs, reentry of RVs, or the operation of facilities that support these activities.

The analysis of the conditions of the proposed action and the alternatives assumes that the issuance of licenses for horizontally launched LVs, reentry of RVs, and facilities where such actions would occur would not influence the number of commercial licenses issued or the number of vertically launched LVs. The analysis of the conditions of the no action alternative assumes that not issuing licenses for the horizontal launch of LVs, the reentry of RVs, or the facilities where such actions would occur would not influence the number of commercial licenses issued or the number of vertically launched LVs.

The FAA recognizes that at some point in the future, more than 10 years, the issuance of licenses for horizontally launched LVs or for reentry of RVs may influence the number of licenses issued as well as the number of commercial vertically launched LVs. Because the horizontal launch technology is currently under development, a shift from one launch platform to another (e.g., vertical to horizontal) will take place over a period of time and is not ready for analysis at this time.

The environmental consequences were reviewed in accordance with all relevant legal requirements, as described in Appendix C, including 40 CFR Part 1502.16 and the FAA Regulations (FAA Order 1050.1E) for implementing NEPA, which specify what types of impacts would be considered a significant impact on a particular resource. The scope of the analysis presented in this section encompasses the programmatic environmental impacts from licensing horizontal vehicle launches, reentry of RVs, and the operation of facilities that support these activities. The analyses contained in this PEIS address the routine activities of horizontal launches of LVs, reentries of RVs, and development, modification, and operation of launch or reentry facilities; a discussion of potential accident scenarios and their impacts associated with the routine activities is presented in Appendix E, Potential Accident Scenarios.

This section focuses on the programmatic issues that are ready for decision and provides a roadmap for subsequent site-specific environmental analyses that would tier from this document. The analysis in this section addresses the direct and indirect impacts, while the analysis in Section 5 covers the cumulative impacts associated, as defined at 40 CFR Parts 1508.7 and 1508.8 and in FAA Order 1050.1E. The direct and indirect impacts are derived from the proposed number of horizontal vehicle launches and reentries that would fall under the licensing authority of the FAA per year, while the cumulative impact analysis includes an analysis of all the launches licensed by the FAA (horizontal and vertical vehicle launches) as well as all other U.S. Government and foreign (commercial and government) launches and reentries per year. The forecasted number of launches and reentries extends through year 2015, and reflects a conservative estimate of the number of launches by vehicle based on the current technology and future demand for access to space.

The indirect or induced impacts associated with the proposed action and alternatives that would occur at a particular site or location would be analyzed in a site-specific NEPA document that would tier from this PEIS. Where appropriate, this PEIS evaluates the indirect effects associated with the proposed action or an alternative. Subsequent site-specific environmental analyses that would tier from this PEIS include supplemental EISs, EISs, and EAs. The tiered documents would be narrower in scope than the information presented in this PEIS, would analyze site-specific actions and impacts, and would not repeat the analysis presented in this PEIS. Appendix D provides insight into the required consultation and permit processes that could be required in subsequent site-specific analyses.

The following sections present the environmental consequences (direct and indirect) on each of the environmental resource areas presented in Section 3, Affected Environment.

4.1 Atmosphere

In this section, atmospheric impacts are assessed beginning at ground level with consideration of tropospheric effects (i.e., total atmospheric load from the ground cloud near the launch site and its contribution to the formation of acid rain). Stratospheric effects, including global warming, ozone depletion, and acid rain, are detailed in Section 4.1.2. The potential for changes in ionosphere electron concentrations is assessed in Section 4.1.4. Consideration of deposition from a ground cloud near a launch site is found in Section 4.6.1, Geology and Soils.

The composition of exhaust emissions from horizontal LVs varies depending on the type of propellant and the type of propulsion systems used (i.e., jet engine and/or rocket motors). Exhibit 4-1 shows the major exhaust products from propulsion systems that are currently used by horizontal LVs or are in development. The types of exhaust products from jet engines are fairly consistent across jet fuel types. The exhaust products from rocket motors, however, vary based on the propellant type (fuel and oxidizer) and are presented separately. The type of propellant that each LV Concept uses is detailed in Exhibit 2-4.

Exhibit 4-1. Main Exhaust Products from Propulsion Systems

Jet Engines	Rocket Motor by Propellant System Type			
	Solid	*Liquid Hydrocarbon*	*Cryogenic*	*Hybrid Propellant*
CO, NO_X, Sulfur Oxides (SO_X), PM, VOC	HCl, PM, CO, N_2, CO_2, NO_X, Cl^-, H_2O	CO_2, CO, Molecular Hydrogen (H_2), H_2O, OH^-, NO_X	H_2, H_2O	CO_2, CO, H_2, H_2O, OH^-, NO_X, PM

(Department of the Air Force, 1990, 1991, and 1994 as referenced in the FAA Launch Licensing 2001 PEIS) (Versar, Inc., 1991 as referenced in the FAA Launch Licensing 2001 PEIS) (Naval Surface Warfare Center, 1996 as referenced in the FAA Launch Licensing 2001 PEIS) (USAF, 1986) (FAA, 2004d) (U.S. EPA, 1980 as referenced in the Final EA for the East Kern Airport District Launch Site Operator License for the Mojave Airport, February 2004) (Alamo Area Council of Governments, 1999)

Of the chemical species that are generated by emissions from horizontal LVs, the emissions of concern include HCl, Cl, PM, NO_X, SO_X, CO, CO_2, H_2O, and VOCs. As indicated in Exhibit 4-1, not all of these substances are produced by all of the various propulsion systems. The potential impacts of emissions of these pollutants in the different atmospheric layers are discussed in Sections 4.1.1 through 4.1.4. Emissions of the other main exhaust products are either insignificant or would not have an adverse impact on any layer of the atmosphere. Appendix E presents potential accident scenarios and their contribution to the atmosphere and other resource areas. Appendix F describes how the emissions calculations for each vehicle and atmospheric layer were performed.

For the analyses presented for the proposed action and alternatives, eight launch vehicle types were considered, and two types of reentry vehicles were considered. Exhibit 4-2, presents of summary of the vehicle types. Additional information is presented in Appendix F. Reentry vehicles with unpowered landings were not included in this analysis because they would not contribute to emissions.

Exhibit 4-2. Overview of Launch and Reentry Vehicle Types

Vehicle Type[a]	Rocket Fuel Type	Notes
	Concept 1	
Vehicle Type A	LOX/Kerosene	Jet engine ignited for lift off; rocket engine ignited at approximately 6,000 meters (m) (20,000 feet [ft]); jet engines stop at 24,000 m (80,000 ft) and rocket engines stop at 45,000 m (150,000 ft); landing powered by reigniting jet engines
	Concept 2	
Vehicle Type B	LOX/Kerosene	Rocket engine ignited for lift off; no jet engine; rocket engines stop at 60,000 m (200,000 ft); unpowered landing
Vehicle Type C	LOX/Kerosene	Similar to Vehicle Type B, but twice as large; landing powered by reigniting rocket engines

Exhibit 4-2. Overview of Launch and Reentry Vehicle Types

Vehicle Type[a]	Rocket Fuel Type	Notes
TBD Vehicle	LOX/Kerosene	Emissions assumed to be equivalent to the average of the Concept 2 vehicle emissions (weighted based on the number of launches of each type of Concept 2 vehicle between 2005-2015)
Concept 3		
Vehicle Type D	N_2O/HTPB	Jet-powered carrier vehicle; rocket engine ignited at 15,000 m (50,000 ft) and burns for approximately one minute; unpowered landing
Vehicle Type E	Solid	Jet-powered carrier vehicle; two-stage rocket engine; stage 1 ignited at 12,000 m (40,000 ft) and burns out at 51,000 m (170,000 ft); stage 2 ignited at 51,000 m (170,000 ft) and burns out at 140,000 m (450,000 ft); unpowered landing
Vehicle Type F	N_2O/HTPB, Solid	Jet-powered carrier vehicle; two-stage rocket engine; stage 1 (powered by N_2O/HTPB) ignited at 60,000 m (200,000 ft) and burns out at 140,000 m (450,000 ft); stage 2 (powered by solid fuel) ignited at 140,000 m (450,000 ft) and burns out at 160,000 m (530,000 ft); unpowered landing
TBD Vehicle	N_2O/HTPB, Solid	Emissions assumed to be equivalent to the average of the Concept 3 vehicle emissions (weighted based on the number of launches of each type of Concept 3 vehicle between 2005-2015)
Reentry Vehicle		
Reentry Vehicle Landing Using Rocket Engines	LOX/LH_2	Assumed vehicle would use parachutes to slow its descent, engines would be ignited approximately 3,000 m (10,000 ft) from the ground, and one-fourth of the vehicle's fuel capacity would be consumed at a constant rate until it reached the ground
Reentry Vehicle Landing Using Jet Engines	n/a	Emissions assumed to be equivalent to one-half of the jet engine emissions of Vehicle Type A

[a] Vehicles with unpowered landings were not included in this analysis because they would not be expected to contribute any emissions.

4.1.1 Troposphere

The following subsections present the impacts of the proposed action and the alternatives on the troposphere.

4.1.1.1 Proposed Action

Under the proposed action, the impacts on the troposphere would result from LV jet engine emissions (Concept 1 vehicles), carrier aircraft jet engine emissions (Concept 3 vehicles), and/or emissions generated by the ignition of rocket motors in the troposphere (Concept 2 vehicles or RVs). Other potential impacts on the troposphere could result from accidents on the launch pad or during flight. Exhibit 4-3 presents the projected annual emissions for LVs and RVs below 914 meters (3,000 feet) of the specific chemical species of concern from 2005 through 2015. The 914-meter (3,000-feet) altitude is appropriate for evaluating impacts in the troposphere because the Federal government uses 914 meters (3,000 feet) and below to assess contributions of emissions to the ambient air quality and for the *de minimis* calculations under the CAA. (U.S. EPA, 1992) The emissions in Exhibit 4-3 were calculated by estimating the emissions per launch or reentry for each vehicle type, multiplying these per launch or reentry emissions by the estimated annual launches or reentries for each vehicle type, and then summing across all vehicle types.

Exhibit 4-3. Estimated Annual Emissions below 914 meters (3,000 feet) for Proposed Action (All Vehicle Types Combined), Kilograms (Pounds)

	HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
2005	-	-	77 (170)	34 (75)	4 (9)	321 (708)	2,392 (5,273)	893 (1,969)	99 (219)
2006	-	-	198 (437)	10 (22)	4 (9)	681 (1,501)	14,352 (31,641)	5,358 (11,813)	82 (181)
2007	-	-	671 (1,478)	34 (75)	13 (29)	2,305 (5,081)	17,851 (39,355)	6,663 (14,689)	261 (575)
2008	-	-	724 (1,595)	74 (161)	17 (37)	2,559 (5,638)	32,673 (72,032)	12,194 (26,884)	363 (800)
2009	-	-	797 (1,758)	76 (168)	19 (44)	2,814 (6,204)	38,225 (84,274)	14,439 (31,833)	371 (818)
2010	-	-	1,063 (2,341)	80 (174)	23 (51)	3,705 (8,165)	48,531 (106,993)	18,459 (40,682)	464 (1,023)
2011	-	-	843 (1,859)	117 (256)	23 (53)	3,045 (6,713)	53,319 (117,548)	20,599 (45,413)	472 (1,041)
2012	-	-	847 (1,868)	79 (174)	20 (44)	2,986 (6,582)	57,279 (126,279)	22,608 (49,842)	406 (895)
2013	-	-	862 (1,901)	118 (260)	23 (53)	3,111 (6,858)	57,279 (126,279)	23,140 (51,015)	477 (1,052)
2014	-	-	854 (1,883)	80 (176)	20 (44)	3,009 (6,634)	61,240 (135,011)	24,972 (55,054)	406 (895)
2015	-	-	869 (1,917)	118 (260)	23 (53)	3,135 (6,910)	65,200 (143,741)	26,981 (59,483)	477 (1,052)

Note: No emissions of HCl and Cl would occur in the troposphere because under the proposed action no solid rocket motor engines would be fired in the troposphere.

Exhibit 4-4 presents the emissions per launch or reentry for each of the 10 vehicle types considered (i.e., one Concept 1, three Concept 2, four Concept 3, and two reentry vehicles). Appendix F provides detailed descriptions of the different vehicles types and how the emissions per launch or reentry for each vehicle type were calculated. Exhibit F-39 provides the estimated number of annual launches of each vehicle type.

Exhibit 4-4. Estimated Emissions below 914 meters (3,000 feet) by LV Launch or RV Reentry Based on Vehicle Type

Vehicle Type by Concept	Emission Loads per Launch/Reentry, Kilograms (Pounds)								
	HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
Concept 1 Vehicles									
Vehicle Type A	-	-	11 (24)	0.5 (1.1)	0.2 (0.4)	38 (83)	-	-	4.0 (8.8)
Concept 2 Vehicles									
Vehicle Type B	-	-	-	-	-	-	478 (1,055)	179 (394)	-
Vehicle Type C	-	-	-	-	-	-	958 (2,111)	357 (788)	-
TBD Concept 2 Vehicle[a]	-	-	-	-	-	-	792 (1,746)	296 (652)	-
Concept 3 Vehicles									
Vehicle Type D[b]	-	-	11 (24)	0.6 (1.3)	0.3 (0.7)	38 (84)	-	-	5.2 (12)
Vehicle Type E	-	-	11 (24)	30 (65)	2.3 (5.1)	93 (204)	-	-	68 (150)
Vehicle Type F[b]	-	-	0.2 (0.4)	8.3 (18)	1.4 (3.1)	18 (41)	-	-	2.3 (5.1)
TBD Concept 3 Vehicle[b,c]	-	-	11 (23)	2.5 (5.5)	0.4 (0.9)	40 (88)	-	-	8.5 (19)
Reentry Vehicles									
Reentry Vehicle – Rocket	-	-	-	-	-	-	-	709 (1,563)	-
Reentry Vehicle – Jet	-	-	5.5 (12)	0.2 (0.5)	0.1 (0.2)	19 (41)	-	-	-

[a] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 2 vehicle emissions (weighted based on the number of launches of each type of Concept 2 vehicle between 2005-2015).

[b] The available emissions factors do not include PM emissions from the (N_2O/HTPB) rocket engines assumed to be used by these vehicles. N_2O/HTPB engines are expected to generate particulate matter emissions (Wright, et al, 2005; Chouinard, et al, 2002); however, analyses of other vehicle types with higher PM emissions than would be expected with these vehicle types indicate these emissions have no significant impact; thus, any PM emissions from these vehicles would be expected to have negligible impacts.

[c] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 3 vehicle emissions (weighted based on the number of launches of each type of Concept 3 vehicle between 2005-2015).

Criteria Pollutants

EPA has set national air quality standards for six common pollutants, referred to as "criteria" pollutants. These criteria pollutants include ozone, PM, CO, NO_2, SO_2, and Pb. Depending on the vehicle and propellant type, LV and RV emissions can contain any of these pollutants with the exception of Pb. A conformity analysis would be required if a horizontal LV launch or RV reentry occurred in a region that was in non-attainment for a particular criteria pollutant. The Federal government is exempt from the requirements to perform a conformity analysis if (1) the ongoing activities do not produce emissions above the *de minimis* levels specified in the rule; and (2) the Federal action is not considered a regionally significant action. A Federal action is considered regionally significant when the total emissions from the action equal or exceed 10 percent of the air quality control area's emissions inventory for any criteria pollutant. This PEIS compares annual emissions to the *de minimis* levels. Determination of regional significance would be determined through site-specific analysis.

If a horizontal LV launch or RV reentry occurred in a region that was in non-attainment for Federal attainment standards for ozone, a conformity analysis would be required if the emissions of ozone precursors (VOC or NO_X) exceed the applicable *de minimis* levels on an annual basis. Exhibit 4-3 indicates that in the years with the highest ozone emissions (2013 and 2015), the total annual NO_X and VOC emissions for the proposed action from all horizontal launches and reentries would be 118 kilograms (260 pounds) and 477 kilograms (1,052 pounds), respectively. Even if all horizontal launches and reentries were assumed to occur in the same region (which is highly unlikely), both the total annual NO_X or VOC emissions would be substantially below the *de minimis* level of 9,072 kilograms (10 tons) per year for an area in severe non-attainment (the worst type of non-attainment status for ozone). In addition, the maximum annual emissions from all horizontal launches and reentries in the U.S. only represent 5×10^{-7} percent and 3×10^{-6} percent of the total emissions of NO_X and VOC, respectively, in the year 2002. (U.S. EPA OAQPS, 2004) Thus, NO_X or VOC emissions associated with the proposed action would not result in a significant impact on ambient air quality.

The estimated horizontal launch and reentry emissions of PM below 914 meters (3,000 feet) under the proposed action during the period 2005 to 2015 range from about 77 kilograms (0.1 ton) to 1,063 kilograms (1 ton) annually, summed across all horizontal launches and reentries. By comparison, the total annual PM_{10} and $PM_{2.5}$ emissions from all U.S. sources for 2002 were approximately 2.2 billion kilograms and 1.6 billion kilograms (2.4 and 1.8 million tons), respectively. (U.S. EPA OAQPS, 2004) If it were conservatively assumed that 100 percent of the emissions from the proposed action are PM_{10}, these emissions from the year with the highest emissions (2010) would only comprise approximately 5×10^{-5} percent of the total annual PM_{10} emissions nationwide, based on 2002 emission estimates. (U.S. EPA OAQPS, 2004) Likewise, if it were assumed that 100 percent of PM emissions from the proposed action are $PM_{2.5}$, these emissions would only comprise approximately 6×10^{-5} percent of total $PM_{2.5}$ emissions for the year 2002. (U.S. EPA OAQPS, 2004) Even if all horizontal launches and reentries were assumed to occur in the same region (which is highly unlikely), the total annual PM_{10} emissions would be substantially below the *de minimis* level of 63,640 kilograms (70 tons) per year for an area in serious non-attainment (the worst type of non-attainment status for PM_{10}). Given the magnitude of PM emissions from horizontal launches and reentries relative to total annual PM emissions nationwide, and the fact that the emissions are far below the *de minimis* level, PM emissions associated with the proposed action would not result in a significant impact on ambient air quality.

If a horizontal launch or reentry occurred in a region that was in non-attainment for Federal attainment standards for CO, a conformity analysis would be required if the emissions of CO were above certain *de minimis* levels per year. The total estimated horizontal launch and reentry emissions of CO below 914 meters (3,000 feet) for the proposed action for the period 2005 to 2015 range from about 320 kilograms (0.4 ton) to 3,704 kilograms (4 tons) annually, summed across all horizontal launches and reentries. By comparison, the total annual CO emissions from all U.S. sources for 2002 were over 96 million tons. (U.S. EPA OAQPS, 2004) The incremental contribution of horizontal launch and reentry emissions from the proposed action would be an extremely small fraction (less than 4×10^{-6} percent) of this amount, even for the year in which CO emissions are highest (i.e., 2010). Even if all horizontal launches and reentries were assumed to occur in the same region (which is highly unlikely), the total annual CO emissions would be substantially below the *de minimis* level of 90,718 kilograms (100 tons) per year for an area in non-attainment. Given the small amount of CO emissions from horizontal launches and reentries relative to the total annual emissions, and the fact that the emissions would be far below the *de minimis* level, CO emissions associated with the proposed action would not result in a significant impact on ambient air quality.

In addition to contributing to the formation of ozone, NO_2 can cause respiratory problems in humans, contribute to the formation of acid rain and nutrient overload that deteriorates water quality, and reduce visibility. A conformity analysis would be required if the following conditions apply: (1) a horizontal launch or reentry occurred in a region that was in non-attainment for Federal NO_2 attainment standards, and (2) the emissions of NO_2 exceeded the applicable *de minimis* levels per year. Even if all horizontal launches and reentries were assumed to occur in the same region (which is highly unlikely), the total annual NO_X emissions (part of which is NO_2) of 116 kilograms (0.1 ton) for the years with the highest NO_X emissions (2013 and 2015) would be substantially below the *de minimis* level of 90,910 kilograms (100 tons) per year for an area in non-attainment. Thus, NO_2 emissions associated with the proposed action would not result in a significant impact on ambient air quality.

SO_2 and NO_X together are the major precursors to acidic deposition (i.e., acid rain), which is associated with the acidification of soils, lakes, and streams and accelerated corrosion of buildings and monuments. SO_2 also is a major precursor to $PM_{2.5}$, which is a health concern and a main contributor to poor visibility. If a horizontal launch or reentry occurred in a region that was in non-attainment for SO_X for Federal attainment standards, a conformity analysis would be required if the emissions of SO_X exceeded the applicable *de minimis* levels per year.

The estimated horizontal LV and RV emissions of SO_X below 914 meters (3,000 feet) for the proposed action during the period 2005 to 2015 would range from about 4 kilograms (0.004 ton) to 23 kilograms (0.03 ton) annually, summed across all horizontal launches and reentries. By comparison, the total annual SO_2 emissions from all U.S. sources for 2002 were over 13 metric tons (15 million tons). (U.S. EPA OAQPS, 2004) The incremental contribution of horizontal launch and reentry emissions would be an extremely small fraction (less than 2×10^{-7} percent) of this amount, even for the years in which CO emissions would be the highest (i.e., 2011, 2013, and 2015). In addition, even if all horizontal launches and reentries were assumed to occur in the same region (which is highly unlikely), the total annual SO_X emissions would be substantially below the *de minimis* level of 90,910 kilograms (100 tons) per year for an area in non-attainment. Thus, SO_X emissions associated with the proposed action would not result in a significant impact on ambient air quality. Given the small NO_X and SO_X emissions associated with the proposed action relative to the total annual emissions and the fact that the emissions would be far below the *de minimis* level, NO_X and SO_X emissions would not result in a significant impact on ambient air quality, the formation of acid rain, or visibility.

For the purposes of this PEIS, the operational emissions associated with a launch site for horizontal launches would include the emissions from the launch vehicle and its support aircraft. As provided above, even if FAA assumed that all the horizontal launches and reentries would occur in the same region (which is highly unlikely), none of the *de minimis* thresholds for NAAQS would be exceeded; therefore, the emissions associated with the proposed action would conform to the SIP. Emissions associated with other launch site operations including generators, fueling activities, boilers, or other activities that would result in emissions, were not included in this analysis. Such impacts and whether or not they would be considered to be a significant impact would be addressed in a site-specific NEPA document that would tier from this PEIS.

Air Toxics

Two HAPs (HCl and Cl) also called air toxics, are sometimes components of rocket engine emissions, depending on the propellant type. None of the programmatic horizontal LVs that use solid rocket motors ignite these motors in the troposphere; thus no HCl or Cl is emitted to the troposphere from horizontal LVs. In addition, none of the programmatic RVs with powered landings use propellants that result in HCl or Cl emissions.

Regional Haze

The FAA reviewed the regional haze rule (64 FR 35714, dated July 1, 1999), which requires states to develop SIPs to address visibility at designated mandatory Class I areas, including 156 designated national parks, wilderness areas, and wildlife refuges. General features of the regional haze rule are that all states are required to prepare an emissions inventory of all haze-related pollutants (i.e., VOC, NO_X, SO_2, PM_{10}, $PM_{2.5}$, and NH_3) from all sources in all constituent counties. Most states will develop their regional haze SIP in conjunction with their $PM_{2.5}$ SIP over the next several years.

The five member states of WRAP are Arizona, New Mexico, Wyoming, Utah, and Oregon. WRAP has elected to submit regional haze SIPs under the provisions of Section 309 of the regional haze rule, which includes a CAC that extends from Nevada and Utah to Oregon and Idaho. Those preliminary regional haze SIPs were submitted to EPA in December 2003. The WRAP policy on CACs, completed on November 13, 2002, concluded that a 25 percent increase in weighted emissions would have only a minimal impact on visibility at Class I areas on the Colorado Plateau. (WRAP, 2002) The minimal emissions of the haze-related pollutants associated with the proposed action would have a negligible impact on the visibility at the designated Class I areas.

4.1.1.2 Alternative 1

Under alternative 1, there would be no emissions from RVs. This would result in a reduction in emissions in the troposphere (between zero and five percent, on average) relative to the proposed action. Thus, the overall impacts on air quality in the troposphere from alternative 1 would be the same or slightly less than those posed from the proposed action.

4.1.1.3 Alternative 2

Under alternative 2, the emissions from RVs would be twice as much as in the proposed action. However, this would only result in an increase in emissions in the troposphere (between zero and five percent, on average) from the proposed action. A five percent increase of emissions in the troposphere over the proposed action would not exceed any established *de minimis* thresholds for ambient air quality. Thus, the overall impacts on air quality in the troposphere from alternative 2 would be the same or slightly more than those posed from the proposed action.

4.1.1.4 Alternative 3

Under alternative 3, the overall emissions to the troposphere from the proposed action would be reduced for most pollutants of interest. This reduction would be approximately 40 percent for PM, 20 percent for CO, 70 percent for NO_X, 50 percent for VOCs, and 60 percent for SO_X. There were no estimated changes in emissions from the proposed action for the other pollutants of interest. Thus, the overall impacts on air quality in the troposphere from alternative 3 would be less than those posed from the proposed action.

4.1.1.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no addition or removal of emissions to the troposphere. Air quality in the troposphere would not be impacted by implementation of the no action alternative.

4.1.2 Stratosphere

The following subsections present the impacts of the proposed action and the alternatives on the stratosphere.

4.1.2.1 Proposed Action

Under the proposed action, the potential impacts to the stratosphere that may result from horizontal LV and RV emissions include global warming from contributions of greenhouse gases and depletion of the stratospheric ozone layer. The potential for these impacts is discussed in this section. Emissions to the stratosphere were calculated by estimating the emissions per launch or reentry for each vehicle type, multiplying these per launch or reentry estimates by the estimated annual launches for each vehicle type, and then summing across all vehicle types. The emissions per launch or reentry by vehicle are provided in Exhibit 4-5 and described in detail in Appendix F. There were 10 different vehicle types in this analysis (one type for Concept 1, three for Concept 2, four for Concept 3, and two reentry vehicles), and thus there are multiple vehicle types listed for Concepts 2 and 3 and reentry vehicles. There are no estimated emissions for one Concept 3 vehicle type (Vehicle Type F) or either reentry vehicle type because these vehicles are not expected to consume any propellant while in the stratosphere. The estimated annual number of launches for each vehicle type is also provided in Exhibits F-41 to F-43 in Appendix F. Estimated annual emissions to the stratosphere (across all vehicle types) are presented in Exhibit 4-6.

Exhibit 4-5. Estimated Emissions in Stratosphere by LV Launch or RV Reentry Based on Vehicle Type

Vehicle Type by Concept	Emission Loads per Launch/Reentry, Kilograms (Pounds)						
	HCl	Cl	PM	NO_X	CO	CO_2	H_2O
Concept 1 Vehicles							
Vehicle Type A	-	-	-	-	648 (1,428)	1,589 (3,502)	973 (2,144)
Concept 2 Vehicles							
Vehicle Type B	-	-	-	-	516 (1,138)	1,264 (2,787)	774 (1,706)
Vehicle Type C	-	-	-	-	1,032 (2,275)	2,528 (5,573)	1,548 (3,413)
TBD Concept 2 Vehicle[a]	-	-	-	-	854 (1,883)	2,092 (4,612)	1,281 (2,824)
Concept 3 Vehicles							
Vehicle Type D	-	-	-	-	305 (672)	46 (101)	335 (739)
Vehicle Type E	3,153 (6,951)	23 (51)	5,705 (12,577)	50 (110)	-	6,906 (15,225)	4,054 (8,938)
Vehicle Type F	-	-	-	-	-	-	-
TBD Concept 3 Vehicle[b]	171 (377)	1.2 (2.6)	310 (683)	2.7 (6.0)	275 (606)	417 (919)	523 (1,153)
Reentry Vehicles							
Reentry Vehicle – Rocket	-	-	-	-	-	-	-
Reentry Vehicle – Jet	-	-	-	-	-	-	-

[a] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 2 vehicle emissions (weighted based on the number of launches of each type of Concept 2 vehicle between 2005-2015).

[b] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 3 vehicle emissions (weighted based on the number of launches of each type of Concept 3 vehicle between 2005-2015).

Exhibit 4-6. Estimated Annual Emissions to the Stratosphere (All Vehicle Types Combined), Kilograms (Pounds)

	HCl	Cl	PM	CO	CO_2	NO_X	H_2O
2005	3,153 (6,951)	23 (51)	5,705 (12,577)	4,408 (9,718)	13,502 (29,766)	50 (110)	9,934 (21,901)
2006	-	-	-	24,401 (53,795)	54,177 (119,439)	-	35,627 (78,544)
2007	171 (377)	1 (2)	310 (683)	54,992 (121,238)	127,465 (281,012)	3 (7)	81,381 (179,414)
2008	4,010 (8,841)	29 (64)	7,256 (15,997)	72,069 (158,885)	175,182 (386,211)	63 (139)	111,491 (245,796)
2009	2,571 (5,668)	18 (40)	4,652 (10,255)	80,184 (176,776)	186,993 (412,249)	41 (89)	120,958 (266,667)
2010	2,571 (5,668)	18 (40)	4,652 (10,255)	107,189 (236,312)	253,853 (559,650)	41 (89)	161,587 (356,239)
2011	6,581 (14,509)	47 (104)	11,907 (26,250)	97,209 (214,308)	235,727 (519,688)	104 (228)	151,344 (333,656)
2012	3,428 (7,557)	24 (53)	6,202 (13,673)	101,782 (224,391)	239,325 (527,621)	54 (119)	154,029 (339,575)
2013	6,581 (14,509)	47 (104)	11,907 (26,250)	101,782 (224,391)	246,231 (542,847)	104 (228)	158,083 (348,512)
2014	3,428 (7,557)	24 (53)	6,202 (13,673)	106,051 (233,803)	249,784 (550,679)	54 (119)	160,432 (353,693)
2015	6,581 (14,509)	47 (104)	11,907 (26,250)	110,320 (243,214)	267,149 (588,963)	104 (228)	170,890 (376,747)

Global Warming

Under the proposed action, the potential horizontal LV emissions that may affect global warming directly as greenhouse gases include CO_2 and H_2O. An approximation of the potential for these LV emissions to affect global warming was obtained by comparing the estimated annual horizontal LV emissions of each pollutant to stratosphere (see Exhibit 4-6) to the annual emissions from all U.S. sources for these pollutants. The estimated horizontal LV emissions of CO_2 to the stratosphere for the period 2005 to 2015 would range from about 13 metric tons (15 tons) to 263 metric tons (294 tons) annually. By comparison, the total annual CO_2 emissions from all U.S. sources for 1999 were over 5.5 billion metric tons (6.1 billion tons). (U.S. EPA, 2001) The incremental contribution of horizontal LV emissions would be an extremely small fraction (less than 5×10^{-5} percent) of this amount, even for the year in which CO_2 emissions are highest (i.e., 2015), which would result in a negligible impact on global warming. Horizontal LV emissions of H_2O would also have an insignificant effect on global warming due to the preponderance of other natural and anthropogenic sources of H_2O.

CO and NO_X, two photochemically important pollutants that can influence the creation and destruction of greenhouse gases, also would be present in horizontal LV emissions. Contributions from horizontal LV emissions of these pollutants to the atmospheric burden, however, would be extremely small relative to U.S. annual emissions (over 100 billion kilograms [111 million tons] and 22 billion kilograms [25 million tons] of CO and NO_X, respectively) for 2000. (U.S. EPA OAQPS, 2004) As a result, the presence of these chemicals in horizontal LV emissions would have a negligible impact on global warming.

Ozone Depletion

Under the proposed action, only Concept 3 LVs would emit primary chemicals of concern (HCl and Cl). To assess the potential impact of emissions to the stratosphere associated with the proposed action, several relatively recent studies on the contribution of LV emissions on ozone depletion were reviewed. The field study on Rocket Impact on Stratospheric Ozone (RISO) confirmed that ozone depletion related to launch emissions is a temporary and limited phenomenon. In general, findings from this study indicate that the potential for ozone depletion associated with LV exhaust to cause an increase in solar UV intensity near launch sites is extremely limited. (Ross et al., 2000)

A study carried out by the World Meteorological Organization considered the effects of Cl releases from launches of the Space Shuttle, Titan IV, and Ariane 5, which were estimated to release a total of 150,000 kilograms (1,570 tons) of Cl per year to the stratosphere. This release amount was reported to be an extremely small fraction (less than 0.07 percent) of the 1994 total stratospheric burden of chlorine from industrial sources. (World Meteorological Organization, 1995) This amount is, in turn, substantially larger than the total HCl and Cl that would be released by LV emissions under the proposed action, indicating that the impacts on ozone depletion would be insignificant.

An additional study conducted for the EA of the Atlas IIAS concluded that the ozone depletion potential from that launch, which was reported to emit about 7,200 kilograms (7.9 tons) of HCl, was relatively low. (Versar, Inc., 1991) By comparison, horizontal LV emissions from a Concept 3 launch (the only one of the three launch concepts that would result in stratospheric HCl emissions) are less than 180 kilograms (0.2 ton) per launch. Furthermore, an additional study entitled “Atmospheric Environmental Implications of Propulsion Systems” concluded that even vastly increased launch activities (e.g., 50 Space Shuttle or Energia launches per year) would not significantly impact stratospheric ozone depletion. This study found that although LVs do release chlorine into the atmosphere as HCl, the global effects would be far below and indistinguishable from the effects caused by other natural and man-made causes. (McDonald et al., 1994 as referenced in the FAA Launch Licensing 2001 PEIS)

PM also would be emitted to the stratosphere by some of the LVs associated with the proposed action. PM may affect stratospheric ozone, possibly by acting as a catalytic site for ozone destruction; however, the exact impact of PM on ozone depletion is unclear. A 1999 study prepared for the USAF on the stratospheric impact of solid rocket motor launch emissions concluded that the global impacts of PM from such emissions on ozone depletion are very small. (Ko et al., 1999) The estimated total emissions of Al_2O_3 (i.e., PM) to the stratosphere used in calculations for that study were approximately 1,015 metric tons per year (1,120 tons per year). This amount is larger than the 10-year total emissions of PM estimated for all launch types in the current assessment; therefore, the impacts of PM emissions associated with the proposed action on stratospheric ozone depletion would be negligible.

Releases of NO_X can also result from LV emissions, and NO_X is a chemical of concern for ozone depletion. However, emissions of NO_X from horizontal LVs and RVs would be extremely small relative to total U.S. emissions of NO_X. About 19 million metric tons (21 million tons) were released in the U.S. in 2002 alone (U.S. EPA OAQPS, 2004), and it is anticipated that total global emissions over the 10-year period between 2005 and 2015 would be substantially larger.

4.1.2.2 Alternative 1

Under alternative 1, there would be no emissions from RVs. Because all reentry emissions were estimated to occur in the troposphere, the emissions to the stratosphere under alternative 1 would be the same as under the proposed action. Thus the overall air quality impacts in the stratosphere from alternative 1 would be the same as the impacts associated with the proposed action.

4.1.2.3 Alternative 2

Under alternative 2, the emissions from RVs would be twice as much as in the proposed action. Because all reentry emissions would occur in the troposphere, the emissions to the stratosphere under alternative 2 would be the same as under the proposed action. Thus the overall air quality impacts in the stratosphere from alternative 2 would be the same as the impacts associated with the proposed action.

4.1.2.4 Alternative 3

Under alternative 3, the overall emissions to the stratosphere from the proposed action would be reduced or eliminated for most pollutants of interest. Emissions would be reduced by 10 percent for CO and CO_2, and 20 percent for H_2O. There would be no changes in emissions from the proposed action for the other pollutants of interest. Thus, the overall impacts on air quality in the stratosphere from alternative 3 would be less than those associated with the proposed action.

4.1.2.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no addition or removal of emissions to the stratosphere. Air quality in the stratosphere would not be impacted by implementation of the no action alternative.

4.1.3 Mesosphere

The following subsections present the impacts of the proposed action and the alternatives on the mesosphere.

4.1.3.1 Proposed Action

Under the proposed action, negligible impacts on the mesosphere would occur during normal launches. The mesosphere is a relatively narrow band of the atmosphere where rockets tend to pass through fairly quickly. For launches and reentries under the proposed action, the amount of rocket emissions in this layer would be extremely small. Furthermore, impacts in the mesosphere associated with the compounds emitted by LVs are not known to exist.

4.1.3.2 Alternative 1

Under alternative 1, there would be no emissions from RVs. Because all reentry emissions would occur in the troposphere, the emissions to the mesosphere under alternative 1 would be the same as under the proposed action. Thus the overall air quality impacts in the mesosphere from alternative 1 would be the same as the impacts associated with the proposed action. Because there are negligible impacts to the mesosphere associated with the proposed action, there would be negligible impacts to the mesosphere associated with alternative 1.

4.1.3.3 Alternative 2

Under alternative 2, the emissions from RVs would be twice as much as in the proposed action. Because all reentry emissions would occur in the troposphere, the emissions to the mesosphere under alternative 2 would be the same as under the proposed action. Thus the overall air quality impacts in the mesosphere from alternative 2 would be the same as the impacts associated with the proposed action. Because there are negligible impacts to the mesosphere associated with the proposed action, there would be no impacts to the mesosphere associated with alternative 2.

4.1.3.4 Alternative 3

Under alternative 3, the overall emissions to the mesosphere from the proposed action would be reduced or eliminated for most pollutants of interest. Thus the overall air quality impacts in the mesosphere from alternative 3 would be the less than the negligible impacts associated with the proposed action.

4.1.3.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no addition or removal of emissions to the mesosphere. Air quality in the mesosphere would not be impacted by implementation of the no action alternative.

4.1.4 Ionosphere

The following subsections present the impacts of the proposed action and the alternatives on the ionosphere.

4.1.4.1 Proposed Action

Under the proposed action, some exhaust products from horizontal LVs[21] during launch from Earth to space have been found to have a temporary effect on electron concentrations in the F layer of the ionosphere.[22] Such a temporary effect would result in a negligible impact on the ionosphere. The specific exhaust products include CO_2, H_2O, and H. These compounds can react with ambient electrons and ions in the F layer of the ionosphere to effectively form a "hole" in this region by reducing the concentration of electrons and ions within the path of the vehicle. This effect in the F layer is believed to be caused by a rapid charge-exchange reaction between the LV exhaust products and the ambient atomic oxygen ions (O^+) in the F layer. Ambient O^+s are the dominant ion in the F layer. At lower altitudes of the ionosphere (i.e., below 140 kilometers [87 miles]), this reaction is not effective because the dominant positive ions are NO^+ and O_2^+, not O^+. For example, the reaction between H_2O and O^+ is

$$H_2O + O^+ \rightarrow H_2O^+ + O$$

followed by the rapid recombination

$$H_2O^+ + e^- \rightarrow OH^- + H^-$$

Similar reactions also occur with CO_2 and H. These reactions result in a net decrease in electron concentration in the F layer, potentially affecting radio communication, such as short-wave broadcasts, which interact with the ionosphere. (U.S. DOT, 1992)

An experimental test firing of the propulsion unit used by the Space Shuttle for maneuvering within the ionosphere was conducted in 1985. This test firing provides some data on the rapidity with which a "hole" in the F layer may disappear. The propellants used in this test firing were monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4), similar to the propellants used for routine launches of other LVs.[23] The test involved consuming 290 kilograms (640 pounds) total mass of MMH and N_2O_4. Exhaust products from this experimental test firing consisted of approximately 117.7 kilograms (260 pounds) (40.6 percent) N, 92.5 kilograms (203 pounds) (31.9 percent) CO_2, 75.7 kilograms (166 pounds) (26.1 percent) H_2O, and 4.1 kilograms (9 pounds) (1.4 percent) H. The percentages represent percent by mass, and complete combustion was assumed. Thus, about 172 kilograms (344 pounds) of potential electron-depleting substances (CO_2, H_2O, and H) were emitted. The associated "ion/electron hole" disappeared into the lower F layer within five minutes.

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[21] Reentry vehicles are not expected to have impacts on the ionosphere because they do not use engines at these altitudes.

[22] The F layer is the highest region of the ionosphere.

[23] Neither of these specific propellants is proposed to be used by horizontally launched LVs; however, the persistence of the ion/electron hole produced by these vehicles may be similar to that observed in this study.

The amount of electron-depleting substances released per horizontal LV launch is presented in Exhibit 4-7. The largest amount per launch that would occur under the proposed action would be approximately 1,385 kilograms (3,053 pounds). This is about eight times the amount of exhaust products released during Space Shuttle testing. Data are unavailable to estimate the differences in the size of the "ion/electron hole" that might be created with larger vehicles and the amount of time it would take for these holes to dissipate. However, other studies of the Saturn V launch of Skylab that measured the size of the ionospheric hole created by that launch suggest that in the worst case, the ionospheric hole appears to dissipate in a matter of minutes. (Mendillo et al., 1975 as referenced in the FAA Launch Licensing 2001 PEIS) In addition, for the vehicles considered in the current assessment, no parking orbit exists, resulting in a rather short-term effect on the ionosphere. Therefore, it does not appear that the effects of this phenomenon could accumulate to any degree, unless there were launches through the same region of the atmosphere every few minutes (which is highly unlikely).

Exhibit 4-7. Estimated Range of Emissions of Electron-depleting Substances Released into the Ionosphere

Pollutant	Range in kilograms (pounds)	
	Minimum	Maximum
H	-	-
H_2O	835 (1,841)	1,240 (2,734)
CO_2	93 (205)	145 (320)
Total electron-depleting substances	1,040 (2,293)	1,385 (3,053)

4.1.4.2 Alternative 1

Under alternative 1, there would be no emissions from RVs. Because all reentry emissions would occur in the troposphere, the emissions to the ionosphere under alternative 1 would be the same as under the proposed action. Thus the overall air quality impacts in the ionosphere from alternative 1 would be the same as the impacts associated with the proposed action.

4.1.4.3 Alternative 2

Under alternative 2, the emissions from RVs would be twice as much as in the proposed action. Because all reentry emissions would occur in the troposphere, the emissions to the ionosphere under alternative 2 would be the same as under the proposed action. Thus the overall air quality impacts in the ionosphere from alternative 2 would be the same as the impacts associated with the proposed action.

4.1.4.4 Alternative 3

Under alternative 3, the overall emissions to the ionosphere from the proposed action would be eliminated for most pollutants of interest. The Concept 1 and Concept 3 vehicles analyzed do not use their engines in the ionosphere, whereas some of the Concept 2 vehicles do. By not licensing Concept 2 vehicles, all emissions to the ionosphere would be eliminated.

4.1.4.5 No Action Alternative

Under the no action alternative, FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no addition or removal of emissions to the ionosphere. Air quality in the ionosphere would not be impacted by implementation of the no action alternative.

4.2 Airspace

The following subsections discuss the impacts associated with each alternative on airspace and the use of designated airspace.

4.2.1 Proposed Action

Under the proposed action, the FAA would issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities. Because the launch profiles and flight paths for each of the proposed 1,279 horizontal launches, as well as the reentry profiles and flight paths of the 51 reentries, must under undergo FAA's safety review and approval process, such launch and reentry activities would not result in a significant impact on designated airspace or its use.

The FAA safety review and approval process determines whether a license applicant, payload owner, or operator has obtained all required licenses, authorizations, and permits. (See Appendix A, FAA Licensing Program, for additional information.) Under this process, the applicant may be required to obtain airspace use authorizations to use military airspace or may be required to coordinate with the FAA Air Route Traffic Control Center (ARTCC) to provide for adequate airspace safety during launch or reentry activities. (See Appendix D, Regulatory Process Description for more information.) The same safety review and approval process would be followed for the development of a new launch or reentry site that would accommodate horizontally launched LVs or reentry or RVs. The establishment of any new designated airspace with such a facility would be addressed in a subsequent site-specific analysis.

4.2.2 Alternative 1

Under alternative 1, FAA's safety review and approval process would be followed for the licenses issued under this alternative, as described under the proposed action; therefore, designated airspace or its use would not be significantly impacted by implementation of alternative 1.

4.2.3 Alternative 2

Under alternative 2, FAA's safety review and approval process would be followed for the licenses issued under this alternative, as described under the proposed action; therefore, designated airspace or its use would not be significantly impacted by implementation of alternative 2.

4.2.4 Alternative 3

Under alternative 3, FAA's safety review and approval process would be followed for the licenses issued under this alternative, as described under the proposed action; therefore, designated airspace or its use would not be significantly impacted by implementation of alternative 3.

4.2.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no addition or removal of aircraft within designated airspace. Designated airspace or its use would not be impacted by implementation of the no action alternative.

4.3 Biological Resources

The following subsections present the impacts associated with the proposed action and the alternatives on biological resources.

4.3.1 Proposed Action

4.3.1.1 Terrestrial and Aquatic Vegetation

The proposed action may result in local adverse impacts on vegetation. Such impacts would result from the deposition of rocket engine emissions (e.g., HCl, various metals, and other substances based on the propellant type and characteristics), which would decrease the fitness of an affected local plant population, but would not likely result in the permanent removal or loss of a particular vegetative community. (See Section 4.1, Atmosphere for additional information on rocket engine emissions.) Additionally, the development of new launch or reentry facilities, or the modification of existing facilities, may result in the removal or alteration of existing vegetative communities, causing an adverse impact. Finally, the deposition of LV stages (booster rockets) or the landing of an RV in vegetative areas would result in an adverse impact on the localized vegetative community. Such impacts, and whether or not they would be considered a significant impact, would be addressed in a site-specific NEPA document that would tier from this PEIS. (See Section 8, Fish, Wildlife, and Plants of Appendix A, FAA Order 1050.1E for additional information.)

4.3.1.2 Terrestrial and Aquatic Wildlife

The proposed action may result in local adverse impacts on wildlife. Such impacts would result from the deposition of rocket engine emissions (e.g., HCl, various metals, and other substances based on the propellant type and characteristics), which may be absorbed, inhaled, or ingested by local wildlife. (See Section 4.1, Atmosphere for additional information on rocket engine emissions.) Additionally, the removal of a vegetative community, or the decrease in the fitness of it, would reduce the size of the wildlife population that such an area would be able to support, increase the competition amongst the wildlife species for the reduced resources, and decrease the fitness of the local wildlife populations, resulting in an adverse impact on wildlife. The noise associated with the launch of an LV or the reentry and landing of an RV may startle wildlife and temporarily disrupt their activities (feeding/foraging, breeding, or resting), resulting in an adverse impact (see Section 4.4, Noise). Additional adverse impacts on wildlife would result from the development of a new launch or reentry facility, or modification of an existing facility. Adverse impacts would occur because the removal of vegetative habitat would reduce the amount of wildlife habitat and would preclude species that are intolerant of human disturbances and activities from utilizing such areas. Such impacts and whether or not they would be considered to be a significant impact would be addressed in a site-specific NEPA document that would tier from this PEIS. (See Section 8, Fish, Wildlife, and Plants of Appendix A, FAA Order 1050.1E for additional information.)

4.3.1.3 State- and Federally-Listed Rare, Threatened, or Endangered Species

The proposed action may result in location- and species-specific adverse impacts on state- or federally-listed rare, threatened, or endangered species. Activities could affect habitat, reproductive fitness, population size, distribution, or other species-specific activities (e.g., feeding/foraging, breeding, migration, or resting). Such impacts and whether or not they would be considered a significant impact, would be analyzed in a site-specific NEPA document that would tier from this PEIS. (See Section 8, Fish, Wildlife, and Plants of Appendix A, FAA Order 1050.1E for additional information.) Appendix D describes the required consultations regarding these impacts.

4.3.2 Alternative 1

Under alternative 1, the impacts and process to consider site-specific impacts on biological resources would be the same as those described for the proposed action.

4.3.3 Alternative 2

Under alternative 2, the impacts and process to consider site-specific impacts on biological resources would be the same as those described for the proposed action.

4.3.4 Alternative 3

Under alternative 3, the impacts and process to consider site-specific impacts on biological resources would be the same as those described for the proposed action.

4.3.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, the existing conditions would not change and no biological resources would be impacted. No additional site-specific NEPA documents would be prepared for horizontal launches of LVs or reentry of RVs because such activities would not occur under the no action alternative.

4.4 Cultural Resources

The following subsections discuss the impacts associated with the proposed action and the alternatives on cultural resources.

4.4.1 Proposed Action

The licensing of horizontal launches and reentries under the proposed action is not likely to have a significant impact on cultural resources. Such activities would not result in ground disturbing activities or alterations that would affect the character or setting of a cultural resource that is eligible or listed on the National Register. Should a horizontal launch or reentry require new ground disturbing activities, such impacts and whether or not they would be considered a significant impact, would be analyzed in a site-specific NEPA document that would tier from this PEIS. (See Section 11, Historical, Architectural, Archeological, and Cultural Resources of Appendix A, FAA Order 1050.1E for additional information.)

The development of a new or modification of an existing launch or reentry facility under the proposed action may adversely impact a cultural resource that is listed or eligible for listing on the National Register. Such impacts would result from ground disturbing activities that would physically impact a cultural resource, or the development of a structure or a flight path that would adversely affect the setting of a cultural resource. Such impacts and whether or not they would be considered a significant impact, would be analyzed in a site-specific NEPA document that would tier from this PEIS. (See Section 11, Historical, Architectural, Archeological, and Cultural Resources of Appendix A, FAA Order 1050.1E for additional information.)

In addition to completing the environmental review under NEPA, such activities would conform to the regulations and requirements of Section 106 of the NHPA, EO 13287, and EO 13007. (See Appendix D for a description of the procedures required by these regulations.) Should the location of the proposed development of a new, or modification of an existing, launch or reentry site impinge upon an Indian Sacred Site, as defined in EO 13007, regardless of whether it is the subject of Section 106 consultation or eligible for the National Register, the FAA must consult with the Tribe under the AIRFA, EO 13007, Indian Sacred Sites, and the Executive Memorandum dated April 29, 1994, "Government-to-Government Relations With Native American Tribal Governments."

4.4.2 Alternative 1

Implementation of alternative 1 would result in the same impacts as those presented for the proposed action.

4.4.3 Alternative 2

Implementation of alternative 2 would result in the same impacts as those presented for the proposed action.

4.4.4 Alternative 3

Implementation of alternative 3 would result in the same impacts as those presented for the proposed action.

4.4.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be impact on cultural resources.

4.5 Geology and Soils

The following subsections discuss the impacts associated with each alternative on the geology and soils in the launch environment. Impacts on geology and soils would be considered significant if the proposed action and alternatives resulted in exposure of individuals or structures to potential substantial adverse effects, including risk of loss, injury, or death from strong seismic activity. If soils experienced substantial erosion or loss of topsoil, then an impact might be considered significant.

4.5.1 Proposed Action

4.5.1.1 Geology

Under the proposed action, the horizontal launch of an LV or the reentry of an RV would not impact geology. The development or modification of a launch or reentry facility associated with such activities may result in geological impacts. Such impacts include geologic mineral right claims (mining/drilling activities) and issues with the stability and seismic activity of the geologic formations where activities would occur. Such impacts, and whether or not they would be considered a significant impact, would be assessed in a site-specific NEPA document that would tier from this PEIS.

4.5.1.2 Soils

Under the proposed action, the takeoff and subsequent launch of Concept 1 and 3 vehicles would not impact soils. Such vehicles would take off from the ground using conventional jet power, and would subsequently ignite the rocket engines at altitudes in excess of 6,096 meters (20,000 feet) MSL. The emissions and deposition (see Section 4.1, Atmosphere) from such activities would not result in a significant impact on the structure, composition, or chemical properties of the soil. The takeoff and subsequent launch of Concept 2 vehicles would result in ground level rocket emissions and deposition (see Section 4.1, Atmosphere). The deposition of rocket engine emissions may impact the composition and chemical properties of the soil by increasing the concentration of trace metals and increasing the pH. The takeoff of all LVs under the proposed action would occur under specific climatic conditions so that the dispersion of any rocket engine emissions and associated deposition would occur in areas in the vicinity of the runway. Such areas are typically managed areas (mowed and graded areas) adjacent to the runway, which would be included in the storm water management plan of a specific facility. In addition to addressing water quality issues and runoff, site-specific storm water management plans would address surface soil and sediment transport. Because of those factors, such impacts are not considered to be significant impacts on soil.

The unpowered landing of RVs under the proposed action would have no emissions or impacts on soil. The powered landing of RVs under the proposed action would have rocket engine emissions and associated deposition. The emissions that would occur near ground surface would result in local deposition at and around the reentry facility. The deposition would have similar impacts on soil as those described for the launch of Concept 2 vehicles. Such impacts would affect managed areas adjacent to reentry landing pads or runways, and as indicated for LVs, such impacts would not be considered significant impacts on soil.

The development of a new or modification of an existing launch or reentry facility to support the launch of LVs or reentry of RVs under the proposed action may impact soil. Such impacts would occur during construction and would include soil compaction and mixing of soil horizons, erosion, and covering with impervious surfaces. Such impacts, and whether or not they would be considered a significant impact, would be addressed in a site-specific NEPA document that would tier from this PEIS.

4.5.2 Alternative 1

Impacts on geology from alternative 1 would be the same as those associated with the proposed action.

Implementation of alternative 1 would result in slightly fewer impacts on soils than those presented under the proposed action because all RVs would have unpowered landings and would not result in emissions and associated deposition.

4.5.3 Alternative 2

Impacts on geology from alternative 2 would be the same as those associated with the proposed action.

Implementation of alternative 2 would result in slightly more impacts on soils than those presented under the proposed action because all RVs would have powered landings and would result in slightly higher emissions and associated deposition. Section 4.1, Atmosphere, presents the amount of increased emissions and deposition. Such impacts would not be considered a significant impact on soils.

4.5.4 Alternative 3

Impacts on geology from alternative 3 would be the same as those associated with the proposed action.

Implementation of alternative 3 would result in slightly fewer impacts on soils than those presented under the proposed action because rocket powered LVs would not takeoff from the ground surface, thereby reducing rocket emissions and associated deposition.

4.5.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, the existing conditions would not change and there would be no impacts on geology or soils.

4.6 Hazardous Materials and Waste

The following subsections address the use, release, and disposal of hazardous material and waste associated with the proposed action and alternatives.

4.6.1 Proposed Action

For RVs and LVs associated with the proposed action, the primary hazardous materials used would be propellants. All propellants would be stored and used in compliance with Federal regulations 14 CFR §420.65 and 14 CFR §420.67 for solid and liquid propellants, respectively. In addition to the propellants, the LVs and RVs associated with the proposed action may incorporate the use of hazardous materials (various composites, synthetics, and metals) into their design.

All propellants would be burned in the event of an explosion; however, propellants may be released into the environment through a variety of sources. Leaks could occur from a leaking storage or fuel tank, faulty fuel injection lines, or after an LV or RV sustains damage such as in a failed launch or landing, or in a collision with another object. All activities associated with USTs, aboveground storage tanks, and fueling activities would comply with all relevant and applicable Federal, state, and local regulations. All uncontrolled releases would be reported to the appropriate local, state, and Federal authorities and would be cleaned up as necessary.

Some of the LVs and RVs as well as the payloads carried into space that would be associated with the proposed action may incorporate hazardous materials into their design. Reusable and expendable stages that contain hazardous material that would be dropped mid-air back to Earth or that would not burn up in the atmosphere during reentry and fall to Earth, would be tracked, located, and retrieved. The impacts associated with such activities would not result in a significant impact from the use of hazardous materials. (See Section 10, Hazardous Materials, Pollution Prevention, and Solid Waste of Appendix A, FAA Order 1050.1E for additional information.) Should LVs or RVs incorporate hazardous materials into an expendable component that is permanently discarded, such activities and their impact would be addressed in a site-specific NEPA analysis that would tier from this PEIS.

The development of a new or modification of an existing launch or reentry site under the proposed action may include operational activities that use or generate hazardous materials or hazardous waste. For example, radar activation activities may produce hazardous materials and hazardous waste. Hazardous wastes generated during radar activation activities may consist of materials such as waste oils, hydraulic fluids, fire suppressants, antifreeze, cleaning fluids, and cutting fluids. In addition, radar components and antenna units may require periodic application of petroleum-based lubricating oils. Used petroleum, oil, and lubricants would be generated in small amounts that are not normally considered hazardous waste (designation varies by state). The minimal quantities of hazardous waste that could potentially be generated would be disposed of in accordance with appropriate waste disposal regulations. Accidental releases of hazardous materials would be reported to the appropriate local, state, and Federal authorities and would be cleaned up as necessary.

Minor amounts of hazardous materials such as paint, lubricants, cooling fluids, generator fuels, and solvents may be used at some launch facilities. These hazardous materials would be stored and used in compliance with the regulations applicable to their storage and use already in place at designated launch sites. Temporary storage tanks and other facilities for the storage of hazardous materials would be located in protected and controlled areas designed to comply with Spill Prevention, Control, and Countermeasure (SPCC) rules as outlined in 40 CFR §112. All accidental releases of hazardous materials under the proposed action would be subject to reporting requirements. Under 40 CFR Part 302, which governs the CERCLA, a release of hazardous materials must be reported to the National Response Center if the quantity exceeds its reportable quantity as noted in CERCLA §103(a). Reportable quantities for hazardous substances are listed in 40 CFR §302.4 and 40 CFR §355. Commercial space transportation licensees would also comply with Section 304(a) of the Emergency Planning and Community Right to Know Act (EPCRA), promulgated by 40 CFR §355.40, to report accidental releases of hazardous materials to the appropriate State Emergency Response Commission and Local Emergency Planning Committees of releases greater than the reportable quantity.

Because the activities associated with the proposed action (horizontal launches of LVs and reentry of RVs, the development or modification of a launch or reentry site) would comply with all the relevant and applicable Federal, state, and local regulations related to hazardous materials and hazardous waste, no significant impacts would result from the implementation of the proposed action. (See Section 10, Hazardous Materials, Pollution Prevention, and Solid Waste of Appendix A, FAA Order 1050.1E for additional information.) However, if a launch or reentry event results in the release of an expendable component that contains hazardous materials and if the component was not collected, such activities and their impacts would be addressed in a site-specific NEPA document that would tier from this PEIS.

4.6.2 Alternative 1

Implementation of alternative 1 would result in the same impacts as those presented for the proposed action.

4.6.3 Alternative 2

Implementation of alternative 2 would result in the same impacts as those presented for the proposed action.

4.6.4 Alternative 3

Implementation of alternative 3 would result in the same impacts as those presented for the proposed action.

4.6.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no impact on hazardous materials and waste.

4.7 Health and Safety

The following subsections discuss the impacts associated with each alternative on public health and safety.

4.7.1 Proposed Action

Under the proposed action, the FAA Licensing and Safety Division would be responsible for regulating and licensing launch and reentry activities for safety by completing a Mission and Safety Review see Appendix A, FAA Licensing Program, for additional information. The FAA's responsibilities include reviewing license applications for adequate safety and developing public safety requirements and standards. The Safety Review is a critical part of the licensing process and ensures that license applicants comply with established FAA requirements and procedures. In addition to the Safety Review, the FAA would complete a hazard analysis to support the FAA licensing determination. The hazard analysis assesses the possible hazards associated with proposed ground, flight, and landing operations. Launches of LVs and reentries of RVs require specific launch and reentry licenses from the FAA, and each applicant would be required to conduct a risk analysis. FAA regulations governing the licensing of commercial LVs and RVs require licensees to calculate the debris dispersion radius from within the flight corridor given particular accident scenarios.

Licensees under the proposed action and pursuant to the FAA regulations must meet a risk tolerance threshold for mission risk to an individual, and for general public health and safety, for falling debris generated from a worst-case accident. Potential launch operators would estimate the casualty expectation associated with their proposed flight corridors or impact dispersion areas for standard and secondary flights routes and operations. All licensed launches and reentries under the proposed action would not exceed the 30×10^{-6} risk threshold developed by the FAA. The Mission and Safety review process would ensure the selection of a flight corridor, which minimizes the risk to public health, safety, and property. As such, the horizontal launch of LVs associated with the proposed action would not result in significant impacts on public health and safety.

The selection of flight corridors associated with LVs and RVs would also ensure that the risk threshold developed by the FAA is not exceeded. The trajectory of jettisoned expendable or reusable launch or reentry assist equipment (booster rockets) typically would be directed to land in the open ocean away from populated areas and active shipping lanes. In some cases jettisoned expendable or reusable components would be directed to land at designated terrestrial areas, which would be cleared of personnel prior to use. As such, the path that the equipment would follow, and its subsequent impact on the surface of the Earth, would not result in a significant impact on public health and safety.

The development or modification of a launch or reentry facility that would support the activities under the proposed action would incorporate appropriate health and safety standard operating procedures to protect both onsite and offsite personnel. Launch and reentry facilities and associated launch and reentry trajectories from such facilities would be selected to ensure that launch and reentry missions would be able to achieve the FAA established risk threshold. Personnel at facilities would be sheltered at a safe distance, as determined by FAA regulations and facility safety personnel, and therefore, would be protected from harmful air emissions, debris, and explosions. All FAA safety procedures would be followed, safety zones would be established, and participating personnel would be trained and certified to reduce the potential for impacts on health and safety. As such, the impacts on health and safety would not be significant.

Under the proposed action, manned horizontal launches of LVs would expose the flight crew and any spaceflight participants to cosmic radiation. Similar to commercial airline pilots, the flight crew and spaceflight participants would be exposed to small amounts of cosmic radiation during flight. Cosmic radiation stems from high-energy proton radiation from outer space and lower energy protons originating from the sun. The lower energy particles emitted from the sun do not contribute significantly to levels of cosmic radiation except at times of increased activity from the sun and solar flares. In flight exposure, the effect on the body will depend on the route, altitude, length of time in the air, and aircraft type. (British Airways, 2004)

The physical risks of cosmic radiation are very low. For an accumulated dose of 5 millisieverts per year over a career span of 20 years, (more than the anticipated annual exposure for crew members aboard a long-haul commercial airline), the likelihood of developing cancer due to the radiation is 0.4 percent. (British Airways, 2004) In LEO, the geomagnetic field (magnetosphere) surrounding the Earth provides substantial shielding against cosmic radiation and solar radiation; however, at a certain location over the South Atlantic Ocean, off the coast of Brazil, the shielding effect is much less effective. This oddity, called the South Atlantic Anomaly, drastically increases exposure to cosmic radiation to those flying over the area. (NASA, 2004b)

Because the duration in space of the manned LVs and RVs associated with the proposed action would be short in duration, the exposure to cosmic radiation would be minimal and the associated risk would not pose a significant impact on the health and safety of the crew or spaceflight participants.

4.7.2 Alternative 1

Implementation of alternative 1 would result in the same impacts as those presented for the proposed action.

4.7.3 Alternative 2

Implementation of alternative 2 would result in the same impacts as those presented for the proposed action.

4.7.4 Alternative 3

Implementation of alternative 3 would result in the same impacts as those presented for the proposed action.

4.7.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no impact on health and safety.

4.8 Land Use

The following subsections discuss the impacts associated with each alternative on land use and Section 4(f) Resources.

4.8.1 Proposed Action

4.8.1.1 Land Use

The licensing of horizontal launches, reentries, and the operation of facilities that conduct these activities under the proposed action that conform to local, state, and Federal land use management practices would not have a significant impact on land use. The activities under the proposed action that would conflict with or preclude such land management practices would adversely impact land use. For the development of a new or modification of an existing launch or reentry facility to support the activities under the proposed action, the FAA would consult with the USDA NRCS to determine if the FPPA applies to the land potentially impacted by the proposed action. See Appendix D for a description of the formal consultation procedures. Such impacts, and whether or not they would be considered a significant impact, would be analyzed in a site-specific NEPA document that would tier from this PEIS. (See Section 4, Compatible Land Use of Appendix A, FAA Order 1050.1E for additional information.)

4.8.1.2 Section 4(f) Resources

In accordance with FAA procedures, the FAA would cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the state or local officials with jurisdiction to identify potential impacts on section 4(f) resources and an analysis of such impacts would be considered in a site-specific NEPA document that would tier from this PEIS. (See Appendix D for a discussion of the consultation procedures.)

The activities associated with the proposed action would conform to the regulations of section 4(f) of the DOT act. Under section 4(f), the FAA would not approve any proposed action that uses publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance or land from an historic site of national, state, or local significance as determined by the officials having jurisdiction thereof, unless (1) no feasible and prudent alternative exists to the use of such land and such program, and (2) the proposed action includes all possible planning to minimize harm resulting from the use. (See Section 6, DOT Act: Sec. 4(f) of Appendix A, FAA Order 1050.1E for additional information.)

4.8.2 Alternative 1

Implementation of alternative 1 would result in the same impacts as those presented for the proposed action for both Land Use and Section 4(f) Resources.

4.8.3 Alternative 2

Implementation of alternative 2 would result in the same impacts as those presented for the proposed action for both Land Use and Section 4(f) Resources.

4.8.4 Alternative 3

Implementation of alternative 3 would result in the same impacts as those presented for the proposed action for both Land Use and Section 4(f) Resources.

4.8.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, there would be no change to current land uses and no use of lands qualifying as Section 4(f) Resources. Land use would not be impacted by implementation of the no action alternative. Section 4(f) Resources would not be impacted by implementation of the no action alternative.

4.9 Noise

A significant noise impact would occur if the implementation of an action would cause noise-sensitive areas to experience an increase in noise of DNL 1.5 dB or more at or above DNL 65 dB, when compared to the no action alternative for the same time frame. To calculate the impacts associated with noise, a site-specific NEPA analysis would use the most current version of the FAA's Integrated Noise Model (INM), Heliport Noise Model (HNM), Noise Integrated Routing System (NIRS), or equivalent methodology and computer model. The following subsections present a review of the noise-related impacts associated with the proposed action and each alternative.

4.9.1 Proposed Action

Activities associated with the proposed action that may impact ambient noise levels include sounds generated from a rocket engine or from a jet engine, during launch and landing and sonic booms associated with launch and reentry, and the development of a new or modification of an existing launch or reentry facility. These noise impacts may affect a particular noise sensitive receptor (humans, wildlife, or a structure). The activities that would be performed under the proposed action (horizontal launches of an LV and reentry of an RV) would occur at licensed launch facilities and at designated reentry locations that would have established noise criteria and standards. Should the launch or reentry of such LVs or RVs exceed the level of significance, as presented in Appendix A of FAA order 1050.1E, additional noise modeling would be conducted. The noise associated with the development and operation of a new or modification of an existing launch or reentry facility would be analyzed in a site-specific NEPA document that would tier from this PEIS. For a site-specific NEPA document that would tier from this PEIS, a detailed noise analyses would be completed using the most current version of the FAA's INM, HNM, NIRS, or equivalent methodology and computer model, as appropriate. The use of an equivalent methodology and computer model (e.g., Area Equivalent Method or Air Traffic Noise Screening [ATNS]) would be reviewed and approved from the FAA's Office of Environment and Energy.

Engine Noise

Under the proposed action, ground level noise emissions would result from either jet powered (Concept 1 and 3) or rocket powered take off (Concept 2). Jet powered engine take off would generate noise ranging from 110 to 120 dBA, between 15 to 61 meters (50 to 200 feet) from the vehicle. (FAA, 2001) At 305 meters (1,000 feet) from the launch site, the noise level would be approximately 98 dBA. (Federal Interagency Committee on Noise, 1992) Concept 2 vehicles would generate noise levels that exceed 128 dBA at 10 meters (33 feet) from the source. (XCOR Aerospace, 2004) The ignition (Concept 1 and 3) or full ignition (Concept 2) of a rocket engine at or above 6,096 meters (20,000 feet) above the ground surface would not impact noise sensitive receptors on the surface of the Earth, as the noise generated at such levels would dissipate and lose energy as it would travel through the air towards the surface of the Earth. Although engine noise associated with landing would result from powered landings, no engine noise would be associated with unpowered landings. Powered landings would use either jet engines or retro-thrust rocket engines. The use of either method of powered landing would produce the same or less noise than the noise generated during launch. As such, should the noise generated during a reentry exceed established noise criteria and standards at a reentry site, a detailed noise analysis would be completed.

Sonic Boom Noise

Concept 1, 2, and 3 vehicles outlined under the proposed action would reach supersonic speeds during launch, and would produce sonic booms. Reentry vehicles with powered and unpowered landings would produce sonic booms during reentry; however, once the RV is within the lower portions of the atmosphere, it would be traveling at subsonic speeds. The magnitude of a sonic boom is measured as overpressure in pounds per square foot (psf). The likely overpressure generated by the vehicles associated with the proposed action would be less than 2 psf measured on the surface of the Earth. The relatively low psf of the vehicles associated with the proposed action is based on the small size of the vehicle (the smaller size, the smaller the pressure wave), the launch and reentry trajectories (the more perpendicular to surface of the Earth, the less area affected by the pressure wave), and the altitudes at which such vehicles would exceed the speed of sound (the higher the elevation the less effect at ground level). The PEIS LL reviewed the effects of sonic booms on humans, structures, aquatic and terrestrial wildlife and found no significant impacts. Because of the relatively low overpressure, the findings of the PEIS LL, the limited number of annual launch and reentry events that would result in a sonic boom, and the fact that all sonic booms associated with the proposed action would be below the National Academy of Sciences/National Research Council Committee on Hearing, Bioacoustics, and Biomechanical criteria for impulse noise threshold sound pressure level of 145 dB, or 365 Newtons per square meter (7.25 psf); the sonic booms associated with the proposed action would not result in significant impacts.

Activities associated with the proposed action that would expose populated areas, structures, or other noise-sensitive areas (e.g., wildlife habitat, sanctuaries, parks, monuments) to sonic boom pressure waves greater than or equal to 2 psf would be analyzed in a site-specific NEPA analysis that would tier from this PEIS. The analysis would indicate whether or not such areas would be significantly impacted and would develop appropriate mitigation measures.

4.9.2 Alternative 1

Noise impacts associated with alternative 1 would be slightly less than those under the proposed action because only RVs with unpowered landings would be licensed; therefore, engine noise associated with landing of RVs would be eliminated.

4.9.3 Alternative 2

Noise impacts associated with alternative 2 would be slightly greater than those under the proposed action because all RVs would have powered landings. Therefore, a slight increase in overall noise associated with the landings of RVs would occur under alternative 2 as compared to the proposed action.

4.9.4 Alternative 3

Noise impacts associated with alternative 3 would be slightly less than those under the proposed action. Alternative 3 would preclude the use of rocket-powered launches from ground surface. Because rocket powered launches generate more noise than a jet powered takeoff, the elimination of rocket-powered launches from ground surface would decrease the overall noise impact as compared to the proposed action.

4.9.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, the existing conditions would not change and there would be no additional noise-related impacts.

4.10 Orbital Debris

For the purpose of this PEIS, the FAA assumed that some horizontal LVs would be used to transport objects and people in LEO (approximately 2,000 kilometers [1,292 miles]) and objects into GEO, an altitude approximately 35,786 kilometers (22,241 miles) above the surface of the Earth. Debris generated in GEO would continue orbiting the Earth for centuries, if not perpetually, before the orbit of the debris decays, drawing it closer and closer to Earth. Debris orbiting in lower orbits could reenter relatively quickly, on the order of months or years depending on the altitude of the orbit. The duration of orbit varies based on the trajectory, velocity, and altitude of an object, with lower altitude orbits decaying faster than high altitude orbits. As debris eventually reenters the atmosphere of the Earth, it would most likely be incinerated rather than falling back to the surface of the Earth. As an object's orbit draws closer to Earth, atmospheric drag beginning in the upper portions of the atmosphere (i.e., the ionosphere) would slow the object down rapidly, causing it to deorbit and either incinerate or fall to Earth. The process limits the lifetime of orbital debris to a maximum of a few days for debris generated below 200 kilometers (124 miles), a few months for debris originating between 200 and 400 kilometers (124 and 248 miles), a few years between 400 and 600 kilometers (248 and 370 miles), decades between 600 and 800 kilometers (370 and 490 miles), centuries over 800 kilometers (490 miles), and potentially forever if over 36,000 kilometers (22,300 miles). (NASA Johnson Space Center, 2004)

4.10.1 Proposed Action

Under the proposed action, LVs and RVs would contribute to the existing debris orbiting the Earth, collectively known as orbital debris. The majority of the LVs and RVs associated with the proposed action would operate well below LEO (2,000 kilometers [1,242 miles]), and most likely below 200 kilometers (124 miles). (NASA Orbital Debris Program Office, 2004) Debris generated at this altitude would rapidly drop into successively lower orbits and either be incinerated during reentry or would survive reentry and fall back to the surface of the Earth. The risk that an individual would be hit and injured by reentering orbital debris is estimated to be less than one in one trillion. (The Aerospace Corporation, 2005) As a reference point, the risk that an individual in the U.S. will be struck by lightning is approximately one in 1.4 million. Over the last 40 years, more than 1,400 metric tons (1,543 tons) of material is estimated to have survived reentry with no reported casualties. (The Aerospace Corporation, 2005)

For each orbit altitude (i.e., below LEO, LEO, Medium Earth Orbit [MEO], and GEO), as presented in Section 3.1.4, Orbital Debris, the following presents a discussion of the impacts related to solid rocket motor ejecta, operational debris, fragmentation debris, and deterioration debris.

Solid Rocket Motor Ejecta

Under the proposed action, particulates would be emitted into the space environment when rocket motors powered by solid or solid/liquid (hybrid) propellants are fired. Rocket motors are activated to move the LV to a desired location in space, such as to a trajectory that would allow the placement of a payload (satellite) into orbit or for an RV to reenter the Earth's atmosphere. Rocket motor ejecta consist of Al_2O_3 particulate dust from the engines or chunks of unburned solid propellant or slag produced when unspent fuel is expelled into space. The rocket motor ejecta typically would be less than 0.01 centimeter (0.004 inch) in diameter but may nonetheless cause surface pitting and erosion to exterior surfaces and chemical contamination on other objects in space. (National Science and Technology Council, 2004) Long-term exposure to the effects of the ejecta may degrade the operation of optical windows, solar panels, or other vulnerable exterior components on a satellite, space station, or spacecraft. In addition to equipment degradation, ejecta could sever electrical wires or cause short circuits within electrical components. (NASA, 1995) The high velocity of solid rocket motor particles, in combination with a low mass and the low orbit at which a particle would most likely be emitted, causes the particles to decay rapidly and ultimately incinerate as they fall from orbit and reenter the atmosphere. Solar radiation also contributes to the rapid decay process, which usually progresses within a few days. (NASA, 1995) The low mass of rocket motor ejecta precludes them from causing any structural damage to objects. In addition, the short lifespan of solid rocket motor ejecta in space at LEO or lower altitudes precludes spacecraft from sustaining damage from the ejecta. Consequently, low orbit altitude emission of solid rocket motor ejecta would result in no significant impacts on spacecraft.

Solid rocket motor ejecta emitted at GEO would, despite their low mass, continue orbiting for potentially hundreds of years before eventually losing enough altitude to be burned up in the Earth's atmosphere. At high altitudes, ejecta may pose a threat to orbiting satellites and other spacecraft due to the extended length of time these systems would be exposed. The lengthy space-lives of satellites and other spacecraft, coupled with the persistence of ejecta in GEO, create ample time for solid rocket motor ejecta to damage exterior components. Because the location of debris clouds and the damage potentially caused by such debris are incorporated into the design and orbital trajectories of spacecraft and the limited amount of solid rocket motor ejecta that would be emitted under the proposed action relative to the volume of space, spacecraft would not be significantly impacted.

Operational Debris

Under the proposed action, operational debris would be composed of inactive payloads and objects typically released during satellite-related missions. This class of debris encompasses objects ranging in size from small bolts to spent rocket motor bodies and payload fairings. It should be noted that this analysis assumes that operators would conform to current best practices to limit the formation of debris in space. However, all objects, especially larger ones, pose a potentially serious threat to spacecraft in orbit. The size, mass, and velocity of such objects pose the potentially serious threat to other spacecraft that they may encounter along their decaying orbit. Because the impact of such debris with a spacecraft would likely disable or destroy the spacecraft, such debris (larger than 10 centimeters [3.9 inches]) is tracked at all orbits (i.e., below LEO, LEO, MEO, and GEO) by ground-based tracking stations. The ground-based tracking stations provide advanced warning of encroaching debris so operators can move the vehicles out of the debris trajectory. (National Science and Technology Council, 1995)

Operational debris associated with the proposed action created below 400 kilometers (249 miles) would lose orbit and reenter the Earth's atmosphere and either incinerate or fall to Earth. This would happen within a few days or a few months depending on its original orbital altitude. At higher altitudes, operational debris associated with the proposed action would remain orbital for longer time periods. Upon reaching the atmosphere, most operational debris would likely be incinerated. In addition, LV upper stage propulsion systems may be used to force operational debris into storage orbits, where the debris would either remain indefinitely in orbit, or be retrieved at a later date. Given the accelerated pace at which operational debris loses orbit and reenters the atmosphere below LEO; the minimal risk to public safety from de-orbiting debris (current risk of injury from falling debris is one in a trillion); the current level of debris in space (estimated to be more than 111,000 pieces larger than one centimeter [0.4 inch]); and the current debris mitigation efforts being incorporated into LV and RV designs, operational debris would not pose a significant impact on spacecraft and would not substantially increase the risk to public safety. (National Science and Technology Council, 1995; NASA, 2004a; The Aerospace Corporation, 2005)

Fragmentation Debris

Under the proposed action, fragmentation debris would be produced when an LV or RV explodes while in orbit. An explosion could occur for a number of reasons, including: 1) the catastrophic failure of internal components such as batteries, 2) propellant-related explosions, 3) failure of pressurized tanks, and 4) intentional destruction. The primary source of the approximately 2,200 pieces of rocket body debris now in orbit was caused by the over-pressurization of residual propellants, batteries, or pressure due to solar heating. (U.S. DOT,

2002) Fragmentation debris may also be generated by collisions with other orbital objects. (National Science and Technology Council, 1995)

Fragmentation debris generated at or below LEO would not persist for long periods of time in the space environment before losing orbit and reentering the atmosphere. At higher altitudes, fragmentation debris would remain orbital for much longer time periods before losing orbit and reentering the atmosphere. Debris would then either incinerate in the Earth's atmosphere or fall to Earth. Impacts with large fragmentation debris (greater than 10 centimeters [3.9 inches]) at all orbits would generate exponentially more fragmentation debris, thereby amplifying the dangers to spacecraft. Given that fragmentation debris is caused by accidents and unintended events in space, the accelerated pace at which fragmentation debris loses orbit and reenters the atmosphere below LEO; the minimal risk to public safety from de-orbiting debris (current risk of injury from falling debris is one in a trillion); the current level of debris in space (estimated to be more than 111,000 pieces larger than one centimeter [0.4 inch]); and the current debris mitigation efforts being incorporated into LV and RV designs, fragmentation debris would not pose a significant impact on spacecraft and would not substantially increase the risk associated with public safety. (National Science and Technology Council, 1995; NASA, 2004a; The Aerospace Corporation, 2005)

The probability of a fragmentation event associated with the proposed action would be low; every effort to prevent and mitigate fragmentation events would be made. Methods for prevention and mitigation include

- Tracking and avoiding debris using radar and propulsion systems;
- Improved booster and payload design; and
- The release of all nonessential propellants, pressurants, and battery energy to prevent solar heating resulting in explosion.

Deterioration Debris

Under the proposed action, LVs or RVs in space would be subject to surface disintegration caused by gases, solar radiation, small meteors, or small particles of orbital debris. As a result, paint, plastic, metal, thermal blankets, or insulation on the exteriors of LVs and RVs could become corrupted and could begin to flake off and separate from the LV or RV. The flakes created typically would be very small and of low mass, and would be similar to solid motor ejecta debris and its associated effects. (NASA, 1995) Because the location of debris clouds and the damage potentially caused by such debris are incorporated into the design and orbital trajectories of spacecraft and the limited amount of deterioration debris that would be emitted under the proposed action relative to the volume of space, spacecraft would not be significantly impacted.

4.10.2 Alternative 1

Implementation of alternative 1 would result in the same impacts on spacecraft and the general public as those associated with the proposed action.

4.10.3 Alternative 2

Implementation of alternative 2 would result in the same impacts on spacecraft and the general public as those associated with the proposed action.

4.10.4 Alternative 3

Implementation of alternative 3 would result in slightly less impacts on spacecraft and the general public than those presented under the proposed action. Alternative 3 would preclude the use of rocket powered launches from ground surface, and would reduce the total number of missions and their associated debris that would be released into space.

4.10.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, the existing conditions would not change and there would be no additional orbital debris related impacts.

4.11 Socioeconomics

The following subsections discuss the socioeconomic and environmental justice impacts associated with each alternative.

4.11.1 Proposed Action

4.11.1.1 Socioeconomics

Under the proposed action, the FAA would issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities. Licensing these activities may result in an increase in the employment of skilled and professional workers, and therefore, would have an economically beneficial impact. Jobs associated with the commercial launch industry are generally technology-based and require employees with specialized skills and higher levels of education. The creation of jobs in the commercial launch industry would have secondary economic effects on local communities due to the increased personal income and the associated tax base. Furthermore, the new or additional workers may increase the size of the surrounding community and may create a need for more local services, which in turn creates additional jobs within that community.

The licensing of a particular horizontal LV or RV mission could result in a temporary increase in the local work force at a particular launch or reentry facility, and would be considered a negligible impact on the local economy. The development of a new or modification of an existing launch or reentry site would result in temporary local employment during construction, and new permanent employment during operation. The relative impact on the local socioeconomic settings depends on the conditions (e.g., size of the local economy and capacity of the local services). Such impacts, and whether or not they would be considered a significant impact, would be analyzed in a site-specific NEPA document that would tier from this PEIS.

(See Section 16, Socioeconomic Impacts, Environmental Justice, and Children's Health and Safety Risks of Appendix A, FAA Order 1050.1E for additional information.)

Implementation of the proposed action would have a negligible impact on the national economy; however, it would have a beneficially significant impact on the commercial launch industry. Implementation of the proposed action would allow the continued development of horizontally launched LVs and RVs for commercial applications. The proposed action would allow U.S.-based companies to remain competitive in the global aerospace industry and its expanding commercial space applications.

4.11.1.2 Environmental Justice

Under the proposed action, the FAA would issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities. EO 12898 requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of Federal programs, policies, and activities on minority and low-income populations. A Presidential Memorandum that was issued concurrently with EO 12898 specifically states that NEPA is one of the tools for addressing these issues: "Each agency must analyze the environmental effects, including human health, economic, and social effects, of its actions, including their effects on minority communities and low-income communities, when such analysis is required by the NEPA." As such, activities that would result in adverse environmental effects would be reviewed for their effects on minority communities and low-income populations in a site-specific NEPA document that would tier from this PEIS. (See Section 16, Socioeconomic Impacts, Environmental Justice, and Children's Health and Safety Risks of Appendix A, FAA Order 1050.1E for additional information.)

4.11.2 Alternative 1

4.11.2.1 Socioeconmics

Implementation of alternative 1 would result in similar impacts as those presented under the proposed action; however, alternative 1 would limit the development of commercial RVs to those with unpowered landings. Licensing only a subset of the RV activities outlined in the proposed action could reduce the magnitude of this impact and could limit the development and growth of the commercial launch industry.

4.11.2.2 Environmental Justice

Under alternative 1, the FAA would review environmental justice concerns as presented in the proposed action.

4.11.3 Alternative 2

4.11.3.1 Socioeconomics

Implementation of alternative 2 would result in similar impacts to those presented under the proposed action; however, alternative 2 would limit the development of commercial RVs to those with unpowered landings. Licensing only a subset of the RV activities outlined in the proposed action could reduce the magnitude of this impact and could limit the development and growth of the commercial launch industry.

4.11.3.2 Environmental Justice

Under alternative 2, the FAA would review environmental justice concerns as presented in the proposed action.

4.11.4 Alternative 3

4.11.4.1 Socioeconomics

Implementation of alternative 3 would result in similar impacts as those presented under the proposed action; however, alternative 3 would limit the development of commercial LVs to Concepts 1 and 3. Licensing only a subset of the LV concepts outlined in the proposed action could reduce the magnitude of this impact and could limit the development and growth of the commercial launch industry.

4.11.4.2 Environmental Justice

Under alternative 3, the FAA would review environmental justice concerns as presented in the proposed action.

4.11.5 No Action Alternative

4.11.5.1 Socioeconomics

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, all U.S. licensed launches would be vertical launches as described in the Launch Licensing PEIS.

Not licensing the activities described under the proposed action may result in an adverse impact on the socioeconomics of a local community where one of the major employers is the commercial horizontal launch industry. By not issuing licenses for horizontally launched LVs, reentry of RVs, or for facilities that would support such activities, industries would not have a market to provide services and would be forced to change industries and markets. Such impacts on a local community may result in substantial decreases in the local tax base which could adversely affect the socioeconomic setting. These issues would need to be addressed in site-specific analyses that would tier from this PEIS. In addition, the U.S. horizontal commercial launch industry would not be able to expand and remain competitive in the global horizontal launch and reentry markets. Foreign markets would continue to grow their market share and develop technology, while the U.S. would lag behind in this market sector, both economically and technologically.

4.11.5.2 Environmental Justice

Because the no action alternative would not change the current status of human health or the environment, there would be no impact on minority or low-income populations.

4.12 Visual and Aesthetic Resources

The following subsections discuss the impacts associated with each alternative on visual and aesthetic resources.

4.12.1 Proposed Action

The licensing of horizontal launches, reentries, and the operation of facilities that support these activities under the proposed action would not have a significant impact on aesthetics and visual resources. Launches and reentries under the proposed action would conform to the VRM policies and statutes of local, state, and Federal agencies and tribes for both designated and undesignated areas of great natural beauty and scenic diversity, such as national forests; national monuments; national, state, or county parks; national wildlife refuges; wilderness areas; scenic byways; national trails; and historic places and districts. The development of a new or modification of an existing launch or reentry facility that would support the activities under the proposed action would adhere to the relevant and appropriate Federal, state, and local regulations, ordinances, and zoning associated with aesthetic and visual resources. (See Section 12, Light Emissions and Visual Impacts of Appendix A, FAA Order 1050.1E for additional information.)

4.12.2 Alternative 1

Implementation of alternative 1 would result in the same impacts as those presented for the proposed action.

4.12.3 Alternative 2

Implementation of alternative 2 would result in the same impacts as those presented for the proposed action.

4.12.4 Alternative 3

Implementation of alternative 3 would result in the same impacts as those presented for the proposed action.

4.12.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, no changes would occur to the current visual landscape. Aesthetics and visual resources would not be impacted by implementation of the no action alternative.

4.13 Water Resources

The following subsections present the impacts associated with the proposed action and alternatives on freshwater and marine systems, wetlands, floodplains, and ground water.

4.13.1 Proposed Action

4.13.1.1 Freshwater Systems and Marine Systems

The proposed action may result in local adverse impacts on freshwater or marine systems. Such impacts would result from the deposition associated with rocket engine emissions that would be deposited on a particular water body or in its associated watershed. Section 4.1, Atmosphere, presents a discussion of the rocket emissions that may affect the water quality of a specific water body. The impacts on a particular water body would be evaluated based on the designated use of the water body (agricultural/industrial use, recreation, or drinking water) and its associated water quality criteria as defined under Section 303 of the CWA (see Section 17, Water Quality of Appendix A, FAA Order 1050.1E for additional information). For marine systems, the size of the system and its ability to tolerate particular concentrations and volumes of rocket motor deposition would be reviewed to assess the potential impact. Such impacts and whether or not they would be considered a significant impact would be addressed in a site-specific NEPA document that would tier from this PEIS. A site-specific NEPA document would address the NPDES permits and SWPPPs. In addition, for construction activities greater than five acres, a NPDES would be required. The development of a new or modification of an existing launch or reentry facility may impact freshwater and/or marine systems. Such impacts would be addressed in a site-specific NEPA document that would tier from this PEIS.

4.13.1.2 Wetlands

The proposed action may result in local adverse impacts on wetlands. The deposition of rocket engine emissions into wetlands, the development of new or modification of existing facilities that would affect a wetland, the deposition of spent LV equipment (e.g., booster rockets), or landing of an RV or its associated equipment into such areas could result in impacts on wetlands. Impacts to wetlands could alter the function or value of a wetland. A site-specific NEPA document that would tier from this PEIS would evaluate wetland impacts and whether impacts would be considered significant. The development of a new or modification of an existing launch or reentry facility may impact wetlands. Such impacts would be addressed in a site-specific NEPA document that would tier from this PEIS. (See Section 18, Wetlands of Appendix A, FAA Order 1050.1E for additional information.)

4.13.1.3 Floodplains

Horizontal launches of LVs or reentries of RVs under the proposed action would not impact floodplains. The development of new or the modification of existing facilities that would support the horizontal launch of LVs or reentry of RVs within or adjacent to a floodplain may impact floodplains. Such impacts on floodplains, and whether or not they would be considered a significant impact, would be addressed in a site-specific NEPA document that would tier from this PEIS. (See Section 9, Floodplains of Appendix A, FAA Order 1050.1E for additional information.)

4.13.1.4 Ground Water

Horizontal launches of LVs or reentries of RVs under the proposed action would not impact ground water. Horizontal launches and reentries would be performed from and to existing or future water-permitted facilities that have been or would be designed and operated to protect sensitive ground water resources (e.g., well head protection areas). The development of new, or the modification of existing facilities that would support the horizontal launch of LVs or reentry of RVs may impact ground water. Such impacts would include construction activities that affect local hydrology, construction activities within a wellhead protection area, or new or modified facilities that alter ground water recharge or discharge. Such impacts on ground water, and whether or not they would be considered significant impacts, would be addressed in a site-specific NEPA analysis that would tier from this PEIS.

4.13.2 Alternative 1

Implementation of alternative 1 would result in slightly fewer impacts on water resources than those presented under the proposed action because all RVs would have unpowered landings and would not result in emissions and associated deposition.

4.13.3 Alternative 2

Implementation of alternative 2 would result in slightly more impacts on water resources than those presented under the proposed action because all RVs would have powered landing and would result in slightly higher emissions and associated deposition. Section 4.1, Atmosphere presents the amount of increased emissions and deposition. Such impacts would not be considered a significant impact on water resources.

4.13.4 Alternative 3

Implementation of alternative 3 would result in slightly fewer impacts on water resources than those presented under the proposed action because rocket powered LVs would not take off from the ground surface, thereby reducing rocket emissions and associated deposition.

4.13.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and reentry of RVs, as well as for the operation of facilities for such activities; therefore, the existing conditions would not change and there would be no impacts on water resources.

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5 POTENTIAL CUMULATIVE IMPACTS

Introduction

This section of the PEIS describes the potential cumulative impacts that would result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR part 1508.7). For the purpose of this analysis, the FAA considered the effects of all FAA-licensed launches and all non-FAA-licensed launch and reentry activities (U.S. and foreign government and foreign commercial launches and reentries). The FAA reviewed the cumulative impacts associated with 1,478 FAA licensed commercial launches, 519 U.S. Government launches, 411 foreign government launches, 239 foreign commercial launches, and 51 FAA-licensed commercial reentries, 33 U.S. Government reentries, 49 foreign government reentries, and 11 foreign commercial reentries between 2005 and 2015. These figures (and the cumulative impact discussion presented in this section) include the 1,279 horizontally launched LVs between 2005 and 2015 (maximum of 154 launches per year) and 51 reentries between 2005 and 2015 (maximum of 15 reentries per year); these impacts were discussed in Section 4 of this PEIS.

The FAA classified the FAA-licensed commercial launches and foreign commercial launches based on whether or not the LV was launched on suborbital or orbital trajectories. For orbital LVs, the weight of the payload and its destined orbit were used to further classify the LVs. Exhibit 5-1 presents the weight class for suborbital and orbital (Geosynchronous Transfer Orbit [GTO] and LEO) launches.

Exhibit 5-1. Payload Weight Class

Weight Class	Suborbital or Orbital Mass
Other*	Suborbital – 270 kilograms (594 pounds)
Small	Orbital – < 900 kilograms (2,000 pounds) GTO or < 2,250 kilograms (5,000 pounds) LEO
Medium	Orbital – 900-1,719 kilograms (2,000-3,999 pounds) GTO or 2,250-6,750 kilograms (5,000-15,000 pounds) LEO
Intermediate	Orbital – 1,720-4,081 kilograms (4,000-8,999 pounds) GTO or > 6,750 kilograms (15,000 pounds) LEO
Heavy	Orbital – 4,082-4,500+ kilograms (9,000-10,000+ pounds) GTO

*For purposes of this analysis, all FAA-licensed horizontally launched LVs are included under the “Other” weight class.

The number of FAA-licensed horizontal and vertical launches and reentries as well as the launches and reentries of U.S. and foreign governments and foreign commercial enterprises from 2005 to 2015, are presented in Exhibit 5-2, Horizontal and Vertical Launch Totals by Maximum Payload Capacity, and Exhibit 5-3, Total Orbital Reentries.

Exhibit 5-2. Horizontal and Vertical Launch Totals by Maximum Payload Capacity

Category	Payload Capacity	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed)	Other/Suborbital	19	51	103	128	129	161	150	152	154	158	165
	Small	2	1	2	2	1	2	2	2	2	2	2
	Medium	2	2	2	1	2	1	1	2	1	1	2
	Intermediate	0	0	0	0	0	0	0	0	0	0	0
	Heavy	7	6	7	7	6	6	7	6	6	6	7
U.S. Government	Other/Suborbital	22	30	25	20	24	24	26	24	22	24	22
	Small	2	3	2	4	2	3	2	2	2	2	2
	Medium	10	9	8	9	9	9	9	9	9	9	9
	Intermediate	0	0	0	0	0	0	0	0	0	0	0
	Heavy	14	13	12	13	14	14	13	9	10	9	10
Foreign Government	Other/Suborbital	8	15	12	8	10	8	15	10	8	8	15
	Small	3	3	5	2	2	2	3	2	3	2	3
	Medium	13	18	17	14	15	15	14	15	15	14	15
	Intermediate	2	1	2	1	2	1	2	1	2	1	2
	Heavy	7	6	9	8	7	7	9	8	7	7	7
Foreign Commercial	Other/Suborbital	2	0	2	0	1	3	4	6	8	10	12
	Small	2	4	3	2	1	2	2	3	3	3	4
	Medium	2	3	1	1	2	1	1	1	1	1	1
	Intermediate	1	0	0	0	0	0	0	0	0	0	0
	Heavy	11	10	12	13	13	13	15	15	15	15	14
TOTAL		**129**	**175**	**224**	**233**	**240**	**272**	**275**	**267**	**268**	**272**	**292**

Notes: Based on vehicle full payload capacity, not estimated payload(s) mass. Most commercial vehicles are no longer in Intermediate class. Foreign and U.S. Government suborbital estimates are based on vehicles similar to criteria for an FAA-licensed launch.

Exhibit 5-3. Total Orbital Reentries

Category	Reentry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (Licensed)	Horizontal	0	0	0	0	1	1	2	5	7	9	12
	Vertical	0	0	0	0	0	1	2	2	3	3	3
U.S. Government	Horizontal	3	4	4	4	4	0	0	0	0	0	0
	Vertical	0	1	0	0	0	0	1	2	2	4	4
Foreign Government	Horizontal	0	0	0	0	0	0	0	0	0	0	0
	Vertical	4	5	5	4	4	5	4	5	4	5	4
Foreign Commercial	Horizontal	0	0	0	0	0	0	0	0	0	0	0
	Vertical	0	0	0	0	0	0	1	2	2	3	3
Total		**7**	**10**	**9**	**8**	**9**	**7**	**10**	**16**	**18**	**24**	**26**

Notes: Capsule and/or parachute landings were counted as Vertical reentry. Vertical also includes International Space Station cargo return.
Reentries were only counted for vehicles that land substantially intact.
Suborbital launches and subsequent landings are not included.

In accordance with FAA Order 1050.1E and the CEQ regulations for implementing NEPA, the FAA analyzed the potential cumulative impacts on the resources that would be adversely affected by the implementation of the proposed action or an alternative. Because the scope of this PEIS does not address site-specific, localized effects and their associated cumulative impacts, such site-specific resources are not included in the evaluation of cumulative impacts. The site-specific resources and the associated cumulative impacts would be addressed in a site-specific NEPA document that would tier from this PEIS. Cumulative impacts are assessed for the following resource areas.

- Atmosphere
- Health and Safety
- Orbital Debris
- Socioeconomics

5.1 Atmosphere

The following subsections discuss the cumulative impacts on the atmosphere associated with each alternative.

5.1.1 Troposphere

5.1.1.1 Proposed Action

Potential impacts on the troposphere are discussed in this section for LV and RV emissions, particularly impacts from emissions of criteria pollutants, air toxics, precursors of acid rain, and regional haze.

The total estimated emissions (from the proposed action and from other Federal and non-Federal launch and reentry activities) from LVs and RVs to the troposphere for the period 2005 to 2015 are presented in Exhibit 5-4. The portion of these emissions associated with the proposed action was estimated as summarized in Section 4 and described in detail in Appendix F. The remaining emissions (i.e., FAA-licensed vertical launches, U.S government launches, and foreign commercial and government launches) were calculated by estimating the emissions per launch or reentry for each vehicle type and then multiplying these per launch and reentry emissions by the estimated number of launches and reentries for each vehicle type. A description of how the per launch and reentry emissions for each vehicle type were calculated is provided in Appendix F; the emissions per launch and reentry for each vehicle type are also provided in Appendix F. The estimated number of launches and reentries for each vehicle type are provided in Exhibits F-41 and F-42, respectively; a description of how these launch and reentry estimates were estimated is provided in Appendix F.

Exhibit 5-4. Summary of Emission Loads from LVs and RVs to the Troposphere from 2005 to 2015 in Metric Tons (Tons)

Launch/Reentry Type		HCl	PM	CO_2	H_2O	Cl	NO_X	CO	SO_X
Proposed Action		-	8 (8.8)	999 (1099)	428 (471)	-	0.8 (0.9)	70 (77)	0.2 (0.22)
Federal and Non-Federal Activities	U.S. Licensed Vertical	1,884 (2,071)	3,410 (3,750)	11,171 (12,288)	4,308 (4,740)	17 (19)	30 (33)	1 (1.1)	<0.01 (<0.02)
	U.S. Government	3,359 (3,694)	6,079 (6,687)	7,592 (8,351)	53,006 (58,306)	24 (26)	53 (58.3)	0.2 (0.22)	-
	Foreign Commercial	873 (960)	1,568 (1,724)	10,584 (11,642)	7,072 (7,779)	8 (8.8)	11,516 (12,667)	0.2 (.22)	-
	Foreign Government	2,937 (3,230)	5,308 (5,838)	11,874 (13,061)	7,296 (8,025)	22 (24)	6,506 (7,156)	0.1 (0.1)	-
	Total	9,053 (9,958)	16,365 (18,001)	41,220 (45,342)	71,696 (78,865)	72 (79)	18,105 (19,915)	2 (2.2)	<0.01 (<0.02)
TOTAL ALL LAUNCHES		**9,053 (9,958)**	**16,373 (18,010)**	**42,219 (46,440)**	**72,124 (79,336)**	**72 (79)**	**18,106 (19,915)**	**72 (79)**	**0.2 (0.22)**

Criteria Pollutants

The estimated amount of NO_X (part of which is NO_2) released to the troposphere per year by all launches and reentries worldwide (approximately 18,000 metric tons [20,160 tons]) would not result in a significant cumulative impact on ambient air quality. As a point of comparison, the total emissions of NO_X for all U.S. sources for 2002 were estimated to be about 18.9 million metric tons (21.2 million tons). (U.S. EPA OAQPS, 2004) This figure is about three orders of magnitude larger than the total NO_X released by all LV and RV emissions, worldwide, for the 10-year period considered in this PEIS. Considering the sum total annual NO_X emissions from all sources worldwide would further reduce the proportion of NO_X emissions released by LVs and RVs. Because the cumulative amount of NO_X emissions associated with LVs and RVs would be such a small portion of the global NO_X emissions, and that all the LV and RV emissions would be distributed globally, the cumulative emissions would not have a significant impact on the formation of ground-level ozone or ambient air quality.

The estimated total LV and RV emissions of PM worldwide during the period 2005 to 2015 would be approximately 16,400 metric tons (18,000 tons). This figure is expected to be substantially less than the total PM released by all other sources. For example, by comparison, the total annual PM_{10} and $PM_{2.5}$ emissions for 2002 from U.S. sources only were approximately 2.2 and 1.6 million metric tons (2.4 million to 1.7 million tons), respectively. (U.S. EPA OAQPS, 2004) Worldwide emissions of PM over this 10-year period would be expected to be substantially larger, and thus potential emissions from all launches and reentries are expected to have a negligible cumulative impact.

The estimated total LV and RV emissions of CO worldwide during the period 2005 to 2015 would be approximately 71 metric tons (78 tons). By comparison, the total annual CO emissions from all U.S. sources for 2002 alone were over 87 million metric tons (95 million tons). (U.S. EPA OAQPS, 2004) The incremental contribution of LV and RV emissions to this total from all launch and reentry types is an extremely small fraction. Given the small CO emissions from LVs and RVs relative to the total annual emissions, the CO emissions would not result in a cumulative impact on ambient air quality.

The estimated LV and RV emissions of SO_X to the troposphere worldwide during the period 2005 to 2015 would be approximately 0.2 metric tons (200 kilograms). This amount is very small compared to total expected SO_X emissions from all sources. As a point of comparison, the total annual SO_2 emissions from all U.S. sources for 2002 alone were over 12.3 million metric tons (13.5 million tons). (U.S. EPA OAQPS, 2004) The incremental annual contribution of emissions associated with all launch and reentry types combined would be an extremely small fraction of this number alone, and would be an even smaller fraction of worldwide emissions. The SO_X emissions would not result in a significant cumulative impact on ambient air quality.

Air Toxics

Two HAPs, HCl and Cl, are components of some rocket engine emissions, depending on the propellant type. The estimated LV and RV emissions of HCl and Cl to the troposphere worldwide during the period 2005 to 2015 would be approximately 9,000 metric tons (9,900 tons), and 72 metric tons (79 tons), respectively. The proposed action would not be expected to contribute any emissions of HCl and Cl to the troposphere. The worldwide emissions of HCl and Cl from all launches and reentries would be insignificant relative to emissions of HCl and Cl from all other natural and anthropogenic sources. For example, total annual emissions of HCl from the natural dechlorination of sea salt are about 7.6 million metric tons (8.4 million tons). (Erickson et al., 1999) This one-year total is substantially larger than total worldwide LV and RV emissions of HCl for the 10-year period assessed in this PEIS; annual emissions from LV and RV sources would be expected to comprise an even smaller fraction. Likewise, Cl emissions, which are substantially less than HCl emissions, are expected to be an insignificant contribution to the global inventory of Cl emissions; therefore, no significant cumulative impacts are associated with the emission of HCl or Cl in the troposphere.

Acid Rain

SO_2 and NO_X, two criteria pollutants, are the primary causes of acid rain. As described above, emissions of SO_2 and NO_X from all LVs and RVs worldwide are expected to contribute an extremely small percentage of the total emissions of these pollutants worldwide. Thus, emissions from LVs and RVs would not result in a significant cumulative impact on the development of acid rain.

Regional Haze

The FAA reviewed the regional haze rule (64 FR 35714, dated July 1, 1999), which requires states to develop SIPs to address visibility at designated mandatory Class I areas, including 156 designated national parks, wilderness areas, and wildlife refuges. General features of the regional haze rule are that all states are required to prepare an emissions inventory of all haze related pollutants (i.e., VOC, NO_X, SO_2, PM_{10}, $PM_{2.5}$, and NH_3) from all sources in all constituent counties. The areas that have opted to implement the Section 309 regional haze SIP option are the States of Arizona, New Mexico, Wyoming, Utah, and Oregon. The WRAP Policy on CACs, completed on November 13, 2002, concluded that a 25 percent increase in weighted emissions would have only a minimal impact on visibility at Class I areas on the Colorado Plateau. (WRAP, 2002) As described above, the minimal emissions of the haze related pollutants and the fact that all launches and reentries occur globally would result in a negligible cumulative impact on the visibility at the designated Class I areas.

5.1.1.2 Alternative 1

Under alternative 1, there would be no emissions from RVs from activities under the proposed action. This would result in an insignificant reduction in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the troposphere. Thus the cumulative air quality impacts in the troposphere from alternative 1 would not be substantially different from the impacts associated with the proposed action.

5.1.1.3 Alternative 2

Under alternative 2, the emissions from RVs would be twice those presented under the proposed action. This would result in an insignificant increase in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the troposphere. Thus the cumulative air quality impacts in the troposphere from alternative 2 would not be substantially different from the impacts associated with the proposed action.

5.1.1.4 Alternative 3

Under alternative 3, the overall emissions to the troposphere from the proposed action would be reduced for most pollutants of interest. Although this reduction would be substantial when considering the direct impacts (see Section 4.1.1.4), this would result in an insignificant increase in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the troposphere. Thus the cumulative air quality impacts in the troposphere from alternative 3 would not be substantially different from the impacts associated with the proposed action.

5.1.1.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs, reentry of RVs, or the operations of facilities to support these activities; therefore, there would be no addition or removal of emissions to the troposphere by this alternative. No cumulative impacts on air quality in the troposphere would be expected by implementation of the no action alternative.

5.1.2 Stratosphere

5.1.2.1 Proposed Action

Potential impacts on the stratosphere include global warming from contributions of greenhouse gases and depletion of the stratospheric ozone layer. The total estimated emissions (from the proposed action and from other Federal and non-Federal launch and reentry activities) from LVs and RVs to the stratosphere for the period 2005 to 2015 are presented in Exhibit 5-5. The portion of these emissions associated with the proposed action was estimated as summarized in Section 4 and described in detail in Appendix F. The remaining emissions (i.e., FAA-licensed vertical launches, U.S government launches, and foreign commercial and government launches) were calculated by estimating the emissions per launch or reentry for each vehicle type and then multiplying these per launch and reentry emissions by the estimated number of launches and reentries for each vehicle type. A description of how the per launch and reentry emissions for each vehicle type were calculated is provided in Appendix F; the emissions per launch and reentry for each vehicle type are provided in Appendix F. The estimated number of launches and reentries for each vehicle type are provided in Exhibits F-41 and F-42, respectively; a description of how these launch and reentry estimates were estimated is provided in Appendix F.

Exhibit 5-5. Summary of Emission Loads from LVs and RVs to the Stratosphere from 2005 to 2015 in Metric Tons (Tons)

Launch Type		HCl	PM	CO_2	H_2O	Cl	NO_X	CO	SO_X
Proposed Action		39 (43)	71 (78)	2,049 (2,253)	1,316 (1,447)	0.3 (.33)	0.6 (0.66)	860 (946)	0.2 (0.22)
Federal and Non-Federal Activities	U.S. Licensed Vertical	1,884 (2,072)	3,410 (3,751)	11,385 (12,523)	4,365 (4,801)	17 (19)	30 (33)	1 (1.1)	0.01 (0.01)
	U.S. Government	3,359 (3,694)	6,079 (6,686)	8,290 (9,119)	53,188 (58,506)	24 (26)	53 (58)	-	-
	Foreign Commercial	873 (960)	1,568 (1,724)	10,712 (11,783)	7,100 (7,810)	8 (9)	11,516 (12,667)	-	-
	Foreign Government	2,937 (3,231)	5,308 (5,307)	12,185 (13,404)	7,351 (8,086)	22 (24)	6,506 (7,157)	-	-
	Total	9,054 (9,959)	16,365 (18,002)	42,571 (46,828)	72,004 (79,204)	72 (79)	18,105 (19,916)	1 (1.1)	-
TOTAL ALL LAUNCHES		**9,093 (10,002)**	**16,436 (18,080)**	**44,620 (49,082)**	**73,320 (80,652)**	**72 (79)**	**18,106 (19,916)**	**861 (946)**	**0.2 (0.22)**

Global Warming

The potential LV and RV emissions from all launch and reentry types that may affect global warming directly as greenhouse gases include CO_2 and H_2O. The cumulative impact on global warming from all launches and reentries would be insignificant when compared to other sources. For example, the total annual CO_2 emissions from all U.S. sources for 1999 were over 5,500 million metric tons (6,050 million tons). (U.S. EPA, 2001) The total contribution of all LV and RV emissions for the entire 10-year period assessed is a small fraction of this one-year figure.

Annual contributions from LVs and RVs would be expected to comprise an even smaller fraction of the global total, even if CO_2 emissions from other sources decrease over this period. Emissions of H_2O from LVs and RVs would also have an insignificant effect on global warming due to the preponderance of other natural and anthropogenic sources of H_2O.

CO and NO_X, two photochemically important pollutants that can influence the creation and destruction of greenhouse gases, are also present in launch and reentry emissions. Contributions from LV and RV emissions of these pollutants to the atmospheric burden would be extremely small relative to U.S. annual emissions, which are 87 million metric tons (95 million tons) and 18.9 million metric tons (20.1 million tons) of CO and NO_X, respectively, for 2002. (U.S. EPA OAQPS, 2004) The relative contribution from LV and RV emissions to the global pool of these chemicals would be expected to be even smaller. As a result, the presence of these chemicals in horizontal LV emissions would have a negligible cumulative impact on global warming.

Ozone Depletion

Chemicals of concern with respect to ozone depletion that would be included in launch emissions in the stratosphere include HCl and Cl and, to a lesser extent, PM and NO_X. Currently, CFCs are the main source of stratospheric chlorine. These organic compounds have one or more carbon-chlorine bonds. CFCs of concern for ozone depletion typically have long lifetimes (i.e., up to hundreds of years). The carbon-chlorine bond can be broken by photolysis or other chemical reaction to release "inorganic" chlorine that then enters the catalytic ozone destruction cycle.

Relatively recent studies indicate that the impacts from worldwide emissions of HCl and Cl from all launch types on stratospheric ozone depletion would not be significant. The RISO field study indicated that ozone depletion related to launch emissions is a temporary and limited phenomenon. In general, findings from this study indicate that the potential for ozone depletion associated with LV exhaust to cause an increase in solar UV intensity near launch sites is extremely limited. (Ross et al., 2000) In addition, ozone depletion from LV exhaust is likely to be limited spatially and temporally and would not be expected to have a globally significant cumulative impact on stratospheric chemistry. (Ross et al., 1997 as referenced in the FAA Launch Licensing 2001 PEIS)

Another study prepared for the USAF in 1994 is directly relevant to the analysis of the global impact of emissions from all space launches worldwide on stratospheric ozone depletion. (Brady et al., 1994) This study noted that the manufacturing of CFCs and other organic chlorine compounds by industrial (non-rocket) sources results in the formation of about 272,000 metric tons (304,640 tons) of inorganic chlorine in the stratosphere annually. This amount is much larger than the total amount of stratospheric inorganic chlorine – about 725 metric tons (812 tons) – introduced by worldwide space launches in 1994 as estimated by Brady et al. The amount is also substantially larger than the 9,200 metric tons (10,304 tons) estimated in this PEIS that would be released by all launch types for the 10 years between 2005 and 2015.

Brady et al. note that the phase-out of most CFCs during the 1990s will reduce the industrial inputs of inorganic chlorine to the stratosphere. The long half-life of CFCs will result in continuing contributions of inorganic chlorine from the current total stratospheric CFC mass for many years. As a result, the annual contribution of inorganic chlorine from these residual compounds is not expected to decrease by half for at least 50 to 100 years. The CFC manufacturing phase-out, coupled with expected increases in contributions from LVs (and the evolving nature of atmospheric science), suggest that more research may be necessary to fully understand the impact of future LV emissions on stratospheric ozone. However, for the current PEIS, the cumulative impacts of launch emissions on stratospheric ozone would be relatively small.

Releases of NO_X can also result from LV emissions, and NO_X is a chemical species of lesser concern for ozone depletion (compared to inorganic chlorine). Specifically, NO_X is involved in the reactions that lead to ozone depletion but is not directly responsible for the destruction of ozone. Total emissions of NO_X from all launch types would be extremely small relative to total global emissions of NO_X. As described in Section 5.1.1.1, about 19 million metric tons (21 million tons) were released in the U.S. in 2002 alone (U.S. EPA OAQPS, 2004); it is anticipated that total global emissions over the 10-year period between 2005 and 2015 would be significantly larger.

PM would be emitted to the stratosphere by some launches. PM may affect stratospheric ozone, possibly by acting as a catalytic site for ozone destruction; however, the exact impact of PM on ozone depletion is unclear. A 1999 study prepared for the USAF on the stratospheric impact of solid rocket motor launch emissions concluded that the global impacts of PM from such emissions on ozone depletion are very small. (Ko et al., 1999) The estimated total emissions of Al_2O_3 to the stratosphere used in calculations for that study were about 1,015 metric tons (1,137 tons) per year. If multiplied by 10 (to approximate the total emissions released over a 10-year period), the result would be similar to the 10-year total emissions of PM estimated for all launch types in the current assessment. Therefore, the cumulative impacts of PM on stratospheric ozone depletion would be negligible.

5.1.2.2 Alternative 1

Under alternative 1, there would be no emissions from RVs from activities under the proposed action. This would result in an insignificant reduction in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the stratosphere. Thus, the cumulative impacts on global warming and ozone depletion in the stratosphere from alternative 1 would not be substantially different from the impacts associated with the proposed action.

5.1.2.3 Alternative 2

Under alternative 2, the emissions from RVs would twice that of the proposed action. This would result in an insignificant increase in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the stratosphere. Thus, the cumulative impacts global warming and ozone depletion in the stratosphere would not be substantially different from the impacts associated with the proposed action.

5.1.2.4 Alternative 3

Under alternative 3, the overall emissions to the stratosphere from the proposed action would be reduced for most pollutants of interest. Although this reduction would be substantial when considering the direct impacts (see Section 4.1.2.4), this would result in an insignificant increase in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the troposphere. Thus the cumulative impacts global warming and ozone depletion in the stratosphere would not be substantially different from the impacts associated with the proposed action.

5.1.2.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs, the reentry of RVs, or the operation of facilities to conduct these activities; therefore, there would be no addition or removal of emissions to the stratosphere by this alternative. No cumulative impacts on global warming and ozone depletion in the stratosphere would result from implementation of the no action alternative.

5.1.3 Mesosphere

5.1.3.1 Proposed Action

The mesosphere is a relatively narrow band of the atmosphere that rockets tend to pass through fairly quickly. Significant cumulative impacts in the mesosphere associated with the compounds emitted by LVs and RVs are not known to exist. The emission loads to the mesosphere are presented in Appendix F, Exhibits F-66 through F-75.

5.1.3.2 Alternative 1

The cumulative air quality impacts in the mesosphere from alternative 1 would be the same as the impacts associated with the proposed action.

5.1.3.3 Alternative 2

The cumulative air quality impacts in the mesosphere from alternative 2 would be the same as the impacts associated with the proposed action.

5.1.3.4 Alternative 3

The cumulative air quality impacts in the mesosphere from alternative 3 would be the same as the impacts associated with the proposed action.

5.1.3.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs, the reentry of RVs, or the operation of facilities to conduct these operations; therefore, there would be no addition or removal of emissions to the mesosphere, and the cumulative emissions would be unaffected.

5.1.4 Ionosphere

5.1.4.1 Proposed Action

Some exhaust products from horizontal LVs[24] during launch from Earth to space have been found to have a temporary effect on electron concentrations in the F layer of the ionosphere. Specifically, these exhaust products are CO_2, H_2O, and H. These compounds can react with ambient electrons and ions in the F layer of the ionosphere to effectively form a "hole" in this region by reducing the concentration of electrons and ions within the path of the vehicle. The reactions that take place can result in a net decrease in electron concentration in the F layer, potentially affecting radio communication, such as short-wave broadcasts, which interact with the ionosphere. (U.S. DOT, 1992)

However, as described in more detail in Section 4.1.4.1, the ionospheric hole that would be created as a result of launch emissions would be temporary and appears to dissipate in a matter of minutes. Therefore, it does not appear that the effects of this phenomenon would accumulate to any degree, unless there were launches through the same region of the atmosphere every few minutes. The cumulative impacts on the ionosphere would be negligible.

5.1.4.2 Alternative 1

The cumulative impacts on the ionosphere from alternative 1 would be the same as the impacts associated with the proposed action.

5.1.4.3 Alternative 2

The cumulative impacts on the ionosphere from alternative 2 would be the same as the impacts associated with the proposed action.

5.1.3.3 Alternative 3

Under alternative 3, the programmatic emissions to the ionosphere from the proposed action would be eliminated for most pollutants of interest. Although this reduction would be substantial when considering the direct impacts (see Section 4.1.4.4), this would result in an insignificant increase in total emissions from the activities associated with the proposed action and the other Federal and non-Federal launch and reentry activities in the ionosphere. Thus the cumulative impacts on the ionosphere would not be substantially different from the impacts associated with the proposed action.

5.1.4.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs, the reentry of RVs, or the operation of facilities to conduct these operations; therefore, there would be no addition or removal of emissions to the ionosphere. The implementation of the no action alternative would not result in cumulative impacts on air quality in the ionosphere.

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[24] Reentry vehicles are not expected to have impacts on the ionosphere because they do not use engines at these altitudes.

5.2 Health and Safety

The following subsections discuss the cumulative impacts on public health and safety associated with each alternative.

5.2.1 Proposed Action

Under the proposed action, public health and safety would be the same as that presented in Section 4.13, Public Health and Safety. The FAA Licensing and Safety Division would apply the same risk tolerance threshold (30 x 10^{-6} risk threshold) for all activities that it has the authority to license. Other Federal and non-Federal agencies would implement similar public health and safety standards for similar launch, reentry, or launch or reentry sites (e.g., NASA safety standards and DoD safety standards). As such, the cumulative impacts on public health and safety would not be significant.

5.2.2 Alternative 1

The cumulative impacts on public health and safety associated with alternative 1 would be the same as those associated with the proposed action.

5.2.3 Alternative 2

The cumulative impacts on public health and safety associated with alternative 2 would be the same as those associated with the proposed action.

5.2.4 Alternative 3

The cumulative impacts on public health and safety associated with alternative 3 would be the same as those associated with the proposed action.

5.2.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs and would not issue licenses for the reentry of RVs; therefore, there would be no addition or removal of public health and safety concerns. No cumulative impacts on public health and safety would be expected by implementation of the no action alternative.

5.3 Orbital Debris

The following subsections discuss the cumulative impacts of orbital debris associated with each alternative.

5.3.1 Proposed Action

The FAA reviewed the cumulative impacts on orbital debris associated with 1,478 FAA licensed commercial launches (horizontal and vertical), 519 U.S. Government launches, 411 foreign government launches, 239 foreign commercial launches, and 51 FAA-licensed commercial reentries, 33 U.S. Government reentries, 49 foreign government reentries, and 11 foreign commercial reentries between 2005 and 2015. The cumulative effect of the activities presented in this PEIS with other Federal and non-Federal launch activities would result in more solid rocket motor ejecta, operational debris, fragmentation debris, and deterioration debris within each orbit altitude (i.e., below LEO, LEO, MEO, and GEO). The impact analysis presented in Section 4.3, Orbital Debris, applies to the discussion of cumulative impacts. The processes related to and characteristics of orbital debris presented in Section 4.3 also hold true for the other Federal and non-Federal activities considered in this cumulative impact analysis. As such, the cumulative impacts associated with orbital debris would be slightly more than those presented in Section 4.3; however, would not result in significant impacts.

5.3.2 Alternative 1

The cumulative impacts from orbital debris associated with alternative 1 would be the same as those associated with the proposed action.

5.3.3 Alternative 2

The cumulative impacts from orbital debris associated with alternative 2 would be the same as those associated with the proposed action.

5.3.4 Alternative 3

The cumulative impacts from orbital debris associated with alternative 3 would be the same as those associated with the proposed action.

5.3.5 No Action Alternative

Under the no action alternative, the FAA would not issue licenses for the horizontal launch of LVs, the reentry of RVs, or the operation of facilities to support these activities; therefore, there would be no addition or removal of space objects that could contribute to orbital debris. No cumulative impacts on orbital debris would be expected by implementation of the no action alternative.

5.4 Socioeconomics

The following subsections discuss the cumulative impacts on socioeconomics associated with each alternative.

5.4.1 Proposed Action

The cumulative socioeconomic impact associated with the proposed action would be a beneficial impact resulting from the continued growth of both the U.S. and foreign space industries. Such continued growth would occur from the FAA issuing licenses for launches of horizontal LVs, reentries of RVs, and the operation of facilities to support these activities. As the market and demand would grow in the U.S., it would also grow in the foreign markets. Cumulative socioeconomic impacts associated with a specific licensing activity, such as building a new launch facility, would be assessed in a site-specific NEPA document that tiers from this PEIS.

5.4.2 Alternative 1

Licensing the activities described under the proposed action would have a beneficial cumulative socioeconomic impact; however, licensing only a subset of the activities outlined in the proposed action could reduce the magnitude of this beneficial impact and could limit the development and growth of the commercial launch industry.

5.4.3 Alternative 2

Licensing the activities described under the proposed action would have a beneficial cumulative socioeconomic impact; however, licensing only a subset of the activities outlined in the proposed action could reduce the magnitude of this beneficial impact and could limit the development and growth of the commercial launch industry.

5.4.4 Alternative 3

Licensing the activities described under the proposed action would have a beneficial cumulative socioeconomic impact; however, licensing only a subset of the activities outlined in the proposed action could reduce the magnitude of this beneficial impact and could limit the development and growth of the commercial launch industry.

5.4.5 No Action Alternative

Not licensing horizontal launches, reentries, or the operation of launch and reentry facilities, coupled with the fact that vertical launches are already being licensed, would likely cause a negative effect on the U.S. commercial launch industry in general. If launch companies foresee that their technological developments could be hindered by not being able to pursue horizontal launch technologies in additional to vertical technologies, then it is possible that they might choose to move their operations and alter their organizational structure so that the company would not fall under the regulatory authority of the FAA. In addition, by not issuing horizontal launch, reentry, or launch site operator licenses, the market and demand for the development of such technologies would decrease. Furthermore, the effects of thwarting the development of this technology could resonate to other technologically similar markets, and cause companies to stop developing new technologies. Overall, this cumulative effect on the national economy could be negative, while the effect on foreign markets might be positive.

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6 MITIGATION

This section addresses the broad mitigation measures that may be implemented to prevent or reduce the environmental effects of the activities considered in this PEIS. The mitigation measures presented are program-wide mitigation measures, as site-specific mitigation measures would be developed based on the parameters of the activity that would be licensed by the FAA. As such, the site-specific NEPA document that would be prepared for a FAA licensing activity that would tier from this PEIS would include site-specific mitigation measures. In addition, the FAA does not consider compliance with existing regulatory standards to be a mitigation measure, as compliance with such standards would be mandatory with any action.

In developing mitigation measures for the activities considered in this PEIS, the FAA reviewed its licensing procedures to identify operational controls or methods that could be implemented as mitigation measures. The FAA would continue to develop and implement environmental monitoring programs on a case-by-case basis, as appropriate. Specifically, the FAA would consider developing monitoring programs to ensure that licensees meet requirements of various regulations including the Endangered Species Act, Marine Mammal Protection Act, and National Historic Preservation Act. These monitoring requirements may be listed as part of the terms and conditions of future licenses.

In addition to the development of monitoring programs, the FAA would continue to prepare

- Commercial Space Transportation Forecasts,
- Quarterly Launch Reports,
- Licensing and Safety Reports,
- Annual Development and Concept Reports, and
- Commercial Space Transportation, Year End Reports.

Such reports would allow the FAA to maintain accountability of both commercial and non-commercial launch activities, track successful and failed launches, maintain current safety standards, and remain abreast of future launch activities and concepts. The FAA would also continue to make this information available for the public via its internet site (http://ast.faa.gov/rep_study/). As the commercial space industry would grow and expand into new areas or surpass the level of activity or technologies analyzed in current NEPA documents prepared by the FAA, this process would allow the FAA to proactively identify new concepts or increased levels of activities that would require review in accordance with NEPA.

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7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Natural and man-made resources would be expended under the implementation of the proposed action. Human effort would be irretrievably committed for the preparation and processing of license applications and their associated reviews (see Section 1.2, FAA Licensing Program). The development and launch of horizontal LVs, reentries of RVs, and the development and operation of facilities to support these activities would require the use of various natural resources. The materials used to manufacture such vehicles include a modest amount of metals, such as aluminum, nickel, stainless steel, carbon, copper, titanium, and other materials. These materials are readily available in large quantities. Composite materials or fiber reinforced plastics (FRP) would also be used on in the construction of such vehicles. Composites may be composed of glass, carbon, or aramide fibers imbedded in resin; specific vehicle structural parts or tanks would then be fabricated by winding filaments or tape or laying up impregnated cloth or tape as required by the application. In general, the amount of metal and composite materials that would be required for the horizontal LVs or RVs is negligible compared to the quantities routinely produced.

Solid and liquid propellants and other consumable fluids would be expended during the launch of horizontally launched LVs and during the reentry of RVs. Appendix F describes these materials and their quantities. Any support aircraft would typically use jet fuel. Solid rocket motors in conjunction with liquid LOX/RP-1 systems, or hybrid propellants may also be used during particular portions of a vehicle launch or reentry.

The development of a new or modification of an existing launch or reentry facility would result in the irreversible and irretrievable commitment of both natural and man-made resources. Human effort would be irretrievably committed during the planning, construction, operation, maintenance phases of the facility, while natural resources (construction material) would be committed to the facility. Such irreversible and irretrievable commitment of resources and the amount would be presented in a site-specific NEPA document that would tier from this PEIS.

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10 GLOSSARY

A-Weighted Decibel (dBA): A number representing the sound level that is frequency-weighted according to a prescribed frequency response of the human ear, as established by the American National Standards Institute (ANSI). (*See definition for decibel*).

Accident Scenario: A probable, possible, and/or plausible incident or sequence of failure events that can lead to the occurrence of an accident.

Acid rain: Rain with a potential of hydrogen (pH) level of less than 5.6. (*See definition for potential of hydrogen [pH]*).

Airspace: The portion of the atmosphere that lies above a nation and comes under its jurisdiction. Airspace is a finite resource that can be defined vertically, horizontally, and temporally. The FAA controls U.S. airspace from ground level to a ceiling of 18,288 meters (60,000 feet).

Ambient Air Quality Standards (AAQS): Defined limits for airborne concentrations of designated criteria pollutants. They are established on a state or Federal level to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards). (*See definition for criteria pollutant*).

Apogee: The point during a vehicle's flight path where the vehicle is furthest from Earth.

Attainment Area: A region that meets the U.S. EPA National Ambient Air Quality Standards (NAAQS) for a criteria pollutant under the Clean Air Act. (*See definitions for criteria pollutant and NAAQS*).

Aquifer: An underground bed or layer of earth, gravel, or porous stone that yields water for wells, springs, and other water bodies.

Best Management Practice (BMP): Structural, nonstructural, and managerial technique recognized to be the most effective and practical means to manage a process or address and issue (e.g., a method that reduces ground water contamination while still allowing the productive use of resources).

Biological Resources: Terrestrial and aquatic plants and animals and the various ecosystems that they inhabit.

Brackish: Descriptive term for water having salinity values ranging from approximately 0.50 to 17.00 parts per thousand. Brackish water may result from mixing of seawater with fresh water, as in estuaries, or it may occur naturally, as in brackish fossil aquifers.

Carbon Monoxide (CO): A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion. Carbon monoxide is one of the six criteria pollutants for which there is a NAAQS. (*See definition for criteria pollutant*).

Criteria Pollutant: A pollutant determined to injure health, harm the environment, and cause property damage and regulated under EPA's NAAQS (carbon monoxide, lead, nitrogen dioxide, ozone (1-hour and 8-hour), particulate matter (2.5 and 10), and sulfur dioxide). The 1970 amendments to the Clean Air Act require EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime.

Cryogenic: A type of propellant for launch vehicle propulsion systems that is gaseous at room temperature and maintained as liquid at very low temperatures (e.g., liquid oxygen [LOX], liquefied hydrogen [LH_2]).

Cultural Resources: Includes prehistoric and historic structures, artifacts, archaeological sites, underwater sites, burial sites, and Native American/Hawaiian religious sites. Related to cultural resources are historic properties, which include artifacts, archaeological sites, standing structures or other historic resources listed, or potentially eligible for listing, on the National Register of Historic Places.

Cumulative Impacts: The combined impacts resulting from all activities occurring concurrently at a given location.

Day-Night Average Noise Level (DNL): A noise metric combining the levels and durations of noise events and the number of events over an extended time period. It is a cumulative average computed over a set of 24-hour periods to represent total noise exposure. DNL also accounts for more intrusive night time noise, adding a 10-decibel penalty for sounds after 10:00 p.m. and before 7:00 a.m. (*See definition for decibel*).

Decibel (dB): A unit used to express the intensity of a sound wave, equal to 20 times the common logarithm of the ratio of the pressure produced by the sound wave to a reference pressure (typically one micropascal at one meter).

***De minimis* level:** In the context of air quality, the level at which emissions do not have an impact.

Ecosystem: The set of biotic (living) and abiotic (nonliving) components in a given environment.

Endangered Species: Animal, bird, fish, plant, or other living organism threatened with extinction throughout all or a significant portion of its range. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Environmental Justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Executive Order 12898 specifies how Federal agencies should address the issue.

Ejecta: Material that is expelled into space from solid rocket motor engines or chunks of unburned solid propellant (e.g., aluminum oxide [Al_2O_3] particulate dust).

Erosion: The wearing away of the land surface by wind, water, ice or other geologic agents. It occurs naturally from weather or runoff but is often intensified by human land use practices.

Footprint: The surface area of the Earth likely to be impacted by something, such as falling orbital debris or sonic booms.

Floodplain: Low-lying areas adjacent to rivers and streams that are subject to natural inundations typically associated with precipitation.

Fugitive Dust: Any solid particulate matter that becomes airborne, other than that emitted from an exhaust stack, either directly or indirectly as a result of the activities of man. Fugitive dust may include emissions from dirt roads, wind erosion of exposed soil surfaces, and other activities in which soil is either removed or redistributed. (*See definition for particulate matter*).

Geology and Soils: Geology is the science and study of the Earth, its composition, structure, physical properties, history, and the processes that shape it. Soil is the layer of minerals and organic matter on the land surface, and includes components of moisture and air.

Geosynchronous Earth Orbit (GEO): An orbit 35,890 kilometers (22,300 miles) in altitude that is synchronized with the Earth's rotation. If a satellite in geosynchronous orbit is not at 0 degrees inclination, its ground path forms a figure eight as it travels around the Earth.

Global Warming: The progressive gradual rise of the Earth's surface temperature thought to be caused by the greenhouse effect. Global warming may be responsible for changes in global climate patterns. Global warming has occurred in the past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases. (*See definition for Greenhouse Gases*).

Greenhouse Gases: Gases that raise the temperature of the Earth's atmosphere by absorbing part of the long-wave radiation reflected back from the Earth's surface, also known as the greenhouse effect. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrofluorocarbons, and perfluorinated carbons.

Ground cloud: The concentrated area of pollutants that form close the Earth's surface when a launch vehicle vertically accelerates off a launch pad.

Ground water: Water, both fresh and saline, that is stored below the Earth's surface in pores, cracks, and crevices below the water table.

Geosynchronous Transfer Orbit (GTO): An orbit attained when a spacecraft is first launched into an elliptical orbit with an apogee altitude (the point of orbit which is farthest from the Earth) of approximately 37,000 kilometers (22,991 miles).

Hazardous Air Pollutants (HAPs): A group of 188 chemicals identified in the 1990 Clean Air Act Amendments. Exposure to these pollutants can cause or contribute to cancer, birth defects, genetic damage, and other adverse health effects.

Hazardous Materials and Waste: Substances that, because of their quantity, concentration, or physical, chemical, or infectious characteristics, may present substantial danger to the public health, welfare, or the environment when released.

High payload capacity: The ability of a launch vehicle to lift from 4,082 to 4,536 kilograms (9,000 to 10,000 pounds) into GTO. (*See definition for payload*).

Hybrid propulsion systems/fuels: A propulsion system that uses solid fuel with a liquid oxidizer, giving it the ability to throttle, shut-off, and restart in mid-flight. (*See definition for propulsion system*).

Hydrazine (N_2H_4): A toxic, flammable, fuming, corrosive, strongly reducing liquid used as launch vehicle fuel. (*See definitions of propellant and propulsion systems*).

Hydrocarbon fuel: A carbon-based propellant used for launch vehicle propulsion systems (e.g., Rocket Propellant-1 [RP-1], kerosene plus an oxidizer like liquid oxygen [LOX]).

Hypergolic: Term applied to describe the self-ignition of a fuel and an oxidizer upon mixing with each other without a spark or other external aid.

Impact Analysis: An assessment of the meaning of changes in all attributes being studied for a given resource, an aggregation of all effects, usually measured using a qualitative and nominally subjective technique.

Intermediate payload capacity: The ability of a launch vehicle to carry between 1,814 and 4,082 kilograms (4,000 and 9,000 pounds) into GTO or more than 2,268 kilograms (5,000 pounds) into Low Earth Orbit (LEO). (*See definitions for LEO and payload*).

Ion: An atom or molecule that has acquired an electric charge by the loss or gain of one or more electrons.

Ionization: A process by which a neutral atom or molecule loses or gains electrons, thereby acquiring a net charge and becoming an ion.

Ionosphere: The part of the Earth's upper atmosphere which is sufficiently ionized by solar ultraviolet radiation so that the concentration of free electrons affects the propagation of radio waves. It begins between 85 and 105 kilometers (53 to 65 miles) above the Earth's surface and is considered to extend upwards to 2,000 kilometers (1,243 miles), though it has no well-defined upper boundary.

Land Use: The way land is developed and used in terms of the kinds of anthropogenic activities that occur (e.g., agriculture, residential areas, industrial areas).

Launch vehicle: A rocket launched to deliver a payload from Earth into space. (*See definition for payload*).

Lead: A heavy metal element formerly added to gasoline and paint for improved performance characteristics. Ingestion and accumulation in humans results in damage to the central nervous system and the mental development of children. Lead is one of the six criteria pollutants for which there is a NAAQS.

Low Earth Orbit (LEO): A flight path between the Earth's atmosphere and the bottom of the Van Allen belts, from about 161 to 1,609 kilometers (100 to 1,000 miles) altitude. (*See definition of Van Allen belts*).

Mach 1: Speed of sound, which measures approximately 1,223 kilometers per hour (760 miles per hour); traveling faster than this speed breaks the sound barrier.

Magnetosphere: The region of the Earth in which the geomagnetic field plays a dominant part in controlling the physical processes that take place; it is usually considered to begin at an altitude of about 100 kilometers (62 miles) and to extend outward to a distant boundary that marks the beginning of interplanetary space.

Medium Earth Orbit (MEO): A flight path between Low Earth Orbit (at approximately 1,609 kilometers [1,000 miles]) and below Geosynchronous Earth Orbit (at approximately 35, 890 kilometers [22,300 miles]). Objects orbiting in MEO are generally located between 10,000 kilometers (6,214 miles) and 15,000 kilometers (9,321 miles).

Medium payload capacity: The ability of a launch vehicle to place a 907 to 1,814 kilogram (2,000 to 4,000 pound) payload into GTO. (*See definition for payload*).

Mesosphere: The mesosphere is located between 50 and 80 kilometers (31 to 50 miles) above the Earth's surface, characterized by a temperature that decreases as the altitude increases. The coldest temperatures at the mesopause (the upper boundary of the mesosphere) can reach -100°C (-148°F).

Mitigation: A method or action to reduce or eliminate adverse environmental impacts.

National Environmental Policy Act (NEPA): Public law 91-190, passed by Congress in 1969. The Act established a national policy designed to encourage consideration of the influences of human activities, such as population growth, high-density urbanization, or industrial development, on the natural environment. NEPA procedures require that environmental information be made available to the public before decisions are made. Information contained in NEPA documents must focus on the relevant issues to facilitate the decision-making process.

National Register of Historic Places: A register of districts, sites, buildings, structures, and objects important in American history, architecture, archaeology, and culture, maintained by the Secretary of the Interior under authority of Section 2 (b) of the Historic Site Act of 1935 and Section 101 (1) of the National Historic Preservation Act of 1966, as amended.

Nitrogen Dioxide (NO_2): Gas formed primarily from atmospheric nitrogen and oxygen when fuel combustion takes place at high temperature. NO_2 emissions contribute to acid rain and formation of atmospheric ozone. Nitrogen dioxide is one of the six criteria pollutants for which there is a NAAQS.

Nitrogen Oxides (NO_X): A generic term referring to any one of six different oxides of nitrogen produced during fuel combustion: nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide (N_2O), dinitrogen trioxide (N_2O_3), dinitrogen tetroxide (N_2O_4), and dinitrogen pentoxide (N_2O_5). They are believed to cause health problems, form atmospheric ozone, create acid rain, and cause other ecological problems.

Noise: Sound that is unwanted, either because of its effect on humans, its effect on fatigue or malfunction of physical equipment, or its interference with the perception or detection of other sounds.

Non-Attainment Areas: An area that has been designated by the EPA or the appropriate state air quality agency as exceeding one or more national or state AAQS.

Non-point Source: Type of pollution originating from a combination of sources.

Orbital debris: Man-made material in the Earth's orbit that is no longer serving any function (e.g., outdated satellites or expended portions of spacecraft).

Organic matter: Relating to, or derived from, living organisms.

Overpressure: The local transient pressure exceeding existing atmospheric pressure, usually expressed in pounds per square inch.

Oxidizer: A substance that yields oxygen readily to support the combustion of organic matter, powdered metals, and other flammable material (e.g., chlorate, perchlorate, permanganate, peroxide, nitrate, and oxide).

Ozone (O_3): A molecule made up of three atoms of oxygen. It occurs naturally in the stratosphere and provides a protective layer shielding the Earth from harmful ultraviolet radiation. In the troposphere, it is a chemical oxidant and major component of photochemical smog. Ozone is one of the six criteria pollutants for which there is a NAAQS. (*See definitions of troposphere and stratosphere*).

Ozone Depleting Substances: Substances that can catalyze reactions that break ozone into other compounds, which is an issue of concern in the stratosphere.

Parking orbit: A temporary Earth orbit for a spacecraft.

Particulate Matter (PM): Dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, engines, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases are also considered particulate matter. Particulate matter is one of the six criteria pollutants for which there is a NAAQS. (*See also PM_{10} and $PM_{2.5}$ definitions*).

Payload: The item that an aircraft or rocket carries over and above what is necessary for the operation of the vehicle in flight (e.g., spaceflight participants, cargo, or satellites).

Payload capacity: Payload capacity refers to the weight that a launch vehicle can lift into a particular orbit, such as LEO or GTO (expressed in pounds or kilograms).

Photolysis: The use of radiant energy to produce chemical changes.

PM_{10}: Particulate matter less than or equal to 10 micrometers in diameter.

$PM_{2.5}$: Particulate matter less than or equal to 2.5 micrometers in diameter.

Potential of Hydrogen (pH): A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions. A solution of 0 to 7 is acid, where decreasing values toward 0 indicates an increase in acidity. A solution of 7 to 14 is alkaline, where increasing values toward 14 indicates an increase in alkalinity.

Programmatic Environmental Impact Statement (PEIS): A document prepared in accordance with NEPA for the adoption of programs, such as a group of concerted actions to implement a specific policy or plan. Systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive (40 CFR 1508.18). Such documents assist in tiering. (*See definition for tiering*).

Propellant: A mixture of fuel and oxidizer that reacts (with or without an initiating source) to produce a high-energy stream of product gases that can produce thrust at a controlled, predetermined rate.

Propulsion systems: A mechanical system that provides a propelling or driving force to push an object forward. A propellant is accelerated by the engine, and a reaction produces a force on the engine.

Public Health and Safety: Health and safety includes consideration of any activities, occurrences, or operations that have the potential to affect the well being, safety, or health of workers or members of the general public.

Reentry: To return or attempt to return, purposefully, a reentry vehicle and its payload, if any, from Earth orbit or from outer space to Earth. (*See definition of reentry vehicle*).

Reentry vehicle: A vehicle designed to return from Earth orbit or outer space to Earth substantially intact.

Reusable launch vehicle: A launch vehicle that is designed to return to Earth substantially intact and may be launched more than one time or that contains vehicle stages that may be recovered by a launch operator for future use in the operation of a substantially similar launch vehicle.

Scoping: A process initiated early during the NEPA process to identify the scope of issues to be addressed in the environmental document being prepared, including the significant issues related to the proposed action. During scoping, input is solicited from affected agencies as well as the interested members of the public. (40 CFR 1501.7)

Section 4(f) Resources: Resources protected under section 4(f) of the Department of Transportation Act (recodified as section 303(c) of 49 U.S.C.), which includes any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance or land from an historic site of national, state, or local significance.

Small payload capacity: The ability of a launch vehicle to launch 907 kilograms (2,000 pounds) or less into GTO or 2,268 kilograms (5,000 pounds) or less into LEO.

Socioeconomics: The social and economic indicators specific to the human environment. Social indicators include statistical data related to population distributions, ethnicity, home ownership, education levels, and the availability of medical care, fire and rescue services, educational facilities, or other public amenities such as libraries or recreational opportunities. Key economic indicators include employment trends and unemployment rates, income levels, retail sales, industry, factory, and agricultural activities, and home purchases or sales.

Soil horizons: Layers of soil distinguishable by characteristic physical or chemical properties.

Solid propellant: A rocket propellant in solid form, containing a fuel/oxidizer mix that continually combusts when ignited (e.g., polybutadiene matrix with acrylonitrile, ammonium perchlorate oxidizer, and powdered aluminum).

Sonic boom: A noise caused by a shock wave that emanates from an aircraft or other object traveling at or above the speed of sound (Mach 1).

Sound: An alteration of properties of an elastic medium, such as pressure, particle displacement, or density that propagates through the medium. Sound waves having frequencies above the audible (sonic) range are termed ultrasonic waves. Those with frequencies below the sonic ranges are called infrasonic waves. Sound can also be described as acoustic waves or sound waves.

Stratosphere: The atmospheric shell above the troposphere and below the mesosphere. It extends from the tropopause to about 55 kilometers (34 miles), where the temperature begins again to increase with altitude. (*See definitions for troposphere and tropopause*).

Suborbital trajectory: The intentional flight path, or any portion of that flight path, of a launch vehicle or reentry vehicle, whose vacuum instantaneous impact point (IIP) does not leave the surface of the earth. The IIP of a launch vehicle is the projected impact point on Earth where the vehicle would land if its engines stop or where vehicle debris, in the event of failure and break-up, would land. The notion of a "vacuum" IIP reflects the absence of atmospheric effects in performing the IIP calculation. If the vacuum IIP never leaves the Earth's surface, the vehicle would not achieve Earth orbit and would therefore be on a suborbital trajectory..

Suborbital vehicle: A rocket-propelled vehicle intended for flight on a suborbital trajectory and whose thrust is greater than its lift for the majority of the powered portion of its flight.

Sulfur Dioxide (SO_2): A corrosive gas that combines with water vapor in the atmosphere to form sulfuric acid (H_2SO_4), which falls as acid rain. Sulfur dioxide is one of the six criteria pollutants for which there is a NAAQS.

Tiering: The coverage of general matters in broader environmental impact statements with subsequent more focused statements or environmental analyses, incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared.

Threatened Species: Plant and wildlife species that are likely to become endangered in the foreseeable future.

Trajectory: The path followed by an object moving through space under the action of given forces such as thrust, wind, and gravity.

Tropopause: The boundary zone (or transition layer) between the troposphere and the stratosphere of the Earth's atmosphere. Its height varies from 10 to 20 kilometers (6.2 to 12.4 miles) above the Earth's surface and is characterized by little or no change in temperature as altitude increases.

Troposphere: The layer of the atmosphere from the Earth's surface up to the tropopause, comprised mostly of nitrogen (76.9 percent) and oxygen (20.7 percent). The troposphere is characterized by decreasing temperature with increasing altitude, vertical wind motion, appreciable water vapor content, and sensible weather (clouds, rain, etc.). It contains 75 percent of the total mass of the Earth's atmosphere.

Van Allen belts: Radiation belts surrounding the Earth that contain energetic charged particles trapped by the Earth's magnetic field. The inner belt extends over altitudes of 650 to 6,300 kilometers (404 to 3,915 miles), while the outer belt extends from altitudes of about 10,000 to 65,000 kilometers (6,214 to 40,389 miles).

Visual and Aesthetic Resources: Natural or developed landscapes that provide information for an individual to develop their perceptions of the area. The size, type, gradient, scale, and continuity of landforms, structures, land use patterns, and vegetation are all contributing factors to an area's visual character and how it is perceived.

Volatile Organic Compounds (VOCs): Organic compounds that easily volatize or evaporate and can break down through photodestructive mechanisms. They contribute to air pollution, especially the generation of tropospheric ozone.

Water Resources: This term includes both freshwater and marine systems, wetlands, floodplains, and ground water.

Wetlands: Land or areas exhibiting the following characteristics: hydric soil conditions; saturated or inundated soil during some part of the year and plant species tolerant of such conditions; areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, under normal circumstances, a prevalence of vegetation typically adapted for life in saturated soil conditions. Examples include swamps, marshes, bogs, and similar areas.

APPENDIX A FAA LICENSING PROGRAM

This appendix describes the Federal Aviation Administration's (FAA's) Office of Commercial Space Transportation's (AST's) commercial space transportation licensing program. It also discusses the different types of licenses and the steps involved in the licensing process.

A.1 Licensing Program Overview

The primary objective of the licensing program, which is carried out by the FAA's Licensing and Safety Division, is to ensure public health and safety through the licensing of commercial space launches and reentries, as well as licensing the operation of launch sites. The objective of the FAA's licensing and compliance monitoring/safety inspection processes is the protection of public health and safety and the safety of property. The components of the AST licensing process include pre-application consultation, application evaluation, and compliance monitoring. For the operation of a launch site and for the reentry of a reentry vehicle, the FAA evaluates an applicant's proposal on an individual basis. The FAA issues a license when it determines that an applicant's launch or reentry proposal or proposal to operate a launch site will not jeopardize public health and safety, safety of property, United States (U.S.) national security or foreign policy interests, or international obligations of the U.S. The FAA does not license launches performed by and for U.S. government agencies.

49 United States Code (U.S.C.) 701, *Commercial Space Launch Activities*, gave the FAA the responsibility to:

> "regulate the commercial space transportation industry, only to the extent necessary to ensure compliance with international obligations of the United States and to protect the public health and safety, safety of property, and national security and foreign policy interest of the United States, ... encourage, facilitate, and promote commercial space launches by the private sector, recommend appropriate changes in Federal statutes, treaties, regulations, policies, plans, and procedures, and facilitate the strengthening and expansion of the United States space transportation infrastructure."

The requirements that a launch operator or launch site operator must satisfy to protect the public include: commercial space transportation licensing and safety requirements (including those for operation of a launch site, and for reusable launch vehicle and reentry licensing); financial responsibility requirements; and civil penalty actions (enforcement). Advisory circulars provide guidance and information material of a non-regulatory nature to FAA recipients, industry, the space community, and the public.

A.2 Types of Licenses

The FAA has the authority to issue a total of seven types of commercial space transportation licenses:

1. ***Launch Site Operator License*** – "A license to operate a launch site authorizes a licensee to operate a launch site in accordance with the representations contained in the licensee's application, with terms and conditions contained in any license order accompanying the license, and subject to the licensee's compliance with 49 U.S.C subtitle IX, ch.701 and this chapter. 14 Code of Federal Regulations (CFR) 420.41(a) A license to operate a launch site authorizes a licensee to offer its launch site to a launch operator for each launch point for the type and any weight class of [launch vehicle] LV identified in the license application and upon which the licensing determination is based. 14 CFR 420.41(b) Issuance of a license to operate a launch site does not relieve a licensee of its obligation to comply with any other laws or regulations; nor does it confer any proprietary, property, or exclusive right in the use of airspace or outer space. 14 CFR 420.41(c) A license to operate a launch site remains in effect for five years from the date of issuance unless surrendered, suspended, or revoked before the expiration of the term and is renewable upon application by the licensee." 14 CFR 420.43

2. ***Reusable Launch Vehicle (RLV) Mission-Specific License*** – "A mission-specific license authorizing an RLV mission authorizes a licensee to launch and reenter, or otherwise land, one model or type of RLV from a launch site approved for the mission to a reentry site or other location approved for the mission. A mission–specific license authorizing an RLV mission may authorize more than one RLV mission and identifies each flight of an RLV authorized under the license. A licensee's authorization to conduct RLV missions terminates upon completion of all activities authorized by the license or the expiration date stated in the reentry license whichever comes first." 14 CFR 431.3(a)

3. ***RLV Mission Operator License*** – "An operator license for RLV missions authorizes a licensee to launch and reenter, or otherwise land, any of a designated family of RLVs within authorized parameters, including launch sites and trajectories, transporting specified classes of payloads to any reentry site or other location designated in the license. An operator license for RLV missions is valid for a two-year renewable term." 14 CFR 431.3(b)

4. ***Reentry-Specific License*** – "A reentry-specific license authorizes a licensee to reenter one model or type of reentry vehicle, other than an RLV, to a reentry site or other location approved for the reentry. A reentry-specific license may authorize more than one reentry and identifies each reentry authorized under the license. A licensee's authorization to reenter terminates upon completion of all activities authorized by the license or the expiration date stated in the reentry license, whichever occurs first." 14 CFR 435.3(a)

5. ***Reentry Operator License*** – "A reentry operator license authorizes a licensee to reenter any of a designated family of reentry vehicles, other than an RLV, within authorized parameters, including trajectories, transporting specified classes of payloads to any reentry site designated in the license. A reentry operator license is valid for a two-year renewable term." 14 CFR 435.3(b)

6. ***Launch-Specific License*** – "A launch-specific license authorizes a licensee to conduct one or more launches, having the same launch parameters, of one type of LV from one launch site. The license identifies, by name or mission, each launch authorized under the license. A

licensee's authorization to launch terminates upon completion of all launches authorized by the license or the expiration date stated in the license, whichever occurs first." 14 CFR 415.3(a)

7. ***Launch Operator License*** – "A launch operator license authorizes a licensee to conduct launches from one launch site, within a range of launch parameters, of LVs from the same family of vehicles transporting specified classes of payloads. A launch operator license remains in effect for five years from the date of issuance." 14 CFR 415.3(b)

A.3 Components of the Launch Licensing Process

The following are the three major components of the launch licensing process

1. Pre-Application Consultation
2. Application Evaluation
   a. Policy Review and Approval
   b. Safety Review and Approval
   c. Payload Review and Determination
   d. Financial Responsibility Determination
   e. Environmental Review
3. Compliance Monitoring

Pre-application consultation is accomplished prior to the formal submittal of a license application. The launch license application evaluation requires a series of activities, including policy review, safety review, payload review, financial responsibility determination, and environmental review. Compliance monitoring is performed after the license has been issued.

An applicant may submit data related to the policy review, safety review, and payload review together as a single package or separately. An applicant may also request a maximum probability of loss determination separately to determine its financial responsibility requirements early in the process of developing its launch program. Environmental information is required for evaluation if the proposed activity is not adequately addressed in existing FAA documents.

The following bullets provide additional detail of each step in the launch licensing process.

- **Pre-application consultation.** An applicant must consult with the FAA before submitting an application. Pre-application consultation consists of any and all meetings, communications, or draft application submittals that a potential applicant may undertake with the FAA prior to submitting a formal application. Pre-application consultation allows a prospective applicant to familiarize the FAA with its proposal and the FAA to familiarize the prospective applicant with the licensing process. It also provides a potential applicant with an opportunity to identify any unique aspects of its proposal and develop a schedule for submitting an application.

- **Application evaluation.** This portion of the process is comprised of five individual components. The following provides descriptions of each of the five steps in this portion of the launch licensing process.

- *Policy review and approval.* The FAA reviews a license application to determine whether it presents any issues affecting U.S. national security or foreign policy interests, or international obligations of the U.S. A major element of the policy review is the interagency review of the launch proposal. An interagency review allows government agencies to examine the proposed mission from their unique perspectives. The FAA consults with the Department of Defense (DoD), the Department of State, and other Federal agencies, such as the National Aeronautics and Space Administration (NASA), which are authorized to address national security, foreign policy, or international obligation issues.

- *Safety review and approval.* The purpose of the safety review is to determine whether an applicant can safely conduct the proposed activity. Because the licensee is responsible for public safety, it is important that the applicant demonstrate an understanding of the hazards involved and discuss how the operations will be performed safely. There are a number of technical analyses, some quantitative and some qualitative, that the applicant may perform in order to demonstrate that their commercial launch operations will pose no unacceptable threat to the public. The quantitative analyses focus on the reliability and functions of critical safety systems, the hazards associated with the hardware, and the risk those hazards pose to: public property and individuals near the launch site and along the flight path, satellites, and other on-orbit spacecraft. The qualitative analyses focus on the organizational attributes of the applicant, such as launch safety policies and procedures, communications, qualifications of key individuals, and critical internal and external interfaces. For applicants proposing to launch from a Federal launch range who have contracted with the Federal launch range for the provision of safety-related launch services and property, the FAA issues a safety approval if the applicant satisfies the requirements of the regulations and if those launch services and the proposed use of launch property are within the Federal launch range's experience. AST's Launch Site Safety Assessments document general information and capabilities of a Federal launch range, and provide a safety assessment of the Federal launch range to support the FAA's licensing determination.

- *Payload review and determination.* The FAA reviews a payload proposed for launch to determine whether a license applicant or payload owner or operator has obtained all required licenses, authorization, and permits, unless the payload is exempt from review. The FAA does not review payloads that are subject to regulation by the Federal Communications Commission (FCC), Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), or owned or operated by the U.S. government.

  If not otherwise exempt, the FAA reviews a payload proposed for launch to determine whether its launch would jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the U.S. The FAA may review and issue findings regarding a proposed class of payload (e.g., communications, remote sensing, or navigation). However, each payload is subject to compliance monitoring by the FAA before launch.

- *Financial responsibility determination*. Section 70112 of the Commercial Space Launch Act[25] requires that all commercial licensees demonstrate financial responsibility to compensate for the maximum probable loss from claims by a third party for death, bodily injury, or property damage or loss resulting from an activity carried out under the license; and the U.S. government against a person for damage or loss to government property resulting from an activity carried out under the license. Section 70112 also requires that the Department of Transportation (DOT) set the amounts of financial responsibility required of the licensee. The licensee can then elect to meet this requirement by proving they have financial reserves equal to or exceeding the amount specified, or placing the required amount in escrow, or purchasing liability insurance equal to the amount specified. The most common and preferred method is via the purchase of liability insurance.

  The maximum probable loss determination is based on an analysis and assessment of the maximum monetary losses likely to be incurred by government and third party personnel and property in the event of a mishap. It is calculated by assessing the dollar value of government and third party properties at risk by launch accidents likely to occur as the result of the conduct of launch activities.

- *Environmental review*. The environmental evaluation ensures that proposed launch activities pose no unacceptable danger to the natural environment. The FAA is required to consider the environmental effects of commercial space launches authorized under a license because the issuance of a license is considered to be a major Federal action under the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.). An applicant must provide information sufficient to enable the FAA to comply with the requirements of NEPA, the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA, 40 CFR Parts 1500-1508, and the FAA’s Procedures for Considering Environmental Impacts (FAA Order 1050.1E).

▪ **Compliance monitoring.** The purpose of compliance monitoring is to ensure that a licensee complies with the Commercial Space Launch Act, the regulations, and the terms and conditions set forth in its license. A launch licensee shall allow access by, and cooperate with, Federal officers or employees or other individuals authorized by the FAA to observe any activities of the licensee, or of the licensee’s contractors or subcontractors, associated with the conduct of a licensed launch. Specific information to be included in an application for a license is located on the Application Information and Reports and Studies web pages.

A.4 Exemptions

Applicants proposing to launch unguided suborbital launch vehicles, such as for amateur rockets, require a license unless the launch is exempt. To be exempt under the regulations (14 CFR 400.2), a launch must take place from a private site and involve a rocket that meets all three of the following conditions:

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[25] The Commercial Space Launch Act of 1984, as codified at 49 U.S.C. Subtitle IX--Commercial Space Transportation, Ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70119 (1994).

- Has a motor or combination of motors with a total impulse of 200,000 pound-seconds or less;
- Whose motor or combination of motors have a total burning time or operating time of less than 15 seconds; and
- The rocket has a ballistic coefficient (i.e., gross weight in pounds divided by frontal area of rocket vehicle) less than 12 pounds per square inch.

A.5 Additional Resources

Detailed information about statutes, regulations, advisory circulars, and notices pertaining to licensing are available online at http://ast.faa.gov/lrra/stats_notices.htm. Guidelines and other information related to the licensing process are also available online at http://ast.faa.gov/lrra/app_info.htm.

An online list of current licensees including the license number, company name, vehicles licensed, location, original effective date, and expiration date of the license is available at http://ast.faa.gov/lrra/current_licenses.cfm.

APPENDIX A REFERENCES

FAA, Associate Administrator for Commercial Space Transportation, "Licensing Regulations & Regulatory Activity," accessed at http://ast.faa.gov/lrra/ on April 23, 2004.

FAA, Associate Administrator for Commercial Space Transportation, "Licensing Regulations & Regulatory Activity: About the Licensing Process," accessed at http://ast.faa.gov/lrra/about_lrra.htm on April 23, 2004.

APPENDIX B PUBLIC INVOLVEMENT MATERIALS

In order to provide adequate opportunity for public participation in the National Environmental Policy Act (NEPA) process, the Federal Aviation Administration (FAA) has and will continue to conduct public outreach during the preparation of this Programmatic Environmental Impact Statement (PEIS). The FAA adheres to the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 CFR 1506.6) and FAA Order 1050.1E when conducting all public involvement activities. Public participation in the NEPA process not only provides for and encourages open communication between the FAA and the public, but also promotes better decision-making.

B.1 Scoping

Scoping for this PEIS began on August 20, 2003, with the publication of the Notice of Intent (NOI) to prepare the Draft PEIS in the *Federal Register* (68 FR 50210). See Exhibit B-1 for a copy of the NOI as it appeared in the *Federal Register*. During the scoping period, the FAA invited the participation of Federal, state, and local agencies, Native American tribes, environmental groups, organizations, citizens, and other interested parties to assist in determining the scope of the proposed action and significant issues to be evaluated in the PEIS. The FAA provided the public, organizations, and agencies with an opportunity to request a public scoping meeting; however, no interest or request for a public scoping meeting was received by the FAA and no such meeting was sponsored by the FAA.

On October 16, 2003, the FAA published a notice of extension in the *Federal Register* (68 FR 59676), which extended the scoping period from September 26, 2003 to October 31, 2003. See Exhibit B-2 for a copy of this notice. The extension was provided to allow the public sufficient opportunity to explore alternatives and raise issues pertinent to the scope of the PEIS.

The FAA also requested information from members of the commercial space launch industry in order to ensure consideration of all potential launch vehicle concepts. The FAA requested data during the February 2004 AST Annual Forecast Conference and again at the May 2004 Commercial Space Transportation Advisory Committee (COMSTAC) meeting. No information was received by AST at the Conference or as a result of the COMSTAC meeting.

Exhibit B-1. Notice of Intent (68 FR 50210)

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386–5394. The AC will also be available on the Internet at *http://www.airweb.faa.gov/AC.*

Issued in Kansas City, Missouri, on August 5, 2003.

Michael Gallagher,

Manager, Small Airplane Directorate, Aircraft Certification Service.

[FR Doc. 03–21318 Filed 8–19–03; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice Before Waiver With Respect to Land at Raleigh County Memorial Airport, Beckley, WV

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of intent of waiver with respect to land.

SUMMARY: The FAA is publishing notice of proposed release of 218.37 acres of land at the Raleigh County Memorial Airport, Beckley, West Virginia, to the Raleigh County Airport Authority and the Raleigh County Commission for the development of an industrial park. there are no impacts to the Airport and the land is not needed for airport development as shown on the Airport Layout Plan. Fair Market Value of the land will be paid to the Raleigh County Airport and the Raleigh County Commission, and used for Airport purposes.

DATES: Comments must be received on or before September 19, 2003.

ADDRESSES: Comments on this application may be mailed or delivered in triplicate to the FAA at the following address:

Connie Boley-Lilly,
Program Specialist,
Federal Aviation Administration,
Beckley Airports District Office,
176 Airport Circle, Room 101,
Beaver, West Virginia 25813.

In addition, one copy of any comments submitted to the FAA must be mailed or delivered to Thomas Cochran, Airport Manager, Raleigh County Memorial Airport at the following address:

Thomas Cochran, Airport Manager,
Raleigh County Memorial Airport,
176 Airport Circle, Room 105,
Beaver, West Virginia 25813.

FOR FURTHER INFORMATION CONTACT: Connie Boley-Lilly, Program Specialist, Beckley Airport District Office, (304) 252–6216 ext. 125, FAX (304) 253–8028.

SUPPLEMENTARY INFORMATION:

On April 5, 2000, new authorizing legislation became effective. That bill, the Wendell H. Ford Aviation investment and Reform Act for the 21st Century, Public Law 10–181 (April 5, 2000; 114 Stat. 61) (AIR 21) requires that a 30 day public notice must be provided before the Secretary may waive any condition imposed on an interest in surplus property.

Issued in Beckley, West Virginia, on August 6, 2003.

Larry F. Clark,

Manager, Beckley Airport District Office, Eastern Region.

[FR Doc. 03–21327 Filed 8–19–03; 8:45 am]

BILLING CODE 4910–13–M

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Premium War Risk Insurance

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of extension of aviation insurance.

SUMMARY: This notice contains the text of a memo from the Secretary of Transportation to the President regarding the extension of the provision of aviation insurance coverage for U.S. flag commercial air carrier service in domestic and international operations.

DATES: Dates of extension from August 12, 2003 through October 11, 2003.

FOR FURTHER INFORMATION CONTACT: Helen Kish, Program Analyst, APO–3, or Eric Nelson, Program Analyst, APO–3, Federal Aviation Administration, 800 Independence Ave., SW., Washington, DC 20591, telephone (202) 267–9943 or (202) 267–3090. Or online at FAA Insurance Web site: *http://insurance.faa.gov.*

SUPPLEMENTARY INFORMATION: On August 11, 2003, the Secretary of Transportation authorized a 60-day extension of aviation insurance provided by the Federal Aviation Administration as follows:

Memorandum to the President

"Pursuant to the authority delegated to me by the President in paragraph (3) of Presidential Determination No. 01–29 of September 23, 2001, and the direction of Section 1202 of the Homeland Security Act of 2002, I hereby extend that determination to allow for the provision of aviation insurance and reinsurance coverage for U.S. Flag commercial air carrier service in domestic and international operations for an additional 60 days.

Pursuant to section 44306(b) of Chapter 443 of 49 U.S.C., Aviation Insurance, the period for provision of insurance shall be extended from August 13, 2003, through October 11, 2003."

/s/ Norman Y. Mineta

Affected Public: Air Carriers who currently have Premium War-Risk Insurance with the Federal Aviation Administration.

Issued in Washington, DC on August 14, 2003.

John M. Rodgers,

Director, Office of Aviation Policy and Plans.

[FR Doc. 03–21326 Filed 8–19–03; 8:45 am]

BILLING CODE 4910–13–M

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice of Intent and Request for Comment

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Notice of Intent (NOI) to prepare a Programmatic Environmental Impact Statement for licensing launches of horizontally launched vehicles and reentries of reentry vehicles.

SUMMARY: The FAA is publishing this notice to announce its intent to prepare a Programmatic Environmental Impact Statement (PEIS) in accordance with the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality implementing regulations. This NOI also serves as an official request for comments in preparation of the PEIS. This PEIS will assess environmental impacts associated with the proposed action, reasonable alternatives including those identified during scoping, the no action alternative, and cumulative impacts. This PEIS will support decisions made to meet the FAA's responsibility to license commercial launches and reentries and launch and reentry site operations consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. Issuing a launch or reentry license is considered a Federal action and is therefore subject to NEPA review.

Proposed Action and Possible Alternatives: The proposed action for this PEIS is to license the launch and landing of horizontally launched vehicles and the reentry of reentry vehicles. Reentry vehicles are defined as vehicles designed to return from Earth orbit or outer space to Earth; or reusable launch vehicles designed to return substantially intact from Earth orbit or outer space to Earth. A launch is defined as to place or try to place a launch vehicle or reentry vehicle and any payload from Earth (A) in a suborbital trajectory; (B) in Earth orbit in outer space; or (C) otherwise in outer space, including activities involved in the preparation of a launch vehicle or payload for launch.

Alternatives to the proposed action may include activities such as not licensing horizontal launches, not licensing vertical reentries, not licensing horizontal reentries, not licensing powered reentries, and not licensing unpowered reentries.

FAA exercises licensing authority in accordance with the Commercial Space Launch Act and Commercial Space Transportation Licensing Regulations, 14 CFR Ch.III, which authorize the FAA to license the launch of a launch vehicle when conducted within the U.S. and those operated by U.S. citizens abroad. The scope of the PEIS would include launches on both orbital and suborbital trajectories.

In May 1992, the U.S. Department of Transportation issued the *Final Programmatic Environmental Impact Statement for Commercial Reentry Vehicles* that assessed the environmental impacts of licensing the unpowered reentry of reentry vehicles from space to Earth. This 1992 PEIS relied in part on the analysis in the *Programmatic Environmental Assessment of Commercial Expendable Launch Vehicle Programs,* February 1986.

In May 2001, the FAA issued the *Programmatic Environmental Impact Statement for Licensing Launches,* which assessed the environmental impacts of licensing commercial launches. This 2001 PEIS updated and replaced the 1986 Programmatic Environmental Assessment (EA).

The PEIS for Licensing Launches of Horizontally Launched Vehicles and Reentries of Reentry Vehicles will update and replace the 1992 PEIS and address the launch of horizontally launched vehicles and the reentry of all reentry vehicles.

Scoping: Public scoping will be conducted as part of the PEIS development process to ensure that all interested government and private organizations, and the general public have an opportunity to express their concerns and identify topics that should be addressed in the PEIS. The FAA has developed a public participation Web site (*http://ast.faa.gov/*) which provides information on the development of this PEIS and provides the public an opportunity to submit comments electronically. Materials on the Web site include information about licensing and the NEPA process; frequently asked questions, a fact sheet on the PEIS; a comparison of the analysis of the previous programmatic documents; and public comment forms. Scoping meetings may be requested by organizations or individuals that feel their concerns cannot be met through the online opportunity to comment. Information regarding the development of the PEIS is available on the public participation Web site at *http://ast.faa.gov/*, under the "What's new on the AST Web site—Announcements" section.

To Submit Comments: Written comments, statements, and/or questions regarding scoping issues or the PEIS process should be addressed to Ms. Michon Washington, FAA Environmental Specialist, FAA PEIS, c/o ICF Consulting, 9300 Lee Highway, Fairfax, Virginia 22031; phone (703) 934–3950; fax (703) 934–3951; e-mail at *FAA.PEIS@icfconsulting.com;* or by Web site *http://ast.faa.gov/.*

Comments should clearly identify and describe the specific issue(s) or topics to be included in the PEIS. To ensure sufficient time to consider issues identified during public scoping, comments should be submitted no later than September 26, 2003.

Issued in: Washington DC.

Responsible Official:

Herbert Bachner,

Manager, Space Systems Development Division.

[FR Doc. 03–21319 Filed 8–19–03; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Maritime Administration

[Docket No. MARAD 2003 15934]

Information Collection Available for Public Comments and Recommendations

ACTION: Notice and request for comments.

SUMMARY: In accordance with the Paperwork Reduction Act of 1995, this notice announces the Maritime Administration's (MARAD's) intentions to request extension of approval for three years of a currently approved information collection.

DATES: Comments should be submitted on or before October 20, 2003.

FOR FURTHER INFORMATION CONTACT: Thomas M.P. Christensen, Office of National Security Plans, Maritime Administration, 400 Seventh St., SW., Washington, DC 20590. Telephone: 202–366–5900; FAX 202–488–0941 or e-mail: *tom.christensen@marad.dot.gov.*

Copies of this collection can also be obtained from that office.

SUPPLEMENTARY INFORMATION:

Title of Collection: Voluntary Tanker Agreement.

Type of Request: Extension of currently approved information collection.

OMB Control Number: 2133–0505.

Form Numbers: None.

Expiration Date of Approval: Three years after date of approval by the Office of Management and Budget.

Summary of Collection of Information: The collection consists of a request from the Maritime Administration (MARAD) that each participant in the Voluntary Tanker Agreement submit a list of the names of ships owned, chartered or contracted for by the participant, and their size and flags of registry. There is no prescribed format for this information.

Need and Use of the Information: The collected information is necessary to evaluate tanker capability and make plans for the use of this capability to meet national emergency requirements. This information will be used by both MARAD and Department of Defense to establish overall contingency plans.

Description of Respondents: Tanker companies that operate in international trade and who have agreed to participate in this agreement.

Annual Responses: 15.

Annual Burden: One hour per response.

Comments: Comments should refer to the docket number that appears at the top of this document. Written comments may be submitted to the Docket Clerk, U.S. DOT Dockets, Room PL–401, 400 Seventh Street, SW., Washington, DC 20590. Comments may also be submitted by electronic means via the Internet at *http://dmses.dot.gov/submit.* Specifically address whether this information collection is necessary for proper performance of the functions of the agency and will have practical utility, accuracy of the burden estimates, ways to minimize this burden, and ways to enhance the quality, utility, and clarity of the information to be collected. All comments received will be available for examination at the above address between 10 a.m. and 5 p.m. EDT, Monday through Friday, except Federal Holidays. An electronic version of this document is available on the World Wide Web at *http://dms.dot.gov.*

By Order of the Maritime Administrator,

Exhibit B-2. Notice of Extension of the Scoping Period (68 FR 59676)

59676 **Federal Register** / Vol. 68, No. 200 / Thursday, October 16, 2003 / Notices

Issued in Washington, DC on October 8, 2003.

Michael A. Robinson,

Information Technology Program Management, United States Department of Transportation.

[FR Doc. 03–26127 Filed 10–15–03; 8:45 am]

BILLING CODE 4910–62–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice of Extension of Scoping

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Notice of extension of scoping for the Programmatic Environmental Impact Statement for Licensing Launches of Horizontally Launched Vehicles and Reentries of Reentry Vehicles.

SUMMARY: The FAA is preparing a Programmatic Environmental Impact Statement (PEIS) in accordance with the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality implementing regulations and is requesting comments in preparation of the PEIS. The FAA has extended public scoping for the PEIS to ensure that all interested government and private organizations, and the general public have an opportunity to express their concerns and identify topics that should be addressed in the PEIS. Scoping comments will be accepted until October 31, 2003. This PEIS will assess environmental impacts associated with the proposed action, reasonable alternatives including those identified during scoping, the no action alternative, and cumulative impacts. This PEIS will support decisions made to meet the FAA's responsibility to license commercial launch and reentry operations and the operation of launch and reentry sites consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. Issuing a launch or reentry license is a Federal action and is therefore subject to NEPA review.

Proposed Action and Possible Alternatives: The proposed action for this PEIS is to license the launch and landing of horizontally launched vehicles and the reentry of reentry vehicles. A reentry vehicle is defined in 14 CFR 401.5 as "a vehicle designed to return from Earth orbit or outer space to Earth substantially intact. A reusable launch vehicle (RLV) that is designed to return from Earth orbit or outer space to Earth substantially intact is a reentry vehicle." Launch, as defined in 14 CFR 401.5, means "to place or try to place a launch vehicle or reentry vehicle and any payload from Earth in a suborbital trajectory, in Earth orbit in outer space, or otherwise in outer space, and includes activities involved in the preparation of a launch vehicle for flight, when those activities take place at a launch site in the United States. The term launch includes the flight of a launch vehicle and pre-flight ground operations beginning with the arrival of a launch vehicle or payload at a U.S. launch site. For purposes of an expendable launch vehicle launch, flight ends after the licensee's last exercise of control over its launch vehicle. For purposes of an orbital RLV launch, flight ends after deployment of a payload for an RLV having payload deployment as a mission objective. For other orbital RLVs, flight ends upon completion of the first sustained, steady-state orbit of an RLV at its intended location."

Alternatives to the proposed action may include activities such as not licensing horizontal launches, not licensing vertical reentries, not licensing horizontal reentries, not licensing powered reentries, and not licensing unpowered reentries.

FAA exercises licensing authority in accordance with the Commercial Space Launch Act and Commercial Space Transportation Licensing Regulations, 14 CFR Ch.III, which authorize the FAA to license the launch of a launch vehicle when conducted within the U.S. and those operated by U.S. citizens abroad. The scope of the PEIS would include launches on both orbital and suborbital trajectories.

In May 1992, the U.S. Department of Transportation issued the Final Programmatic Environmental Impact Statement for Commercial Reentry Vehicles that assessed the environmental impacts of licensing the unpowered reentry of reentry vehicles from space to Earth. This 1992 PEIS relied in part on the analysis in the Programmatic Environmental Assessment of Commercial Expendable Launch Vehicle Programs, February 1986.

In May 2001, the FAA issued the Programmatic Environmental Impact Statement for Licensing Launches, which assessed the environmental impacts of licensing commercial launches. This 2001 PEIS updated and replaced the 1986 Programmatic Environmental Assessment (EA).

The PEIS for Licensing Launches of Horizontally Launched Vehicles and Reentries of Reentry Vehicles will update and replace the 1992 PEIS and address the launch of horizontally launched vehicles and the reentry of all reentry vehicles.

Scoping: Public scoping will be conducted as part of the PEIS development process to ensure that all interested government and private organizations, and the general public have an opportunity to express their concerns and identify topics that should be addressed in the PEIS. The FAA has developed a public participation Web site (*http://ast.faa.gov/*), which provides information on the development of this PEIS and provides the public an opportunity to submit comments electronically. Materials on the web site include information about licensing and the NEPA process; frequently asked questions, a fact sheet on the PEIS; a comparison of the analysis of the previous programmatic documents; and public comment forms. Scoping meetings may be requested by organizations or individuals that feel their concerns cannot be met through the online opportunity to comment. Information regarding the development of the PEIS is available on the public participation web site at *http://ast.faa.gov/*, under the "What's new on the AST Web site "Announcements" section.

To Submit Comments: Written comments, statements, and/or questions regarding scoping issues or the PEIS process should be addressed to Ms. Michon Washington, FAA Environmental Specialist, FAA PEIS, c/o ICF Consulting, 9300 Lee Highway, Fairfax, Virginia 22031; phone (703) 934–3950; fax (703) 934–3951; e-mail at *FAA.PEIS@icfconsulting.com*; or by Web site *http://ast.faa.gov/*. Comments should clearly identify and describe the specific issue(s) or topics to be included in the PEIS. To ensure sufficient time to consider issues identified during public scoping, comments should be submitted no later than October 31, 2003.

Charles Larsen,

(Acting) Manager, Space Systems Development Division.

[FR Doc. 03–26090 Filed 10–15–03; 8:45 am]

BILLING CODE 4910–13–P

B.2 Information Available to the Public

The FAA developed a web site to provide information on the PEIS and to solicit public comments. The web site contains information about FAA licensing, the NEPA process, the PEIS, launch and reentry, and public involvement. The web site also provides links to all available documents, so that members of the public can easily download each of these documents.

- The NOI (see Exhibit B-1)
- Notice of Availability of Draft PEIS
- Draft PEIS

A PEIS fact sheet and a pdf version of the frequently asked questions were available on the web site during public scoping, but are no longer posted on the web site.

As they become available, additional documents will be posted on the web site, as indicated by the placeholders in the Information Resources page of the site. The documents that will be posted later in the NEPA process include

- Notice of Availability of Final PEIS,
- Final PEIS, and
- Record of Decision.

The Information Resources portion of the web site also provides links to relevant web sites such as the FAA public web site, the EPA's NEPA compliance site, and the CEQ's web site.

B.3 Scoping Comments Received

The FAA required that all scoping comments be received no later than October 31, 2003. Even though the FAA requested comments from the commercial space industry, no comments were received. Comments were solicited at the February 2004 AST Annual Forecast Conference, and the May 2004 COMSTAC[26] meeting. No comments were received as a result of this, but additions were made to the distribution list. See Appendix G for the full distribution list for this PEIS. The FAA reviewed and analyzed comments to help determine the scope and the significant issues to be analyzed in depth in the Draft PEIS. During scoping, the FAA received a total of 13 comments. See Exhibit B-3 for a summary of those comments received.

[26] COMSTAC was established in 1984 to provide information, advice, and recommendations to the Administrator of the FAA on matters related to the U.S. commercial space transportation industry. Members include executives from the U.S. commercial space transportation industry, large aerospace companies, and the satellite industry; space-related state government officials; academia; and representatives from space advocacy organizations.

Exhibit B-3. List of Comments Received

Commenter Name	Commenter Organization	Comment Number
Shari Silbert	NASA, Wallops Flight Facility	P001
Darrell Echols	Padre Island National Seashore, National Parks Service	E001
Lou Gomez	New Mexico Office of Space Commercialization	E002
John Bossard	Private Citizen	E003
Randall Clague	XCOR Aerospace	E004
Angeline Chen	Lockheed Martin Commercial	W001
Greg Mullen	Private Citizen	W002
Hossam Ashour	Private Citizen	W003
Kevin Doyle	Private Citizen	W004
Mark Belles	Private Citizen	W005
Richard D. Baldwin	Virginia Space Flight Center	W006
Robert F. Jones	Sea Launch Range Safety	W007
Yaroslay Pustovyi	National Space Agency of Ukraine	W008

The majority of commenters (9) simply requested a copy of the Draft PEIS when it was completed. These commenters were added to the distribution list (see Appendix G) and the FAA mailed a copy of the Draft PEIS to them when it was released to the public. The other four comments were reviewed by the FAA and where appropriate were used in determining the scope and the significant issues to be analyzed in depth in the Draft PEIS.

B.4 Comments on Draft PEIS

The FAA received two formal comment documents on the Draft PEIS. One comment document consisted of a letter from the Environmental Protection Agency (EPA) indicating a lack of objection to the proposed action. A copy of this letter is included as Exhibit B-4. The second comment document was provided by XCOR Aerospace. The FAA offers the following responses to XCOR Aerospace's comments.

XCOR Aerospace Comment 1: "First the definition of "reentry" is drawn from existing FAA regulation, in that "reentry" is considered a voluntary act following a deorbit maneuver. Under this definition, suborbital vehicles, which never reach a stable orbit, are considered not to reenter. While this use is consistent with the language in FAA regulations, it is quite different from standard technical usage. From the standpoint of physics and environmental impact, suborbital vehicles do briefly leave the atmosphere, and hence do reenter. Some additional discussion on this matter would clarify the PEIS."

> ***FAA Response:*** The FAA appreciates the importance of "standard technical usage" when communicating with applicants; however, as the commenter correctly states, the wording in the PEIS is consistent with the FAA's regulations. To further clarify the

distinction between "reentry," defined by the FAA regulations to occur when vehicles are launched along orbital trajectories, and "landing" as they pertain to potential environmental impacts, the FAA has added wording to the PEIS. This wording focuses on impacts associated with landing as a part of the reentry process.

XCOR Aerospace Comment 2: "Second, on page 3-29, in the discussion of sonic boom, the PEIS correctly states that sonic boom overpressure is measured in pounds per square foot (psf) – and then incorrectly says that they may also be measured in "kilograms per square meter". As overpressure is measured in units of pressure, the proper metric unit is the Newton per square meter, or the Pascal, not the kilogram per square meter."

FAA Response: The reference on page 3-29 has been changed to "Newtons per square meter."

XCOR Aerospace Comment 3: "Third, there is an error regarding the emissions from hybrid-propellant rockets which appears throughout the discussion of environmental impact, beginning with Exhibit 4-1 on page 4-3. Hybrid rockets generate substantial particulate matter (PM), in the form of soot. A glance at the plumes generated by ground tests or flights of the nitrous oxide/HTPB hybrids used by SpaceShipOne in 2004 shows the presence of substantial particulate matter in the exhaust. This error propagates throughout later sections such as Table 4-5, Vehicle Type D. However, it has no effect on the overall conclusion because vehicles with solid rockets, which generate higher PM, have already been considered and found to have negligible impact."

FAA Response: The FAA has performed a literature search and was unable to locate emission factors for particulate matter for these types of engines. However, several articles reviewed noted that particulate matter was produced during the firing of these types of engines. Therefore, language similar to the following has been added where noted by the commenter and throughout the PEIS, where appropriate "The available emissions factors do not include PM emissions from the N_2O/HTPB rocket engines assumed to be used by these vehicles. N_2O/HTPB engines are expected to generate particulate matter emissions (Wright, et al, 2005; Chouinard, et al, 2002); however, analyses of other vehicle types with higher PM emissions than would be expected from vehicles using these engine types indicate these emissions have no significant impact; thus, any PM emissions from vehicles using these engines would be expected to have negligible impacts."

XCOR Aerospace Comment 4: "Fourth the same error applies to the discussion of ejecta on page 4-33 et. seq – hybrid motors will generate solid particle ejecta. However, as with solids, the resulting impact is negligible, so the conclusion of the PEIS remains valid."

FAA Response: The text of the PEIS appears to address the commenter's concern. The existing text states that "Under the proposed action, particulates would be emitted into the space environment when rocket motors powered by solid or solid/liquid (hybrid) propellants are fired."

Exhibit B-4. EPA Comments on Draft PEIS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

Mr. Doug Graham
FAA Environmental Specialist
FAA PEIS
c/o ICF Consulting
9300 Lee Highway
Fairfax, VA 22031

SEP 12 2005

Dear Mr. Graham:

In accordance with our responsibilities under Section 309 of the Clean Air Act and the National Environmental Policy Act, the Environmental Protection Agency (EPA) has reviewed the Federal Aviation Administration, Office of Commercial Space Transportation's draft programmatic Environmental Impact Statement (EIS) for Horizontal Launch and Reentry of Reentry Vehicles.

This programmatic EIS assesses the potential environmental effects of licensing horizontal launches of launch vehicles and reentries of reentry vehicles, as well as the licensing of facilities that support these activities. All site-specific impacts would be assessed in environmental documents tiered to this programmatic document and other programmatic analyses as appropriate.

EPA believes the EIS is helpful in surveying the scope of potential environmental and cumulative atmospheric impacts from U.S. commercial horizontal launch and reentry activity. On the basis of our review, we have assigned a rating of LO (Lack of Objections) to the proposed action.

We appreciate the opportunity to review this programmatic EIS. The staff contact for this review is Ken Mittelholtz (202-564-7156).

Sincerely,

for Anne Norton Miller
Director
Office of Federal Activities

Internet Address (URL) • http://www.epa.gov
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APPENDIX C APPLICABLE LEGAL REQUIREMENTS

This appendix provides an overview of the applicable legal requirements, which includes the following: Federal statutes enacted by Congress; corresponding regulations promulgated by the Federal agency charged with implementing the statute; Executive Orders (EOs) signed by the President of the United States (U.S.) and directed to Federal agencies; internal orders, directives,[27] and policies implemented by the Federal agencies; and international treaties and conventions to which the U.S. is a party. This overview is not exhaustive, as it does not include all possibly relevant legal requirements. Therefore, site-specific environmental documentation may require a more thorough investigation into the specific Federal and international legal requirements. Likewise, local and State laws and regulations are excluded and should be addressed in site-specific environmental documentation. With the exception of requirements that apply generally to the Federal Aviation Administration (FAA) or to this Programmatic Environmental Impact Statement (PEIS), the legal requirements in this appendix are organized by resource area.

Although only summarized briefly in this appendix, FAA Order 1050.1E should be referenced when completing a site-specific National Environmental Policy Act (NEPA) document that tiers from this PEIS. FAA Order 1050.1E provides FAA policy and procedures to ensure agency compliance with the requirements set forth in the Council on Environmental Quality (CEQ) regulations for implementing the provisions of NEPA, 40 Code of Federal Regulations (CFR) parts 1500-1508; Department of Transportation (DOT) Order 5610.1C, Procedures for Considering Environmental Impacts; and other related statutes and directives.

C.1 Generally Applicable Requirements

NEPA, as amended (42 United States Code [U.S.C.] 4321), requires Federal agencies, early in the agency's planning process, to assess the potential environmental impacts of implementing major Federal actions so that this information can be used in the decision-making process. The Act requires analysis of effects from the full range of project alternatives, along with public comment and review. NEPA specifies several levels of environmental review, ranging from a Categorical Exclusion for actions with no potentially significant impact, to an Environmental Impact Statement (EIS) for major, unprecedented, or controversial actions having potentially significant environmental impacts. NEPA is implemented through CEQ regulations at 40 CFR Parts 1500-1508.

Regulations developed by CEQ (40 CFR Part 1500) define the procedures for completing the environmental review and analysis called for in NEPA. The regulations outline the principles to be followed in the environmental impact analysis process, including incorporating environmental review early in project planning, preparing an action-forcing environmental document to assist in project decisions rather than one that documents decisions previously made, and ensuring public involvement throughout the process. The regulations also include guidelines for determining what level of environmental review is required; the contents of environmental documents; procedures for comments by the public and Federal agencies; and schedules. The regulations

[27] For example, FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures*.

specify that notices will be published in the Federal Register prior to preparation of an EIS, and require all EISs to be filed with the Environmental Protection Agency's (EPA's) Office of Federal Activities upon completion.

FAA Order 1050.1E provides a description of NEPA as it relates to FAA activities. Each chapter describes a different aspect of the NEPA process. Chapter 2 of FAA Order 1050.1E provides details about NEPA planning and integration with the FAA and will help an applicant determine the following.

- Whether an action is advisory (not subject to NEPA procedures), categorically excluded, or whether it requires an Environmental Assessment (EA) or an EIS.
- Whether the FAA is the lead Federal agency for the NEPA process.
- Which FAA office is responsible for NEPA compliance, including preparing environmental analyses and documents, ensuring public involvement, and completing interagency and intergovernmental coordination and consultation.

Chapter 3 of FAA Order 1050.1E describes categorical exclusions, as well as advisory and emergency actions. Chapter 4 summarizes and supplements CEQ requirements for EAs and Findings of No Significant Impact (FONSIs). Chapter 5 summarizes and supplements CEQ requirements for EISs and Records of Decision (RODs).

EO 13148, Greening the Government Through Leadership in Environmental Management (65 FR 24595, 2000), requires Federal agencies to "develop a plan to phase out the procurement of Class I ozone depleting substances for all nonexcepted uses by December 31, 2010." Plans should target the cost-effective reduction of environmental risk by phasing out Class I ozone depleting substance applications as the equipment using those substances reaches its expected service life.

International Framework

Some activities that fall under the licensing authority of the FAA may occur outside the continental U.S., its territories, and possessions. Because NEPA and other environmental laws do not generally apply to such areas, EOs have been implemented. Because the NEPA does not apply to overseas actions, EO 12114, Environmental Effects Abroad of Major Federal Actions (44 FR 1957 [1979]), represents the U.S. exclusive and complete requirement for taking into account considerations with respect to actions that do significant harm to the environment of places outside the U.S.

EO 12114 provides for the consideration of potential environmental effects from Federal actions on the global commons outside of the jurisdiction of any nation or on natural resources of global importance designated for protection by the President or by international agreement.
The EO's purpose is to

> "enable responsible officials of Federal Agencies having ultimate responsibility for authorizing and approving actions encompassed by this Order to be informed of pertinent considerations and to take such considerations into account with other

> pertinent considerations of national policy, in making decisions regarding such actions. While based on independent authority, this Order furthers the purpose of the [NEPA] …and represents the United States Government's exclusive and complete determination of the procedural and other actions to be taken by Federal agencies to further the purpose of the [NEPA], with respect to the environment outside the United States, its territories and possessions."

The categories of actions included in and covered by this EO include: (a) major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the oceans or Antarctica); (b) major Federal actions significantly affecting the environment of a foreign nation not participating with the U.S. and not otherwise involved in the action; and (c) major Federal actions significantly affecting the environment of a foreign nation which provide to that nation a product or physical project "which is strictly regulated by Federal law in the United States."

The EO states that NEPA compliance may be required, including the consideration of potential environmental impacts, for actions that have the potential to significantly impact foreign countries and/or the global commons. In the case where an action occurs on foreign soil and the foreign government requires an EA or EIS as part of its own government's regulations, Federal agencies may reserve the right to accept the environmental documentation required by the foreign government.

The foreign government may have entered into internationally binding Treaties or Agreements, which must be addressed in the environmental documentation even if the U.S. is not a party to the treaty. Additional environmental requirements may be placed upon a U.S. company doing business abroad by the World Bank, The United Nations (to potentially include organizations sanctioned by the United Nations), and any local or regional regulatory body recognized by the foreign government.

C.2 Atmosphere

United States. Under 49 U.S.C., Subtitle IX, Chapter 701, Commercial Space Launch Activities, the FAA regulates the commercial space activities performed by U.S. citizens and corporations. Portions of the troposphere are regulated under the Clean Air Act (CAA), which is described in more detail in the "Air Quality" section below. Some air traffic is controlled by the Federal Aviation Regulations, which are presented in the "Airspace" section below.

International. The following three international treaties and conventions are relevant to operations and activities in the various layers of the atmosphere and exosphere.

- Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967
- Convention on International Liability for Damage Caused by Space Objects, 1972
- Convention on Registration of Objects Launched into Outer Space, 1976

C.3 Air Quality

United States. The CAA (42 U.S.C. 7401) requires the adoption of primary and secondary National Ambient Air Quality Standards (NAAQS) to protect the public health, safety, and welfare from known or anticipated effects of the identified criteria air pollutants. The primary standards were established to protect public health with an adequate margin of safety, while the secondary standards were intended to protect the public welfare from any known or anticipated adverse effects of a pollutant (e.g., plant life, cultural monuments, and wildlife). These threshold levels were determined based on years of research on the health effects of various concentrations of pollutants on biological organisms. Exhibit C-1 summarizes the primary and secondary NAAQS.

Exhibit C-1. National Ambient Air Quality Standards

		National Standards[a]	
Pollutant	**Averaging Time**	**Concentration Primary**[b,c]	**Concentration Secondary**[b,d]
Ozone	1 hour	0.12 ppm[e] (235 μg/m^3)[f]	Same as primary
	8 hour[g]	0.08 ppm (157 μg/m^3)	Same as primary
Carbon monoxide	8 hour	9.0 ppm (10 mg/m^3)	---
	1 hour	35 ppm (40 mg/m^3)	---
Nitrogen dioxide	Annual arithmetic mean	0.053 ppm (100 μg/m^3)	Same as primary
Sulfur dioxide	1 hour	---	---
	3 hours	---	0.5 ppm (1,300 μg/m^3)
	24 hour	0.14 ppm (365μg/m^3)	---
	Annual arithmetic mean	0.03 ppm (80 μg/m^3)	---
Particulate matter as PM_{10}	24 hour	150 μ/m^3	Same as primary
	Annual (arithmetic mean)	50 μg/m^3	Same as primary
Particulate matter as $PM_{2.5}$	24 hour	65 μg/m^3	Same as primary
	Annual arithmetic	15 μg/m^3	Same as primary
Lead	Quarterly average	1.5 μg/m^3	Same as primary
	30-day average	---	---

Source: EPA, 2003f

[a] These standards, other than for ozone, particulate matter, and those based on annual averages, must not be exceeded more than once per year. The eight-hour ozone standard is attained when the fourth highest eight-hour concentration in a year, averaged over three years, is equal to or less than the standard. For PM_{10}, the 24-hour standard is attained when the expected number of days per calendar year with a 24-hour average concentration above the standard is equal to or less than one. For $PM_{2.5}$, the 24-hour standard is attained when 98 percent of the daily concentrations, averaged over three years, are equal to or less than the standard.
[b] Concentration is expressed first in units in which it was adopted and is based on a reference temperature of 25°Celsius (°C) (77 °Fahrenheit [°F]) and a reference pressure of 760 millimeters (1,013.2 millibars) of mercury. All measurements of air quality must be corrected to a reference temperature of 25°C (77 °F) and a reference pressure of 760 millimeters (1,013.2 millibars) of mercury. Parts per million (ppm) in this exhibit refers to parts per million by volume or micromoles of pollutant per mole of gas.
[c] National primary standards are the levels of air quality necessary, with an adequate margin of safety, to protect the public health.
[d] National secondary standards are the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant
[e] Parts per million (ppm) by volume or micromoles per mole of gas
[f] Micrograms per cubic meter (μg/m^3)
[g] The eight-hour ozone standard was issued in 1997 to replace the one-hour standard due to significant evidence that longer-term exposure to lower levels of ozone can affect human health. Implementation of the new standard was held up by legal disputes; however, on April 15, 2004, EPA established new attainment classifications and designated attainment/nonattainment areas based on the eight-hour standard. The new designations and classifications take effect on June 15, 2004.

The CAA gives state and local authorities the responsibility to ensure regional attainment of NAAQS. To further define local and regional air quality, the EPA provides designations indicating the air quality of a given area. These classifications generally are based on air quality monitoring data collected at certain sites in the state. Those areas with air quality better than the NAAQS are designated as attainment areas, and those areas with air quality worse than the NAAQS are non-attainment areas. The criteria for non-attainment designations vary by pollutant. An area is in non-attainment for ozone if it has violated or has contributed to a violation of the recently implemented 8-hour ozone standard over a three-year period at a single monitoring station. An area is in non-attainment for any other pollutant if its NAAQS has been exceeded more than once per year. Some areas are designated as unclassified because insufficient data exist to characterize the area. Other areas are deemed maintenance areas if the area is in attainment but NAAQS were exceeded in the past.[28]

The CAA requires the preparation of a State Implementation Plan (SIP) that describes how the state will meet or attain the NAAQS. The SIP contains emission limitations as well as record keeping and reporting requirements for affected sources. As a result of the CAA Amendments, the requirements and compliance dates for reaching attainment are based on the severity of the air quality standard violation. A Federal agency cannot support an action (e.g., fund, license) unless the activity will conform to the EPA-approved SIP for the region. This is called a conformity determination or conformity analysis. A conformity determination may involve performing air quality modeling and implementing measures to mitigate the air quality impacts. The U.S. Federal government is exempt from the requirement to perform a conformity analysis if the following two conditions are met.

1. The ongoing activities do not produce emissions above the *de minimis* levels specified in the rule. Exhibit C-2 shows the *de minimis* threshold levels of various non-attainment areas.

2. The Federal action is not considered a regionally significant action. A Federal action is considered regionally significant when the total emissions from the action equal or exceed 10 percent of the air quality control area's emissions inventory for any criteria pollutant.

[28] Additionally, a maintenance area must have a revised State Implementation Plan (SIP) that has provided for attainment status for the 10 years after the area is redesignated from non-attainment to maintenance.

Exhibit C-2. *De Minimis* Thresholds in Non-Attainment Areas

Pollutant	Degree of Non-Attainment	*De minimis* Level (metric tons/year [tons/year])
Ozone (VOCs and NO_X)	Serious	45 (50)
	Severe	23 (25)
	Extreme	9 (10)
	Marginal/Moderate (outside ozone transport region)	45 (50 VOC)
	Marginal/Moderate (inside ozone transport region)	91 (100 NO_X)
CO	All	91 (100)
PM	Moderate	91 (100)
	Serious	64 (70)
SO_2 or NO_2	All	91 (100)
Pb	All	23 (25)

Source: 40 CFR 93.153(b)

The EPA considers emissions at or below 914 meters (3,000 feet) to evaluate ambient air quality and calculate *de minimis* levels. Air quality modeling is used to determine the effects of air emission sources on the ambient air concentrations. The types and amounts of pollutants, the topography of the air basin, and the prevailing meteorological parameters that most often affect pollutant dispersions are wind speed, wind direction, atmospheric stability, mixing height, and temperature.

The General Conformity Rule (40 CFR parts 51 and 93) implements the CAA conformity provision, which mandates that the Federal government not engage, support, or provide financial assistance for licensing or permitting; or approve any activity not conforming to an approved CAA implementation plan. A conformity analysis may be required if a facility is located in a non-attainment area for a particular pollutant and if new emission sources generate the same pollutant above a certain number of tons per year.

International. Since its adoption in 1979, the Convention on Long Range Transboundary Air Pollution has addressed some of the major environmental problems of the United Nations Economic Commission for Europe through a process of international scientific collaboration and policy negotiation. The Convention aims to protect human health and the environment against air pollution and to limit, gradually reduce, and prevent air pollution, including long-range transboundary air pollution. The objectives of the Convention Protocols are to reverse freshwater and soil acidification, forest dieback, eutrophication, exposure to excess ozone, degradation of cultural monuments and historic buildings, and accumulation of heavy metals and persistent organic pollutants in the soil, water, vegetation, and other living organisms.

The 1985 Convention for the Protection of the Ozone Layer (Vienna Convention) aims to protect human health and the environment against adverse effects resulting from modifications of the ozone layer, especially from increased ultraviolet solar radiation. It requires that states reduce their reliance on ozone depleting substances and conduct collaborative research to find alternatives to harmful substances such as chlorofluorocarbons (CFCs) and halons. The Montreal Protocol on Substances that Deplete the Ozone Layer was developed under the guidance of the United Nations Environmental Program in September 1987 and based on the recommendations of the Vienna Convention. The Montreal Protocol identifies the main ozone depleting substances and specifies a timetable for phasing out the consumption and production of ozone depleting substances. Title VI of the CAA Amendments of 1990 establishes phase out requirements for ozone depleting substances consistent with the Montreal Protocol.

The United Nations Framework Convention on Climate Change, an international agreement for addressing climate change, was adopted at the United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro, Brazil in 1992. The framework aims to regulate levels of greenhouse gas concentrations in the atmosphere.

C.4 Airspace

United States. Airspace management and use in the U.S. are governed by the Federal Aviation Act of 1958 (Public Law 85-725) and its implementing regulations set forth by the FAA. FAA Order 7490, "Policies and Procedures for Air Traffic Environmental Actions," includes procedures and guidance for special use airspace environmental issues between FAA and DoD. FAA Order 7610.4H, "Special Military Operations," specifies procedures for air traffic control planning, coordination, and services during defense activities, and special military operations conducted in airspace controlled by or under the jurisdiction of the FAA.

The U.S. airspace is divided into 21 zones (centers), and each zone is divided into sectors. Also within each zone are portions of airspace, about 81 kilometers (50 miles) in diameter, called TRACON (Terminal Radar Approach CONtrol) airspaces. Several airports exist within each TRACON airspace, and each airport has its own airspace with an eight-kilometer (five-mile) radius.

International. For international airspace, the procedures of the International Civil Aviation Organization (ICAO) are followed. These procedures are outlined in ICAO Document 444, "Rules of the Air and Air Traffic Services." The ICAO ensures the safe, efficient, and orderly evolution of international civil aviation through the establishment of international standards and recommended practices.

C.5 Biological Resources

United States. The Endangered Species Act of 1973 (ESA) requires all Federal departments and agencies to seek to conserve endangered species and threatened species (16 U.S.C. 1531). The Secretary of the Interior was directed to create lists of endangered and threatened species. Endangered species designation is given to any plant or animal species that is in danger of extinction throughout all or a significant portion of its range. The ESA defines a threatened species as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Critical habitat for a threatened or endangered species is defined as specific areas, within the geographical area occupied by the species at the time it is listed, which contain the physical or biological features essential to conservation of the species and may require special management considerations or protection. Critical habitat also includes specific areas, outside the geographic area occupied by the species at the time it is listed, which are essential to conservation of the species.

A key provision of the ESA for Federal activities is Section 7, Consultation. Under Section 7 of the ESA, every Federal agency must consult with the Secretary of the Interior, U.S. Fish and Wildlife Service (USFWS), to ensure that any agency action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of such species. Under the ESA, if a threatened or endangered species may be affected, a biological assessment is required to determine the impact. The agency must undertake mitigation measures if the impact is found to be negative, or the project must be stopped.

The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712) implements various treaties and conventions between the U.S., Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds and their resources. (USFWS, 2005) Specifically, the Act prohibits the pursuit, hunting, taking, capture, possession, or killing of such species or their nests and eggs. The USFWS Division of Migratory Bird Management develops migratory bird permit policy. The regulations governing migratory bird permits can be found in General Permit Procedures (50 CFR 13) and Migratory Bird Permits (50 CFR 21). Most states require a state permit for activities involving migratory birds. (USFWS, 2002) Taking of migratory birds by Federal agencies is prohibited, unless authorized under regulations promulgated under the Migratory Bird Treaty Act. (USFWS, 2000) EO 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, provides further direction to departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act.

The Marine Mammal Protection Act of 1972 (16 U.S.C. 1361) outlines prohibitions for the taking of marine mammals. The Act gives the USFWS and NOAA Fisheries (formerly the National Marine Fisheries Service) co-authority to protect the resource. The Marine Mammal Commission, which was established under the Act, reviews laws and international conventions, studies worldwide populations, and makes recommendations to Federal officials concerning marine mammals.

The Marine Protection, Research, and Sanctuaries Act (33 U.S.C. 1401) regulates the disposal of all materials into the ocean to prevent adverse effects to human welfare, the marine environment, ecological systems, or the economy. It provides the EPA with the authority to issue permits for ocean dumping.

The Bald and Golden Eagle Protection Act (16 U.S.C. 668) establishes penalties for the unauthorized taking, possession, selling, purchase, or transportation of bald or golden eagles, their nests, or their eggs. If a Federal activity might disturb eagles or a nest is found in areas where launches or reentries may occur, consultation with the USFWS for appropriate mitigation is required.

The National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee) consolidates the categories of lands that are administered by the Secretary of the Interior for the conservation of fish and wildlife, including species that are threatened with extinction. Provisions of the Act relating to determinations of the compatibility of a use shall not apply to overflights above a refuge or activities authorized, funded, or conducted by a Federal agency (other than USFWS) that has primary jurisdiction over a refuge or a portion of a refuge, if the management of those activities is in accordance with a memorandum of understanding between the Secretary/Director and the head of the Federal agency with primary jurisdiction over the refuge governing the use of the refuge.

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801) requires Federal agencies to consult with NOAA Fisheries on activities that could harm Essential Fish Habitat areas. Essential Fish Habitat is defined as "those waters and substrate (sediment, hard bottom) necessary to fish for spawning, breeding, feeding or growth to maturity."

The Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2901-2912) provides for financial and technical assistance to states to develop conservation plans, subject to approval by the Department of Interior, and implement state programs for fish and wildlife resources. The Act also encourages all Federal departments and agencies to utilize their statutory and administrative authority to conserve and promote conservation of non-game fish and wildlife and their habitats.

EO 11990, Protection of Wetlands (42 FR 26961), requires Federal agencies to provide leadership and work to minimize the destruction, loss, and degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands while carrying out the agency's responsibility for acquiring, managing, using, and disposing of Federal lands. The Defense Department Fiscal Year 2004 Authorizations bill authorizes the Federal government to participate in mitigation banks for wetlands. The mitigation banks allow developers to fill wetlands in one area in exchange for a payment to create wetlands in another area.
The Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661) requires Federal agencies to consult with the USFWS and state wildlife agencies where any water body or wetlands under U.S. Army Corps of Engineers jurisdiction is proposed to be modified by a Federal agency.

Under Section 404 of the Clean Water Act, the U.S. Army Corps of Engineers is responsible for issuing Federal permits. The program regulates the discharge of dredged and fill material into the waters of the U.S., including wetlands. Activities that are regulated under this program include fills for development, water resource projects (e.g., dams or levees), infrastructure development (e.g., highways and airports), and conversion of wetlands to uplands for farming and forestry.

EO 13061, Federal Support of Community Efforts Along American Heritage Rivers (62 FR 48445), requires Federal agencies to preserve, protect, and restore rivers designated as American Heritage Rivers, including their natural resources and associated historical, cultural, and economic resources.

EO 13089, Coral Reef Protection (63 FR 32701), requires all Federal agencies whose actions may affect U.S. coral reef ecosystems to "identify their actions that may affect U.S. coral reef ecosystems; utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and to the extent permitted by law, ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems."

EO 13112, Invasive Species (64 FR 6183), directs the prevention of invasive species introduction and provides means for their control to minimize economic, ecological, and human health impacts they may cause.

International. The Convention on Wetlands was signed in Ramsar, Iran in 1971. It is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention aims to stem the progressive encroachment on and loss of wetlands, now and in the future. It requires its Parties to designate at least one national wetland of international importance; establish wetlands nature reserves and cooperate in information exchange for wetlands management; assess the impacts of any changes in use on identified wetland sites; and take responsibility for conservation, management, and wise use of migratory stocks of waterfowl. (Ramsar, 2005)

The 1986 Convention for the Protection of the Natural Resources and Environment of the South Pacific Region is a comprehensive, umbrella agreement for the protection, management, and development of the marine and coastal environment of the South Pacific Region. Sources of pollution that require control under the South Pacific Regional Environment Programme (SPREP) are ships, dumping, land-based sources, seabed exploration and exploitation, atmospheric discharges, storage of toxic and hazardous wastes, testing of nuclear devices, mining, and coastal erosion.

C.6 Cultural Resources

Numerous laws and regulations require that possible effects on cultural resources be considered during the planning and execution of Federal undertakings. These laws and regulations stipulate a process of compliance, define the responsibilities of the Federal agency proposing the action, and prescribe the relationship among other involved agencies (e.g., State Historic Preservation Officer, the Advisory Council on Historic Preservation).

The National Historic Preservation Act (16 U.S.C. 470f and 470h-2(a)) establishes a national policy to preserve, restore, and maintain cultural resources. The Act establishes the National Register of Historic Places as the mechanism to designate public or privately owned properties deserving protection. Section 106 (36 CFR 800) of the Act requires Federal agencies to "take into account" the effect of a project on any property included in or eligible for inclusion in the National Register. Section 106 prescribes the following for consideration of historic properties under NEPA: early coordination, inclusion of historic preservation issues, and actions categorically excluded under NEPA.

Under the Historic Sites Act of 1935, the Secretary of the Interior is authorized to designate areas as national natural landmarks for listing on the National Registry of Natural Landmarks. In conducting an environmental review of a proposed Federal action, an agency shall consider the

existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR 62.6(d) to avoid undesirable impacts upon such landmarks.
The Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001) is triggered by the possession of human remains or cultural items by a federally funded repository or by the discovery of human remains or cultural items on Federal or tribal lands. It provides for the inventory, protection, and return of cultural items to affiliated Native American groups. Permits are required for intentional excavation and removal of Native American cultural items from Federal or tribal lands. The Act includes provisions that, upon inadvertent discovery of remains, the action will cease in the area where the remains were discovered, and the responsible official will protect the materials and notify the appropriate land management agency.
The Archaeological Resources and Protection Act (16 U.S.C. 470aa - 470mm) ensures the protection of archaeological sites on Federal land. It requires Federal permits to be obtained before cultural resource investigations begin at sites on Federal land and investigators to consult with the appropriate Native American groups prior to initiating archaeological studies on sites of Native American origin.

The American Indian Religious Freedom Act (42 U.S.C. 1996) states that it is the policy of the U.S. to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.

The Antiquities Act of 1906 (16 U.S.C. 431) authorizes declaration of Federal lands as national monuments for the purpose of protecting sites and objects of antiquity, including historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon lands owned or controlled by the U.S. The Act prohibits excavation or destruction of such antiquities unless a permit is obtained.

EO 13007, Indian Sacred Sites (61 FR 26771), requires each executive branch that manages Federal lands, whenever practicable and permitted by law, to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and to avoid adversely affecting the physical integrity of such sacred sites.

EO 13287, Preserving America (68 FR 10635), establishes Federal policy to provide leadership in preserving America's heritage by actively advancing the protection, enhancement, and contemporary use of the historic properties owned by the Federal government, and by promoting intergovernmental cooperation and partnerships for the preservation and use of historic properties.

C.7 Geology and Soils

There are no Federal regulations pertaining specifically to geology and soils; however, most areas fall under local jurisdiction and their associated sediment and erosion control plans. Indirectly, the Clean Water Act sections 402 and 405 National Pollutant Discharge Elimination System (NPDES) permitting program, codified at 40 U.S.C. 1342 and 1345, respectively, requires the preparation of an NPDES permit for all construction activities greater than five acres

(0.02 square kilometers) where storm water runoff would enter a water body considered to be waters of the U.S.

Avoidance of development in floodplains (EO 11988, Floodplain Management) and DOT Order 5650.2, Floodplain Management and Protection, are applicable as discussed below in Section C.15, Water Resources.

C.8 Hazardous Materials and Waste

United States. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or Superfund, (42 U.S.C. 9601) creates authority and procedures for conducting emergency responses, removal, and remediation actions at sites requiring a cleanup of releases of hazardous substances. CERCLA specifies standards of liability and provides procedures for determining compensation, reportable quantities of releases of hazardous substances, penalties, employee protection, claims procedures, and cleanup standards.

The Superfund Amendment and Reauthorization Act (SARA) of 1986 revised and extended CERCLA in 1986. SARA Title III, the Emergency Planning and Community Right-To-Know Act (EPCRA), provides for emergency planning and preparedness, community right-to-know reporting, and toxic chemical release reporting. EPCRA requires information about hazardous materials be provided to state and local authorities, including material safety data sheets, emergency and hazardous chemical inventory forms, and toxic chemical release reports.

Resource Conservation and Recovery Act (RCRA), or Solid Waste Disposal Act, (42 U.S.C. 6901) authorizes the EPA to regulate the generation, storage, and disposal of hazardous wastes. RCRA also applies to underground storage tanks and establishes a "cradle-to-grave" or life cycle system of requirements for managing hazardous waste, from generation to eventual disposal.

The Pollution Prevention Act of 1990 (42 U.S.C. 1310) defines pollution prevention as source reduction and other practices that reduce or eliminate the creation of pollutants. It requires the EPA to develop standards for measuring waste reduction, serve as an information clearinghouse, and provide matching grants to State agencies to promote pollution prevention. Facilities with more than 10 employees that manufacture, import, process, or otherwise use any chemical listed in and meeting threshold requirements of the EPCRA must file a toxic chemical source reduction and recycling report.

The Hazardous Materials Transportation Act of 1975 (49 U.S.C. 1801) gives the DOT authority to regulate shipments of hazardous substances by air, highway, or rail. These regulations may govern any safety aspect of transporting hazardous materials, including packing, repacking, handling, labeling, marking, placarding, and routing (other than with respect to pipelines).

The Ocean Dumping Act (33 U.S.C. 1401) imposes restrictions on what items and substances may be dumped into the open ocean. To protect the marine environment, the Act restricts dumping to designated locations and strictly prohibits dumping of materials such as biological warfare substances. The U.S. Coast Guard conducts surveillance as a regulatory enforcement measure.

The Oil Pollution Act of 1990 (33 U.S.C. 2701) requires oil storage facilities and vessels to submit to the Federal government plans detailing how they will respond to large discharges. The Oil Pollution Act requires the Federal government to "ensure effective and immediate removal of a discharge, and mitigation or prevention of a substantial threat of a discharge, of oil or a hazardous substance" into the navigable waters of the U.S., adjoining shorelines, and the exclusive economic zone (EEZ). The Act requires the development of Area Contingency Plans to prepare and plan for oil spill response on a regional scale.

The Toxic Substances Control Act of 1976 (15 U.S.C. 2601) gives the EPA authority to require testing of new and existing chemical substances entering the environment and the authority to regulate these substances. Section 6 of the Act specifically addresses, among others, polychlorinated biphenyls (PCBs) and asbestos.

EO 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements (58 FR 41981), requires the head of each Federal agency to develop and implement a written pollution prevention strategy that aims to minimize release of toxic chemicals to the environment and report in a public manner toxic chemicals entering the waste stream of the agency. This order relates to compliance with the EPCRA and the Pollution Prevention Act.

International. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, generally known as the London Dumping Convention, was adopted in 1972. Its objective is to control pollution of the sea caused by dumping and to encourage regional agreements supplementary to the Convention. It prohibits the dumping of certain hazardous materials, requires a prior special permit for the dumping of a number of other identified materials, and requires a prior general permit for other wastes or matter. "Dumping" has been defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves. Discharges of spent stages, from missiles, and residual propellants are part of the normal operation of launch vehicles and therefore, are not covered by the London Dumping Convention or other related agreements.

The 1989 Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) aims to establish obligations for State Parties with the objective of reducing transboundary movements of wastes subject to the Basel Convention to a minimum consistent with the environmentally sound and efficient management of such wastes; minimizing the amount and toxicity of hazardous wastes generated and ensuring their environmentally sound management (including disposal and recovery operations) as close as possible to the source of generation; and assisting developing countries in environmentally sound management of the hazardous and other wastes they generate. Hazardous wastes shall be exported only if the country of export does not have the technical capacity and facilities to dispose of them in environmentally sound management.

C.9 Health and Safety

Regulatory requirements related to the Occupational Safety and Health Act of 1970 (29 U.S.C. 651 et seq.) have been codified in the General Industry Standards (29 CFR 1910) and

Construction Industry Standards (29 CFR 1926). The regulations specify equipment, performance, and administrative requirements necessary for compliance with Federal occupational safety and health standards, and apply to all occupational (workplace) situations in the U.S. The requirements are monitored and enforced by OSHA, which is a part of the U.S. Department of Labor.

The Occupational Safety and Health Standards regulations (29 CFR 1910) address electrical and mechanical safety and work procedures, sanitation requirements, life safety requirements (such as fire and evacuation safety and emergency preparedness), design requirements for certain types of facility equipment (such as ladders and stair lifting devices), mandated training programs (such as employee Hazard Communication training and use of powered industrial equipment), and record-keeping and program documentation requirements. For any construction or construction-related activities, additional requirements specified in the Safety and Health Regulations for Construction (29 CFR 1926) also apply.

The Safe Drinking Water Act provides the EPA with the authority to set standards for drinking water quality and oversee states, localities, and water suppliers who implement those standards. Additional information on the Safe Drinking Water Act can be found in Section 3.1.13 of this PEIS, Water Resources.

RCRA gave the EPA the authority to control hazardous waste from "cradle-to-grave." This includes generation, transportation, treatment, storage, and disposal of hazardous waste. Additional information on RCRA can be found in Section 3.1.6 of this PEIS, Hazardous Materials and Waste.

The Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 U.S.C. 1251) has special enforcement provisions for oil and hazardous substances. For example, the Spill Prevention Control and Countermeasure Plan covers the release of hazardous substances, as identified by EPA, which could reasonably be expected to discharge into the waters of the U.S. Additional information on the Clean Water Act can be found in Section 3.1.13 of this PEIS, Water Resources.

Requirements pertaining to the safe shipping and transport handling of hazardous materials, which can include hazardous chemical materials and explosives, are found in the DOT Hazardous Materials Regulations and Motor Carrier Safety Regulations. (49 CFR parts 107, 171-180 and 390-397) These regulations specify all requirements that must be observed for shipment of hazardous materials over highways or by air. Requirements include those for specific packaging, material compatibility issues, permissible vehicle/shipment types, vehicle marking, driver training and certification, and notification.

Safety and Health Regulations for Marine Terminals (29 CFR 1917) apply to employment within a marine terminal including the loading, unloading, movement or other handling of cargo, ship's stores, or gear within the terminal or into or out of any land carrier, holding or consolidation area, and any other activity within and associated with the overall operation and functions of the terminal, such as the use and routine maintenance of facilities and equipment. Cargo transfers accomplished with the use of shore-based material handling devices also are regulated.

Safety and Health Regulations for Longshoring (29 CFR 1918) applies to longshoring operations and related employments aboard marine vessels.

EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (62 FR 19885), as amended by EO 13229 (66 FR 52013) and EO 13296 (68 FR 19931), provides for the consideration of potential environmental effects from Federal actions on health and safety risks that may disproportionately affect children.

RCC 319-92, Flight Termination System Commonality Standards, specifies performance requirements for flight termination systems used on various flying weapons systems.

C.10 Land Use

Land Use

United States. The Coastal Zone Management Act (16 U.S.C. 1451) seeks to preserve, protect, and restore coastal areas. Coastal areas include wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. All Federal agencies must assess whether their activities will affect a coastal zone and ensure, to the maximum extent possible, that the activities are consistent with approved state Coastal Zone Management Plans.

The Coastal Barrier Resources Act of 1982 (16 U.S.C. 3501) is designed to curtail Federal subsidization of development on fragile coastal barriers. The Act prohibits designated Federal expenditures and financial assistance, including flood insurance, for development within the coastal barrier system.

The Farmland Protection Policy Act of 1981 (7 U.S.C. 4201) is designed to require Federal agencies to consider alternatives to projects that would convert farmlands to nonagricultural use. The Act is limited to procedures to assure that the actions of Federal agencies do not cause U.S. farmland to be irreversibly converted to nonagricultural uses in cases in which other national interests do not override the importance of the protection of farmland nor otherwise outweigh the benefits of maintaining farmland resources.

The Wilderness Act of 1964 (16 U.S.C. 1131-1136) provides Congressional protection of several named wilderness areas and establishes a National Wilderness Preservation System for inclusion of lands within national forests, national parks, and national wilderness refuges.

The Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701) repeated a number of public land statutes and instituted a number of new programs including review of all lands managed by the Bureau of Land Management for possible designation by Congress as "wilderness," including a stipulation that the Federal agency must manage the public lands so as not to impair their wilderness potential.

The Aviation Safety and Noise Abatement Act of 1979 (49 U.S.C. 47501) addresses the compatibility of existing and planned land uses in the vicinity of an airport. As outlined in FAA Order 1050.1E, these issues are closely tied to the noise analysis.

International. The Convention on Environmental Impact Assessment in a Transboundary Context of 1991 aims to promote environmentally sound and sustainable economic development through the application of environmental impact assessment, especially as a preventive measure against transboundary environmental degradation. It stipulates the obligations of parties to assess the environmental impact of certain activities at an early stage of planning. It also requires countries to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

Section 4(f) Resources

The Department of Transportation Act includes a section of provisions that govern impacts to publicly owned land. Although this section was originally designated under 4(f), it has since been recodified as section 303(c) of 49 U.S.C. The provisions are referred to as section 4(f) in this PEIS because the terminology is still used to refer to the provisions.

According to section 4(f), the FAA shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, state, or local officials having jurisdiction thereof, or any land from an historic site of national, state, or local significance as so determined by such officials unless (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreation areas, wildlife and waterfowl refuge, or historic sites resulting from such use. In carrying out the national policy, the FAA shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the States regarding potential impacts on such resources.

C.11 Noise

Federal and state governments have established noise regulations and guidelines for the purpose of protecting citizens from potential hearing damage and various other adverse physiological, psychological, and social effects associated with noise. The Federal government preempts the state on control of noise emissions from aircraft, helicopters, railroads, and interstate highways.

The Noise Control Act (42 U.S.C. 4901) directs all Federal agencies, to the fullest extent within their authority, to carry out programs in a manner that promotes an environment that is free from noise. The Act requires a Federal department or agency engaged in any activity resulting in the emission of noise to comply with Federal, state, interstate, and local requirements respecting control and abatement of environmental noise.

Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910.95) establish a maximum noise level of 90 dBA for a continuous eight-hour exposure during a workday and higher sound levels for a shorter time of exposure in the workplace. When information indicates that an employee's exposure may equal or exceed an eight-hour time-weighted average of 85 dB, the employer shall develop and implement a monitoring program.

Additional, FAA-specific regulations and laws must be followed. Descriptions of how to implement the following legal requirements are located in FAA Order 1050.1E.

- The Aviation Safety and Noise Abatement Act of 1979 (49 U.S.C. 47501)
- Airport Noise and Capacity Act of 1990 (49 U.S.C. 2101 et seq.)
- The Control and Abatement of Aircraft Noise and Sonic Boom Act of 1968
- Noise Control and Compatibility Planning for Airports Advisory Circular 150/5020
- 14 CFR part 161 Notice and Approval of Airport Noise and Access Restrictions

C.12 Orbital Debris

Executive Branch Policy Directive, National Space Policy (1996) directive provides guidance for orbital debris: "The U.S. will seek to minimize the creation of space debris. NASA, the Intelligence Community and the DoD, in cooperation with the private sector, will develop design guidelines for future government procurements of spacecraft, launch vehicles and services. The design and operation of space tests, experiments and systems will minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness."

C.13 Socioeconomics and Environmental Justice

Socioeconomics

The CEQ implementing regulations for NEPA provide no specific thresholds of significance for socioeconomic impact assessment. Significance varies depending on the setting of the proposed action. 40 CFR 1508.27(a) However, 40 CFR 1508.8 states that indirect effects may include those that are growth inducing and others related to induced changes in the pattern of land use, population density, or growth rate. Specific direction on how to analyze socioeconomic impacts can be found in FAA Order 1050.1E. Property and land acquisition requirements are outlined in FAA Order 1050.1E per the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. 4601) and FAA Order 5100.37A, Land Acquisition and Relocation Assistance for Airport Projects.

Environmental Justice

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (56 FR 7629), requires each Federal agency to achieve environmental justice by addressing "disproportionately high and adverse human health and environmental effects on minority and low-income populations." The demographics of the affected area should be examined to determine whether minority populations, low-income populations, or Indian tribes are present in the area impacted by the proposed action. If so, a determination must be made whether the implementation of the proposed action may cause disproportionately high and adverse human health or environmental effects on the minority populations or low-income populations present. DOT Order 5610.2, Environmental Justice in Minority and Low-Income Populations, generally describes the process that DOT will use to incorporate environmental justice principles into existing programs, policies, and activities. (DOT, 1997)

EO 13045, Protection of Children from Environmental Health Risks and Safety Risks, directs Federal agencies, as appropriate and consistent with the agency's mission, to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children.

C.14 Visual Resources

The Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271-1287) protects certain rivers because of their scenic or other similar value. The Act states that rivers with "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values" be preserved in free-flowing condition. Additionally, the immediate environments of the river are also protected.

There are no Federal aesthetics permits or regulations for visual resources applicable to the proposed action and alternatives. Local planning guidelines may be included in city and county general plans to preserve and enhance the visual quality and aesthetic resources within the plan's jurisdiction. Protection of visual resources typically results from local zoning and building ordnances. Although no special purpose laws or regulations exist, FAA Order 1050.1E provides a description of how to evaluate light emissions and visual impacts associated with FAA actions.

C.15 Water Resources

United States. The Clean Water Act (33 U.S.C. 1251) establishes water pollution control standards and programs with the objective of restoring and maintaining the chemical, physical, and biological integrity of U.S. water resources. The Act provides for the elimination of the discharge of pollutants into navigable waters and for water quality goals to protect fish and wildlife. The Act specifies (1) that actions must comply with Federal and state water quality criteria; (2) regulations for issuing permits under the NPDES for storm water discharge be established by the EPA; and (3) states assess non-point source water pollution problems and develop pollution management plans.

Water quality and the consumption and diversion of water are regulated by a number of Federal and state agencies in the U.S. The EPA has the primary authority for implementing and enforcing the Clean Water Act. (33 U.S.C. 1251) The EPA, along with state agencies to which the EPA has delegated some of its authority, issues permits under the Clean Water Act to maintain and restore the quality of U.S. water resources. The Clean Water Act requires permits for activities that result in the discharge of pollutants to water resources or the placement of fill material in waters of the U.S.

Storm Water Pollution Prevention Plans (SWPPPs) are typically prepared and permitted under the NPDES program to ensure construction activities do not lead to unacceptable levels of erosion and water pollution. The Safe Drinking Water Act of 1974 (42 U.S.C. 300f) provides the EPA with the authority to regulate the quality of U.S. drinking water supplies, including surface water and ground water sources. The EPA has delegated some of its authority for enforcement to all of the states, with the exception of Wyoming and the District of Columbia (Washington, D.C.). The appropriation of water, including diversions, consumption of potable water, and other uses, usually is regulated by the same state agencies that regulate water quality.

EO 11988, Floodplain Management (42 FR 26951, 1977), requires Federal agencies to provide leadership and work to minimize the impacts of floods on property loss and human health and safety and to simultaneously preserve the natural and beneficial values served by floodplains, while carrying out the agency's responsibility for acquiring, managing, using, and disposing of Federal lands. DOT Order 5650.2, "Floodplain Management and Protection," prescribes policies and procedures for ensuring that proper consideration is given to the avoidance and mitigation of adverse floodplain impacts in agency actions, planning programs, and budget requests. (FTA, 2004)

International. The European Union has adopted a number of directives related to water quality including the following:[29]

- Water Framework Directive (2000/60/EC) – European water policy for river basin management,
- Urban Waste Water Treatment Directive (91/271/EEC) – Regulates water pollution coming from urban waste water and certain industrial sectors,
- Discharges of Dangerous Substances Directive (76/464/EEC) and the Priority Substances under the Water Framework Directive – Regulates dangerous substances and pollution control from industry,
- Nitrates Directive (91/676/EEC) – Regulates water pollution caused by Nitrates from agricultural sources,
- Bathing Water Quality Directive (Council Directive 76/160/EEC concerning the quality of bathing water) and its proposed revision – Regulates bathing water quality of rivers, lakes, and coastal waters, and
- Drinking Water Directive (98/83/EC) – Regulates drinking water quality.

In addition to analyzing the European Union requirements for water quality, site-specific environmental documentation should carefully analyze the particular water regulations for each member of the European Union.

APPENDIX C REFERENCES

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Federal Transit Administration (FTA), 2004. "Floodplains." Accessed at http://www.fta.dot.gov/transit_data_info/reports_publications/publications/environment/4805_9804_ENG_HTML.htm on November 24, 2004

[29] Detailed information regarding these directives may be accessed at http://europa.eu.int/comm/environment/water/index.html

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APPENDIX D REGULATORY PROCESS DESCRIPTION

As specified under Federal law, the FAA is required to complete or assure that: (1) consultations with regulatory agencies occur and (2) the appropriate permits are obtained. This appendix provides a brief summary of the consultations associated with the National Historic Preservation Act, the Endangered Species Act (ESA), and the Farmland Protection Policy Act. This appendix also presents a discussion of the FAA airspace review process and wetlands permit process under Section 404 of the Clean Water Act. The processes presented are those that an applicant should address when conducting a site-specific analysis under the National Environmental Policy Act (NEPA) that tiers from this Programmatic Environmental Impact Statement (PEIS). This appendix is not all-inclusive and is meant only as a guide to assist applicants' understanding of the environmental documentation and review process. For further clarification and detail, applicants should refer to FAA Order 1050.1E, available at: http://www.aee.faa.gov/aee-200/1050-1E/1050-1E.htm.

This appendix includes six different consultation processes that applicants will most likely need to engage in during their preparation of a site-specific NEPA analysis that tiers from this PEIS. Each consultation process is related to an applicable resource area, as described in this PEIS. Furthermore, there are regulations and laws that apply, and that specify the one or more agencies that the applicant must contact. Exhibit D-1 provides an outline to this appendix.

Exhibit D-1. Outline of Appendix D

Applicable Resource Area	Cross-Reference to PEIS	Law or Regulation	Agency(ies) for Consultation
Airspace	Sections 3.1.2 and 4.2	Various sections under 14 CFR	FAA Office of Commercial Space Transportation (AST); FAA Regional Air Traffic Control office; Department of Defense airspace managers
Biological Resources	Sections 3.1.3 and 4.3	Endangered Species Act, Section 7	U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration (NOAA) Fisheries
Cultural Resources	Sections 3.1.4 and 4.4	National Historic Preservation Act, Section 106	Advisory Council on Historic Preservation; State or Tribal Historic Preservation Officer
Land Use and Section 4(f) Resources	Sections 3.1.8 and 4.10	Farmland Protection Policy Act and Department of Transportation (DOT) Act, section 4(f)	Natural Resources Conservation Service and Department of the Interior, Housing and Urban Development, and Agriculture
Water Resources	Sections 3.1.3 and 4.13	Clean Water Act	U.S. Army Corps of Engineers; U.S. Environmental Protection Agency

D.1 Consultation with FAA Regarding Airspace

To adequately address all airspace issues, an applicant must consult with the appropriate airspace management authorities including: AST, FAA Regional Air Traffic Control (ATC) office, and Department of Defense (DoD) airspace managers as appropriate. An applicant must also enter into official agreements with these agencies, as appropriate, to ensure that all parties agree to the airspace management strategies. Airspace agreements are named depending upon their purpose. The FAA and DoD enter into Letters of Agreement that specify airspace responsibilities. Other agencies may use Memoranda of Understanding or Interagency Agreements to document coordination between agencies. Airspace agreements establish protocol for both emergency and non-emergency situations.

The next sections describe the steps an applicant must take to ensure that all requirements related to airspace are met.

D.1.1 Pre-application consultation with AST

As part of the pre-application consultation process, an applicant must contact AST for consultation on airspace issues. The applicant can contact AST through their web site at http://ast.faa.gov/ or by contacting the designated AST Space Systems Development Division point of contact for his proposed project. The applicant will be directed to the appropriate FAA Regional ATC office. AST staff will work with the applicant to contact the FAA Regional ATC office and identify potential airspace management agencies with interests in the area proposed to be used by the applicant.

D.1.2 Consultation with FAA Regional ATC Office

Once the applicant has reviewed the existing airspace in the area of interest, the applicant must contact the appropriate FAA Regional ATC office. The applicant and the FAA Regional ATC office staff will discuss the types of launch vehicle(s) the applicant would use and the types of airspace available in the general vicinity of the proposed launch and/or reentry locations. The Regional ATC office would take the information provided by the applicant and analyze the air traffic flow of the airspace (e.g., commercial airliners and military activity). Then, the Regional ATC office would work with the applicant to ensure that other agencies, which are conducting activities in the airspace that would be impacted by the proposed activities in the airspace, are consulted. The FAA Regional ATC office may assist the applicant in identifying corridors where the proposed activities could take place and identifying windows of time for the activities.

In addition to this consultation, an applicant could be required to enter into a number of official agreements relating to the particular site and vehicle. These agreements would be with the appropriate agencies including FAA, U.S. Coast Guard, DoD, and the launch range or launch site operator as described in more detail in Sections D.4.3 through D.4.6.

D.1.3 Agreements with FAA

To comply with **launch site** airspace requirements, an applicant would be required to complete an agreement with the FAA Regional ATC office having jurisdiction over the affected airspace. In accordance with 14 CFR 420.31, the agreement would

- Define procedures for issuing Notices to Airmen (NOTAMs) prior to a launch or reentry,
- Define procedures for closing air routes during the launch or reentry window, and
- Identify other measures necessary to protect public health and safety.

To comply with **launch vehicle** airspace requirements, an applicant would complete an agreement with the FAA Regional ATC office having jurisdiction over the airspace. In accordance with 14 CFR 431.75, the agreement would

- Define procedures for issuing NOTAMs prior to a launch or reentry,
- Establish procedures to close air routes during the launch and reentry windows, and
- Identify other measures as necessary to protect public health and safety.

D.1.4 Agreements with U.S. Coast Guard

To comply with **launch site** airspace requirements, an applicant would be required to complete an agreement with the local U.S. Coast Guard district. In accordance with 14 CFR 420.31, the agreement would

- Define procedures for issuance of NOTAMs prior to launch or reentry, and
- Define other measures as necessary to protect public health and safety.

To comply with **launch vehicle** airspace requirements, an applicant must complete an agreement with the local U.S. Coast Guard district. In accordance with 14 CFR 431.75, the agreement would

- Establish procedures for the issuance of NOTAMs to a launch or reentry, and
- Establish procedures for other measures as necessary to protect public health and safety.

D.1.5 Agreement with Launch Range or Launch Site Operator

To comply with **launch vehicle** airspace requirements, an applicant must complete an agreement with the Federal launch range and/or licensed site operator. In accordance with 14 CFR 431.75, the agreement would

- Provide for access to and use of property and services required to support launch or reentry, and
- Provide for public safety related operations and support.

D.1.6 Other Agreements

For certain proposed launch sites or for proposed launch or reentry corridors, controlled military airspace may be affected. In such situations, the applicant may need to coordinate and sign agreements (i.e., letters of agreement) with the DoD airspace management entity. Each military service has designated persons within most FAA Regional ATC offices to facilitate coordination on airspace issues. The military service representatives are responsible for interfacing with the FAA. These military representatives can assist in identifying the appropriate military points of contact for dealing with airspace issues. Any agreements that are required would be developed on a case by case basis, as needed.

D.2 Consultation under the Endangered Species Act (Biological Resources)

Section 7 of the ESA sets forth requirements for consultation to determine if the proposed action may affect an endangered or threatened species. An applicant should initiate consultation with the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration (NOAA) Fisheries (formerly the National Marine Fisheries Service [NMFS]), as appropriate, and state natural resource agencies for Federal- and state-listed endangered, threatened, and candidate species or designated critical habitat. Initial contact (informal consultation) with such agencies would be completed to document the location and extent of such protected resources and for concurrence of no effect determinations. The FAA or the applicant would then determine whether or not the proposed action or an alternative may affect an endangered or threatened species or its critical habitat, and present its findings to the appropriate agencies (USFWS or NOAA Fisheries, as appropriate and state natural resource agencies) for concurrence. Should the action considered in the EA or EIS have the potential to affect an endangered or threatened species or its critical habitat, then under Section 7(a)2, the FAA would consult with the USFWS or NOAA Fisheries, as appropriate, to ensure that any action the agency authorizes, funds, or carries out is not likely to jeopardize the continued existence of any federally listed endangered or threatened species or result in the destruction or adverse modification of critical habitat. For species that are proposed for listing as endangered or threatened, the FAA would confer with the USFWS or NOAA Fisheries, as appropriate, in accordance with Section 7(a)4.

Informal consultation is a process that includes all discussions, correspondence, etc., between the USFWS or NOAA Fisheries and the FAA or its designated non-Federal representative. The process is designed to assist Federal agencies in determining whether formal consultation or a conference is required. The informal consultation process under the Endangered Species Act begins with the preparation of a list of threatened or endangered species potentially affected by the proposed action. The USFWS requires 30 calendar days to ensure that the list is correct and to prepare for the remainder of the informal consultation process. After 30 days, the USFWS reviews the list and evaluates if threatened or endangered species or critical habitat are present. If no threatened or endangered species or critical habitat will be impacted, the informal consultation process is complete and the USFWS provides documentation concurring with the no impact determination. During informal consultation, the Service may suggest modifications to the proposed action that the FAA could implement to avoid the likelihood of adverse effects to listed species or critical habitat.

Formal consultation with USFWS or NOAA Fisheries under section 7(a)(2) of the ESA is triggered when: (1) the FAA determines that the proposed action "may affect" federally listed species or designated critical habitat, or (2) the USFWS or NMFS does not concur with the agency's determination that the proposed action is not likely to adversely affect federally listed species or designated critical habitat. If the proposed action may impact threatened or endangered species or critical habitat, a biological assessment is prepared by the applicant or the FAA and submitted to USFWS, which has 30 days to respond. A Biological Assessment is defined as information prepared by, or under the direction of, a Federal agency to determine whether a proposed action is likely to: (1) adversely affect listed species or designated critical habitat; (2) jeopardize the continued existence of species that are proposed for listing; or (3) adversely modify proposed critical habitat.

After the submission of the biological assessment, the USFWS or NOAA Fisheries either supplies written concurrence that the proposed action is not likely to adversely affect federally listed species or designated critical habitat, otherwise the entire process moves forward through formal consultation. The formal consultation process, which takes a minimum of 135 days, is used to determine whether the proposed action is likely to jeopardize the continued existence of a listed threatened or endangered species or to destroy or adversely modify critical habitat. The lead agency must request initiation of formal consultation with USFWS or NOAA Fisheries, and submit additional information to the USFWS or NOAA Fisheries to support a finding that the proposed action is or is not likely to jeopardize the continued existence of a listed threatened or endangered species or destroy or adversely modify critical habitat. If the USFWS or NOAA Fisheries finds that the biological assessment is insufficient, the Federal agency has 90 days to complete collecting the necessary data. If the biological assessment is complete, the USFWS takes 90 days to formulate a Biological Opinion and incidental take statement and an additional 45 days to review the draft statement and finalize it. Formal consultation is concluded when USFWS or NOAA Fisheries issues the Biological Opinion, which will either be a No Jeopardy/Adverse Modification Opinion (including an incidental take statement), or a Jeopardy/Adverse Modification Opinion.

If a Biological Opinion states that the proposed action is not likely to jeopardize the continued existence of federally listed threatened or endangered species in the affected area or result in the destruction or adverse modification of federally designated critical habitat in the affected area, it is a No Jeopardy/Adverse Modification Opinion. An incidental take statement included in this opinion may provide one or more reasonable and prudent measures, with associated terms and conditions, to minimize the level of incidental take. If a Biological Opinion determines that the proposed action is likely to jeopardize the species or adversely modify critical habitat (a Jeopardy/Adverse Modification Opinion), it will include nondiscretionary reasonable and prudent alternatives. Formal consultation may be reinitiated when

- The amount or extent of incidental take is exceeded;
- New information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
- The action is modified in a manner causing effects to listed species or critical habitat not previously considered; or

- A new species is listed or critical habitat is designated that may be affected by the action. (See 50 CFR 402.14 for further guidance on formal consultation.)

Pursuant to the Fish and Wildlife Coordination Act, where there is a potential impact on water resources the lead Federal Agency must consult with Federal, State, and local agencies and Tribes having administration over fish, wildlife, and plant resources.

D.3 Consultation under Section 106 of the National Historic Preservation Act (Cultural Resources)

Section 106 of the National Historic Preservation Act requires Federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment. (36 CFR Part 800) In determining if the effects of their undertaking on a site listed or eligible for listing on the National Register of Historic Places (NRHP), the Federal agency must define the area of potential effect (APE), as defined in 36 CFR Part 800.16(d) below:

> (d) *Area of potential effects* means the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The area of potential effects is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking.

Typically the State Historic Preservation Officer (SHPO) and/or Tribal Historic Preservation Officer (THPO) with jurisdiction or knowledge of cultural resources within the APE would be contacted to define the location and characteristics of a site listed or eligible for listing on the NRHP. If the Federal agency determines that (1) it has no undertaking, or (2) its undertaking is a type of activity that has no potential to affect sites listed or eligible for listing on the NRHP, the Federal agency provides documentation to the SHPO and/or THPO and, barring any objection in 30 days, proceeds with the undertaking. Should the SHPO or THPO request additional information, upon receipt of that information, they again have 30 days to review and comment or concur with the finding of no effect.

If the undertaking may affect a historic property, the Federal agency must identify the appropriate SHPO or THPO with whom to consult during the evaluation process. If all parties agree no adverse effects will occur, the agency proceeds with the undertaking and any agreed upon conditions. If the Federal agency and the SHPO or THPO find that there would be an adverse effect, then the Federal agency begins consultation to seek ways to avoid, minimize, or mitigate the adverse effect. If the parties cannot agree, the SHPO or THPO can request an evaluation by the ACHP, but this must occur within the 30-day review and comment period. Should the SHPO or THPO not respond to the Federal agency within 30 days, the Federal agency can then file the finding of no adverse effect with the ACHP, which has a 15-day review period; their review of no adverse effect determinations is limited to whether or not the criteria have been correctly applied. If the ACHP fails to respond within 15 days, the Federal agency may assume their concurrence.

If the undertaking will affect a historic property, the Federal agency must prepare a Memorandum of Agreement (MOA). The MOA that the appropriate parties prepare and sign verifies that the FAA has complied with Section 106. It describes the undertaking and contains instruction and terms that the FAA will ensure are implemented to avoid, minimize, or mitigate adverse effects. Detailed information on MOAs is contained in 36 CFR 800.6(b) and (c). Appendix A of these regulations provides detailed guidance on addressing archeological sites. The ACHP may be invited to join the consultation, but must respond to the request within 15 days of receipt. If the FAA and the SHPO/THPO cannot agree when the ACHP is not participating, the FAA must request that the ACHP join in the consultation. The public must be provided an opportunity to comment on the MOA; typically, a 30-day comment period is sufficient. Upon completion of the MOA, the ACHP is provided a 45-day comment period. Depending on the proposed action, consultation with the SHPO or THPO and the ACHP could take anywhere from 30 days to over a year.

If a Federal agency uses the NEPA process to make their cultural resources impact analysis more efficient and effective, close adherence to the requirements of 36 CFR 800.8 is required. Cooperation among FAA, SHPO/THPO, consulting parties, the public, and in some instances, ACHP, is necessary when combining the NEPA and Section 106 processes. Specific requirements for Environmental Assessment (EA) and Environmental Impact Statement (EIS) preparation and content are detailed in 36 CFR 800.8(c)(1)-(4).

D.4 Consultation Regarding Land Use and Section 4(f) Resources

D.4.1 Consultation under the Farmland Protection Policy Act

The Farmland Protection Policy Act regulates Federal actions with the potential to convert farmland to non-agricultural uses. Consultation with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) should occur to determine if the Farmland Protection Policy Act applies to the land the proposed action would convert to non-agricultural use, or if an exemption to the Act exists. If it is determined that the farmland is protected by the Farmland Protection Policy Act, formal coordination is required per 7 CFR part 658.

For farmland regulated by the Farmland Protection Policy Act, scoring of the relative value of the site for preservation is performed by the NRCS and the proponent. The scoring is completed on Form AD-1006, "Farmland Conversion Impact Rating", available at http://www.nrcs.usda.gov/programs/fppa/pdf_files/AD1006.PDF. If the total score on Form AD-1006 is below 160, no further analysis is necessary. Scores between 160 and 200 may have potential impacts and require further consideration of alternatives that would avoid this loss. The applicant should consider reducing the amount of protected farmland that the project would convert or using alternative farmland that has a relative lower value. If NRCS fails to respond within 45 days, and if further delay would interfere with construction activities, the action may proceed as though the site were not farmland protected by the Farmland Protection Policy Act. The FAA then documents a "no response" by the NRCS in the environmental document.

D.4.2 Consultation under the Department of Transportation Act Section 4(f)

Section 4(f) of the Department of Transportation Act, as amended, 49 U.S.C. 303, provides the DOT policy on lands, wildlife and waterfowl refuges, and historic sites. The Act provides that the Secretary of Transportation will not approve any program or project that requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance or land from an historic site of national, state, or local significance as determined by the officials having jurisdiction thereof, unless

1. There is no prudent and feasible alternative to using that land; and
2. The program or project includes all possible planning to minimize harm to the park, recreation area, wildlife and waterfowl refuge, or historic site resulting from the use.

The lands, wildlife and waterfowl refuges, and historic sites that fall under the protection of section 4(f) include the following.

- Lands of the National Park System
- Lands of the National Wildlife Refuge System
- Lands acquired for mitigation purposes pursuant to the authority of the Fish and Wildlife Coordination Act, including general plan lands under Section 3(b) of that act
- Lands under the jurisdiction of the Bureau of Land Management that are administered for recreation, cultural, and wildlife purposes
- Local and State lands, and interests therein, and certain Federal lands under lease to the States, acquired or developed in whole or in part with moneys from the Land and Water Conservation Fund (LWCF)
- State lands and interests therein acquired or developed or improved with Federal grants for fish and wildlife conservation, restoration, or management such as the Federal Aid in Sport Fish Restoration Act of 1950 (Dingell-Johnson Act), the Federal Aid in Wildlife Restoration Act of 1937 (Pittman-Robertson Act), and the Anadromous Fish Act of 1965
- Federal surplus real property that has been deeded to State and local governments for park, recreation, wildlife, and historic purposes
- Properties listed on or eligible for inclusion in the National Register of Historic Places
- National Park Service “Affiliated Areas”
- Lands of the National Fish Hatchery System
- Lands under the jurisdiction of the Bureau of Reclamation that are administered as parks, recreation areas, wildlife refuges, or historic sites
- Indian lands held in trust by Interior as parks, recreation areas, wildlife refuges, or historic sites
- Recreation areas and facilities developed or improved, in whole or in part, with grants under the Urban Park and Recreation Recovery Act of 1978 (Title 10 of PL 95-625)
- Areas publicly owned in fee, less than fee, lease, or otherwise, that receive de facto use as park, recreation, or refuge lands. De facto use is determined on a case-by-case basis by the Interior bureau having statutory or program jurisdiction over or interest in the land in question. In the case of Indian trust lands, such determination will be made in consultation with the appropriate tribal officials. De facto use may also include publicly owned lands or interest therein proposed or under study for inclusion in the National Wild and Scenic Rivers System, the National Trails System, or the National Wilderness Preservation System, or as

critical habitat for endangered or threatened species. Early coordination with Interior about the applicability of section 4(f) is especially important whenever lands administered by the Bureau of Reclamation or the Bureau of Land Management, or Indian trust lands administered by the Bureau of Indian Affairs, are affected by DOT project

- Abandoned railroad rights-of-way acquired by State and local governments for recreational or conservation uses under Section 809(b) of the Railroad Revitalization and Regulatory Reform Act of 1976

The Secretary of Transportation shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the states, in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of lands crossed by transportation activities or facilities.

In accordance with FAA Order 1050.1E, the FAA shall consult with the officials having jurisdiction over the section 4(f) property(ies), and other agencies, as necessary. An EIS prepared by the FAA would thoroughly analyze and document prudent and feasible alternatives that would avoid the use of section 4(f) property and provide detailed measures to minimize harm.

Furthermore, FAA Order 1050.1E specifies that a significant impact would occur pursuant to NEPA when a proposed action either involves more than a minimal physical use of a section 4(f) property or is deemed a "constructive use" substantially impairing the 4(f) property, and mitigation measures do not eliminate or reduce the effects of the use below the threshold of significance (e.g., by replacement in kind of a neighborhood park). Substantial impairment would occur when impacts to section 4(f) lands are sufficiently serious that the value of the site in terms of its prior significance and enjoyment are substantially reduced or lost. If there is a physical or constructive use, the FAA is responsible for complying with section 4(f) even if the impact is less than significant for NEPA purposes.

The Department of Interior's *Handbook on Departmental Review of section 4(f) Evaluations* provides detailed information about the consultation process. The handbook is available at http://www.doi.gov/oepc/handbook.html. The handbook provides a description of the format and content that should be included in consultation letters, including the addressee, project identification, and general comments. The handbook describes the way that the agency may respond to an applicant's letter, and what information is required if they do not conclude that there is no feasible and prudent alternative to the proposed use of the area. If applicable, the second phase of the section 4(f) review is to ensure that all possible planning has been done to minimize harm to section 4(f) lands. All applicants should consult the handbook for more information.

D.5 Permits under the Clean Water Act (Water Resources)

This section describes three different types of permits that could be required under the Clean Water Act.

D.5.1 Section 404 Wetlands

The purpose of Section 404 of the Clean Water Act is to ensure that the nation's waterways are protected from irresponsible and unregulated discharges of dredged or fill material. Generally, if any action or proposed action is expected to result in the addition of any fill material to navigable waters, or result in the loss to an established threshold of acreage, then the action is subject to regulation under Section 404. A jurisdictional determination decides whether the specific body of water in question is subject to Section 404. If the water body is subject to Section 404, the proposed action then enters into the permitting process.

Determining whether a specific action is subject to Section 404 requires that the body of water be determined jurisdictional or non-jurisdictional. If the action is expected to impact wetlands, those wetlands must first meet the criteria of (1) being defined as a wetland as established by the U.S. Army Corps of Engineers (see http://www.wetlands.com/regs/tlpge02e.htm) and (2) being defined as "navigable waters of the United States" (33 CFR 329) or "waters of the United States" (33 CFR 328). "Navigable waters of the United States" are those waters that are subject to the ebb and flow of the tide or may be used for interstate or foreign commerce. "Waters of the United States" are those waters that may be used for foreign or interstate commerce; are interstate (including wetlands); are impoundments of waters otherwise defined as waters of the U.S.; or are wetlands adjacent to other waters of the U.S., except other wetlands. If the wetland meets any of these criteria, then a jurisdictional determination is made and the action must enter the permitting process.

Once it has been established that a wetland is jurisdictional, the applicant must enter into the permitting process. There are two types of permits that are issued for wetlands: (1) nationwide permits and (2) individual permits. Under Section 404, the U.S. Army Corps of Engineers has the authority to review and issue these permits.

Applying for a nationwide permit allows a proposed action with minimal impacts to proceed more quickly through the approval process. 33 CFR 330.1 If a project site does not exceed one-half acre and falls into one of the broad categories of projects established by the U.S. Army Corps of Engineers, it is eligible to enter into the nationwide permitting process (see http://www.spk.usace.army.mil/organizations/cespk-co/regulatory/nwp.html). The proposed action must meet a number of mitigation and impact standards, such as having no impact to endangered species or historical properties, for the proposed action to be approved for a nationwide permit (see http://www.wetlands.com/coe/nwp3cond.htm).

If a project is not eligible for a nationwide permit, it must apply for an individual permit. Individual permits are generally issued for those actions that are larger in scope and thought to have a more significant impact on the environment. As such, the process usually takes over six months and requires a very detailed analysis of the proposed action. After approval of the application, the proposed action is subject to a public review period and the U.S. Army Corps of Engineers considers all comments before issuing a final decision.

D.5.2 National Pollutant Discharge Elimination System (NPDES) Permits

The Clean Water Act regulates the discharge of waste water under the National Pollutant Discharge Elimination System (NPDES) program. Through this program, any person responsible for the discharge of any "point source" pollutant into any "waters of the United States" must obtain a permit to do so. In this case, point source is defined as "any discernable, confined and discrete conveyance…from which pollutants are or may be discharged." And, "waters of the United States" is defined broadly as "all waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to ebb and flow of the tide; all interstate waters…; and all other waters…"

Storm water discharges are also regulated under the NPDES program, but only for specific industrial activities. For industrial facilities that fall into one of 11 categories established by the EPA, and discharge their storm water into a municipal separate storm water system (MS4) or waters of the U.S., a permit is required. For construction activity, a facility is required to apply for a NPDES storm water permit if greater than five acres are going to be disturbed and the site will discharge storm water into a MS4 or waters of the U.S.

For more information about permit applications and other information about the NPDES program, see EPA's web site at http://cfpub.epa.gov/npdes/. See also the Federal Register notice about the details of the program at http://a257.g.akamaitech.net/7/257/2422/12feb20041500/edocket.access.gpo.gov/cfr_2004/julqtr/pdf/40cfr122.2.pdf.

D.5.3 Section 401 Water Quality Certification Permits

Section 401 of the Clean Water Act requires that anyone seeking to obtain a Federal permit to discharge pollutants in the waters of a state must receive a section 401 permit from that state in order to proceed. For example, if a project requires a NPDES permit and will affect state waters, then the project must first obtain a section 401 permit from the state where the action will take place before it can proceed with any Federal permitting.

APPENDIX D REFERENCES

14 CFR 420.31, Criteria and Information Requirements for Obtaining a License, available at http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/cfr_2003/14cfr420.31.htm; accessed on April 6, 2005.

14 CFR 431.75, Post-Licensing Requirements – Reusable Launch Vehicle Mission License Terms and Conditions, available at http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/cfr_2003/14cfr431.75.htm; accessed on April 6, 2005.

Federal Aviation Administration (FAA), 2004. FAA Order 1050.1E, revised June 8, 2004. Available at http://www.aee.faa.gov/aee-200/1050-1E/1050-1E.htm

Interagency Airspace Coordination Guide, available at
http://www.fs.fed.us/r6/fire/aviation/airspace/web/guide/index.html; accessed on April 11, 2005.

APPENDIX E POTENTIAL ACCIDENT SCENARIOS

This appendix presents various accident scenarios and their associated impacts of the activities considered in this Programmatic Environmental Impact Statement (PEIS). This appendix discusses methods and regulations, including safety criteria used by the Federal Aviation Administration (FAA) in licensing decisions, for preventing and mitigating threats to public health, public safety, property, and the environment. The discussion of these topics serves as a roadmap for the additional, mission-specific analyses a licensee applicant must carry out before receiving a license from the FAA to conduct a launch or reentry.

E.1 FAA Safety Considerations in Licensing Decisions

The FAA Licensing and Safety Division is responsible for regulating and licensing the safety aspects of launch activities. The FAA's responsibilities include reviewing license applications for safety adequacy and developing public safety requirements and standards. A Safety Review is a critical part of the licensing process, as discussed in Appendix A of this PEIS, and ensures that license applicants will comply with FAA-established requirements and procedures.

Commercial launches may occur at either Federal launch facilities, licensed launch facilities, or international facilities. Each Federal launch range has safety requirements and procedures. U.S.-licensed launch site operators are subject to the FAA's licensing and safety regulations. Licensed launch sites co-located with Federal launch ranges are subject to the FAA's licensing and safety criteria; however, these facilities may adopt existing Federal range requirements as long as they are found to meet the FAA regulations outlined in 14 CFR §415-420.

Although the risk to public safety and property can never be completely eliminated, safety systems and procedures are used to ensure the risks to public safety and property are minimized to acceptable levels. Safety systems and procedures include

- Real-time tracking;
- Flight safety systems;
- Payload review;
- Autonomous, on-board, safety systems; and
- Redundant engineering of key electrical, mechanical, and communication systems.

In the event of a systems failure, redundant engineering provides the operator with a backup system that will ensure control of the launch vehicle (LV). Backup communication systems provide operators with the ability to contact FAA flight coordinators and ground control personnel at all times. These communication systems, in conjunction with real-time, GPS-based monitoring systems, allow the LV to be tracked at any point along its flight path. Ground personnel are thus able to accurately predict where the LV would land following a systems failure and send appropriate emergency responders and public notice to that area.

Launch facilities and flight corridors are chosen to prevent debris from impacting on or near populated areas. FAA regulation 14 CFR §431.45 requires LV and Reentry Vehicle (RV) licensees to prepare a comprehensive emergency response plan, part of which includes a method for notifying local officials as far in advance as possible in the event of an off-site or unplanned landing.

E.2 Accident on the Launch Pad

Accidents during launch usually occur after the ignition of the LV's propulsion system. For the activities considered in this PEIS, the ignition of the LV's propulsion system may take place from a ground-based or an air-based launch platform (e.g., released from support aircraft). Before a launch can take place, a flight hazard area must be established. The FAA has defined flight hazard areas as regions of land, sea, and air that are exposed to the potential adverse effects of planned and unplanned launch vehicle flight events that must be monitored, controlled, or evacuated in order to ensure public safety. Pursuant to this definition and FAA regulation 14 CFR §417.225, flight hazard areas must be protected by emergency response plans and emergency response personnel. In the event of an accident, emergency response plans must include a means for communicating information to the public, evacuating the area, and sending first responder units to the accident scene.

An explosion immediately after ignition of the LV propulsion system potentially represents the worst type of accident scenario because the LV contains the maximum amount of propellant it would carry throughout its mission, culminating in the greatest explosion possible. Debris and fragments from the explosion may be blown a significant distance from the ignition area. The distance this debris and fragments travel would depend on the amount and type of propellant aboard and the atmospheric conditions (e.g., wind speed, humidity levels, temperature, etc.) at the location of the explosion. A large smoke plume would rise (or fall depending on altitude of the accident) and drift in a downwind direction, along with particulates, potentially affecting surrounding areas. Although air quality would be the environmental resource predominantly affected, the extent of the impact depends upon atmospheric conditions and the surrounding areas. See Section 4.1 of this PEIS for a discussion of impacts on the atmosphere.

To protect public health and safety, launch site personnel are sheltered at a safe distance, as determined by FAA regulation 14 CFR §420.21 and Range Safety personnel, from the launch area and are therefore protected from an explosion. FAA regulation 14 CFR §420.21 governs the licensing of commercial LVs and requires licensees to calculate the debris dispersion radius from within the flight corridor given particular accident scenarios. Licensees, pursuant to regulation 14 CFR §415.35, must meet a risk tolerance threshold for mission risk to an individual, and to the general public and their health and safety, for falling debris generated from a worst-case accident. The process requires a probability and consequence assessment of all reasonably foreseeable hazardous events (e.g., inclement weather) and systems failures. These probabilities are incorporated into the flight corridor selection process, which helps minimize the risk to public health, safety, and property by ensuring flight paths intersect minimally populated areas.

For an air-based launch platform, an accident occurring during the initial 10 seconds after release from the carrier aircraft could likely expose the carrier aircraft to fragments, potentially causing an emergency landing, crash, or subsequent explosion. An air explosion of one or both the LV and carrier aircraft would send emissions into the ambient air similar to a ground-based launch accident. However, an explosion would disperse debris and fragments over a far greater area than a ground-based launch platform explosion. As stated, FAA regulations require a licensee to define a flight corridor for horizontal launch that minimizes the risk of falling debris to public health and/or property.

E.3 Accident during Vehicle Ascent or Descent

Vehicle ascent is defined as the period after the initial rocket engine is ignited when an LV is under power and rising through the atmosphere. Vehicle descent occurs when the vehicle is moving downward through the atmosphere in either a powered or unpowered landing approach. Accidents that may occur during vehicle ascent or descent include mechanical, electrical, or computer failures; propellant releases; or mid-air explosions, defined as an explosion during ascent or descent. FAA regulation 14 CFR §431.45 requires LV and RV licensees to prepare a comprehensive emergency response plan, part of which includes a method for notifying local officials as far in advance as possible in the event of an off-site or unplanned landing.

E.3.1 Mechanical, Electrical, or Computer Failure

Although redundant engineering of key electrical and mechanical systems aid in preventing a midair computer or mechanical failure, licensees must present methods of mitigating the impacts of a system failure during ascent or descent, per FAA guidance. In the event of a mechanical or systems failure, an emergency landing at an alternate or unforeseen landing site may be necessary. Alternate landing sites should be chosen before launch during the development of the flight corridor. Real-time tracking and monitoring of the LV's or RV's location using Global Positioning Systems (GPS), along with communication with FAA air traffic controllers, enables the determination of an instantaneous impact point (the point at which the LV or pieces of it would land in the event of a failure).

LVs retain the capability of terminating engines and aborting mission objectives in the event that a problem arises. In case of engine failure, an LV may be equipped with a variety of safety mechanisms that allow an operator to guide the vehicle without engine power to an alternate landing site to prevent the LV and its payload from reaching any populated or protected areas. Other safety features potentially employed to prevent an uncontrolled landing include the use of a precise deorbit burn by using GPS and orbital maneuvering system engines, or by using altitude propulsion systems to make trajectory corrections during guided reentry. LVs may also be equipped with safety devices such as parachutes that provide a soft landing in the event of an emergency.

Should all safety mechanisms fail to prevent an uncontrolled landing, remaining propellant may ignite, resulting in a cascading propellant explosion on the ground. During ascent, spacecrafts contain greater amounts of propellant than they hold during descent. Therefore, failures that occur during ascent that result in uncontrolled landings will create larger explosions than crashes that occur during descent.

E.3.2 Midair Explosion

FAA regulation 14 CFR §420.23 requires commercial launch licensees to design a flight corridor for the LV that minimizes risk to public health, safety, and property. Risk is minimized by ensuring the flight corridor traverses only sparsely populated areas and, in the event of a midair explosion, the debris dispersion radius falls within the flight corridor. Before a flight corridor is approved by the FAA, calculated risk estimates for public endangerment from falling debris and associated impacts must meet risk tolerance criteria for public endangerment pursuant to FAA regulations 14 CFR §417.227 and 14 CFR §420.25. If the risk level exceeds a certain threshold value, the launch is not authorized.

The extent of a midair explosion would depend on the amount of propellant the LV is carrying at the time of explosion, a factor relative to the amount of time that had elapsed after initial launch. An explosion can potentially release large amounts of emissions, debris, and fragments into the air, which would disperse within the flight corridor.

E.3.3 Accident during Reentry

FAA regulations require operators and mission control personnel to monitor and verify the status of safety-critical systems before enabling reentry flights to assure the vehicle can reenter safely to Earth. Should an anomaly cause an explosion during reentry, the ramifications would be dependent on the construction methods and materials used in the RV. However, only large pieces of debris would likely fall to Earth instead of smaller debris. Falling debris would likely remain within the flight corridor, thereby minimizing impacts to public safety, health, property, or the environment. Propellants would likely be incinerated during reentry.

RVs retain the capability of terminating engines and aborting mission objectives in the event that a problem arises. In case of engine failure, an RV may be equipped with a variety of safety mechanisms that allow an operator to guide the vehicle without engine power to an alternate landing site to prevent the RV and its payload from reaching any populated or protected area. Other safety features potentially employed to prevent an uncontrolled landing include the use of a precise deorbit burn by using GPS and orbital maneuvering system engines, or by using attitude propulsion systems to make trajectory corrections during guided reentry. RVs may also be equipped with safety devices such as parachutes that provide a soft landing in the event of an emergency.

E.4 Accidental Release of Propellant or Hazardous Substances

Accidental spills must be reported to the National Response Center within 24 hours if propellants, (i.e., fuels and oxidizers), and associated materials or other hazardous materials as defined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §101(14) (42 U.S.C. 9601.101(14)) are present on-board the RV and are spilled in volumes greater than the Reportable Quantities established by EPA under CERCLA. Spill cleanup shall then be performed in accordance with the procedures defined in the National Contingency Plan (outlined in regulation 40 CFR §300).

In the event that the RV releases any extremely hazardous substances (listed in 40 CFR Part 355), it may also be necessary to notify the State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC) established under the Emergency Planning and Community Right-to-Know Act (EPCRA, 40 CFR §355).

The site-specific impacts and specific spill response plans at the landing and recovery site(s) due to accidental propellant release are beyond the scope of this PEIS. Although license applicants will be required to submit plans that will address responding to accidental spills, impacts related to spills would be analyzed in a site-specific NEPA document that would tier from this PEIS.

E.5 Reporting Requirements

Notification must be sent to the FAA's Washington, DC Operations Center immediately following a launch or reentry accident that results in fatality or serious injury. Accidents not involving fatalities or serious injury must be reported to the FAA within 24 hours. Reports must be submitted following any report of an accident. These requirements allow the FAA to continuously upgrade safety regulations in response to problems leading to accidents.

E.6 Air Quality Impacts

This section presents impacts associated with catastrophic accidents on the launch pad, during ascent, during reentry, and during descent. Catastrophic impacts are analyzed in a separate section due to the infrequent nature of such events.

E.6.1 Catastrophic Accidents during Launch

Catastrophic accidents during launch (which include mid-air launches) would result in substantial emissions of various air pollutants. The impacts would differ from normal flights because all or the majority of the propellant would burn at the launch pad, or during the first 10 seconds after ignition. An accident during launch may impact the air quality in the atmosphere at the time of the accident. However, because of the infrequency of these events, the overall impact in comparison to other emission sources is not substantial. The impacts of accidents are typically described by propellant type. However, some LVs, especially medium- and high-capacity vehicles, may use a combination of propellant systems. Therefore, this section classifies emissions according to concept type.

Given the rapid rate of technological development and innovation occurring, predictions about which technologies or current LV models will be used over the course of the next decade are impossible. Consequently, the maximum potential emissions for each air pollutant generated from an explosion during launch were calculated for each concept type and presented in Exhibit E-1 below.

Exhibit E-1. Estimated Emissions from an Accident during Launch Based on Concept Type

Pollutant	Vehicle Type in Kilograms (Pounds)		
	Concept 1	*Concept 2*	*Concept 3*
HCl	-	-	4,124.2 (9,073.2)
Cl	-	-	29.5 (64.9)
PM	11 (24.2)	-	7,473.8 (16,442.4)
CO	772.5 (1,699.5)	1,905.2 (4,191.4)	323.0 (710.6)
CO_2	1,800.3 (3,960.7)	4,667.7 (10,268.9)	9,033.9 (19,874.6)
NO_X	0.5 (1.1)	-	94.3 (207.5)
H_2O	15.4 (33.9)	2,857.8 (6,287.2)	5,302.5 (11,665.5)
SO_X	.2 (0.44)	-	2.3 (5.1)
VOC	4.0 (8.8)	-	68.2 (150)

The HCl may combine with moisture in the air to form hydrochloric acid. This vapor may exist in hazardous quantities in the immediate vicinity of the launch pad and downwind. High wind conditions (greater than 6.4 kilometers [4 miles] per hour) and strong sunshine could dissipate HCl concentrations. HCl may also be extracted from the ambient air by moisture, causing wet deposition onto the ground, most likely within close proximity to the launch pad.

To evaluate the impacts associated with the emissions of HCl, the FAA reviewed the Level 2 Emergency Response Planning Guidelines (EPRG-2) for concentrations below which nearly all people could be exposed for one hour without irreversible or other serious health effects or symptoms that would impair their ability to take protective action.[30] For HCl, the ERPG-2 is 20 parts per million (ppm), which assumes at least one hour of exposure at this concentration level and a total dose of 1,200 ppm per minute.[31] At a wind speed of eight kilometers (five miles) per hour, modeling of the HCl emissions (2,018 kilograms [4,450 pounds]) indicated that the maximum threat zone (distance from the catastrophic accident where the concentration would be at least 20 ppm) would extend up to 3.9 kilometers (2.4 miles) downwind from the area; however, individuals at that location would only be exposed to the 20 ppm concentration for less than 10 minutes and would not receive a total dose of 1,200 ppm per minute. The model also

[30] EPA, Hydrogen Fluoride Study, Final Report to Congress, Section 112(n)(6) Clean Air Act as Amended
[31] Provided by the ALOHA program

demonstrated that the maximum distance from the test pad where an individual would be exposed to a total dose of 1,200 ppm per minute is 0.97 kilometer (0.6 mile) downwind at eight kilometers (five miles) per hour.

At a wind speed of 4.8 kilometers (3 miles) per hour, modeling of the HCl emissions (2,018 kilograms [4,450 pounds]) indicated that the maximum threat zone would extend for 3.4 kilometers (2.1 miles) downwind from the catastrophic accident; however, individuals at that location would only be exposed to the 20 ppm concentration for less than 15 minutes and would not receive a total dose of 1,200 ppm per minute. The concentration of HCl in the emission cloud would be reduced to safe levels (less than 20 ppm) within approximately 30 minutes in eight kilometers (five miles) per hour wind and 45 minutes in 4.8 kilometers (3 miles) per hour wind.

The CO_2 emissions could affect global warming, but even with the open burning of all the propellant, emissions from LV accidents would be negligible compared to the rest of the CO_2 emissions sources in the U.S. and worldwide.

Concept 3 vehicles may emit a substantial amount of particulate matter into the air during launch, which might briefly impact air quality levels. However, because Concept 3 vehicles are launched in the air, particulate matter emitted from an explosion would be quickly dissipated. The rate of dissipation would be dependent upon existing air quality conditions, humidity levels, and wind characteristics at the time of the accident.

E.6.2 Catastrophic Accidents during Ascent

Catastrophic accidents that occur during ascent produce fewer emissions at the time of the explosion than those produced from an explosion on the launch pad. Fewer emissions would result because some propellant would already have been consumed to power the LV, leaving less propellant available to combust in an explosion. The quantity of emissions generated from a mid-air explosion during ascent is thus a function of the amount of propellant consumed to reach the altitude where the explosion occurred.

To determine the quantity of emissions created by a mid-air explosion, the sum of the emissions burned during ascent prior to the accident is subtracted from the total amount of emissions that can possibly be generated from an explosion (i.e., the amount generated during an explosion on the launch pad). Metrics for calculating the amount of emissions created during ascent is presented in Exhibit E-2 below in kilograms of air pollutant per kilometer traveled for each concept vehicle. Because the amount of pollutants varied across atmospheric layers, the maximum pollutant emission rates were used in order to provide conservative estimates.

Exhibit E-2. Maximum Emission Rates for All Layers of the Atmosphere, in Kilograms of Air Pollutant per kilometer Traveled per Vehicle (kilograms/kilometer)

Vehicle	Emission Rates (kilogram/kilometer)								
	HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
Concept 1	0.0	0.0	12.0	0.55	0.22	41.2	41.8	25.6	4.38
Concept 2	0.0	0.0	0.0	0.0	0.0	26.5	1050.0	391.0	0.0
Concept 3	78.8	0.56	143.0	32.3	2.5	101.0	173.0	101.0	74.6

The amount of emissions generated prior to the accident can be subtracted from the emission rates for an explosion for each concept type found in Exhibit E-2. The impacts of these emissions are dependent upon the altitude at which the explosion occurs and the atmospheric conditions at the time of the accident. The potential effects of these air emissions are discussed briefly in Section E.6.1 above, as well as in Section 4.1 of this PEIS.

E.6.3 Catastrophic Accidents during Reentry

All emissions created from an explosion during reentry would burn in the atmosphere. Therefore, no air quality impacts are anticipated from this accident scenario.

E.6.4 Catastrophic Accidents during Descent

Only Concept 1 RVs would ignite and use engines during descent. Other concept RVs are required by regulation 14 CFR §415.39 to expel unused propellants, vent pressurized systems, and remove all forms of stored energy prior to reentry. Therefore, only Concept 1 RVs would be carrying enough propellant to support a midair explosion in the event that an electrical or mechanical problem arises during descent.

All jet engine propellant would be consumed in a midair explosion and the amount of air pollutants emitted would be dependent on the amount of unused propellant remaining prior to the accident. The amount of air pollutants generated from an explosion during descent would, however, be insignificant when compared to the daily rates of air pollutants emitted by commercial airliners across the country. Similarly, particulate matter and debris would quickly be dispersed through the air and/or fall to the Earth. The rate at which the particulate matter disperses would depend on atmospheric conditions at the time of the accident. No significant impacts are anticipated from this scenario.

APPENDIX E REFERENCES

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Department of Transportation, 2001. Final Programmatic Environmental Impact Statement for Licensing Launches (PEIS LL). Department of Transportation, Office of Commercial Space Transportation, May. Available at http://ast.faa.gov/lrra/comp_coop.htm

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APPENDIX F EMISSIONS ASSOCIATED WITH THE PROPOSED ACTION AND ALTERNATIVES AND OTHER SPACE LAUNCH ACTIVITIES

This appendix identifies the emissions/afterburning products from various propellants used in expendable and reusable launch vehicle (LV) activities. It also discusses a methodology for determining the loads of these emissions in the various atmospheric layers and provides exhibits of these loads by atmospheric layer. Finally, this appendix describes how the methodology can be linked with the categorization of LVs (e.g., payload capacity, launch method) proposed in the Programmatic Environmental Impact Statement (PEIS), and how the loads of the emissions are calculated for both the proposed action and alternative activities and other estimated future U.S. and foreign launch activities. Exhibits F-39 through F-41 provide estimates of the number of launch activities through 2015.

F.1 Methodology for Determining Per Launch/Reentry Emissions Loads in Various Atmospheric Layers

The four principal layers in the Earth's atmosphere are the troposphere, stratosphere, mesosphere, and ionosphere. They are generally defined by temperature, structure, density, composition, and degree of ionization. (DOT, 1992) The approximate altitude of these layers is provided in Exhibit F-1. The troposphere is the turbulent region where weather occurs, containing 75 percent of the total mass of the Earth's atmosphere. The troposphere is critical because any rocket emission can potentially increase ambient pollution in the air or can deposit to Earth. The stratosphere contains a critical ozone layer that protects the Earth's surface from ultraviolet (UV) radiation. Both the stratosphere and the troposphere are of most concern when considering greenhouse gases and global warming. This analysis focuses on the portion of the troposphere below 914 meters (3,000 feet) because this is the altitude range to which ambient air quality standards apply.

Exhibit F-1. Altitude Range for Various Atmospheric Layers

	Troposphere	Stratosphere	Mesosphere	Ionosphere
Altitude Range in Kilometers (Miles)	Surface to 10 (6.2)	10 to 50 (6.2 to 31)	50 to 80 (31 to 50)	80 to 1,000 (50 to 621)

LVs used to transport payloads or passengers into space would be propelled through several layers of the atmosphere including the troposphere, stratosphere, mesosphere, and ionosphere. The load of the emissions in each of these atmospheric layers depends on the stage firing, engine type, type of propellant, burn rate of propellant, and residence time in the atmospheric layer. In developing the following methodology, the FAA initially focused on the tropospheric and the stratospheric layers that are generally viewed with greater environmental concern.

Total emissions associated with the proposed action and alternatives and other space launch activities were estimated by completing the following steps:

- Estimating the emissions per launch or reentry into each layer of the atmosphere for each type of vehicle;

- Estimating the total annual launches and reentries for each type of vehicle; and
- Multiplying the number of launches and reentries by the appropriate emissions per launch or reentry.

The following sections describe the methodologies used to complete these steps for both the proposed action and alternative activities and other estimated future U.S. and foreign launch activities.

F.2 Emissions Associated with Proposed Action and Alternative Activities

This PEIS considers three types (or concepts) of horizontal LVs. Concept 1 vehicles would take off from a runway under jet power and would ignite rocket engines at a specified altitude. Concept 2 vehicles would take off from a runway under rocket power. Concept 3 vehicles would take off from a runway while mated to a jet-powered assist aircraft and would ignite rocket engines at a specified altitude after being released from the assist aircraft. For Concept 1 and Concept 3 vehicles, the emissions generated by jet engines were calculated separately from rocket emissions, as described below.

A range of different types of Concept 2 and 3 vehicles with different propellant types, flight characteristics, and emission profiles is anticipated. In light of this, the FAA included several different types of Concept 2 and 3 vehicles in this assessment to represent this range of vehicle types. The characteristics of these vehicles were developed from launch data provided on the X Prize web site (http://www.xprize.com) and from other publicly available data on LV characteristics. A brief overview of each of these vehicles is provided in Exhibit F-2.

F.2.1 Jet Engine Launch Emissions

To estimate jet engine emissions per launch for each vehicle, the FAA used emission factors (e.g., amount of releases per take off/landing cycle) based on the type and number of engines being used. Exhibit F-3 provides the total emissions below 914 meters (3,000 feet) per take off/landing cycle[32] for each representative vehicle type. As noted above, several different types of support aircraft can carry the horizontal LVs and Exhibit F-3 provides emissions for the representative aircraft included in this analysis. Emissions from jet engines would also occur above 914 meters (3,000 feet). However, jet engine emissions above 914 meters (3,000 feet) from the fairly limited number of Concept 1 and Concept 3 flights and jet-powered landings would be very small relative to the number of annual jet aircraft flights in the U.S., and therefore these emissions are not included in the overall emission estimates. Exhibit F-9 provides the total emissions per launch, including both jet engine and rocket emissions, to each layer of the atmosphere for each vehicle type included in this analysis.

[32] The take off/landing cycle includes idle, takeoff, climb out to 914 meters (3,000 feet), descent starting at 914 meters (3,000 feet), approach, and landing.

Exhibit F-2. Overview of Launch and Reentry Vehicle Types

Vehicle Type	Rocket Propellant Type	Notes
Concept 1		
Vehicle Type A	LOX/Kerosene	Jet engine ignited for lift off; rocket engine ignited at approx. 6,000 meters (m) (20,000 feet [ft]); jet engines stop at 24,000 m (80,000 ft) and rocket engines stop at 46,000 m (150,000 ft); landing powered by reigniting jet engines
Concept 2		
Vehicle Type B	LOX/Kerosene	Rocket engine ignited for lift off; no jet engine; rocket engines stop at 61,000 m (200,000 ft); unpowered landing
Vehicle Type C	LOX/Kerosene	Similar to Vehicle Type B, but two times larger; landing powered by reigniting rocket engines
TBD Vehicle	LOX/Kerosene	Emissions assumed to be equivalent to the average of the Concept 2 vehicle emissions (weighted based on the number of launches of each type of Concept 2 vehicle from 2005-2015).
Concept 3		
Vehicle Type D	N_2O/HTPB	Jet-powered carrier vehicle; rocket engine ignited at 15,000 m (50,000 ft) and burns for approximately one minute; unpowered landing
Vehicle Type E	Solid	Jet-powered carrier vehicle; two-stage rocket engine; stage 1 ignited at 12,000 m (40,000 ft) and burns out at 52,000 m (170,000 ft); stage 2 ignited at 52,000 m (170,000 ft) and burns out at 140,000 m (450,000 ft); unpowered landing
Vehicle Type F	N_2O/HTPB, Solid	Jet-powered carrier vehicle; two-stage rocket engine; stage 1 (powered by N_2O/HTPB) ignited at 61,000 m (200,000 ft) and burns out at 140,000 m (450,000 ft); stage 2 (powered by solid propellant) ignited at 140,000 m (450,000 ft) and burns out at 162,000 m (530,000 ft); unpowered landing
TBD Vehicle	N_2O/HTPB, Solid	Emissions assumed to be equivalent to the average of the Concept 3 vehicle emissions (weighted based on the number of launches of each type of Concept 3 vehicle from 2005-2015)
Landing		

Vehicle Type	Rocket Propellant Type	Notes
Reentry Vehicle Landing Using Rocket Engines	LOX/LH_2	Assumed vehicle would use parachutes to slow its descent, engines would be ignited approximately 3,000 m (10,000 ft) from the ground, and one-fourth of the vehicle's propellant capacity would be consumed at a constant rate until it reached the ground.
Reentry Vehicle Landing Using Jet Engines	n/a	Emissions assumed to be equivalent to one-half of the jet engine emissions of Vehicle Type A

Exhibit F-3. Jet Engine Emissions per Take Off/Landing Cycle Below 914 meters (3,000 feet)

Vehicle Type	Emissions, kilograms (pounds)					Source
	CO	NO_X	VOC	SO_X	PM	
Vehicle Type A (Concept 1)	38 (83)	0.48 (1.1)	4.0 (8.8)	0.17 (0.37)	11 (24)	a
Vehicle Type D (Concept 3)	38 (83)	0.55 (1.2)	5.2 (12)	0.28 (0.62)	11 (24)	b
Vehicle Type E (Concept 3)	92 (203)	29 (64)	68 (150)	2.3 (5.1)	11 (24)	c
Vehicle Type F (Concept 3)	18 (40)	8.3 (18)	2.3 (5.1)	1.5 (3.3)	0.16 (0.35)	d

[a] CO, NO_X, VOC, SO_X for Learjet 25c (EDMS, 2004); no PM emissions were specified for Learjet 25c so it was assumed that the particulates were similar to F-14 Tomcat (EPA, 1980).
[b] CO, NO_X, VOC, SO_X for T-38 Tiger (EPA, 1980); no PM emissions were specified for T-38 Tiger so it was assumed that the particulates were similar to F-14 Tomcat (EPA, 1980).
[c] For L-1011 (3 Rolls Royce engines RB-211-22B) (EPA, 1980).
[d] Information for F-15 obtained at: http://www.aacog.dst.tx.us/naturalresources/1996%20Emissions%20Inventory/1996EI_AirMilitary.html#RandolphAir, Last accessed: November 9, 2004

F.2.2 Rocket Launch Emissions

To estimate rocket emissions per launch for each vehicle, the FAA estimated the propellant consumed in each atmospheric layer and then multiplied these estimates by propellant-specific emission weight fractions for each pollutant. The propellant consumed in each atmospheric layer for each vehicle type was estimated using available data on the total propellant used by that vehicle type and the percentage of time spent in each layer. When vehicle-specific data were not available, the FAA used data for a similar vehicle. The propellant type and estimated propellant consumption in each atmospheric layer for each representative vehicle type are provided in Exhibit F-4. Exhibits F-5 through F-7 present the emission weight fractions for the three rocket propellant types used in the LVs being evaluated in this PEIS. The estimated emissions per launch (from both rockets and jet engines) for each vehicle are presented in Exhibit F-9.

Exhibit F-4. Estimated Propellant Consumption by Atmospheric Layer

Vehicle Type	Rocket Propellant Type	Rocket Propellant Consumption, kilograms (pounds)				
		< 914 meters (3,000 feet)	Troposphere	Stratosphere	Mesosphere	Ionosphere
Vehicle Type A (Concept 1)	LOX/ Kerosene	-	432 (952)	3,242 (7,147)	-	-
Vehicle Type B (Concept 2)	LOX/ Kerosene	595 (1,312)	1,191 (2,626)	2,580 (5,688)	992 (2,187)	-
Vehicle Type C (Concept 2)	LOX/ Kerosene	1,191 (2,626)	2,382 (5,251)	5,160 (11,376)	1,985 (4,376)	-
Vehicle Type D (Concept 3)	N_2O/HTPB	-	-	1,523 (3,358)	-	-
Vehicle Type E (Concept 3)	Solid	-	-	15,014 (33,100)	1,531 (3,375)	3,094 (6,821)
Vehicle Type F[a] (Concept 3)	N_2O/HTPB	-	-	-	169 (373)	1,354 (2,985)
	Solid	-	-	-	436 (961)	3,489 (7,692)

[a] Vehicle Type F (Concept 3) uses two types of rocket propellants; the consumption of each propellant is reported separately.

Exhibit F-5. Emission Weight Fractions for LOX and Kerosene Rocket Propellant Emissions

CO_2	CO	H_2O
0.49	0.20	0.30

Source: DOT, 2002

Exhibit F-6. Emission Weight Fractions for N_2O and HTPB Rocket Propellant Emissions

CO_2	CO	N_2	H_2O	PM[a]
0.03	0.20	0.54	0.22	

Source: Information in U.S. Department of Navy, 1996

[a] The available emissions factors for these rocket engines do not include PM emissions. N_2O/HTPB engines are expected to generate particulate matter emissions (Wright, et al, 2005; Chouinard, et al, 2002); however, analyses of other vehicle types with higher PM emissions than would be expected from vehicles with these engine types indicate these emissions have no significant impact; thus, any PM emissions from vehicles with these engine types are expected to have negligible impact.

Exhibit F-7. Emission Weight Fractions for Solid Rocket Propellant Emissions

HCl	PM[a]	Cl	CO_2[b]	CO[b]	NO_2	H_2O
0.21	0.38	0.0015	0.46	-	0.0033	0.27

Source: DOT, 2001 (Appendix A)
[a] As Al_2O_3.
[b] In the mesosphere and ionosphere, where the oxidation reaction is less likely to occur because of the lack of oxygen, the weight fractions at the exhaust nozzle are 0.23 for CO and 0.03 for CO_2.

F.2.3 Reentry Emissions

To estimate emissions from reentry vehicles (RVs), the FAA first assumed that one-half of reentries would not have powered landings. For the remaining reentries, the FAA assumed that one-half would have jet-powered landings and one-half would have rocket powered landings. The jet emissions per flight were estimated by assuming the RV would be similar to the jet emissions from the Concept 1 vehicle (i.e., Vehicle Type A). Because the Concept 1 emissions presented in Exhibit F-3 represent emissions during the full take off/landing cycle, the FAA assumed that the emissions during reentry would be one-half of the total emissions during the full take off/landing cycle. The rocket emissions per flight were estimated by assuming the RV would be similar to a representative RV with rocket-powered engines used for landing. This vehicle is powered by a LOX/LH_2-fueled engine and has a propellant capacity of 9,800 kilograms (21,605 pounds). (Encyclopedia Astronautica, 2004) Based on flight test data for a representative RV using rocket-engines to land, and the assumption that the vehicle would use parachutes to slow its descent, the FAA assumed that the engines would be ignited approximately 3,000 meters (9,843 feet) from the ground[33] and would consume one-fourth of the vehicle's propellant capacity (2,450 kilograms [5,401 pounds]) at a constant rate until it reached the ground. The emission weight fractions the FAA used for LOX/LH_2 are provided in Exhibit F-8. The estimated emissions per flight for RVs using jet- and rocket-engines to land are provided in Exhibit F-9.

Exhibit F-8. Emission Weight Fractions for LOX and LH_2 Rocket Propellant Emissions

CO_2	CO	H_2O
-	-	0.95

Source: DOT, 2001 (Appendix A)

[33] The ignition altitude was estimated based on information about reentry characteristics of a representative reusable launch vehicle. The vehicle proposed to use a parachute to slow progress during reentry prior to landing (although it proposed a fully unpowered reentry). During reentry, it proposed to release a stabilization parachute at 24,380 meters (80,000 feet). Following deployment of the stabilization parachute, at 6,100 meters (20,000 feet) a drogue parachute would be deployed. Finally, the main parachutes would be deployed at 3,962 meters (13,000 feet). FAA assumed that parachutes, similar to the ones proposed by the vehicle, are used during upper atmosphere reentry and thus it is reasonable to assume that powered descent would begin around 3,000 meters (9,843 feet). (DOT, 2002)

Exhibit F-9. Total Emission Load for Launch or Reentry for Proposed Action and Alternatives by Vehicle

Vehicle Type (Concept)	Emission Loads per Launch/Reentry (kilograms)								
	HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
Vehicle Type A (1)	-	-	11.0	0.5	0.2	37.7	-	-	4.0
Vehicle Type B (2)	-	-	-	-	-	-	478.4	178.6	-
Vehicle Type C (2)	-	-	-	-	-	-	957.6	357.2	-
TBD Vehicle (2)[a]	-	-	-	-	-	-	792.1	295.5	-
Vehicle Type D (3)	-	-	11.0	0.6	0.3	38.0	-	-	5.2
Vehicle Type E (3)	-	-	11.0	29.5	2.3	92.5	-	-	68.2
Vehicle Type F (3)	-	-	0.2	8.3	1.4	18.4	-	-	2.3
TBD Vehicle (3)[b]	-	-	10.5	2.5	0.4	40.1	-	-	8.5
Reentry Vehicle - Rocket	-	-	-	-	-	-	-	709	-
Reentry Vehicle - Jet	-	-	5.5	0.24	0.09	18.8	-	-	-
Vehicle Type A (1)	-	-	11.0	0.5	0.2	124.1	211.8	129.7	4.0
Vehicle Type B (2)	-	-	-	-	-	-	957.5	357.2	-
Vehicle Type C (2)	-	-	-	-	-	-	1,914.7	714.5	-
TBD Vehicle (2)[a]	-	-	-	-	-	-	1584.2	591.1	-
Vehicle Type D (3)	-	-	11.0	0.6	0.3	38.0	-	-	5.2
Vehicle Type E (3)	-	-	11.0	29.5	2.3	92.5	-	-	68.2
Vehicle Type F (3)	-	-	0.2	8.3	1.4	18.4	-	-	2.3
TBD Vehicle (3)[b]	-	-	10.5	2.5	0.4	40.1	-	-	8.5
Reentry Vehicle - Rocket	-	-	-	-	-	-	-	2,328	-
Reentry Vehicle - Jet	-	-	5.5	0.24	0.09	18.8	-	-	-
Vehicle Type A (1)	-	-	-	-	-	648.4	1,588.5	972.6	-
Vehicle Type B (2)	-	-	-	-	-	516.0	1,264.2	774.0	-
Vehicle Type C (2)	-	-	-	-	-	1,032.0	2,528.4	1,548.0	-
TBD Vehicle (2)[a]	-	-	-	-	-	853.8	2,091.8	1,280.7	-
Vehicle Type D (3)	-	-	-	-	-	304.6	45.7	335.1	-
Vehicle Type E (3)	3,152.9	22.5	5,705.3	49.5	-	-	6,906.4	4,053.8	-
Vehicle Type F (3)	-	-	-	-	-	-	-	-	-
TBD Vehicle (3)[b]	171.4	1.2	310.1	2.7	-	274.8	416.6	522.6	-

Exhibit F-9. Total Emission Load for Launch or Reentry for Proposed Action and Alternatives by Vehicle

Vehicle Type (Concept)	Emission Loads per Launch/Reentry (kilograms)								
	HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
Reentry Vehicle - Rocket	-	-	-	-	-	-	-	-	-
Reentry Vehicle - Jet	-	-	-	-	-	-	-	-	-
Vehicle Type A (1)	-	-	-	-	-	-	-	-	-
Vehicle Type B (2)	-	-	-	-	-	198.5	486.2	297.7	-
Vehicle Type C (2)	-	-	-	-	-	396.9	972.4	595.4	-
TBD Vehicle (2)[a]	-	-	-	-	-	328.4	804.6	492.6	-
Vehicle Type D (3)	-	-	-	-	-	-	-	-	-
Vehicle Type E (3)	321.5	2.3	581.7	5.1	-	352.1	45.9	413.3	-
Vehicle Type F (3)	91.6	0.7	165.7	1.4	-	134	18	155.0	-
TBD Vehicle (3)[b]	21.5	0.2	38.8	0.3	-	25.0	3.3	29.2	-
Reentry Vehicle - Rocket	-	-	-	-	-	-	-	-	-
Reentry Vehicle - Jet	-	-	-	-	-	-	-	-	-
Vehicle Type A (1)	-	-	-	-	-	-	-	-	-
Vehicle Type B (2)	-	-	-	-	-	-	-	-	-
Vehicle Type C (2)	-	-	-	-	-	-	-	-	-
TBD Vehicle (2)[a]	-	-	-	-	-	-	-	-	-
Vehicle Type D (3)	-	-	-	-	-	-	-	-	-
Vehicle Type E (3)	649.8	4.6	1,175.8	10.2	-	711.7	92.8	835.4	-
Vehicle Type F (3)	732.7	5.2	1,325.8	11.5	-	1,073.3	145.3	1,239.8	-
TBD Vehicle (3)[b]	67.2	0.5	121.5	1.1	-	85.3	11.4	99.3	-
Reentry Vehicle - Rocket	-	-	-	-	-	-	-	-	-
Reentry Vehicle - Jet	-	-	-	-	-	-	-	-	-

[a] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 2 vehicle emissions (weighted based on the number of launches of each type of Concept 2 vehicle between 2005-2015).

[b] Because these vehicles have yet to be identified, it was assumed that the per launch emissions were equal to the average of the Concept 3 vehicle emissions (weighted based on the number of launches of each type of Concept 3 vehicle between 2005-2015).

Emissions below 3,000 feet and to the Ionosphere

The annual launch and reentry emissions to the atmosphere below 914 meters (3,000 feet) and to the ionosphere associated with the proposed action and alternatives are presented in Exhibits F-10 through F-27. Exhibits F-10 through F-27 present the annual emissions of HCl, Cl, PM, NO_X, SO_X, CO, CO_2, H_2O, and VOC to the to the atmosphere below 914 meters (3,000 feet) and to the ionosphere. As discussed in Section 4 of the PEIS, emissions to the ionosphere are considered negligible because the emissions would be both short lived and occur relatively infrequently. Emissions to the atmosphere below 914 meters (3,000 feet) are broken out here because ground level ambient air quality is only affected by emissions up to 914 meters (3,000 feet) above ground surface. The emissions to the troposphere, stratosphere and mesosphere associated with the proposed action and alternatives are presented as part of the cumulative impact analyses in Exhibits F-44 to F-70.

Exhibit F-10. Estimated Annual HCl Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual HCl Emissions			0	0	0	0	0	0	0	0	0	0	0

Exhibit F-11. Estimated Annual Cl Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual Cl Emissions			0	0	0	0	0	0	0	0	0	0	0

Exhibit F-12. Estimated Annual PM Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	110	550	550	550	825	550	550	550	550	550
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	66	88	110	110	88	77	66	77	77	77	77
	Concept 3	Vehicle Type E	11	-	-	11	-	-	11	-	11	-	11
	Concept 3	Vehicle Type F	-	-	-	-	< 1	-	< 1	-	< 1	-	< 1
	Concept 3	TBD Vehicle	-	-	11	53	158	158	210	210	210	210	210
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	1	3	6	10	14	17	21
Total Annual PM Emissions			77	198	671	724	797	1,063	843	847	862	854	869

Exhibit F-13. Estimated Annual NO_X Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	5	25	25	25	38	25	25	25	25	25
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	4	5	6	6	5	4	4	4	4	4	4
	Concept 3	Vehicle Type E	30	-	-	30	-	-	30	-	30	-	30
	Concept 3	Vehicle Type F	-	-	-	-	8	-	8	-	8	-	8
	Concept 3	TBD Vehicle	-	-	3	13	38	38	50	50	50	50	50
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	< 1	< 1	< 1	< 1	1	1	1
Total Annual NO_X Emissions			34	10	34	74	76	80	117	79	118	80	118

Exhibit F-14. Estimated Annual SO_X Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	2	10	10	10	15	10	10	10	10	10
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	2	2	3	3	2	2	2	2	2	2	2
	Concept 3	Vehicle Type E	2	-	-	2	-	-	2	-	2	-	2
	Concept 3	Vehicle Type F	-	-	-	-	1	-	1	-	1	-	1
	Concept 3	TBD Vehicle	-	-	< 1	2	6	6	8	8	8	8	8
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Total Annual SO_X Emissions			4	4	13	17	19	23	23	20	23	20	23

Exhibit F-15. Estimated Annual CO Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	377	1,885	1,885	1,885	2,828	1,885	1,885	1,885	1,885	1,885
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	228	304	380	380	304	266	228	266	266	266	266
	Concept 3	Vehicle Type E	93	-	-	93	-	-	93	-	93	-	93
	Concept 3	Vehicle Type F	-	-	-	-	18	-	18	-	18	-	18
	Concept 3	TBD Vehicle	-	-	40	201	602	602	802	802	802	802	802
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	5	9	19	33	47	56	71
Total Annual CO Emissions			321	681	2,305	2,559	2,814	3,705	3,045	2,986	3,111	3,009	3,135

Exhibit F-16. Estimated Annual CO_2 Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	CO2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	2,392	14,352	14,352	19,136	9,568	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	1,915	9,576	19,152	28,728	33,516	33,516	33,516	33,516	33,516
	Concept 2	TBD Vehicle	-	-	1,584	3,961	9,505	19,803	19,803	23,763	23,763	27,724	31,684
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO_2 Emissions			2,392	14,352	17,851	32,673	38,225	48,531	53,319	57,279	57,279	61,240	65,200

Exhibit F-17. Estimated Annual H_2O Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	893	5,358	5,358	7,144	3,572	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	714	3,572	7,144	10,716	12,502	12,502	12,502	12,502	12,502
	Concept 2	TBD Vehicle	-	-	591	1,478	3,546	7,388	7,388	8,865	8,865	10,343	11,820
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	177	355	709	1,241	1,773	2,127	2,659
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual H_2O Emissions			893	5,358	6,663	12,194	14,439	18,459	20,599	22,608	23,140	24,972	26,981

Exhibit F-18. Estimated Annual VOC Emission Loads Below 914 Meters (3,000 Feet)

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	40	200	200	200	300	200	200	200	200	200
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	31	42	52	52	42	36	31	36	36	36	36
	Concept 3	Vehicle Type E	68	-	-	68	-	-	68	-	68	-	68
	Concept 3	Vehicle Type F	-	-	-	-	2	-	2	-	2	-	2
	Concept 3	TBD Vehicle	-	-	9	43	128	128	170	170	170	170	170
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual VOC Emissions			99	82	261	363	372	464	471	406	476	406	476

Exhibit F-19. Estimated Annual HCl Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	650	-	-	650	-	-	650	-	650	-	650
	Concept 3	Vehicle Type F	-	-	-	-	733	-	733	-	733	-	733
	Concept 3	TBD Vehicle	-	-	67	336	1,008	1,008	1,344	1,344	1,344	1,344	1,344
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual HCl Emission			650	0	67	986	1,741	1,008	2,727	1,344	2,727	1,344	2,727

Exhibit F-20. Estimated Annual Cl Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	5	-	-	5	-	-	5	-	5	-	5
	Concept 3	Vehicle Type F	-	-	-	-	5	-	5	-	5	-	5
	Concept 3	TBD Vehicle	-	-	1	3	8	8	10	10	10	10	10
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual Cl Emissions			5	0	1	8	13	8	20	10	20	10	20

Exhibit F-21. Estimated Annual PM Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	1,176	-	-	1,176	-	-	1,176	-	1,176	-	1,176
	Concept 3	Vehicle Type F	-	-	-	-	1,326	-	1,326	-	1,326	-	1,326
	Concept 3	TBD Vehicle	-	-	122	608	1,823	1,823	2,430	2,430	2,430	2,430	2,430
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual PM Emissions			1,176	0	122	1,784	3,149	1,823	4,932	2,430	4,932	2,430	4,932

Exhibit F-22. Estimated Annual NO_X Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	10	-	-	10	-	-	10	-	10	-	10
	Concept 3	Vehicle Type F	-	-	-	-	12	-	12	-	12	-	12
	Concept 3	TBD Vehicle	-	-	1	6	17	17	22	22	22	22	22
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual NO_X Emissions			10	0	1	16	29	17	44	22	44	22	44

Exhibit F-23. Estimated Annual SO_X Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual SO_X Emissions			0	0	0	0	0	0	0	0	0	0	0

Exhibit F-24. Estimated Annual CO Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	712	-	-	712	-	-	712	-	712	-	712
	Concept 3	Vehicle Type F	-	-	-	-	1,073	-	1,073	-	1,073	-	1,073
	Concept 3	TBD Vehicle	-	-	85	427	1,280	1,280	1,706	1,706	1,706	1,706	1,706
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO Emissions			712	0	85	1,139	2,353	1,280	3,491	1,706	3,491	1,706	3,491

Exhibit F-25. Estimated Annual CO_2 Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	CO2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	93	-	-	93	-	-	93	-	93	-	93
	Concept 3	Vehicle Type F	-	-	-	-	145	-	145	-	145	-	145
	Concept 3	TBD Vehicle	-	-	11	57	171	171	228	228	228	228	228
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO_2 Emissions			93	0	11	150	316	171	466	228	466	228	466

Exhibit F-26. Estimated Annual H_2O Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	835	-	-	835	-	-	835	-	835	-	835
	Concept 3	Vehicle Type F	-	-	-	-	1,240	-	1,240	-	1,240	-	1,240
	Concept 3	TBD Vehicle	-	-	99	497	1,490	1,490	1,986	1,986	1,986	1,986	1,986
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual H_2O Emissions			835	0	99	1,332	2,730	1,490	4,061	1,986	4,061	1,986	4,061

Exhibit F-27. Estimated Annual VOC Emission Loads to the Ionosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual VOC Emissions			0	0	0	0	0	0	0	0	0	0	0

F.2.4 Emissions Associated with Other Launch and Reentry Activities

To estimate per launch emissions from other past, present and reasonably foreseeable launches and reentries performed by other U.S. governmental agencies, foreign countries, foreign commercial enterprises, as well as commercially launched vertical LVs, the FAA followed the same basic approach used in estimating per launch and reentry emissions for the proposed action and alternative activities. However, it was not feasible to estimate the emissions on a vehicle-by-vehicle basis due to the number of different types of launch and reentry vehicles that could be used in launches and reentries performed by other government agencies or other countries. Instead, LVs were grouped into five classifications based on vehicle type and payload capacity (presented in Exhibit F-28), and then per launch emissions in each atmospheric layer per launch/reentry were estimated for each classification.

Exhibit F-28. Launch Vehicle Categories

Vehicle Classification	Type	Payload Mass[a] in kilograms (pounds)
Suborbital	Suborbital	270 kilograms (594 pounds)
Small	Orbital	<907 kilograms (<2,000 pounds) GTO or <2,268 kilograms (< 5,000 pounds) LEO
Medium	Orbital	907-1,814 kilograms (2,000-3,999 pounds) GTO or 2,268-6,804 kilograms (5,000-15,000 pounds) LEO
Intermediate	Orbital	1,814-4,082 kilograms (4,000-8,999 pounds) GTO or +6,804 kilograms (+15,000 pounds) LEO
Heavy	Orbital	4,082-4,536 kilograms+ (9,000-10,000+ pounds) GTO

[a] GTO = Geosynchronous transfer orbit; LEO = Low Earth orbit

Orbital Launch Emissions

The FAA estimated orbital launch emissions in each atmospheric layer for each vehicle classification based on the propellant consumed in the layer and the propellant type. For each category/propellant type combination, the FAA estimated the amount of propellant consumed in each atmospheric layer. These estimates, which are summarized in Exhibit F-29, are based on estimates for these vehicles from the 2001 PEIS for Licensing Launches. (DOT, 2001) These estimates assume residence times of 60 seconds in the troposphere, 60 seconds in the stratosphere, and 50 seconds in the mesosphere. Propellant consumptions in the ionosphere were not calculated. The FAA then estimated emissions per flight in each atmospheric layer for each category/propellant type combination by multiplying the propellant consumption by the appropriate emission weight fractions. The FAA used the emission weight fractions used in estimating horizontal LV and reentry emissions to the extent possible. Emission weight fractions for the remaining propellant types are provided in Exhibits F-30 through F-34.

Exhibit F-29. Estimated Propellant Consumption for Orbital Launches by Atmospheric Layer

Vehicle Classification[a]	Propellant Type	Propellant Consumption Per Launch (kilograms)		
		Troposphere	Stratosphere	Mesosphere
U.S. Commercial				
Small	Solid	37,500	37,500	5,000
Medium	Solid	45,000	45,000	17,500
	Solid/LOX-RP-1	-	-	17,500
	Solid/Hypergol	-	-	17,500
Heavy	Solid	210,000	210,000	55,000
	Solid/ LOX-RP-1	210,000	210,000	55,000
	LOX-RP-1	-	-	55,000
	Hybrid	210,000	210,000	55,000
	Hypergol	-	-	55,000
U.S. Government				
Small	Solid	37,500	37,500	5,000
Medium	Solid	45,000	45,000	17,500
	Solid/LOX-RP-1	-	-	17,500
	Solid/Hypergol	-	-	17,500
Heavy	Solid	242,000	242,000	-
	LOX-H_2	586,000	586,000	70,000
	Hypergol	-	-	43,000
Foreign Government and Foreign Commercial				
Small	Solid	50,000	50,000	5,000
Medium	Solid	65,000	65,000	10,000
	LOX-RP-1	-	-	10,000
	Hypergol	-	-	10,000
Intermediate	Solid	80,000	80,000	-
	Hybrid	80,000	80,000	12,000
	Hypergol	-	-	12,000
Heavy	Solid/ LOX-LH_2	90,000	90,000	-
	Solid/Hypergol	140,000	140,000	-
	LOX-RP-1	130,000	130,000	90,000
	Hybrid	130,000	130,000	90,000
	Hypergol	140,000	140,000	82,000

Source: DOT, 2001

[a] There are no anticipated U.S. commercial or U.S. government launches of "Intermediate" vehicles from 2005-2015; thus there are no data for these vehicles in this exhibit.

Exhibit F-30. Emission Weight Fractions for LOX and RP-1 Propellant Emissions

CO_2[a]	CO[a]	OH	H_2O
0.931	-	0.035	0.25

Source: DOT, 2001 (Appendix A)

[a] In the mesosphere and ionosphere, where the oxidation reaction is less likely to occur because of the lack of oxygen, the weight fractions at the exhaust nozzle are 0.44 for CO and 0.24 for CO_2.

Exhibit F-31. Emission Weight Fractions for Solid/Liquid Hydrocarbon (Solid/LOX-RP-1) Propellant Emissions

HCl	PM[a]	Cl	CO_2[b]	CO[b]	NO_2	H_2O	OH
0.105	0.19	0.0015	0.7	-	0.0017	0.26	0.017

Source: DOT, 2001 (Appendix A)

[a] As Al_2O_3.

[b] In the mesosphere and ionosphere, where the oxidation reaction is less likely to occur because of the lack of oxygen, the weight fractions at the exhaust nozzle are 0.34 for CO and 0.13 for CO_2.

Exhibit F-32. Emission Weight Fractions for Liquid Hypergolic (N_2O_4-Aerozine 50) Propellant Emissions

CO_2[b]	CO[b]	NO_2	H_2O
0.22	-	1.36	0.35

Source: DOT, 2001 (Appendix A)

[a] As Al_2O_3.

[b] In the mesosphere and ionosphere, where the oxidation reaction is less likely to occur because of the lack of oxygen, the weight fractions at the exhaust nozzle are 0.03 for CO and 0.18 for CO_2.

Exhibit F-33. Emission Weight Fractions for Solid/Liquid Hypergolic Propellant Emissions

HCl	PM[a]	Cl	CO_2	CO[b]	NO_2[b]	N_2	H_2O
0.105	0.185	0.001	0.1	-	0.190	0.21	0.31

Source: DOT, 2001 (Appendix A)

[a] As Al_2O_3.

[b] In the mesosphere and ionosphere, where the oxidation reaction is less likely to occur because of the lack of oxygen, the weight fractions at the exhaust nozzle are 0.13 for CO and 0.02 for NO_2.

Exhibit F-34. Emission Weight Fractions for Solid/LOX-LH_2 Propellant Emissions

HCl	PM[a]	Cl	CO_2	N_2	H_2O
0.106	0.19	0.001	0.231	0.042	0.75

Source: DOT, 2001 (Appendix A)

[a] As Al_2O_3.

Exhibit F-35. Estimated Propellant Consumption for Suborbital Launches by Atmospheric Layer

Representative Vehicle	Propellant Type	Propellant Consumption Per Flight, Kilograms (Pounds)		
		Troposphere	Stratosphere	Mesosphere
LV-1	LOX-RP-1	951 (2,097)	3,803 (8,384)	512 (1,129)
LV-2	LOX-RP-1	3,204 (7,064)	6,546 (14,430)	-

Suborbital Launch Emissions

For U.S. Commercial suborbital vertical launches, the FAA used three different representative types of vehicles for our assumptions, designated as LV-1, LV-2, and LV-3. The FAA assumed all other suborbital launches (U.S. Government, Foreign Commercial, and Foreign Government) were similar to the LV-1. For the LV-1 and LV-2, the FAA used launch data from the X Prize web site (http://www.xprize.com) and assumed that the vehicle traveled at a constant rate until engine cut-off to estimate the propellant consumed in each atmospheric layer. The estimated propellant used in each atmospheric layer for these two vehicles is provided in Exhibit F-35. Because both vehicles used LOX-RP-1 propellant, the FAA used the emission weight fractions in Exhibit F-30 to estimate the emissions per flight in each atmospheric layer. For LV-3, the FAA used estimates of emissions per launch in NASA's Supplemental EIS for Sounding Rocket Program. (NASA, 1998) This vehicle is estimated to use all of its propellant by the time it reaches 30 kilometers (18.6 miles), so FAA assumed that one-half of these emissions occur in the troposphere and one-half occur in the stratosphere. The estimated emissions per flight for all three suborbital vehicles are provided in Exhibits F-36 through F-38.

Reentry Emissions

To estimate reentry vehicle emissions, the FAA assumed that all reentries with powered landings were similar to either the jet-powered or rocket-powered landing used in estimating reentry emissions for the launches associated with the proposed action and alternatives. The emissions per reentry for these two vehicle types are presented in Exhibits F-36 through F-38.

Exhibit F-36. Estimated Emission Loads to the Troposphere per Other Launch or Reentry

			Emission Loads per Launch/Reentry (kilograms)								
Category	Vehicle Classification	Propellant Type or Representative Vehicle	**HCl**	**Cl**	**PM**	**NO_X**	**SO_X**	**CO**	**CO_2**	**H_2O**	**VOC**
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs and RVs)	Small	Solid	7,875	56	14,250	124	-	-	17,250	10,125	-
	Medium	Solid	9,450	68	17,100	149	-	-	20,700	12,150	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid	44,100	315	79,800	693	-	-	96,600	56,700	-
		Solid/LOX-RP-1	22,050	315	39,900	357	-	-	147,000	54,600	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	195,510	52,500	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	885	238	-
		LV-2	-	-	-	-	-	-	2,983	801	-
		LV-3	94	-	179	-	1	144	7	20	-
	Reentry	Jet-powered landing	-	-	5.5	0.24	0.09	18.8	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	2,328	-
U.S. Government	Small	Solid	7,875	56	14,250	124	-	-	17,250	10,125	-
	Medium	Solid	9,450	68	17,100	149	-	-	20,700	12,150	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid	50,820	363	91,960	799	-	-	111,320	65,340	-
		LOX-LH_2	-	-	-	-	-	-	-	556,700	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	885	238	-

Exhibit F-36. Estimated Emission Loads to the Troposphere per Other Launch or Reentry

			Emission Loads per Launch/Reentry (kilograms)								
Category	Vehicle Classification	Propellant Type or Representative Vehicle	**HCl**	**Cl**	**PM**	**NO_X**	**SO_X**	**CO**	**CO_2**	**H_2O**	**VOC**
	Reentry	Jet-powered landing	-	-	5.5	0.24	0.09	18.8	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	2,328	-
Foreign Commercial and Foreign Government	Small	Solid	10,500	75	19,000	165	-	-	23,000	13,500	-
	Medium	Solid	13,650	98	24,700	215	-	-	29,900	17,550	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Intermediate	Solid	16,800	120	30,400	264	-	-	36,800	21,600	-
		Hybrid	-	-	-	-	-	-	74,480	20,000	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid/ $LOX\text{-}LH_2$	9,500	125	17,125	-	-	-	20,750	67,500	-
		Solid/Hypergol	14,700	200	25,900	26,600	-	-	14,000	43,400	-
		LOX-RP-1	-	-	-	-	-	-	121,030	32,500	-
		Hybrid	-	-	-	-	-	-	121,030	32,500	-
		Hypergol	-	-	-	190,400	-	-	30,800	49,000	-
	Suborbital	LV-1	-	-	-	-	-	-	885	238	-
	Reentry	Jet-powered landing	-	-	5.5	0.24	0.09	18.8	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	2,328	-

Exhibit F-37. Estimated Emission Loads to the Stratosphere per Other Launch or Reentry

Category	Vehicle Classification	Propellant Type or Representative Vehicle	Emission Loads per Launch/Reentry (kilograms)								
			HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs and RVs)	Small	Solid	7,875	56	14,250	124	-	-	17,250	10,125	-
	Medium	Solid	9,450	68	17,100	149	-	-	20,700	12,150	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid	44,100	315	79,800	693	-	-	96,600	56,700	-
		Solid/ LOX-RP-1	22,050	315	39,900	357	-	-	147,000	54,600	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	195,510	52,500	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	3,540	951	-
		LV-2	-	-	-	-	-	-	6,095	1,637	-
		LV-3	94	-	179	-	1	144	7	20	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-
U.S. Government	Small	Solid	7,875	56	14,250	124	-	-	17,250	10,125	-
	Medium	Solid	9,450	68	17,100	149	-	-	20,700	12,150	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid	50,820	363	91,960	799	-	-	111,320	65,340	-
		LOX-LH_2	-	-	-	-	-	-	-	556,700	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	3,540	951	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-

Exhibit F-37. Estimated Emission Loads to the Stratosphere per Other Launch or Reentry

Category	Vehicle Classification	Propellant Type or Representative Vehicle	Emission Loads per Launch/Reentry (kilograms)								
			HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
		Rocket-powered landing	-	-	-	-	-	-	-	-	-
Foreign Commercial and Foreign Government	Small	Solid	10,500	75	19,000	165	-	-	23,000	13,500	-
	Medium	Solid	13,650	98	24,700	215	-	-	29,900	17,550	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Intermediate	Solid	16,800	120	30,400	264	-	-	36,800	21,600	-
		Hybrid	-	-	-	-	-	-	74,480	20,000	-
		Hypergol	-	-	-	-	-	-	-	-	-
	Heavy	Solid/ LOX-LH_2	9,500	125	17,125	-	-	-	20,750	67,500	-
		Solid/Hypergol	14,700	200	25,900	26,600	-	-	14,000	43,400	-
		LOX-RP-1	-	-	-	-	-	-	121,030	32,500	-
		Hybrid	-	-	-	-	-	-	121,030	32,500	-
		Hypergol	-	-	-	190,400	-	-	30,800	49,000	-
	Suborbital	LV-1	-	-	-	-	-	-	3,540	951	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-

Exhibit F-38. Estimated Emission Loads to the Mesosphere per Other Launch or Reentry

Category	Vehicle Classification	Propellant Type or Vehicle	Emission Loads per Launch/Reentry (kilograms)								
			HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs and RVs)	Small	Solid	1,050	8	1,900	17	-	1,150	150	1,350	-
	Medium	Solid	3,675	26	6,650	58	-	4,025	525	4,725	-
		Solid/LOX-RP-1	1,838	26	3,325	30	-	2,275	2,275	4,550	-
		Solid/Hypergol	1,875	25	3,250	375	-	2,250	1,750	5,375	-
	Heavy	Solid	11,550	83	20,900	182	-	12,650	1,650	14,850	-
		Solid/LOX-RP-1	5,775	83	10,450	94	-	7,150	7,150	14,300	-
		LOX-RP-1	-	-	-	-	-	24,200	13,200	13,750	-
		Hybrid	-	-	-	-	-	24,200	13,200	13,750	-
		Hypergol	-	-	-	74,800	-	1,650	9,900	19,250	-
	Suborbital	LV-1	-	-	-	-	-	225	123	128	-
		LV-2	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-
U.S. Government	Small	Solid	1,050	8	1,900	17	-	1,150	150	1,350	-
	Medium	Solid	3,675	26	6,650	58	-	4,025	525	4,725	-
		Solid/LOX-RP-1	1,838	26	3,325	30	-	2,275	2,275	4,550	-
		Solid/Hypergol	1,875	25	3,250	375	-	2,250	1,750	5,375	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-
		LOX-LH_2	14,700	105	26,600	231	-	16,100	2,100	18,900	-
		Hypergol	-	-	-	58,480	-	1,290	7,740	15,050	-
	Suborbital	LV-1	-	-	-	-	-	225	123	128	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-

Exhibit F-38. Estimated Emission Loads to the Mesosphere per Other Launch or Reentry

Category	Vehicle Classification	Propellant Type or Vehicle	Emission Loads per Launch/Reentry (kilograms)								
			HCl	Cl	PM	NO_X	SO_X	CO	CO_2	H_2O	VOC
		Rocket-powered landing	-	-	-	-	-	-	-	-	-
Foreign Commercial and Foreign Government	Small	Solid	1,050	8	1,900	17	-	1,150	150	1,350	-
	Medium	Solid	2,100	15	3,800	33	-	2,300	300	2,700	-
		LOX-RP-1	-	-	-	-	-	4,400	2,400	2,500	-
		Hypergol	-	-	-	13,600	-	300	1,800	3,500	-
	Intermediate	Solid	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	5,280	2,880	3,000	-
		Hypergol	-	-	-	16,320	-	360	2,160	4,200	-
	Heavy	Solid/ $LOX-LH_2$	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	39,600	21,600	22,500	-
		Hybrid	-	-	-	-	-	39,600	21,600	22,500	-
		Hypergol	-	-	-	111,520	-	2,460	14,760	28,700	-
	Suborbital	LV-1	-	-	-	-	-	225	123	128	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-

F.3 Methodology for Calculating Cumulative Emissions Loads in Various Atmospheric Layers

To calculate the cumulative emission loads to each atmospheric layer associated with both the proposed action and alternatives and the other launches and reentries (other Federal agencies, other countries, foreign commercial, and FAA licensed vertical launches), the FAA performed the following activities.

1. The FAA estimated the number of launch and reentries by vehicle type and classification (see Exhibits F-39, F-40, and F-41).
2. For the other launches and reentries, the FAA allocated the launches and reentries by propellant type (see Exhibits F-42 and F-43).
3. The FAA multiplied the emission estimates per launch or reentry by the launch estimates for each type of vehicle or propellant type (see Exhibits F-44 to F-70).

For other past, present, and reasonably foreseeable suborbital launches (vertical suborbital launches), this analysis assumed the U.S. Commercial vertical launches consisted of three different types of vehicles, which were based on current vehicle types. The breakdown of the number of launches assumed for each of these vehicle types is provided in Exhibit F-41. For U.S. Government, Foreign Commercial, and Foreign Government suborbital launches, the FAA assumed all launch vehicles would be similar to the LV-1, which is the suborbital launch vehicle that generally has the lowest emissions.

For past, present, and reasonably foreseeable launches performed by other U.S. governmental agencies, foreign countries, foreign commercial enterprises, as well as commercially launched vertical LVs, the emissions varied within each vehicle classification based on propellant type. To determine the number of launches in each vehicle classification using each propellant type, the FAA used the same distribution estimates used in the 2001 PEIS for Licensing Launches. (DOT, 2001) These estimates, presented in Exhibit F-42, are based on flight manifest data and literature on the commercial viability of certain types of launch vehicles.

For past, present, and reasonably foreseeable reentries performed by other U.S. governmental agencies, foreign countries, foreign commercial enterprises, as well as commercially launched vertical LVs, the FAA assumed that one-half of all reentries would not have powered landings. Of the reentries with powered landings, the FAA assumed that one-half were jet-powered and one-half were rocket-powered. These are the same assumptions and vehicles used in estimating reentry emissions associated with the proposed action and alternatives. Exhibit F-43 presents the assumed number of reentries, by vehicle type.

The annual estimated emissions loads from 2005 to 2015 for each vehicle type and compound (HCl, Cl, PM, NO_X, SO_X, CO, CO_2, H_2O, and VOC) are presented in Exhibits F-44 to F-70. Specifically, annual emissions by compound to a particular atmospheric region are presented in

- Exhibits F-44 to F-52 – troposphere
- Exhibits F-53 to F-61 – stratosphere
- Exhibits F-62 to F-70 – mesosphere

Cumulative impacts on the ionosphere were considered to be negligible because the emissions would be short-lived and would occur infrequently. Formal calculations were not prepared for emissions in the ionosphere. For evaluating the cumulative impacts on ambient air quality, all of the emissions from the past, present, and reasonably foreseeable reentries performed by other U.S. governmental agencies, foreign countries, foreign commercial enterprises, as well as commercially launched vertical LVs in the troposphere, were assumed to affect ground level ambient air quality.

Exhibit F-39. Vehicle Launches and Reentries Associated with the Proposed Action and Alternatives, 2005-2015

Representative Vehicle Type	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015
Vehicle Type A	0	10	50	50	50	75	50	50	50	50
Vehicle Type B	5	30	30	40	20	0	0	0	0	0
Vehicle Type C	0	0	2	10	20	30	35	35	35	35
TBD Vehicle	0	0	2	5	12	25	25	30	35	40
Vehicle Type D	6	8	10	10	8	7	6	7	7	7
Vehicle Type E	1	0	0	1	0	0	1	0	0	1
Vehicle Type F	0	0	0	0	1	0	1	0	0	1
TBD Vehicle	0	0	1	5	15	15	20	20	20	20
Reentry Vehicle – Rocket Landing	0	0	0	0	0.25	0.5	1	1.75	3	3.75
Reentry Vehicle – Jet Landing	0	0	0	0	0.25	0.5	1	1.75	3	3.75
Reentry Vehicle – Unpowered Landing	0	0	0	0	0.5	1	2	3.5	6	7.5

Exhibit F-40. Other Vehicle Launches and Reentries, 2005-2015

Category	Vehicle Classification	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Excluding Horiz. LVs and RVs)	Suborbital	7	3	8	7	4	9	8	10	10	11	11
	Small	2	1	2	2	1	2	2	2	2	2	2
	Medium	2	2	2	1	2	1	1	2	1	1	2
	Intermediate	0	0	0	0	0	0	0	0	0	0	0
	Heavy	7	6	7	7	6	6	7	6	6	6	7
U.S. Government	Suborbital	22	30	25	20	24	24	26	24	22	24	22
	Small	2	3	2	4	2	3	2	2	2	2	2
	Medium	10	9	8	9	9	9	9	9	9	9	9
	Intermediate	0	0	0	0	0	0	0	0	0	0	0
	Heavy	14	13	12	13	14	14	13	9	10	9	10
	Reentry Vehicle	3	5	4	4	4	-	1	2	2	4	4
Foreign Government	Suborbital	8	15	12	8	10	8	15	10	8	8	15
	Small	3	3	5	2	2	2	3	2	3	2	3
	Medium	13	18	17	14	15	15	14	15	15	14	15
	Intermediate	2	1	2	1	2	1	2	1	2	1	2
	Heavy	7	6	9	8	7	7	9	8	7	7	7
	Reentry Vehicle	4	5	5	4	4	5	4	5	4	5	4
Foreign Commercial	Suborbital	2	0	2	0	1	3	4	6	8	10	12
	Small	2	4	3	2	1	2	2	3	3	3	4
	Medium	2	3	1	1	2	1	1	1	1	1	1
	Intermediate	1	0	0	0	0	0	0	0	0	0	0
	Heavy	11	10	12	13	13	13	15	15	15	15	14
	Reentry Vehicle	-	-	-	-	-	-	1	2	2	3	3
TOTAL		**117**	**127**	**129**	**112**	**114**	**120**	**137**	**125**	**124**	**125**	**138**

Exhibit F-41. Other Estimated U.S. Commercial Suborbital Launches (Vertical) By Vehicle, 2005-2015

Representative Vehicle Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LV-1	3	3	6	6	3	8	8	8	10	10	10
LV-2	1	-	1	-	1	-	-	1	-	-	1
LV-3	3	-	1	1	-	1	-	1	-	1	-
TOTAL	**7**	**3**	**8**	**7**	**4**	**9**	**8**	**10**	**10**	**11**	**11**

F-42. Percentage of Other Launch Vehicles Using Each Propellant within Each Atmospheric Layer

Vehicle Classification[a]	Propellant Type	Percentage of Flights Using Propellant in Each Layer		
		Troposphere	Stratosphere	Mesosphere
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs and RVs)				
Small	Solid	100%	100%	100%
Medium	Solid	100%	100%	50%
	Solid/LOX-RP-1	-	-	25%
	Solid/Hypergol	-	-	25%
Heavy	Solid	33%	33%	-
	Solid/ LOX-RP-1	33%	33%	-
	LOX-RP-1	-	-	33%
	Hybrid	33%	33%	33%
	Hypergol	-	-	33%
U.S. Government				
Small	Solid	100%	100%	100%
Medium	Solid	100%	100%	50%
	Solid/LOX-RP-1	-	-	25%
	Solid/Hypergol	-	-	25%
Heavy	Solid	33%	33%	-
	LOX-LH_2	66%	66%	66%
	Hypergol	-	-	33%
Foreign Government and Foreign Commercial				
Small	Solid	100%	100%	100%
Medium	Solid	100%	100%	50%
	LOX-RP-1	-	-	25%
	Hypergol	-	-	25%
Intermediate	Solid	60%	60%	-
	Hybrid	40%	40%	45%
	Hypergol	-	-	55%
Heavy	Solid/ LOX-LH_2	10%	10%	-
	Solid/Hypergol	10%	10%	-
	LOX-RP-1	20%	20%	20%
	Hybrid	20%	20%	20%
	Hypergol	40%	40%	60%

Source: DOT, 2001

[a] There are no anticipated U.S. commercial or U.S. government launches of "Intermediate" vehicles from 2005-2015; thus there are no data for these vehicles in this exhibit.

Exhibit F-43. Other Reentry Vehicles, 2005-2015

Category	Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Gov.	Jet Landing	0.75	1.25	1	1	1	-	0.25	0.5	0.5	1	1
	Rocket Landing	0.75	1.25	1	1	1	-	0.25	0.5	0.5	1	1
	Unpowered Landing	1.5	2.5	2	2	2	-	0.5	1	1	2	2
Foreign Gov.	Jet Landing	1	1.25	1.25	1	1	1.25	1	1.25	1	1.25	1
	Rocket Landing	1	1.25	1.25	1	1	1.25	1	1.25	1	1.25	1
	Unpowered Landing	2	2.5	2.5	2	2	2.5	2	2.5	2	2.5	2
Foreign Comm.	Jet Landing	-	-	-	-	-	-	0.25	0.5	0.5	0.75	0.75
	Rocket Landing	-	-	-	-	-	-	0.25	0.5	0.5	0.75	0.75
	Unpowered Landing	-	-	-	-	-	-	0.5	1	1	1.5	1.5
TOTAL		7	10	9	8	8	5	6	9	8	12	11

Exhibit F-44. Estimated HCl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	15,750	7,875	15,750	15,750	7,875	15,750	15,750	15,750	15,750	15,750	15,750
	Medium	Solid	18,900	18,900	18,900	9,450	18,900	9,450	9,450	18,900	9,450	9,450	18,900
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	102,900	88,200	102,900	102,900	88,200	88,200	102,900	88,200	88,200	88,200	102,900
		Solid/LOX-RP-1	51,450	44,100	51,450	51,450	44,100	44,100	51,450	44,100	44,100	44,100	51,450
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	282	-	94	94	-	94	-	94	-	94	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-44. Estimated HCl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	15,750	23,625	15,750	31,500	15,750	23,625	15,750	15,750	15,750	15,750	15,750
	Medium	Solid	94,500	85,050	75,600	85,050	85,050	85,050	85,050	85,050	85,050	85,050	85,050
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	237,160	220,220	203,280	220,220	237,160	237,160	220,220	152,460	169,400	152,460	169,400
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	31,500	31,500	52,500	21,000	21,000	21,000	31,500	21,000	31,500	21,000	31,500
	Medium	Solid	177,450	245,700	232,050	191,100	204,750	204,750	191,100	204,750	204,750	191,100	204,750
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	20,160	10,080	20,160	10,080	20,160	10,080	20,160	10,080	20,160	10,080	20,160
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	6,650	5,700	8,550	7,600	6,650	6,650	8,550	7,600	6,650	6,650	6,650
		Solid/Hypergol	10,290	8,820	13,230	11,760	10,290	10,290	13,230	11,760	10,290	10,290	10,290
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-44. Estimated HCl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	21,000	42,000	31,500	21,000	10,500	21,000	21,000	31,500	31,500	31,500	42,000
	Medium	Solid	27,300	40,950	13,650	13,650	27,300	13,650	13,650	13,650	13,650	13,650	13,650
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	10,080	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	10,450	9,500	11,400	12,350	12,350	12,350	14,250	14,250	14,250	14,250	13,300
		Solid/Hypergol	16,170	14,700	17,640	19,110	19,110	19,110	22,050	22,050	22,050	22,050	20,580
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual HCl Emissions			867,742	896,920	884,404	824,064	829,145	822,309	836,060	756,944	782,500	731,424	822,080

Exhibit F-45. Estimated Annual Cl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	112	56	112	112	56	112	112	112	112	112	112
	Medium	Solid	136	136	136	68	136	68	68	136	68	68	136
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	735	630	735	735	630	630	735	630	630	630	735
		Solid/ LOX-RP-1	735	630	735	735	630	630	735	630	630	630	735
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-45. Estimated Annual Cl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	112	168	112	224	112	168	112	112	112	112	112
	Medium	Solid	680	612	544	612	612	612	612	612	612	612	612
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	1,694	1,573	1,452	1,573	1,694	1,694	1,573	1,089	1,210	1,089	1,210
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	225	225	375	150	150	150	225	150	225	150	225
	Medium	Solid	1,274	1,764	1,666	1,372	1,470	1,470	1,372	1,470	1,470	1,372	1,470
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	144	72	144	72	144	72	144	72	144	72	144
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	88	75	113	100	88	88	113	100	88	88	88
		Solid/Hypergol	140	120	180	160	140	140	180	160	140	140	140
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-45. Estimated Annual Cl Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Foreign Commercial	Small	Solid	150	300	225	150	75	150	150	225	225	225	300
	Medium	Solid	196	294	98	98	196	98	98	98	98	98	98
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	72	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	138	125	150	163	163	163	188	188	188	188	175
		Solid/Hypergol	220	200	240	260	260	260	300	300	300	300	280
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual Cl Emissions			6,851	6,980	7,017	6,584	6,556	6,505	6,717	6,084	6,252	5,886	6,572

Exhibit F-46. Estimated Annual PM Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	110	550	550	550	825	550	550	550	550	550
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	66	88	110	110	88	77	66	77	77	77	77
	Concept 3	Vehicle Type E	11	-	-	11	-	-	11	-	11	-	11
	Concept 3	Vehicle Type F	-	-	-	-	< 1	-	< 1	-	< 1	-	< 1
	Concept 3	TBD Vehicle	-	-	11	53	158	158	210	210	210	210	210
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered lanidng	-	-	-	-	1	3	6	10	14	17	21
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	28,500	14,250	28,500	28,500	14,250	28,500	28,500	28,500	28,500	28,500	28,500
	Medium	Solid	34,200	34,200	34,200	17,100	34,200	17,100	17,100	34,200	17,100	17,100	34,200
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	186,200	159,600	186,200	186,200	159,600	159,600	186,200	159,600	159,600	159,600	186,200
		Solid/LOX-RP-1	93,100	79,800	93,100	93,100	79,800	79,800	93,100	79,800	79,800	79,800	93,100
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	537	-	179	179	-	179	-	179	-	179	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-46. Estimated Annual PM Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	28,500	42,750	28,500	57,000	28,500	42,750	28,500	28,500	28,500	28,500	28,500
	Medium	Solid	171,000	153,900	136,800	153,900	153,900	153,900	153,900	153,900	153,900	153,900	153,900
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	429,147	398,493	367,840	398,493	429,147	429,147	398,493	275,880	306,533	275,880	306,533
		$LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	4	7	6	6	6	-	1	3	3	6	6
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	57,000	57,000	95,000	38,000	38,000	38,000	57,000	38,000	57,000	38,000	57,000
	Medium	Solid	321,100	444,600	419,900	345,800	370,500	370,500	345,800	370,500	370,500	345,800	370,500
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	36,480	18,240	36,480	18,240	36,480	18,240	36,480	18,240	36,480	18,240	36,480
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX-LH_2$	11,988	10,275	15,413	13,700	11,988	11,988	15,413	13,700	11,988	11,988	11,988
		Solid/Hypergol	18,130	15,540	23,310	20,720	18,130	18,130	23,310	20,720	18,130	18,130	18,130
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	6	7	7	6	6	7	6	7	6	7	6
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-46. Estimated Annual PM Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	38,000	76,000	57,000	38,000	19,000	38,000	38,000	57,000	57,000	57,000	76,000
	Medium	Solid	49,400	74,100	24,700	24,700	49,400	24,700	24,700	24,700	24,700	24,700	24,700
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	18,240	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	18,838	17,125	20,550	22,263	22,263	22,263	25,688	25,688	25,688	25,688	23,975
		Solid/Hypergol	28,490	25,900	31,080	33,670	33,670	33,670	38,850	38,850	38,850	38,850	36,260
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	1	3	3	4	4
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual PM Emissions			1,568,937	1,621,985	1,599,436	1,490,301	1,499,637	1,487,537	1,511,885	1,368,817	1,415,143	1,322,726	1,486,851

Exhibit F-47. Estimated Annual NO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	5	25	25	25	38	25	25	25	25	25
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	4	5	6	6	5	4	4	4	4	4	4
	Concept 3	Vehicle Type E	30	-	-	30	-	-	30	-	30	-	30
	Concept 3	Vehicle Type F	-	-	-	-	8	-	8	-	8	-	8
	Concept 3	TBD Vehicle	-	-	3	13	38	38	50	50	50	50	50
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	< 1	< 1	< 1	< 1	1	1	1
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	248	124	248	248	124	248	248	248	248	248	248
	Medium	Solid	298	298	298	149	298	149	149	298	149	149	298
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	1,617	1,386	1,617	1,617	1,386	1,386	1,617	1,386	1,386	1,386	1,617
		Solid/ LOX-RP-1	833	714	833	833	714	714	833	714	714	714	833
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-47. Estimated Annual NO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	248	372	248	496	248	372	248	248	248	248	248
	Medium	Solid	1,490	1,341	1,192	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	3,729	3,462	3,196	3,462	3,729	3,729	3,462	2,397	2,663	2,397	2,663
		$LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	495	495	825	330	330	330	495	330	495	330	495
	Medium	Solid	2,795	3,870	3,655	3,010	3,225	3,225	3,010	3,225	3,225	3,010	3,225
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	317	158	317	158	317	158	317	158	317	158	317
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	18,620	15,960	23,940	21,280	18,620	18,620	23,940	21,280	18,620	18,620	18,620
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	533,120	456,960	685,440	609,280	533,120	533,120	685,440	609,280	533,120	533,120	533,120
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-47. Estimated Annual NO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	330	660	495	330	165	330	330	495	495	495	660
	Medium	Solid	430	645	215	215	430	215	215	215	215	215	215
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	158	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	29,260	26,600	31,920	34,580	34,580	34,580	39,900	39,900	39,900	39,900	37,240
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	837,760	761,600	913,920	990,080	990,080	990,080	1,142,400	1,142,400	1,142,400	1,142,400	1,066,240
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual NO_X Emissions			1,431,782	1,274,655	1,668,393	1,667,483	1,588,783	1,588,677	1,904,062	1,823,994	1,745,654	1,744,811	1,667,498

Exhibit F-48. Estimated Annual SO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	2	10	10	10	15	10	10	10	10	10
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	2	2	3	3	2	2	2	2	2	2	2
	Concept 3	Vehicle Type E	2	-	-	2	-	-	2	-	2	-	2
	Concept 3	Vehicle Type F	-	-	-	-	1	-	1	-	1	-	1
	Concept 3	TBD Vehicle	-	-	< 1	2	6	6	8	8	8	8	8
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	3	-	1	1	-	1	-	1	-	1	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-48. Estimated Annual SO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-48. Estimated Annual SO_X Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms) 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual SO_X Emissions			7	4	14	18	19	24	23	21	23	21	23

Exhibit F-49. Estimated Annual CO Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	1,241	6,205	6,205	6,205	9,308	6,205	6,205	6,205	6,205	6,205
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	228	304	380	380	304	266	228	266	266	266	266
	Concept 3	Vehicle Type E	93	-	-	93	-	-	93	-	93	-	93
	Concept 3	Vehicle Type F	-	-	-	-	18	-	18	-	18	-	18
	Concept 3	TBD Vehicle	-	-	40	201	602	602	802	802	802	802	802
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	5	9	19	33	47	56	71
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	432	-	144	144	-	144	-	144	-	144	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-49. Estimated Annual CO Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	14	24	19	19	19	-	5	9	9	19	19
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	19	24	24	19	19	24	19	24	19	24	19
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-49. Estimated Annual CO Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	5	9	9	14	14
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO Emissions			786	1,593	6,812	7,061	7,172	10,353	7,394	7,492	7,468	7,530	7,507

Exhibit F-50. Estimated Annual CO_2 Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	2,118	10,590	10,590	10,590	15,885	10,590	10,590	10,590	10,590	10,590
	Concept 2	Vehicle Type B	4,788	28,725	28,725	38,300	19,150	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	3,829	19,147	38,294	57,441	67,015	67,015	67,015	67,015	67,015
	Concept 2	TBD Vehicle	-	-	3,168	7,921	19,010	39,605	39,605	47,526	47,526	55,447	63,368
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	34,500	17,250	34,500	34,500	17,250	34,500	34,500	34,500	34,500	34,500	34,500
	Medium	Solid	41,400	41,400	41,400	20,700	41,400	20,700	20,700	41,400	20,700	20,700	41,400
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	225,400	193,200	225,400	225,400	193,200	193,200	225,400	193,200	193,200	193,200	225,400
		Solid/LOX-RP-1	343,000	294,000	343,000	343,000	294,000	294,000	343,000	294,000	294,000	294,000	343,000
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	456,190	391,020	456,190	456,190	391,020	391,020	456,190	391,020	391,020	391,020	456,190
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	2,655	2,655	5,310	5,310	2,655	7,080	7,080	7,080	8,850	8,850	8,850
		LV-2	2,983	-	2,983	-	2,983	-	-	2,983	-	-	2,983
		LV-3	21	-	7	7	-	7	-	7	-	7	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-50. Estimated Annual CO_2 Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	34,500	51,750	34,500	69,000	34,500	51,750	34,500	34,500	34,500	34,500	34,500
	Medium	Solid	207,000	186,300	165,600	186,300	186,300	186,300	186,300	186,300	186,300	186,300	186,300
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	519,493	482,387	445,280	482,387	519,493	519,493	482,387	333,960	371,067	333,960	371,067
		$LOX\text{-}LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	19,470	26,550	22,125	17,700	21,240	21,240	23,010	21,240	19,470	21,240	19,470
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	69,000	69,000	115,000	46,000	46,000	46,000	69,000	46,000	69,000	46,000	69,000
	Medium	Solid	388,700	538,200	508,300	418,600	448,500	448,500	418,600	448,500	448,500	418,600	448,500
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	44,160	22,080	44,160	22,080	44,160	22,080	44,160	22,080	44,160	22,080	44,160
		Hybrid	59,584	29,792	59,584	29,792	59,584	29,792	59,584	29,792	59,584	29,792	59,584
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX\text{-}LH_2$	14,525	12,450	18,675	16,600	14,525	14,525	18,675	16,600	14,525	14,525	14,525
		Solid/Hypergol	9,800	8,400	12,600	11,200	9,800	9,800	12,600	11,200	9,800	9,800	9,800
		LOX-RP-1	169,442	145,236	217,854	193,648	169,442	169,442	217,854	193,648	169,442	169,442	169,442
		Hybrid	169,442	145,236	217,854	193,648	169,442	169,442	217,854	193,648	169,442	169,442	169,442
		Hypergol	86,240	73,920	110,880	98,560	86,240	86,240	110,880	98,560	86,240	86,240	86,240
	Suborbital	LV-1	7,080	13,275	10,620	7,080	8,850	7,080	13,275	8,850	7,080	7,080	13,275
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-50. Estimated Annual CO_2 Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	46,000	92,000	69,000	46,000	23,000	46,000	46,000	69,000	69,000	69,000	92,000
	Medium	Solid	59,800	89,700	29,900	29,900	59,800	29,900	29,900	29,900	29,900	29,900	29,900
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	22,080	-	-	-	-	-	-	-	-	-	-
		Hybrid	29,792	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	22,825	20,750	24,900	26,975	26,975	26,975	31,125	31,125	31,125	31,125	29,050
		Solid/Hypergol	15,400	14,000	16,800	18,200	18,200	18,200	21,000	21,000	21,000	21,000	19,600
		LOX-RP-1	266,266	242,060	290,472	314,678	314,678	314,678	363,090	363,090	363,090	363,090	338,884
		Hybrid	266,266	242,060	290,472	314,678	314,678	314,678	363,090	363,090	363,090	363,090	338,884
		Hypergol	135,520	123,200	147,840	160,160	160,160	160,160	184,800	184,800	184,800	184,800	172,480
	Suborbital	LV-1	1,770	-	1,770	-	885	2,655	3,540	5,310	7,080	8,850	10,620
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO_2 Emissions			3,775,092	3,598,714	4,009,288	3,864,251	3,766,004	3,748,368	4,155,304	3,801,514	3,825,596	3,695,185	3,980,019

Exhibit F-51. Estimated Annual H_2O Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	1,297	6,485	6,485	6,485	9,728	6,485	6,485	6,485	6,485	6,485
	Concept 2	Vehicle Type B	1,786	10,716	10,716	14,288	7,144	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	1,429	7,145	14,290	21,435	25,008	25,008	25,008	25,008	25,008
	Concept 2	TBD Vehicle	-	-	1,182	2,956	7,093	14,778	14,778	17,733	17,733	20,689	23,644
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	582	1,164	2,328	4,074	5,820	6,984	8,730
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	20,250	10,125	20,250	20,250	10,125	20,250	20,250	20,250	20,250	20,250	20,250
	Medium	Solid	24,300	24,300	24,300	12,150	24,300	12,150	12,150	24,300	12,150	12,150	24,300
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	132,300	113,400	132,300	132,300	113,400	113,400	132,300	113,400	113,400	113,400	132,300
		Solid/LOX-RP-1	127,400	109,200	127,400	127,400	109,200	109,200	127,400	109,200	109,200	109,200	127,400
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	122,500	105,000	122,500	122,500	105,000	105,000	122,500	105,000	105,000	105,000	122,500
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	714	714	1,428	1,428	714	1,904	1,904	1,904	2,380	2,380	2,380
		LV-2	801	-	801	-	801	-	-	801	-	-	801
		LV-3	60	-	20	20	-	20	-	20	-	20	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-51. Estimated Annual H_2O Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	20,250	30,375	20,250	40,500	20,250	30,375	20,250	20,250	20,250	20,250	20,250
	Medium	Solid	121,500	109,350	97,200	109,350	109,350	109,350	109,350	109,350	109,350	109,350	109,350
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	304,920	283,140	261,360	283,140	304,920	304,920	283,140	196,020	217,800	196,020	217,800
		LOX-LH_2	5,195,867	4,824,733	4,453,600	4,824,733	5,195,867	5,195,867	4,824,733	3,340,200	3,711,333	3,340,200	3,711,333
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	5,236	7,140	5,950	4,760	5,712	5,712	6,188	5,712	5,236	5,712	5,236
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	1,746	2,910	2,328	2,328	2,328	-	582	1,164	1,164	2,328	2,328
Foreign Government	Small	Solid	40,500	40,500	67,500	27,000	27,000	27,000	40,500	27,000	40,500	27,000	40,500
	Medium	Solid	228,150	315,900	298,350	245,700	263,250	263,250	245,700	263,250	263,250	245,700	263,250
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	25,920	12,960	25,920	12,960	25,920	12,960	25,920	12,960	25,920	12,960	25,920
		Hybrid	16,000	8,000	16,000	8,000	16,000	8,000	16,000	8,000	16,000	8,000	16,000
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	47,250	40,500	60,750	54,000	47,250	47,250	60,750	54,000	47,250	47,250	47,250
		Solid/Hypergol	30,380	26,040	39,060	34,720	30,380	30,380	39,060	34,720	30,380	30,380	30,380
		LOX-RP-1	45,500	39,000	58,500	52,000	45,500	45,500	58,500	52,000	45,500	45,500	45,500
		Hybrid	45,500	39,000	58,500	52,000	45,500	45,500	58,500	52,000	45,500	45,500	45,500
		Hypergol	137,200	117,600	176,400	156,800	137,200	137,200	176,400	156,800	137,200	137,200	137,200
	Suborbital	LV-1	1,904	3,570	2,856	1,904	2,380	1,904	3,570	2,380	1,904	1,904	3,570
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	2,328	2,910	2,910	2,328	2,328	2,910	2,328	2,910	2,328	2,910	2,328

Exhibit F-51. Estimated Annual H_2O Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	27,000	54,000	40,500	27,000	13,500	27,000	27,000	40,500	40,500	40,500	54,000
	Medium	Solid	35,100	52,650	17,550	17,550	35,100	17,550	17,550	17,550	17,550	17,550	17,550
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	12,960	-	-	-	-	-	-	-	-	-	-
		Hybrid	8,000	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	74,250	67,500	81,000	87,750	87,750	87,750	101,250	101,250	101,250	101,250	94,500
		Solid/Hypergol	47,740	43,400	52,080	56,420	56,420	56,420	65,100	65,100	65,100	65,100	60,760
		LOX-RP-1	71,500	65,000	78,000	84,500	84,500	84,500	97,500	97,500	97,500	97,500	91,000
		Hybrid	71,500	65,000	78,000	84,500	84,500	84,500	97,500	97,500	97,500	97,500	91,000
		Hypergol	215,600	196,000	235,200	254,800	254,800	254,800	294,000	294,000	294,000	294,000	274,400
	Suborbital	LV-1	476	-	476	-	238	714	952	1,428	1,904	2,380	2,856
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	582	1,164	1,164	1,746	1,746
Total H_20 Emissions			7,264,388	6,821,930	6,679,051	6,971,665	7,297,077	7,290,341	7,138,008	5,482,883	5,854,759	5,417,256	5,905,305

Exhibit F-52. Estimated Annual VOC Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	40	200	200	200	300	200	200	200	200	200
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	31	42	52	52	42	36	31	36	36	36	36
	Concept 3	Vehicle Type E	68	-	-	68	-	-	68	-	68	-	68
	Concept 3	Vehicle Type F	-	-	-	-	2	-	2	-	2	-	2
	Concept 3	TBD Vehicle	-	-	9	43	128	128	170	170	170	170	170
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-52. Estimated Annual VOC Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-52. Estimated Annual VOC Emission Loads to the Troposphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual VOC Emissions			99	82	261	363	372	464	471	406	476	406	476

Exhibit F-53. Estimated Annual HCl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	3,153	-	-	3,153	-	-	3,153	-	3,153	-	3,153
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	171	857	2,571	2,571	3,428	3,428	3,428	3,428	3,428
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	15,750	7,875	15,750	15,750	7,875	15,750	15,750	15,750	15,750	15,750	15,750
	Medium	Solid	18,900	18,900	18,900	9,450	18,900	9,450	9,450	18,900	9,450	9,450	18,900
	Medium	Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	102,900	88,200	102,900	102,900	88,200	88,200	102,900	88,200	88,200	88,200	102,900
	Heavy	Solid/LOX-RP-1	51,450	44,100	51,450	51,450	44,100	44,100	51,450	44,100	44,100	44,100	51,450
	Heavy	LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Hybrid	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-2	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-3	282	-	94	94	-	94	-	94	-	94	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-53. Estimated Annual HCl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
U.S. Government	Small	Solid	15,750	23,625	15,750	31,500	15,750	23,625	15,750	15,750	15,750	15,750	15,750
	Medium	Solid	94,500	85,050	75,600	85,050	85,050	85,050	85,050	85,050	85,050	85,050	85,050
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	237,160	220,220	203,280	220,220	237,160	237,160	220,220	152,460	169,400	152,460	169,400
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	31,500	31,500	52,500	21,000	21,000	21,000	31,500	21,000	31,500	21,000	31,500
	Medium	Solid	177,450	245,700	232,050	191,100	204,750	204,750	191,100	204,750	204,750	191,100	204,750
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	20,160	10,080	20,160	10,080	20,160	10,080	20,160	10,080	20,160	10,080	20,160
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	6,650	5,700	8,550	7,600	6,650	6,650	8,550	7,600	6,650	6,650	6,650
		Solid/Hypergol	10,290	8,820	13,230	11,760	10,290	10,290	13,230	11,760	10,290	10,290	10,290
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-53. Estimated Annual HCl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	21,000	42,000	31,500	21,000	10,500	21,000	21,000	31,500	31,500	31,500	42,000
	Medium	Solid	27,300	40,950	13,650	13,650	27,300	13,650	13,650	13,650	13,650	13,650	13,650
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	10,080	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	10,450	9,500	11,400	12,350	12,350	12,350	14,250	14,250	14,250	14,250	13,300
		Solid/Hypergol	16,170	14,700	17,640	19,110	19,110	19,110	22,050	22,050	22,050	22,050	20,580
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual HCl Emissions			870,895	896,920	884,575	828,074	831,716	824,880	842,641	760,372	789,081	734,852	828,661

Exhibit F-54. Estimated Annual Cl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	23	-	-	23	-	-	23	-	23	-	23
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	1	6	18	18	24	24	24	24	24
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	112	56	112	112	56	112	112	112	112	112	112
	Medium	Solid	136	136	136	68	136	68	68	136	68	68	136
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	735	630	735	735	630	630	735	630	630	630	735
		Solid/LOX-RP-1	735	630	735	735	630	630	735	630	630	630	735
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-54. Estimated Annual Cl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	112	168	112	224	112	168	112	112	112	112	112
	Medium	Solid	680	612	544	612	612	612	612	612	612	612	612
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	1,694	1,573	1,452	1,573	1,694	1,694	1,573	1,089	1,210	1,089	1,210
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	225	225	375	150	150	150	225	150	225	150	225
	Medium	Solid	1,274	1,764	1,666	1,372	1,470	1,470	1,372	1,470	1,470	1,372	1,470
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	144	72	144	72	144	72	144	72	144	72	144
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	88	75	113	100	88	88	113	100	88	88	88
		Solid/Hypergol	140	120	180	160	140	140	180	160	140	140	140
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-54. Estimated Annual Cl Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	150	300	225	150	75	150	150	225	225	225	300
	Medium	Solid	196	294	98	98	196	98	98	98	98	98	98
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	72	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	138	125	150	163	163	163	188	188	188	188	175
		Solid/Hypergol	220	200	240	260	260	260	300	300	300	300	280
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual Cl Emissions			6,874	6,980	7,018	6,613	6,574	6,523	6,764	6,108	6,299	5,910	6,619

Exhibit F-55. Estimated Annual PM Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	5,705	-	-	5,705	-	-	5,705	-	5,705	-	5,705
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	310	1,551	4,652	4,652	6,202	6,202	6,202	6,202	6,202
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	28,500	14,250	28,500	28,500	14,250	28,500	28,500	28,500	28,500	28,500	28,500
	Medium	Solid	34,200	34,200	34,200	17,100	34,200	17,100	17,100	34,200	17,100	17,100	34,200
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	186,200	159,600	186,200	186,200	159,600	159,600	186,200	159,600	159,600	159,600	186,200
		Solid/LOX-RP-1	93,100	79,800	93,100	93,100	79,800	79,800	93,100	79,800	79,800	79,800	93,100
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-55. Estimated Annual PM Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms) 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	537	-	179	179	-	179	-	179	-	179	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Small	Solid	28,500	42,750	28,500	57,000	28,500	42,750	28,500	28,500	28,500	28,500	28,500
U.S. Government	Medium	Solid	171,000	153,900	136,800	153,900	153,900	153,900	153,900	153,900	153,900	153,900	153,900
U.S. Government	Medium	Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Medium	Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Heavy	Solid	429,147	398,493	367,840	398,493	429,147	429,147	398,493	275,880	306,533	275,880	306,533
U.S. Government	Heavy	LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Heavy	Hypergol	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	57,000	57,000	95,000	38,000	38,000	38,000	57,000	38,000	57,000	38,000	57,000
Foreign Government	Medium	Solid	321,100	444,600	419,900	345,800	370,500	370,500	345,800	370,500	370,500	345,800	370,500
Foreign Government	Medium	LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Medium	Hypergol	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Intermed.	Solid	36,480	18,240	36,480	18,240	36,480	18,240	36,480	18,240	36,480	18,240	36,480
Foreign Government	Intermed.	Hybrid	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Intermed.	Hypergol	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Heavy	Solid/LOX-LH_2	11,988	10,275	15,413	13,700	11,988	11,988	15,413	13,700	11,988	11,988	11,988

Exhibit F-55. Estimated Annual PM Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
		Solid/Hypergol	18,130	15,540	23,310	20,720	18,130	18,130	23,310	20,720	18,130	18,130	18,130
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Commercial	Small	Solid	38,000	76,000	57,000	38,000	19,000	38,000	38,000	57,000	57,000	57,000	76,000
		Solid	49,400	74,100	24,700	24,700	49,400	24,700	24,700	24,700	24,700	24,700	24,700
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
	Medium	Hypergol	-	-	-	-	-	-	-	-	-	-	-
		Solid	18,240	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Hypergol	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-LH_2	18,838	17,125	20,550	22,263	22,263	22,263	25,688	25,688	25,688	25,688	23,975
		Solid/Hypergol	28,490	25,900	31,080	33,670	33,670	33,670	38,850	38,850	38,850	38,850	36,260
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual PM Emissions			1,574,555	1,621,773	1,599,062	1,496,821	1,503,480	1,491,119	1,522,941	1,374,159	1,426,176	1,328,057	1,497,873

Exhibit F-56. Estimated Annual NO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	50	-	-	50	-	-	50	-	50	-	50
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	3	14	41	41	54	54	54	54	54
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	248	124	248	248	124	248	248	248	248	248	248
	Medium	Solid	298	298	298	149	298	149	149	298	149	149	298
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	1,617	1,386	1,617	1,617	1,386	1,386	1,617	1,386	1,386	1,386	1,617
		Solid/LOX-RP-1	833	714	833	833	714	714	833	714	714	714	833
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-56. Estimated Annual NO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	248	372	248	496	248	372	248	248	248	248	248
	Medium	Solid	1,490	1,341	1,192	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	3,729	3,462	3,196	3,462	3,729	3,729	3,462	2,397	2,663	2,397	2,663
		$LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	495	495	825	330	330	330	495	330	495	330	495
	Medium	Solid	2,795	3,870	3,655	3,010	3,225	3,225	3,010	3,225	3,225	3,010	3,225
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	317	158	317	158	317	158	317	158	317	158	317
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	18,620	15,960	23,940	21,280	18,620	18,620	23,940	21,280	18,620	18,620	18,620
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	533,120	456,960	685,440	609,280	533,120	533,120	685,440	609,280	533,120	533,120	533,120
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-56. Estimated Annual NO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	330	660	495	330	165	330	330	495	495	495	660
	Medium	Solid	430	645	215	215	430	215	215	215	215	215	215
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	158	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	29,260	26,600	31,920	34,580	34,580	34,580	39,900	39,900	39,900	39,900	37,240
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	837,760	761,600	913,920	990,080	990,080	990,080	1,142,400	1,142,400	1,142,400	1,142,400	1,066,240
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual NO_X Emissions			1,431,798	1,274,645	1,668,362	1,667,473	1,588,748	1,588,638	1,904,049	1,823,969	1,745,640	1,744,785	1,667,484

Exhibit F-57. Estimated Annual SO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	3	-	1	1	-	1	-	1	-	1	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-57. Estimated Annual SO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-57. Estimated Annual SO_X Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual SO_X Emissions			3	0	1	1	0	1	0	1	0	1	0

Exhibit F-58. Estimated Annual CO Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	6,484	32,420	32,420	32,420	48,630	32,420	32,420	32,420	32,420	32,420
	Concept 2	Vehicle Type B	2,580	15,480	15,480	20,640	10,320	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	2,064	10,320	20,640	30,960	36,120	36,120	36,120	36,120	36,120
	Concept 2	TBD Vehicle	-	-	1,708	4,269	10,246	21,345	21,345	25,614	25,614	29,883	34,152
	Concept 3	Vehicle Type D	1,828	2,437	3,046	3,046	2,437	2,132	1,828	2,132	2,132	2,132	2,132
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	275	1,374	4,122	4,122	5,496	5,496	5,496	5,496	5,496
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	432	-	144	144	-	144	-	144	-	144	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-58. Estimated Annual CO Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-58. Estimated Annual CO Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO Emissions			4,840	24,401	55,137	72,213	80,185	107,333	97,209	101,926	101,782	106,195	110,320

Exhibit F-59. Estimated Annual CO_2 Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	15,885	79,425	79,425	79,425	119,138	79,425	79,425	79,425	79,425	79,425
	Concept 2	Vehicle Type B	6,321	37,926	37,926	50,568	25,284	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	5,057	25,284	50,568	75,852	88,494	88,494	88,494	88,494	88,494
	Concept 2	TBD Vehicle	-	-	4,184	10,459	25,102	52,295	52,295	62,754	62,754	73,213	83,672
	Concept 3	Vehicle Type D	274	366	457	457	366	320	274	320	320	320	320
	Concept 3	Vehicle Type E	6,906	-	-	6,906	-	-	6,906	-	6,906	-	6,906
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	417	2,083	6,249	6,249	8,332	8,332	8,332	8,332	8,332
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	34,500	17,250	34,500	34,500	17,250	34,500	34,500	34,500	34,500	34,500	34,500
	Medium	Solid	41,400	41,400	41,400	20,700	41,400	20,700	20,700	41,400	20,700	20,700	41,400
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	225,400	193,200	225,400	225,400	193,200	193,200	225,400	193,200	193,200	193,200	225,400
		Solid/ LOX-RP-1	343,000	294,000	343,000	343,000	294,000	294,000	343,000	294,000	294,000	294,000	343,000
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	456,190	391,020	456,190	456,190	391,020	391,020	456,190	391,020	391,020	391,020	456,190
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	10,620	10,620	21,240	21,240	10,620	28,320	28,320	28,320	35,400	35,400	35,400
		LV-2	6,095	-	6,095	-	6,095	-	-	6,095	-	-	6,095
		LV-3	21	-	7	7	-	7	-	7	-	7	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-59. Estimated Annual CO_2 Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	34,500	51,750	34,500	69,000	34,500	51,750	34,500	34,500	34,500	34,500	34,500
	Medium	Solid	207,000	186,300	165,600	186,300	186,300	186,300	186,300	186,300	186,300	186,300	186,300
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	519,493	482,387	445,280	482,387	519,493	519,493	482,387	333,960	371,067	333,960	371,067
		$LOX\text{-}LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	77,880	106,200	88,500	70,800	84,960	84,960	92,040	84,960	77,880	84,960	77,880
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	69,000	69,000	115,000	46,000	46,000	46,000	69,000	46,000	69,000	46,000	69,000
	Medium	Solid	388,700	538,200	508,300	418,600	448,500	448,500	418,600	448,500	448,500	418,600	448,500
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	44,160	22,080	44,160	22,080	44,160	22,080	44,160	22,080	44,160	22,080	44,160
		Hybrid	59,584	29,792	59,584	29,792	59,584	29,792	59,584	29,792	59,584	29,792	59,584
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX\text{-}LH_2$	14,525	12,450	18,675	16,600	14,525	14,525	18,675	16,600	14,525	14,525	14,525
		Solid/Hypergol	9,800	8,400	12,600	11,200	9,800	9,800	12,600	11,200	9,800	9,800	9,800
		LOX-RP-1	169,442	145,236	217,854	193,648	169,442	169,442	217,854	193,648	169,442	169,442	169,442
		Hybrid	169,442	145,236	217,854	193,648	169,442	169,442	217,854	193,648	169,442	169,442	169,442
		Hypergol	86,240	73,920	110,880	98,560	86,240	86,240	110,880	98,560	86,240	86,240	86,240
	Suborbital	LV-1	28,320	53,100	42,480	28,320	35,400	28,320	53,100	35,400	28,320	28,320	53,100
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-59. Estimated Annual CO_2 Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	CO2 Emission Loads (kilograms)										
			2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Foreign Commercial	Small	Solid	46,000	92,000	69,000	46,000	23,000	46,000	46,000	69,000	69,000	69,000	92,000
	Medium	Solid	59,800	89,700	29,900	29,900	59,800	29,900	29,900	29,900	29,900	29,900	29,900
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	22,080	-	-	-	-	-	-	-	-	-	-
		Hybrid	29,792	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	22,825	20,750	24,900	26,975	26,975	26,975	31,125	31,125	31,125	31,125	29,050
		Solid/Hypergol	15,400	14,000	16,800	18,200	18,200	18,200	21,000	21,000	21,000	21,000	19,600
		LOX-RP-1	266,266	242,060	290,472	314,678	314,678	314,678	363,090	363,090	363,090	363,090	338,884
		Hybrid	266,266	242,060	290,472	314,678	314,678	314,678	363,090	363,090	363,090	363,090	338,884
		Hypergol	135,520	123,200	147,840	160,160	160,160	160,160	184,800	184,800	184,800	184,800	172,480
	Suborbital	LV-1	7,080	-	7,080	-	3,540	10,620	14,160	21,240	28,320	35,400	42,480
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO_2 Emissions			3,879,842	3,749,488	4,213,029	4,053,745	3,969,956	4,003,456	4,414,535	4,046,260	4,074,136	3,949,977	4,265,952

Exhibit F-60. Estimated Annual H_2O Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	H2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	9,726	48,630	48,630	48,630	72,945	48,630	48,630	48,630	48,630	48,630
	Concept 2	Vehicle Type B	3,870	23,220	23,220	30,960	15,480	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	3,096	15,480	30,960	46,440	54,180	54,180	54,180	54,180	54,180
	Concept 2	TBD Vehicle	-	-	2,561	6,404	15,368	32,018	32,018	38,421	38,421	44,825	51,228
	Concept 3	Vehicle Type D	2,011	2,681	3,351	3,351	2,681	2,346	2,011	2,346	2,346	2,346	2,346
	Concept 3	Vehicle Type E	4,054	-	-	4,054	-	-	4,054	-	4,054	-	4,054
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	523	2,613	7,839	7,839	10,452	10,452	10,452	10,452	10,452
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	20,250	10,125	20,250	20,250	10,125	20,250	20,250	20,250	20,250	20,250	20,250
	Medium	Solid	24,300	24,300	24,300	12,150	24,300	12,150	12,150	24,300	12,150	12,150	24,300
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	132,300	113,400	132,300	132,300	113,400	113,400	132,300	113,400	113,400	113,400	132,300
		Solid/LOX-RP-1	127,400	109,200	127,400	127,400	109,200	109,200	127,400	109,200	109,200	109,200	127,400
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	122,500	105,000	122,500	122,500	105,000	105,000	122,500	105,000	105,000	105,000	122,500
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	2,853	2,853	5,706	5,706	2,853	7,608	7,608	7,608	9,510	9,510	9,510
		LV-2	1,637	-	1,637	-	1,637	-	-	1,637	-	-	1,637
		LV-3	60	-	20	20	-	20	-	20	-	20	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-60. Estimated Annual H_2O Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	H2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	20,250	30,375	20,250	40,500	20,250	30,375	20,250	20,250	20,250	20,250	20,250
	Medium	Solid	121,500	109,350	97,200	109,350	109,350	109,350	109,350	109,350	109,350	109,350	109,350
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	304,920	283,140	261,360	283,140	304,920	304,920	283,140	196,020	217,800	196,020	217,800
		$LOX-LH_2$	5,195,867	4,824,733	4,453,600	4,824,733	5,195,867	5,195,867	4,824,733	3,340,200	3,711,333	3,340,200	3,711,333
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	20,922	28,530	23,775	19,020	22,824	22,824	24,726	22,824	20,922	22,824	20,922
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	40,500	40,500	67,500	27,000	27,000	27,000	40,500	27,000	40,500	27,000	40,500
	Medium	Solid	228,150	315,900	298,350	245,700	263,250	263,250	245,700	263,250	263,250	245,700	263,250
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	25,920	12,960	25,920	12,960	25,920	12,960	25,920	12,960	25,920	12,960	25,920
		Hybrid	16,000	8,000	16,000	8,000	16,000	8,000	16,000	8,000	16,000	8,000	16,000
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	$Solid/LOX-LH_2$	47,250	40,500	60,750	54,000	47,250	47,250	60,750	54,000	47,250	47,250	47,250
		Solid/Hypergol	30,380	26,040	39,060	34,720	30,380	30,380	39,060	34,720	30,380	30,380	30,380
		LOX-RP-1	45,500	39,000	58,500	52,000	45,500	45,500	58,500	52,000	45,500	45,500	45,500
		Hybrid	45,500	39,000	58,500	52,000	45,500	45,500	58,500	52,000	45,500	45,500	45,500
		Hypergol	137,200	117,600	176,400	156,800	137,200	137,200	176,400	156,800	137,200	137,200	137,200
	Suborbital	LV-1	7,608	14,265	11,412	7,608	9,510	7,608	14,265	9,510	7,608	7,608	14,265
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-60. Estimated Annual H_2O Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	H2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	27,000	54,000	40,500	27,000	13,500	27,000	27,000	40,500	40,500	40,500	54,000
	Medium	Solid	35,100	52,650	17,550	17,550	35,100	17,550	17,550	17,550	17,550	17,550	17,550
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	12,960	-	-	-	-	-	-	-	-	-	-
		Hybrid	8,000	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid LOX-LH_2	74,250	67,500	81,000	87,750	87,750	87,750	101,250	101,250	101,250	101,250	94,500
		Solid/Hypergol	47,740	43,400	52,080	56,420	56,420	56,420	65,100	65,100	65,100	65,100	60,760
		LOX-RP-1	71,500	65,000	78,000	84,500	84,500	84,500	97,500	97,500	97,500	97,500	91,000
		Hybrid	71,500	65,000	78,000	84,500	84,500	84,500	97,500	97,500	97,500	97,500	91,000
		Hypergol	215,600	196,000	235,200	254,800	254,800	254,800	294,000	294,000	294,000	294,000	274,400
	Suborbital	LV-1	1,902	-	1,902	-	951	2,853	3,804	5,706	7,608	9,510	11,412
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual H_20 Emissions			7,294,254	6,873,948	6,768,303	7,071,869	7,405,715	7,432,573	7,275,051	5,613,434	5,987,364	5,548,615	6,048,829

Exhibit F-61. Estimated Annual VOC Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-61. Estimated Annual VOC Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-61. Estimated Annual VOC Emission Loads to the Stratosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual VOC Emissions			0	0	0	0	0	0	0	0	0	0	0

Exhibit F-62. Estimated Annual HCl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	322	-	-	322	-	-	322	-	322	-	322
	Concept 3	Vehicle Type F	-	-	-	-	92	-	92	-	92	-	92
	Concept 3	TBD Vehicle	-	-	22	108	323	323	430	430	430	430	430
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	2,100	1,050	2,100	2,100	1,050	2,100	2,100	2,100	2,100	2,100	2,100
	Medium	Solid	3,675	3,675	3,675	1,838	3,675	1,838	1,838	3,675	1,838	1,838	3,675
		Solid/LOX-RP-1	919	919	919	460	919	460	460	919	460	460	919
		Solid/Hypergol	938	938	938	469	938	469	469	938	469	469	938
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-62. Estimated Annual HCl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Government	Small	Solid	2,100	3,150	2,100	4,200	2,100	3,150	2,100	2,100	2,100	2,100	2,100
	Medium	Solid	18,375	16,538	14,700	16,538	16,538	16,538	16,538	16,538	16,538	16,538	16,538
		Solid/LOX-RP-1	4,595	4,136	3,676	4,136	4,136	4,136	4,136	4,136	4,136	4,136	4,136
		Solid/Hypergol	4,688	4,219	3,750	4,219	4,219	4,219	4,219	4,219	4,219	4,219	4,219
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	137,200	127,400	117,600	127,400	137,200	137,200	127,400	88,200	98,000	88,200	98,000
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	3,150	3,150	5,250	2,100	2,100	2,100	3,150	2,100	3,150	2,100	3,150
	Medium	Solid	13,650	18,900	17,850	14,700	15,750	15,750	14,700	15,750	15,750	14,700	15,750
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-62. Estimated Annual HCl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	HCl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Commercial	Small	Solid	2,100	4,200	3,150	2,100	1,050	2,100	2,100	3,150	3,150	3,150	4,200
	Medium	Solid	2,100	3,150	1,050	1,050	2,100	1,050	1,050	1,050	1,050	1,050	1,050
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual HCl Emissions			195,912	191,425	176,780	181,740	192,190	191,433	181,104	145,305	153,804	141,490	157,619

Exhibit F-63. Estimated Annual Cl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	2	-	-	2	-	-	2	-	2	-	2
	Concept 3	Vehicle Type F	-	-	-	-	1	-	1	-	1	-	1
	Concept 3	TBD Vehicle	-	-	< 1	1	3	3	4	4	4	4	4
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	16	8	16	16	8	16	16	16	16	16	16
	Medium	Solid	26	26	26	13	26	13	13	26	13	13	26
		Solid/LOX-RP-1	13	13	13	7	13	7	7	13	7	7	13
		Solid/Hypergol	13	13	13	6	13	6	6	13	6	6	13
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-63. Estimated Annual Cl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	16	24	16	32	16	24	16	16	16	16	16
	Medium	Solid	130	117	104	117	117	117	117	117	117	117	117
		Solid/LOX-RP-1	65	59	52	59	59	59	59	59	59	59	59
		Solid/Hypergol	63	56	50	56	56	56	56	56	56	56	56
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	980	910	840	910	980	980	910	630	700	630	700
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	24	24	40	16	16	16	24	16	24	16	24
	Medium	Solid	98	135	128	105	113	113	105	113	113	105	113
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-63. Estimated Annual Cl Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	Cl Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	16	32	24	16	8	16	16	24	24	24	32
	Medium	Solid	15	23	8	8	15	8	8	8	8	8	8
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual Cl Emissions			1,477	1,440	1,330	1,364	1,444	1,434	1,360	1,111	1,166	1,077	1,200

Exhibit F-64. Estimated Annual PM Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	582	-	-	582	-	-	582	-	582	-	582
	Concept 3	Vehicle Type F	-	-	-	-	166	-	166	-	166	-	166
	Concept 3	TBD Vehicle	-	-	39	194	582	582	776	776	776	776	776
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	3,800	1,900	3,800	3,800	1,900	3,800	3,800	3,800	3,800	3,800	3,800
	Medium	Solid	6,650	6,650	6,650	3,325	6,650	3,325	3,325	6,650	3,325	3,325	6,650
		Solid/LOX-RP-1	1,663	1,663	1,663	831	1,663	831	831	1,663	831	831	1,663
		Solid/Hypergol	1,625	1,625	1,625	813	1,625	813	813	1,625	813	813	1,625
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-64. Estimated Annual PM Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	3,800	5,700	3,800	7,600	3,800	5,700	3,800	3,800	3,800	3,800	3,800
	Medium	Solid	33,250	29,925	26,600	29,925	29,925	29,925	29,925	29,925	29,925	29,925	29,925
		Solid/LOX-RP-1	8,313	7,481	6,650	7,481	7,481	7,481	7,481	7,481	7,481	7,481	7,481
		Solid/Hypergol	8,125	7,313	6,500	7,313	7,313	7,313	7,313	7,313	7,313	7,313	7,313
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	248,267	230,533	212,800	230,533	248,267	248,267	230,533	159,600	177,333	159,600	177,333
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	5,700	5,700	9,500	3,800	3,800	3,800	5,700	3,800	5,700	3,800	5,700
	Medium	Solid	24,700	34,200	32,300	26,600	28,500	28,500	26,600	28,500	28,500	26,600	28,500
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-64. Estimated Annual PM Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	PM Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	3,800	7,600	5,700	3,800	1,900	3,800	3,800	5,700	5,700	5,700	7,600
	Medium	Solid	3,800	5,700	1,900	1,900	3,800	1,900	1,900	1,900	1,900	1,900	1,900
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual PM Emissions			354,075	345,990	319,527	328,497	347,372	346,037	327,345	262,533	277,945	255,664	284,814

Exhibit F-65. Estimated Annual NO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	5	-	-	5	-	-	5	-	5	-	5
	Concept 3	Vehicle Type F	-	-	-	-	1	-	1	-	1	-	1
	Concept 3	TBD Vehicle	-	-	< 1	2	5	5	6	6	6	6	6
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	34	17	34	34	17	34	34	34	34	34	34
	Medium	Solid	58	58	58	29	58	29	29	58	29	29	58
		Solid/LOX-RP-1	15	15	15	8	15	8	8	15	8	8	15
		Solid/Hypergol	188	188	188	94	188	94	94	188	94	94	188
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	174,533	149,600	174,533	174,533	149,600	149,600	174,533	149,600	149,600	149,600	174,533
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-65. Estimated Annual NO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	34	51	34	68	34	51	34	34	34	34	34
	Medium	Solid	290	261	232	261	261	261	261	261	261	261	261
		Solid/LOX-RP-1	75	68	60	68	68	68	68	68	68	68	68
		Solid/Hypergol	938	844	750	844	844	844	844	844	844	844	844
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	2,156	2,002	1,848	2,002	2,156	2,156	2,002	1,386	1,540	1,386	1,540
		Hypergol	272,907	253,413	233,920	253,413	272,907	272,907	253,413	175,440	194,933	175,440	194,933
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	51	51	85	34	34	34	51	34	51	34	51
	Medium	Solid	215	297	281	231	248	248	231	248	248	231	248
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	44,200	61,200	57,800	47,600	51,000	51,000	47,600	51,000	51,000	47,600	51,000
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	17,952	8,976	17,952	8,976	17,952	8,976	17,952	8,976	17,952	8,976	17,952
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	468,384	401,472	602,208	535,296	468,384	468,384	602,208	535,296	468,384	468,384	468,384
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-65. Estimated Annual NO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	NO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	34	68	51	34	17	34	34	51	51	51	68
	Medium	Solid	33	50	17	17	33	17	17	17	17	17	17
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	6,800	10,200	3,400	3,400	6,800	3,400	3,400	3,400	3,400	3,400	3,400
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	8,976	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	736,032	669,120	802,944	869,856	869,856	869,856	1,003,680	1,003,680	1,003,680	1,003,680	936,768
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total NO_X Emission Loads			1,733,910	1,557,951	1,896,410	1,896,805	1,840,478	1,828,006	2,106,505	1,930,636	1,892,240	1,860,177	1,850,408

Exhibit F-66. Estimated Annual SO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered lanidng	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-66. Estimated Annual SO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-66. Estimated Annual SO_X Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	SO_X Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual SO_X Emissions			0	0	0	0	0	0	0	0	0	0	0

Exhibit F-67. Estimated Annual CO Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	993	5,955	5,955	7,940	3,970	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	794	3,969	7,938	11,907	13,892	13,892	13,892	13,892	13,892
	Concept 2	TBD Vehicle	-	-	657	1,642	3,941	8,210	8,210	9,852	9,852	11,494	13,136
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	352	-	-	352	-	-	352	-	352	-	352
	Concept 3	Vehicle Type F	-	-	-	-	134	-	134	-	134	-	134
	Concept 3	TBD Vehicle	-	-	25	125	375	375	500	500	500	500	500
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	2,300	1,150	2,300	2,300	1,150	2,300	2,300	2,300	2,300	2,300	2,300
	Medium	Solid	4,025	4,025	4,025	2,013	4,025	2,013	2,013	4,025	2,013	2,013	4,025
		Solid/LOX-RP-1	1,138	1,138	1,138	569	1,138	569	569	1,138	569	569	1,138
		Solid/Hypergol	1,125	1,125	1,125	563	1,125	563	563	1,125	563	563	1,125
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	56,467	48,400	56,467	56,467	48,400	48,400	56,467	48,400	48,400	48,400	56,467
		Hybrid	56,467	48,400	56,467	56,467	48,400	48,400	56,467	48,400	48,400	48,400	56,467
		Hypergol	3,850	3,300	3,850	3,850	3,300	3,300	3,850	3,300	3,300	3,300	3,850
	Suborbital	LV-1	675	675	1,350	1,350	675	1,800	1,800	1,800	2,250	2,250	2,250
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-67. Estimated Annual CO Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	2,300	3,450	2,300	4,600	2,300	3,450	2,300	2,300	2,300	2,300	2,300
	Medium	Solid	20,125	18,113	16,100	18,113	18,113	18,113	18,113	18,113	18,113	18,113	18,113
		Solid/LOX-RP-1	5,688	5,119	4,550	5,119	5,119	5,119	5,119	5,119	5,119	5,119	5,119
		Solid/Hypergol	5,625	5,063	4,500	5,063	5,063	5,063	5,063	5,063	5,063	5,063	5,063
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	150,267	139,533	128,800	139,533	150,267	150,267	139,533	96,600	107,333	96,600	107,333
		Hypergol	6,020	5,590	5,160	5,590	6,020	6,020	5,590	3,870	4,300	3,870	4,300
	Suborbital	LV-1	4,950	6,750	5,625	4,500	5,400	5,400	5,850	5,400	4,950	5,400	4,950
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	3,450	3,450	5,750	2,300	2,300	2,300	3,450	2,300	3,450	2,300	3,450
	Medium	Solid	14,950	20,700	19,550	16,100	17,250	17,250	16,100	17,250	17,250	16,100	17,250
		LOX-RP-1	14,300	19,800	18,700	15,400	16,500	16,500	15,400	16,500	16,500	15,400	16,500
		Hypergol	975	1,350	1,275	1,050	1,125	1,125	1,050	1,125	1,125	1,050	1,125
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	4,752	2,376	4,752	2,376	4,752	2,376	4,752	2,376	4,752	2,376	4,752
		Hypergol	396	198	396	198	396	198	396	198	396	198	396
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	55,440	47,520	71,280	63,360	55,440	55,440	71,280	63,360	55,440	55,440	55,440
		Hybrid	55,440	47,520	71,280	63,360	55,440	55,440	71,280	63,360	55,440	55,440	55,440
		Hypergol	10,332	8,856	13,284	11,808	10,332	10,332	13,284	11,808	10,332	10,332	10,332
	Suborbital	LV-1	1,800	3,375	2,700	1,800	2,250	1,800	3,375	2,250	1,800	1,800	3,375
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-67. Estimated Annual CO Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	2,300	4,600	3,450	2,300	1,150	2,300	2,300	3,450	3,450	3,450	4,600
	Medium	Solid	2,300	3,450	1,150	1,150	2,300	1,150	1,150	1,150	1,150	1,150	1,150
		LOX-RP-1	2,200	3,300	1,100	1,100	2,200	1,100	1,100	1,100	1,100	1,100	1,100
		Hypergol	150	225	75	75	150	75	75	75	75	75	75
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	2,376	-	-	-	-	-	-	-	-	-	-
		Hypergol	198	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	87,120	79,200	95,040	102,960	102,960	102,960	118,800	118,800	118,800	118,800	110,880
		Hybrid	87,120	79,200	95,040	102,960	102,960	102,960	118,800	118,800	118,800	118,800	110,880
		Hypergol	16,236	14,760	17,712	19,188	19,188	19,188	22,140	22,140	22,140	22,140	20,664
	Suborbital	LV-1	450	-	450	-	225	675	900	1,350	1,800	2,250	2,700
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO Emissions			684,652	637,666	724,172	727,610	713,771	714,438	794,317	718,589	713,503	698,347	722,923

Exhibit F-68. Estimated Annual CO_2 Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	2,431	14,586	14,586	19,448	9,724	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	1,945	9,724	19,448	29,172	34,034	34,034	34,034	34,034	34,034
	Concept 2	TBD Vehicle	-	-	1,609	4,023	9,655	20,115	20,115	24,138	24,138	28,161	32,184
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	46	-	-	46	-	-	46	-	46	-	46
	Concept 3	Vehicle Type F	-	-	-	-	18	-	18	-	18	-	18
	Concept 3	TBD Vehicle	-	-	3	17	50	50	66	66	66	66	66
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	300	150	300	300	150	300	300	300	300	300	300
	Medium	Solid	525	525	525	263	525	263	263	525	263	263	525
		Solid/LOX-RP-1	1,138	1,138	1,138	569	1,138	569	569	1,138	569	569	1,138
		Solid/Hypergol	875	875	875	438	875	438	438	875	438	438	875
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	30,800	26,400	30,800	30,800	26,400	26,400	30,800	26,400	26,400	26,400	30,800
		Hybrid	30,800	26,400	30,800	30,800	26,400	26,400	30,800	26,400	26,400	26,400	30,800
		Hypergol	23,100	19,800	23,100	23,100	19,800	19,800	23,100	19,800	19,800	19,800	23,100
	Suborbital	LV-1	369	369	738	738	369	984	984	984	1,230	1,230	1,230
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-68. Estimated Annual CO_2 Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	300	450	300	600	300	450	300	300	300	300	300
	Medium	Solid	2,625	2,363	2,100	2,363	2,363	2,363	2,363	2,363	2,363	2,363	2,363
		Solid/LOX-RP-1	5,688	5,119	4,550	5,119	5,119	5,119	5,119	5,119	5,119	5,119	5,119
		Solid/Hypergol	4,375	3,938	3,500	3,938	3,938	3,938	3,938	3,938	3,938	3,938	3,938
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		$LOX-LH_2$	19,600	18,200	16,800	18,200	19,600	19,600	18,200	12,600	14,000	12,600	14,000
		Hypergol	36,120	33,540	30,960	33,540	36,120	36,120	33,540	23,220	25,800	23,220	25,800
	Suborbital	LV-1	2,706	3,690	3,075	2,460	2,952	2,952	3,198	2,952	2,706	2,952	2,706
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	450	450	750	300	300	300	450	300	450	300	450
	Medium	Solid	1,950	2,700	2,550	2,100	2,250	2,250	2,100	2,250	2,250	2,100	2,250
		LOX-RP-1	7,800	10,800	10,200	8,400	9,000	9,000	8,400	9,000	9,000	8,400	9,000
		Hypergol	5,850	8,100	7,650	6,300	6,750	6,750	6,300	6,750	6,750	6,300	6,750
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	2,592	1,296	2,592	1,296	2,592	1,296	2,592	1,296	2,592	1,296	2,592
		Hypergol	2,376	1,188	2,376	1,188	2,376	1,188	2,376	1,188	2,376	1,188	2,376
	Heavy	$Solid/LOX-LH_2$	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	30,240	25,920	38,880	34,560	30,240	30,240	38,880	34,560	30,240	30,240	30,240
		Hybrid	30,240	25,920	38,880	34,560	30,240	30,240	38,880	34,560	30,240	30,240	30,240
		Hypergol	61,992	53,136	79,704	70,848	61,992	61,992	79,704	70,848	61,992	61,992	61,992
	Suborbital	LV-1	984	1,845	1,476	984	1,230	984	1,845	1,230	984	984	1,845
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-68. Estimated Annual CO_2 Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	CO_2 Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	300	600	450	300	150	300	300	450	450	450	600
	Medium	Solid	300	450	150	150	300	150	150	150	150	150	150
		LOX-RP-1	1,200	1,800	600	600	1,200	600	600	600	600	600	600
		Hypergol	900	1,350	450	450	900	450	450	450	450	450	450
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	1,296	-	-	-	-	-	-	-	-	-	-
		Hypergol	1,188	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	47,520	43,200	51,840	56,160	56,160	56,160	64,800	64,800	64,800	64,800	60,480
		Hybrid	47,520	43,200	51,840	56,160	56,160	56,160	64,800	64,800	64,800	64,800	60,480
		Hypergol	97,416	88,560	106,272	115,128	115,128	115,128	132,840	132,840	132,840	132,840	123,984
	Suborbital	LV-1	246	-	246	-	123	369	492	738	984	1,230	1,476
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual CO_2 Emissions			504,158	468,058	564,610	575,970	562,035	568,590	654,150	611,962	599,876	596,513	605,297

Exhibit F-69. Estimated Annual H_2O Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	1,489	8,931	8,931	11,908	5,954	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	1,191	5,954	11,908	17,862	20,839	20,839	20,839	20,839	20,839
	Concept 2	TBD Vehicle	-	-	985	2,463	5,911	12,315	12,315	14,778	14,778	17,241	19,704
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	413	-	-	413	-	-	413	-	413	-	413
	Concept 3	Vehicle Type F	-	-	-	-	155	-	155	-	155	-	155
	Concept 3	TBD Vehicle	-	-	29	146	438	438	584	584	584	584	584
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	2,700	1,350	2,700	2,700	1,350	2,700	2,700	2,700	2,700	2,700	2,700
	Medium	Solid	4,725	4,725	4,725	2,363	4,725	2,363	2,363	4,725	2,363	2,363	4,725
		Solid/LOX-RP-1	2,275	2,275	2,275	1,138	2,275	1,138	1,138	2,275	1,138	1,138	2,275
		Solid/Hypergol	2,688	2,688	2,688	1,344	2,688	1,344	1,344	2,688	1,344	1,344	2,688
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	32,083	27,500	32,083	32,083	27,500	27,500	32,083	27,500	27,500	27,500	32,083
		Hybrid	32,083	27,500	32,083	32,083	27,500	27,500	32,083	27,500	27,500	27,500	32,083
		Hypergol	44,917	38,500	44,917	44,917	38,500	38,500	44,917	38,500	38,500	38,500	44,917
	Suborbital	LV-1	384	384	768	768	384	1,024	1,024	1,024	1,280	1,280	1,280
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-69. Estimated Annual H_2O Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	2,700	4,050	2,700	5,400	2,700	4,050	2,700	2,700	2,700	2,700	2,700
	Medium	Solid	23,625	21,263	18,900	21,263	21,263	21,263	21,263	21,263	21,263	21,263	21,263
		Solid/LOX-RP-1	11,375	10,238	9,100	10,238	10,238	10,238	10,238	10,238	10,238	10,238	10,238
		Solid/Hypergol	13,438	12,094	10,750	12,094	12,094	12,094	12,094	12,094	12,094	12,094	12,094
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	176,400	163,800	151,200	163,800	176,400	176,400	163,800	113,400	126,000	113,400	126,000
		Hypergol	70,233	65,217	60,200	65,217	70,233	70,233	65,217	45,150	50,167	45,150	50,167
	Suborbital	LV-1	2,816	3,840	3,200	2,560	3,072	3,072	3,328	3,072	2,816	3,072	2,816
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	4,050	4,050	6,750	2,700	2,700	2,700	4,050	2,700	4,050	2,700	4,050
	Medium	Solid	17,550	24,300	22,950	18,900	20,250	20,250	18,900	20,250	20,250	18,900	20,250
		LOX-RP-1	8,125	11,250	10,625	8,750	9,375	9,375	8,750	9,375	9,375	8,750	9,375
		Hypergol	11,375	15,750	14,875	12,250	13,125	13,125	12,250	13,125	13,125	12,250	13,125
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	2,700	1,350	2,700	1,350	2,700	1,350	2,700	1,350	2,700	1,350	2,700
		Hypergol	4,620	2,310	4,620	2,310	4,620	2,310	4,620	2,310	4,620	2,310	4,620
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	31,500	27,000	40,500	36,000	31,500	31,500	40,500	36,000	31,500	31,500	31,500
		Hybrid	31,500	27,000	40,500	36,000	31,500	31,500	40,500	36,000	31,500	31,500	31,500
		Hypergol	120,540	103,320	154,980	137,760	120,540	120,540	154,980	137,760	120,540	120,540	120,540
	Suborbital	LV-1	1,024	1,920	1,536	1,024	1,280	1,024	1,920	1,280	1,024	1,024	1,920
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-69. Estimated Annual H_2O Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	H_2O Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	2,700	5,400	4,050	2,700	1,350	2,700	2,700	4,050	4,050	4,050	5,400
	Medium	Solid	2,700	4,050	1,350	1,350	2,700	1,350	1,350	1,350	1,350	1,350	1,350
		LOX-RP-1	1,250	1,875	625	625	1,250	625	625	625	625	625	625
		Hypergol	1,750	2,625	875	875	1,750	875	875	875	875	875	875
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	1,350	-	-	-	-	-	-	-	-	-	-
		Hypergol	2,310	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	49,500	45,000	54,000	58,500	58,500	58,500	67,500	67,500	67,500	67,500	63,000
		Hybrid	49,500	45,000	54,000	58,500	58,500	58,500	67,500	67,500	67,500	67,500	63,000
		Hypergol	189,420	172,200	206,640	223,860	223,860	223,860	258,300	258,300	258,300	258,300	241,080
	Suborbital	LV-1	256	-	256	-	128	384	512	768	1,024	1,280	1,536
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual H_2O Emissions			958,064	888,755	1,011,257	1,022,306	1,010,916	1,010,502	1,119,130	1,012,148	1,004,280	981,210	1,006,170

Exhibit F-70. Estimated Annual VOC Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Commercial (FAA Licensed, Horiz. LVs and RVs)	Concept 1	Vehicle Type A	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type B	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	Vehicle Type C	-	-	-	-	-	-	-	-	-	-	-
	Concept 2	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type D	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type E	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	Vehicle Type F	-	-	-	-	-	-	-	-	-	-	-
	Concept 3	TBD Vehicle	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
U.S. Commercial (FAA Licensed, Excluding Horizontal LVs or RVs)	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
		LV-2	-	-	-	-	-	-	-	-	-	-	-
		LV-3	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-70. Estimated Annual VOC Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		Solid/LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Foreign Government	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-

Exhibit F-70. Estimated Annual VOC Emission Loads to the Mesosphere

Vehicle Classification		Propellant Type or Vehicle	VOC Emission Loads (kilograms)										
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign Commercial	Small	Solid	-	-	-	-	-	-	-	-	-	-	-
	Medium	Solid	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Intermed.	Solid	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Heavy	Solid/LOX-LH_2	-	-	-	-	-	-	-	-	-	-	-
		Solid/Hypergol	-	-	-	-	-	-	-	-	-	-	-
		LOX-RP-1	-	-	-	-	-	-	-	-	-	-	-
		Hybrid	-	-	-	-	-	-	-	-	-	-	-
		Hypergol	-	-	-	-	-	-	-	-	-	-	-
	Suborbital	LV-1	-	-	-	-	-	-	-	-	-	-	-
	Reentry	Jet-powered landing	-	-	-	-	-	-	-	-	-	-	-
		Rocket-powered landing	-	-	-	-	-	-	-	-	-	-	-
Total Annual VOC Emissions			0	0	0	0	0	0	0	0	0	0	0

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APPENDIX G DISTRIBUTION LIST

This appendix provides a list of those persons and organizations that have been placed on the distribution list to date. Those on the distribution list receive any mail-out materials related to the development and publication of this Programmatic Environmental Impact Statement (PEIS). This includes notification of the Final PEIS. This appendix is divided into the following general categories: Federal and other agencies, industry, and private citizens. The street address for private citizens is not provided for privacy reasons.

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