Appendix A – February 11, 1999 EA

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FINAL

ENVIRONMENTAL ASSESSMENT FOR THE SEA LAUNCH PROJECT

Prepared for the
U.S. Department of Transportation
Federal Aviation Administration
Office of the Associate Administrator
for Commercial Space Transportation
Washington, DC 20590

by

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This Environmental Assessment becomes a Federal document when evaluated and signed by the responsible Federal Aviation Administration (FAA) Official.

Responsible FAA Official   Date

EXECUTIVE SUMMARY FOR THE SEA LAUNCH FINAL ENVIRONMENTAL ASSESSMENT

INTRODUCTION

The proposed action is for Federal Aviation Administration's (FAA) Office of the Associate Administrator for Commercial Space Transportation (AST) to issue a commercial space launch license to the Sea Launch Limited Partnership (SLLP) for two launches. SLLP proposes to conduct commercial space launch operations from a mobile, floating platform in international waters in the east-central equatorial Pacific Ocean. This Environmental Assessment addresses environmental impacts, mitigation measures that might be required, and alternatives considered for up to six launches per year, in accordance with Executive Order 12114 (E.O. 12114), Environmental Effects Abroad of Major Federal Actions the application of which is guided by the National Environmental Policy Act (NEPA). Pursuant to its requirements, the FAA will reevaluate the adequacy of existing environmental documentation if new circumstances occur.

The SLLP is an international commercial venture formed to launch commercial satellites. It is organized under the laws of the Cayman Islands, BWI, and the partnership members are Boeing Commercial Space Company of the United States; RSC Energia of Russia; KB Yuzhnoye of the Ukraine; and Kværner Maritime a.s of Norway. The SLLP is responsible for the environmental concerns regarding the Sea Launch Program and for all contractual work with customers.

PURPOSE AND NEED

The Sea Launch facility would provide a commercial alternative to launching satellites from Federal installations. The proposed Sea Launch activities would make available infrastructure for placing telecommunications, scientific, and research payloads in equatorial low earth, geosynchronous, geosynchronous transfer or medium earth orbits. The Zenit-3SL expendable launch vehicle fueled by kerosene and liquid oxygen, would be the only launch vehicle used at the Sea Launch facilities. In the first year of operation, 1999, SLLP intends to conduct three launches (one demonstration payload and two satellites); six launches are proposed for each subsequent year.

The Commercial Space Launch Act (CSLA) of 1984 (Public Law 98-575), as amended, 49 U.S.C. Subtitle IX, ch 701 – Commercial Space Launch Activities, authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launch operations and issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary is implementing this authority through FAA AST. FAA exercises licensing authority in accordance with the 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. SLLP has applied for a launch-specific license, and later plans to apply for a launch operator license.

DESCRIPTION OF PROPOSED ACTION

The FAA's proposed action is to issue a commercial launch license to SLLP for two launches as described and configured in the operating plan detailed in Appendix A. SLLP would utilize a launch platform (LP) and an assembly and command ship (ACS). A floating oil drilling platform has been refurbished in Norway to serve as the self-propelled LP. The ACS has been built in Scotland specifically for Sea Launch operations.

The launch is proposed to occur at the Equator in the vicinity of 154° W, maximizing inertial and other launch efficiencies. The distances from South America (over 7,000 km) and from the nearest inhabited island (340 km) ensure that Stage 1, the fairing, and Stage 2 would drop well away from land, coastal commercial activity, and exclusive economic zones.

CONSIDERATION OF ALTERNATIVES

Eliminated from consideration were launch vehicle assets not owned or produced by SLLP members, launch locations that constrained launch flexibility and efficiencies or posed avoidable risks to the public and environment, and logistical arrangements not convenient to SLLP customer satellite manufacturing facilities. Existing launch locations in the United States and elsewhere were eliminated from consideration because they would be too restrictive in terms of access, less optimal for launch physics, and/or more costly and inflexible. In addition, SLLP concluded that building a new land-based launch site would be more disruptive, more time consuming, and more costly. Ultimately, the use of a floating platform as a mobile launch location was considered more commercially desirable than using an existing land-based facility or building a new one.

NO ACTION ALTERNATIVE

Under the No Action alternative, FAA would not issue a commercial launch license to SLLP. Because the CSLA requires a launch operator such as SLLP to obtain a license, the applicant would not be able to conduct commercial launches or offer these services, and thus Sea Launch operations, including launches from a launch platform in the Pacific Ocean, would not occur.

ENVIRONMENTAL IMPACTS

Sea Launch operations at the launch location and range have been broadly grouped into pre-launch operations, successful launch and flight, post-launch operations, and failed missions. The environmental impacts of each of these are discussed below. The environmental impacts of payloads are not discussed because they would be fueled and sealed at the Home Port and only become operational and expend their propellants at an altitude over 35,000 km. Sea Launch activities that are part of the proposed action and are sufficiently addressed in other relevant documents incorporated by reference into this Environmental Assessment, are described in Appendix A. The hazards and mitigation measures associated with activities planned and managed as part of the Home Port and vessel design, development, and permitting processes overseen by various permitting and licensing authorities are described in Appendix B.

Pre-Launch Operations

Normal pre-launch operations would result in no loss of kerosene or liquid oxygen (LOX) other than incidental loss of vapors from the fuel connections, which would dissipate immediately. Freshwater sprayed from a tank on the LP into the LP's flame bucket would be used as a means of dissipating heat and absorbing sound during the initial fuel burn. The fresh water tanks on the Launch Platform hold 27,474 gallons. It is estimated approximately 80 percent of this water would be evaporated by the heat of the rocket exhaust, while the remainder would be dispersed by the force of the exhaust and settle over a wide area on the ocean surface. Negligible impacts to the ecosystem would occur from the use of this water because the natural variation in plankton densities would ensure a nearly instantaneous recolonization in the water surrounding the LP following the input of heated freshwater.

Defueling after a failed launch attempt would result in the release of LOX vapor and approximately 70 kg of kerosene when the fuel line is flushed. This kerosene would primarily wet the exhaust deflector, which is a steel structure located below the launch pad deck. The kerosene would rapidly dissipate and disperse from this steel structure.

Launch and Flight

Inputs to the environment from each launch would be spent stages, residual fuels released from the spent stages to the ocean and atmosphere, combustion emissions released to the atmosphere, and energy transferred to the atmosphere and to the deck of the LP, primarily thermal and acoustic. During normal launches, these inputs would occur and would be distributed across the east-central equatorial pacific region in a highly predictable manner. The inputs are characterized as occurring successively in downrange zones extending across the Pacific Ocean toward South America.

Stage 1 and Stage 2 would fall, rupture, and sink within the areas shown on Figure ES-1. Based on the launch industry's experience with composite fairings, the two halves of the Sea Launch fairing will break up into a number of rigid pieces. Each piece will either float at or below the surface for a number of years, or become waterlogged and sink within a few days. Unlike plastic debris such as fishing nets, rope, string, and packaging materials that readily ensnares or is ingested by sea life, fairing pieces are relatively large, solid sheets of material. As such, floating fairing pieces will offer resting places for sea birds and provide smaller sea life shade and some protection from predators. It is unlikely that falling debris would impact any animals, though a small number of marine organisms would likely be smothered when the debris has sunk.

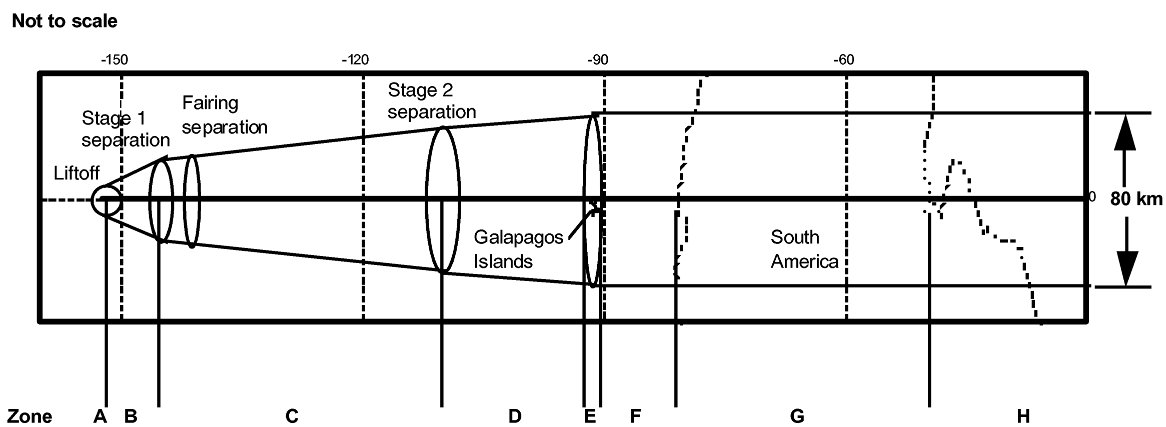

Figure ES-1. Stage 1 and 2 Impact Zones

Approximately 2,450 kg of kerosene would fall unburned in the two Zenit fuel tanks. The kerosene and LOX would be forcibly released when the tanks rupture during descent or upon impact with the ocean surface. Kerosene released during descent would volatilize within a minute or two, while the kerosene that reaches the ocean would form a surface sheen that would likely be a maximum of several millimeters thick in the middle and covering several square kilometers. Over 95% of the kerosene would evaporate from the ocean surface within a few hours, chemically react to form smog, and become dispersed within a few hours while the remainder would disperse or degrade within a few days. Plankton present beneath and within a few meters of the sheen would likely be killed from entrained kerosene, however, overall plankton mortality would be minimal since population densities are at a maximum at around 30 meters below the surface. The residual LOX would instantly vaporize without consequence.

In addition to the debris expended from the integrated launch vehicle (ILV) during normal launches, some debris might be blown off the LP into the ocean during the launch process. As these material inputs would be small in volume and largely inert, they would cause little disruption or impact to the ocean ecosystem.

The noise from a launch is calculated at approximately 150 decibels (dB) at 378 meters and the equivalent sound intensity in the water at this distance is predicted to be less than 75 dB. Little to no impact to the environment is expected from these levels due to the small number of launches per year and the relative absence of the higher trophic level organisms that would typically suffer injury from a loud sound. Animals, including birds, in the area would experience a startle reaction as now occurs at established land-based launch locations.

Atmospheric effects caused by the flight of the Sea Launch rocket would arise from the combustion of onboard fuel stocks with the associated emissions of gases and particulate matter, and the physical passage of the ILV through the atmosphere. Most emissions would be caused by normal operation of the rocket while small quantities of payload fuels would be expended beginning at approximately 35,000 km, beyond the range of concern and potential atmospheric impact.

Launch effects on the atmospheric boundary layer (up to two km) would be due to the initial burn of the first stage of the Zenit-3SL rocket. Current research and studies on emissions in the atmospheric boundary layer have focused on releases in proximity to populated landmasses. Because the atmospheric boundary layer in the region surrounding the proposed launch location is essentially free of combustion emissions, and because of the size of the Pacific Ocean and air space, effects of Zenit-3SL emissions would be short term (i.e., on the order of several hours in duration). Models predict maximum concentrations at Kiritimati (Christmas) Island on the order of 1 mg/m^3 of CO after 36 hours of steady winds to the northwest (NOAA, 1998).

Of the fuel carried in the first stage, approximately 44,700 kg of LOX and 17,000 kg of kerosene would be burned below 2,000 m. These emissions would be dispersed away from Christmas and Malden Islands by the winds and by the local turbulence caused by solar heating. Because dispersion occurs within hours, the planned six missions per year would preclude any chance of accumulation or chronic effects of emissions from normal launches.

All emissions to the free troposphere would come from first stage combustion of LOX and kerosene. Photochemical reactions involving Zenit rocket emissions such as CO and trace hydrocarbons, leading to the formation of CO_2 and oxygenated organic compounds, can be expected to occur. Nitrogen oxide (NO_x), formed in the exhaust trail, would tend to form nitric and nitrous acids. Cloud droplets and atmospheric aerosols efficiently absorb water-soluble compounds such as acids, oxygenated chemical compounds, and oxidants such as OH_x and O_3.

Approximately 36,100 kg of CO would be released into the troposphere during the first 55 seconds of flight, resulting in a CO concentration at Christmas Island estimated to be 9.94 mg/m^3. For comparison, the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit

(PEL) for CO is 55 mg/m^3, the EPA level of concern for CO is 175 mg/m^3, and the industry Emergency Response Planning Guideline-2 for CO is 400 mg/m^3.

Due to nitrogen compounds in the exhaust trail of liquid propellant rockets like the Zenit-3SL, models predict a substantial, temporary reduction of ozone, with return to near background levels within a few hours. Models and measurements of other space systems comparable to Sea Launch indicate these impacts are temporary, and the atmosphere is capable of replacing the destroyed ozone within a few hours by migration or regeneration.

The high-speed movement of the Zenit-3SL rocket and the re-entry of the stages after their use may impact stratospheric ozone. Shock waves caused by the high speed motion of the rocket or re-entry components enhance the formation of NO_x, which in turn contributes to ozone destruction; however, this effect is considered to be relatively small. In addition, the heating of the rocket or re-entry components is believed to possibly cause the production of chemical compounds that may also play a role in ozone destruction. The exact chemistry and relative significance of these processes is not known but is believed to be minimal (AIAA, 1991).

Post-Launch Operations

To cleanse the structure for subsequent operations, particulate residues might be washed from the LP with freshwater. Little more than a few kilograms of debris would be generated from a launch, which would be collected and handled onboard as solid waste for later disposal at the Home Port.

Failed Mission Scenarios

Two severe accident scenarios for mission failure were evaluated and determined to cause only minimal damage to the environment. The worst case failure scenario is an ILV failure and explosion on the LP when the ILV contains the maximum amount of fuel and materials. The probability of ILV failure occurring sometime during the first 20 seconds of flight is 3.643×10^{-4} or 0.0003643. During these 20 seconds, the ILV may be considered to be in the immediate vicinity of the LP with propellants at or near maximum amounts. Two factors contribute to minimizing the likelihood of an ILV failure near the LP. First, the Zenit-3SL has a thrust/weight ratio of 1.6, which means the ILV quickly accelerates away from the LP. Second, to further reduce the risk of an explosion on or near the LP, the ILV trajectory is pitched downrange away from the LP very early in flight. The quick acceleration and pitch change combine to reduce the risk of secondary damage to the LP and its fuels and equipment, thereby reducing potential impacts to safety and the environment from an ILV failure early in flight. Should impact occur on or near the LP, special provisions have been made to harden critical hardware on the LP to increase their survivability. Such a failure would result in a cascading explosion of all ILV fuels. The explosion(s) would scatter pieces of the ILV, and perhaps pieces of the LP launch apparatus, as far as three km away. Particulate material from the smoke plume would drift downwind and be distributed up to a few kilometers distance before dissipating. Such an incident would likely result in the deaths of plankton and fish in the immediate area of the explosion over the course of several days. Thermal energy would be deflected and absorbed by the ocean and an estimated 100% of the fuels would be consumed or released into the atmosphere through combustion and evaporation. Disruptions to the atmosphere and ocean would be assimilated and the environment would return to pre-accident conditions within several days.

The second failure scenario evaluated involved failure of the rocket's upper stage. In the event of a loss and re-entry of the upper stage and payload, most of the material and all of the fuels involved would be heated via friction and vaporize. The remaining objects would fall into the ocean and temporarily disrupt the environment as the warm objects cooled and sank into the deep ocean waters.

The risk of debris striking the Galapagos Islands (4.3 in one million) is very remote and the risk of harm to resident populations or habitat even smaller.

Other Environmental Considerations

Home Port

The design, permitting, construction, and operation of the Home Port would be managed under the jurisdiction of the state, regional, county, municipal, and port authorities in effect in the Port of Long Beach, California. The Home Port facility is a small portion of a vast complex built in the Long Beach Port area that is being surplused by the U.S. Navy.

The Port of Long Beach has approved the construction and operation of the Home Port through the Harbor Development Permit process. One of the standard conditions in the Harbor Development Permit is that SLLP will follow all applicable Federal, state, and local laws and regulations, including those pertaining to safety and the environment.

The LP, ACS, and satellite tracking ships used to transport the launch vehicle, payload and other materials to the launch location and operate the launch will be subject to and will comply with all applicable environmental and maritime international agreement requirements while traveling to and from and while at the launch location.

Notices to Mariners

Standard notices to mariners will be broadcast using US Government protocols via INMARSAT-C in the Pacific Ocean Region on Safety Net channel at 1000 – 1030 and 2200 – 2230 hours GMT each day starting 5 days prior to each launch. For vessels without INMARSAT-C transceivers, the notice will be broadcast in the HF band by U.S. Coast Guard, Honolulu. For vessels without any receiving equipment (expected to be limited to those operating out of Kiribati ports), the standard notice will be delivered from SLLP by fax or mail services to Kiribati government authorities and fishing fleet and tour operators for distribution and posting.

Environmental Monitoring Plan

The Environmental Monitoring and Protection Plan is being developed as an integral part of Sea Launch plans for operations at sea, and its implementation involves the participation of both aerospace and marine crews. FAA approval of the Environmental Monitoring Plan is a condition of issuance of the launch license. The Plan consists of four elements:

- Visual observation for species of concern
- Remote detection of atmospheric effects during launch
- Surface water samples to detect possible launch effects
- Notices to local mariners

A separate plan exists for each element to direct specific actions and coordinate the analysis of acquired data.

Environmental Justice

Current operating plans do not include excessive contact with the Kiribati population (Christmas Island has been evaluated for emergency use only). Due to the limited amount of time that the LP and the ACS will be present at the launch location, social and economic considerations are considered to be negligible.

No Action

Under the No Action alternative the SLLP would not launch satellites from the Pacific Ocean and the Port of Long Beach would remain available for other commercial or government ventures. The goals of the CSLA would not be furthered. Predicted environmental impacts of the proposed launches would not occur and the area surrounding the proposed launch location would remain in its current state.

CUMULATIVE IMPACTS

There are no other foreseeable developments in the area of the proposed launch location, and therefore, no cumulative impacts are expected. The Navy Mole facility is currently underutilized as compared to its historical level of operation and development, and the Home Port facility may be the impetus for other development in the area. The cumulative socioeconomic effects in the area could reach a level equal to that experienced previously when Navy activities at the facility were at their historical high, however, based on the information in the Navy environmental documentation referenced, no cumulative environmental effects are expected.

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LIST OF ACRONYMS

^{o}C	degree centigrade (Celsius)
σ	sigma; symbol for standard deviation
3SL	Zenit-3SL is designation for three-stage rocket
ACS	assembly & command ship
AGARD	Advisory Group for Aerospace Research and Development
AH	anhydrous hydrazine
AIAA	American Institute of Aeronautics and Astronautics
AST	Office of the Associate Administrator for Commercial Space Transportation (formerly known as Office of Commercial Space Transportation)
BCSC	Boeing Commercial Space Company
CCAM	contamination and collision avoidance maneuver
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
COFR	Code of Financial Responsibility
CPIA	Chemical Propulsion Information Agency
dB	Decibels
DM	Block DM is the upper stage of the Zenit-3SL Rocket
DM-SL	Block DM-Sea Launch
DNV	Det Norske Veritas
DoD	Department of Defense
DOS	Department of State
DoT	Department of Transportation
EEZ	exclusive economic zone
EIS	Environmental Impact Statement
EMC	electromagnetic compatibility
E.O.	executive order
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FMH	free molecular heating
FSS	flight safety system
GMT	Greenwich Mean Time
GN_2	gaseous nitrogen
GOST	government standard (Russian)
NFPA	National Fire Protection Association
NMFS	National Marine Fisheries Service
GSE	ground support equipment
GEO	geosynchronous orbit
GTO	geosynchronous transfer orbit
HF	High Frequency
HO_X	hydrogen oxides
HP	Home Port
IIP	instantaneous impact point
ILL	impact limit line
ILV	integrated launch vehicle
IMDG Code	International Maritime Dangerous Goods Code
ISMA	International Safety Management Administration
kg	Kilogram
km	Kilometer
kW	Kilowatt
l	liters (volume measurement)
LDC	Limited Duration Company
LEL	lower explosive limit
LEO	low earth orbit
LOX	liquid oxygen
LP	launch platform
MARPOL	International Convention for the Prevention of Pollution from Ships
MCC	mission control center
MEO	medium earth orbit
MMH	Monomethylhydrazine
N/A	not applicable
N_2	Nitrogen
N_2O_4	nitrogen tetroxide
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
SCG	storage compatibility groups

NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NUC	Naval Undersea Center
O_3	ozone molecule
OH_x	designation for hydroxyl and hydroxide molecules
OSHA	Occupational Safety and Health Administration
Pb	Lead
PEL	permissible exposure limit
PLA	payload adapter
PLF	payload fairing
PPF	payload processing facility
psi	pounds per square inch
PU	payload unit
Q	dynamic pressure
Q-D	quantity distance
RMPP	Risk Management Prevention Plan
RO-RO	Roll-On/Roll-Off
RP-1	kerosene (rocket fuel)
SLLP	Sea Launch Limited Partnership
SLS	Sea Launch System
SOLAS	safety of life at sea
SPREP	South Pacific Regional Programme
SRM	solid rocket motor
STCW	Standard for Training, Certification, and Watchkeeping
T= 0 or T	scheduled launch time
T+	after launch time
T-	before launch time
TBD	to be determined
TDRSS	Tracking Data Relay Satellite System
UN	United Nations
UPS	uninterruptible power supply
USCG	U.S. Coast Guard
USSC	U.S. Space Command
W/m	watts per meter

1. PURPOSE AND NEED FOR PROPOSED ACTION

1.1 INTRODUCTION

The proposed action is for FAA's Associate Administrator for Commercial Space Transportation (referred to as AST) to grant a license to the Sea Launch Limited Partnership (SLLP or Sea Launch) for two launches. SLLP proposes to conduct commercial space launches from a mobile, floating platform in international waters in the east-central equatorial Pacific Ocean. This environmental assessment describes the proposed launch operations and alternatives considered, the affected environment, potential impacts on that environment, and measures to be taken to mitigate environmental effects for up to six launches per year. Pursuant to its requirements, the FAA will evaluate the adequacy of existing environmental documentation should unforeseen circumstances develop.

1.2 PURPOSE AND NEED FOR ACTION

The Sea Launch facility would provide a commercial alternative to launching satellites from Federal installations. The proposed Sea Launch activities would make available infrastructure for placing telecommunications, scientific, and research payloads in equatorial low earth, geosynchronous, geosynchronous transfer or medium earth orbits. The Zenit-3SL launch vehicle, fueled by kerosene and liquid oxygen, would be the only launch vehicle used at the Sea Launch facilities. In the first year of operation, 1999, SLLP intends to conduct three launches (one demonstration payload and two satellites); six launches are proposed for each subsequent year. The Commercial Space Launch Act (CSLA) of 1984 (Public Law 98-575), as amended, 49 U.S.C. Subtitle IX, ch 701 – Commercial Space Launch Activities, was passed by Congress to accomplish the following:

- Promote economic growth and entrepreneurial activity though use of the space environment for peaceful purposes;
- Encourage the U.S. private sector to provide launch vehicles and associated services;
- Strengthen and expand the U.S. space transportation infrastructure; and
- Protect the public health and safety, safety of property, and national security and foreign policy interests of the United States.

The Act authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launch operations and issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary is implementing this authority through the FAA AST. FAA exercises licensing authority in accordance with the Act and Commercial Space Transportation Licensing Regulations, 14 CFR Ch.III, which authorize FAA to license the launch of a launch vehicle when conducted within the U.S. and those operated by U.S. citizens abroad. In this case, the FAA is exercising its exclusive licensing authority as of launch ignition. SLLP will initially apply for a launch-specific license, and later plans to apply for a launch operator license.

Space transportation infrastructure can be divided into two major categories: facilities for large expendable launch vehicles that launch large satellites into stationary, geosynchronous earth orbit; and facilities for small expendable launch vehicles that launch smaller satellites, most of which are expected to be in low earth orbit. AST has determined that current infrastructure is neither sufficient to satisfy the demand for small expendable launch vehicles nor able to support envisioned market expansion (AST, 1993). Sea Launch proposes to support market expansion in the large payload market.

The proposed Sea Launch program would be consistent with the objectives of the Commercial Space Launch Act and the needs that AST has identified (AST, 1995).

1.3 BACKGROUND

1.3.1 Boeing Sea Launch Limited Partnership

The SLLP is an international commercial venture formed with the objective of launching commercial satellites. The partnership members consist of Boeing Commercial Space Company of the United States; RSC Energia of Russia; KB Yuzhnoye of the Ukraine; and Kværner Maritime a.s of Norway. The SLLP is responsible for the environmental concerns on the Sea Launch program, as well as for the development work and for entering into launch contracts with customers and performing those contracts.

1.3.2 Environmental Assessment Scope

The National Environmental Policy Act of 1969, as amended (42 U.S.C. § 4321 *et seq*.) and implementing regulations of the President's Council on Environmental Quality (40 CFR 1500-1508) require Federal agencies to evaluate the impact that proposed Federal actions would have on the environment. AST has prepared this environmental assessment to document the basis for determining whether the proposed action, and up to six launches per year, would have significant impact on the environment.

1.3.3 Public Involvement

AST issued a proposed Environmental Finding Document Finding No Significant Impact. It was made available for public review for 30 days from April 23, 1998 to May 26, 1998. This availability occurred because the nature of the proposed action, licensing operation of offshore space launches, is one without precedent. FAA/AST personnel subsequently held face-to-face talks with representatives of the Government of Ecuador in Washington DC, and the Government of Kiribati at Tarawa. Meetings were also held with representatives of the South Pacific Regional Environmental Programme (SPREP) in Apia, Samoa and with Australian government representatives in Washington DC.

1.3.4 Other Environmental Analyses

The environmental effects of launch operations and launches have been previously analyzed by AST in the 1986 Programmatic Environmental Assessment (EA), which is currently being updated, as noted in a January 10, 1996 Notice of Intent (61 FR 763). The 1986 EA is referenced as necessary.

2. ALTERNATIVES AND PROPOSED SEA LAUNCH ACTION

Pursuant to E.O. 12114, using NEPA as guidance, the FAA considered impacts to the human environment of the licensing of SLLP's commercial space launches. The following sections include a description of the aspects of the proposed Sea Launch operations that the FAA will consider for licensing; a review of the alternatives considered but not selected by SLLP during the planning process; and a discussion of the No Action alternative. SLLP intends to launch one demonstration payload and two satellites in the first year of operation and six per year thereafter. The lifetime of the Sea Launch system would be limited by the useful life of the LP, which is estimated to be twenty years. A detailed description of the proposed operating plan for Sea Launch is provided in Appendix A.

2.1 PROPOSED ACTION

The FAA's proposed action would be to issue a commercial launch license for two Sea Launch launches, a demonstration launch carrying a simulated payload and a launch to deploy a satellite. As the first launch is intended to verify the launch capability of Sea Launch Company, the first payload is a welded steel structure that simulates the design of a Hughes 702 satellite in terms of mass, center of gravity, and electrical interfaces with the Block-DM. This first payload is a passive spacecraft with no communications equipment. It also has no propulsion capability and, therefore, no propellants. The manufacturer is Boeing Commercial Space Company.

Subsequent launches would be as described and configured in the operating plan detailed in Appendix A. Sea Launch operations would utilize an LP and an ACS. A floating oil drilling platform was refurbished in Norway to serve as the self-propelled LP. The ACS was built in Scotland specifically for Sea Launch operations.

The launch vehicle that Sea Launch would use consists of the Zenit rocket, the Block DM-SL upper stage, and a payload adapter and fairing. The adapter, which accommodates the satellite payload on the rocket's Block DM-SL upper stage, and the nose cone fairing (a protective shroud for the satellite) would be manufactured in Seattle, Washington. See Figure 2.1-1 for transit routes to the Home Port and to the launch location. Following manufacture of the LP, the ACS, and the first payload adapter and fairing, a full-system integration test with the two-stage Zenit rocket and Block-DM upper stage would be deployed from the Home Port. The SLLP members each contributed assets to the integrated launch vehicle (ILV) and launch system package: Yuzhnoye - Zenit rocket; Energia - Block-DM upper stage; Kværner - ACS and LP; and BCSC - fairing and adapter. Sea Launch Partnership member responsibilities are discussed in Appendix C.

The three dry rocket segments, the payload fairing, and the payload adapter would be transported to the Home Port in Long Beach harbor, California. Satellite payloads would be transported to the Home Port by the launch customers, most of whom are located in the Southern California area. The rocket segments, fairing, adapter, and payload would be processed and integrated at the Home Port and prepared for ocean transport. Propellants and hazardous materials would be loaded onboard the LP at the Home Port. The ILV, personnel, and supplies (including kerosene and liquid oxygen as primary propellants of the launch vehicle) would be transported onboard the LP and ACS to the launch location at 154° W on the equator. During the seven to ten day sailing to the launch location, ILV electrical systems would be checked and charged, and launch command processes and contingency measures would be rehearsed.

In the hours prior to launch, the LP would be lowered to a more stable, semi-submerged position. The ILV would be erected to a vertical position on the deck of the LP and then mated to remotely operated systems for fueling and launch ignition. Prior to fueling, all personnel on the LP would transfer to the ACS, which would be positioned five km from the LP. The commands for fueling and launch would be initiated remotely from the ACS. Any system failure prior to Stage 1 engine ignition would be detected remotely from the ACS, prompting commands to remotely defuel and stabilize the ILV (see Section 4.3.1). A few seconds prior to ignition of the launch vehicle's Stage 1 engines, launch controls from the ACS would be relinquished and an automated (computer controlled) launch sequence would be initiated. After ignition, hold-down clamps would be released when adequate thrust is achieved. Onboard computers would automatically monitor rocket performance, azimuth, and system deviations (see Section 4.3.2). In the event of uncorrectable deviations from the flight plan, the computer would initiate thrust termination (see Section 4.3.4).

The rocket in flight would be tracked by the ACS, tracking satellites, ground stations, and Tracking Data Relay Satellite System (TDRSS). Following launch, personnel return to the LP and would refurbish the launch pad and begin preparations for the next launch cycle (see Section 4.3.3).

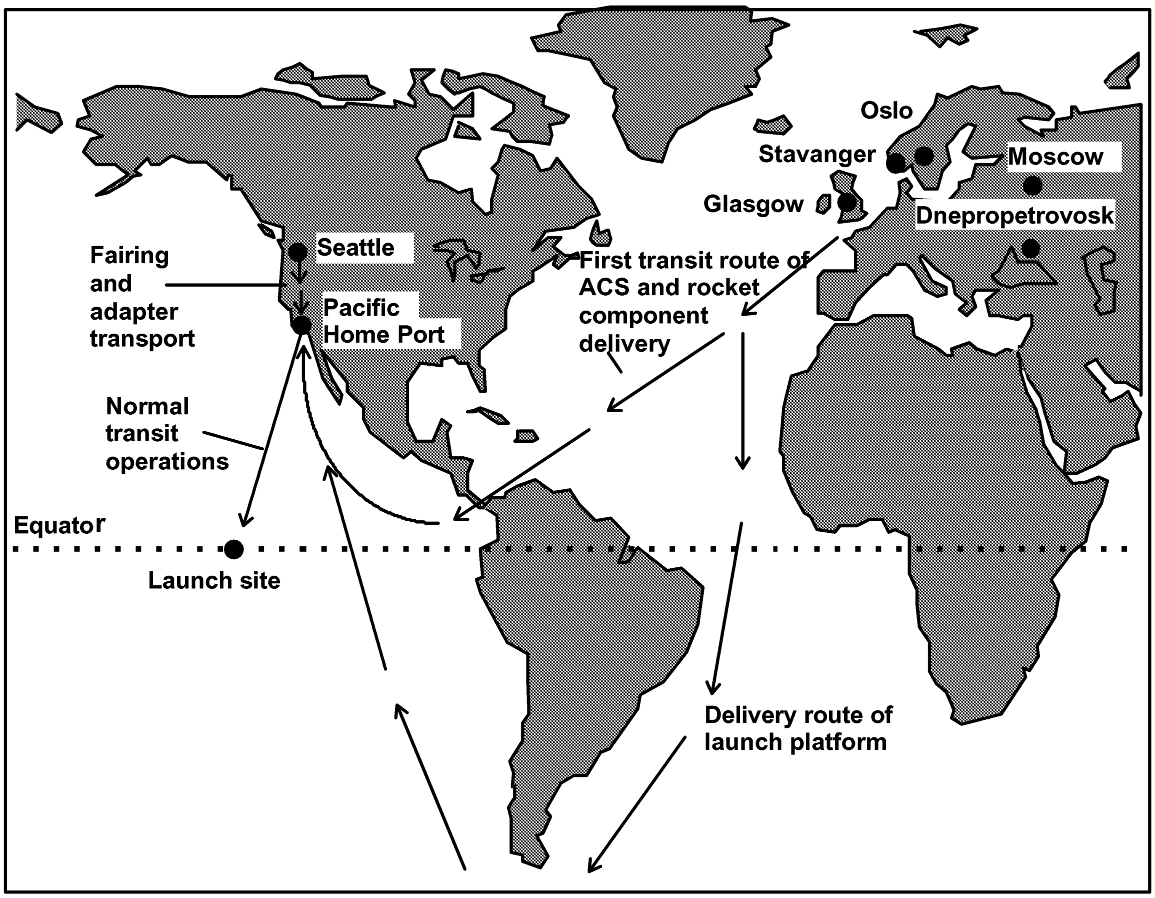

Figure 2.1-1. Sea Launch ACS, LP, and Launch Transit Routes

2.2 ALTERNATIVE ACTIONS

SLLP considered alternative launch vehicles and launch locations during the planning process that were not considered further for various reasons that will be discussed in the following paragraphs.

Under E.O. 12114 using NEPA as guidance, the FAA considered any potential and significant environmental impacts that may arise from its actions, and in turn, consider reasonable alternative actions available that could result in a lesser impact to the environment. In this case, the FAA action is to evaluate the SLLP license application and issue a launch license for two launches and to provide environmental documentation for up to six launches per year. As described in the following paragraphs, SLLP considered several alternatives to the proposed plan.

To select the best plan for SLLP operations, several reasonable alternatives were analyzed by SLLP. As part of this analysis, alternatives were evaluated based on their potential risk and impact to the environment. Alternatives considered were the use of other launch vehicles at a variety of locations with a number of different flight paths. The following discussion reviews the decision process used by SLLP in developing the proposed action described above in Section 2.1.

The goal of SLLP is to establish a safe and commercially viable capability to launch satellites for SLLP's commercial customers. During SLLP's initial planning phase, the following criteria were used to define a successful SLLP partnership:

- SLLP members would each contribute launch system assets.
- SLLP customer requirements would dictate logistics to maximize launch flexibility, including all launch azimuth capability, launch schedule availability, launch vehicle reliability, and proximity to their facilities.
- Costs would be minimized to provide the best possible value for SLLP's customers.
- Launch operations would be conducted in a safe and responsible manner.

Eliminated from SLLP's consideration were launch vehicle assets not owned or produced by SLLP members, launch locations that constrained launch flexibility and efficiencies or posed avoidable risks to the public and environment, and logistical arrangements not convenient to SLLP customer satellite manufacturing facilities. Existing launch locations in the United States and elsewhere were eliminated from consideration as being too restrictive in terms of access, less optimal for launch physics, and/or more costly and inflexible. In addition, building a new land-based launch site would be more disruptive to the environment, more time consuming, and more costly. Ultimately, the use of a floating platform as a mobile launch location was considered more commercially desirable than using an existing land-based facility or building a new one.

Given these criteria, alternative launch vehicles and launch locations were considered (Sections 2.2.1 and 2.2.2). The proposed Sea Launch operating plan was determined by SLLP to best meet operational and safety criteria and goals. The plan involves the Zenit rocket, the Block DM, the LP, and the ACS. Operations would be conducted from the Home Port and from an equatorial pacific launch location (as described in Section 2.1).

2.2.1 Alternative Launch Vehicles

Two launch vehicles, the Zenit and the Cyclone, were available from the partners and suitable for launching satellites. The Cyclone's payload capacity was considered too small to handle the SLLP customers' satellites, while the Zenit satisfied both payload and operational criteria. For the third stage, the partners ruled out the Inertial Upper Stage (IUS), potentially available from The Boeing Company, because it could not be readily mated to the Zenit second stage, leading to the selection of the Block-DM for this purpose.

In addition to cost, efficiency, and market advantages, SLLP determined that Zenit and Block-DM operating systems, staffing requirements, and propellant characteristics were favorable in terms of possible risk to SLLP staff and the environment. Designing and producing a new launch vehicle, or procuring alternative assets from other launch system providers, were not considered commercially viable options by the SLLP.

A feature of the Zenit launch vehicle system that was deemed important by SLLP is the horizontal integration, processing, and transport of the rocket stages and payload. The ILV is only erected in a vertical position immediately prior to fueling and launch. This would allow the ILV to remain in a safe and stable position at the Home Port and during transport to the launch location.

2.2.2 Alternative Launch Locations

Once the operational concept was identified, SLLP began the process of selecting an equatorial launch location in the Pacific Ocean. In this process, public safety and reduced potential for environmental impacts were weighted most highly. Secondary criteria also considered are summarized in the following subsections.

2.2.2.1 Public Safety

The FAA's licensing process addresses safety issues related to SLLP's proposed launches. SLLP adopted as a population risk criteria, an upper limit of one in a million casualty expectation. Public safety assurance and analysis issues are discussed in the Sea Launch Limited Partnership document, "Sea Launch System Safety Plan" (SLLP, 1997). Shifting the launch location to the west (away from South America) caused a commensurate decrease in the value for casualty expectation, and ensured that Stage 1, the fairing, and Stage 2 would drop well away from land and coastal commercial activity. The instantaneous impact point speed would increase over South America, decreasing the dwell time and potential risk as the potential impact point traverses land. This relationship was balanced by economic considerations which dictated that the launch location be no more than 12 transit days from the Home Port.

These two criteria (i.e., casualty expectations and transit days) were considered by SLLP to be compatible with the desire to stay east of the island groups in the central Pacific Ocean to ensure public safety and to be centered on or near the equator. The 33 islands of the Kiribati that lie along the equator in that part of the Pacific Ocean, many of which are uninhabited, are distributed between 170° E and 155° W. The launch area, in the vicinity of 154° W, was finally selected because it is located outside of the Kiribati's 320 km exclusive economic zone (EEZ) and is roughly 340 km from the nearest inhabited island.

2.2.2.2 Environmental Protection

The above approach to ensure public safety was also applied in the analysis used by SLLP to ensure environmental protection; human and most wildlife populations similarly congregate on land or in the adjacent coastal waters. The Pacific Ocean waters encompassed by the launch location and the down range area extending eastward from 154° W on the equator almost to the Galapagos Islands off the coast of South America are marked by relatively uniform and low levels of primary productivity (see Section 3.3). In addition, an alternative to the preferred flight path directly over the equator, i.e., one that originates on the equator at 154° W but detours north around the main Galapagos Islands, was evaluated and was selected to further reduce the already small risk of debris accidentally striking that island group.

The above factors and the final flight plan are believed to effectively limit any risk of impact from the material and energy inputs from Sea Launch operations to the ecosystem in the launch location and range region. This aspect is discussed in detail in Section 4.

2.2.2.3 Secondary Criteria for Launch Location Selection

The following were then evaluated relative to the general area surrounding 154° W on the equator and conditions were found to be favorable:

- weather conditions (particularly low frequency of lightning);
- proximity to commercial activity (fishing, recreation, ship, and air traffic); and
- proximity to sovereign territories.

It was further concluded that within this area, adjustments in launch location position had little effect on any of the criteria. Accordingly, a launch location on the equator was selected to maximize inertial and other launch efficiencies. Finally, the SLLP's principal commercial satellite customer desired an operational base on the West Coast of the United States.

The above factors collectively eliminated from detailed consideration Kingman Reef (South-southwest of Hawaii), and areas off the coasts of Hawaii, Baja California, and Brazil, because of their distance from the equator, access to Home Port, and customer requirements. These factors instead dictated the selection of a floating launch platform and support ship, a west coast Home Port, the Zenit and Block-DM rocket stages, and the SLLP customer performance requirements to launch satellite payloads from a location on the equator in the east-central Pacific Ocean.

2.3 NO ACTION ALTERNATIVE

Under the No Action alternative, the FAA would not issue a commercial launch license to SLLP. Because the CSLA requires SLLP to obtain a launch license, the applicant would not be able to conduct commercial launches or offer these services, and thus Sea Launch operations, including launches from a launch platform in the Pacific Ocean, would not occur. Any potential environmental impacts associated with the siting and launching of the Sea Launch system would not occur, nor would there be the need for the Home Port facilities associated with the proposed action. The area proposed for launches would remain in its natural state, available for many types of international development. There are no other reasonable foreseeable development projects are this time, and this assessment assumes that the no action alternative would result in no development at the Home Port.

3. AFFECTED ENVIRONMENT

3.1 OVERVIEW

The launch platform, when in position on the equator at 154° W, would be at the center of a circular area with a 5 km radius. This represents the safety perimeter and the distance held uprange by the ACS at the time of launch vehicle fueling and ignition. The launch area downrange would be represented by a triangle generally bisected by the equator and expanding eastward from 154° W. At approximately 110° W on the equator, the longitude at which the second stage would be dropped, the triangle has a north-south base of approximately 80 km. This expanding range boundary is determined by the pattern of maximum (i.e., three standard deviation) scatter expected from launch vehicle debris during successful or failed launches (Figure 3.1-1). In the event of a failed mission, with the exception of Block DM-SL upper stage malfunctions, thrust termination would confine the launch vehicle debris to the area within this launch location and range boundary.

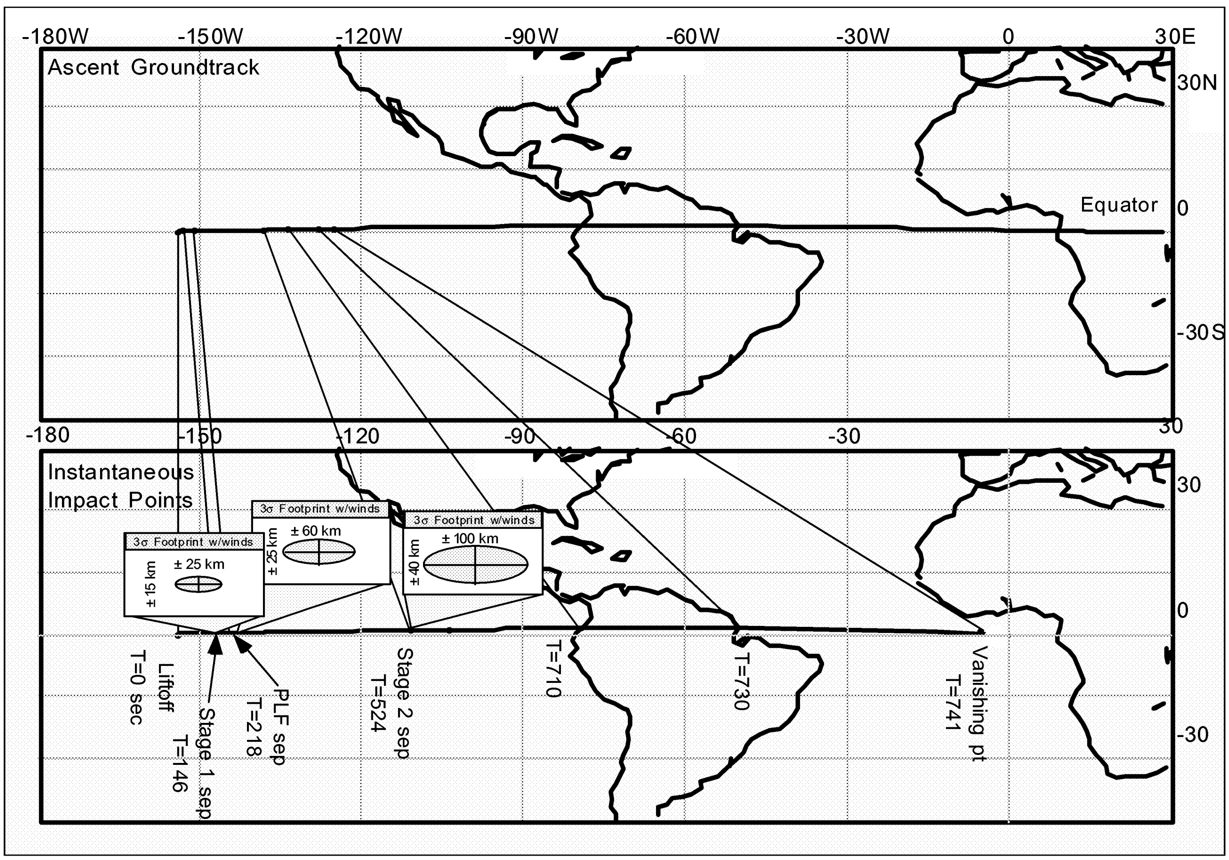

Figure 3.1-1. GTO Mission Ascent Groundtrack, IIP Trace, and Debris Footprint from Launch Location at 0°, 154° W

This triangular area (i.e., the area where SLLP operations would be conducted) is a small portion of the east-central tropical Pacific Ocean environment that is considered the affected environment for this environmental assessment. In this larger context, the environment in this particular area of the Pacific Ocean is shaped by the combined effects of plate tectonics and the patterns of air and water circulation.

3.2 TECTONIC HISTORY

Tectonic processes have largely determined the character of the area's environment in terms of proximity to shorelines, depths to bottom, and the distribution of particular life forms. It is appropriate therefore, to begin a discussion on the environment with a brief reference to its geological setting.

The proposed launch location (Figure 3.2-1) is situated in waters over 4,200 m deep outside the eastern fringe of the Kiribati (pronounced Kiribas) Island groups. The nearest land, Kiritimati (Christmas) Island, is located approximately 340 km to the NW. The nearest land downrange to the east, the Galapagos Island group, is roughly 6,800 km away. This relative distribution of landmasses is a result of seafloor spreading of the Pacific, Nasca, and Cocos Plates (Springer, 1982).

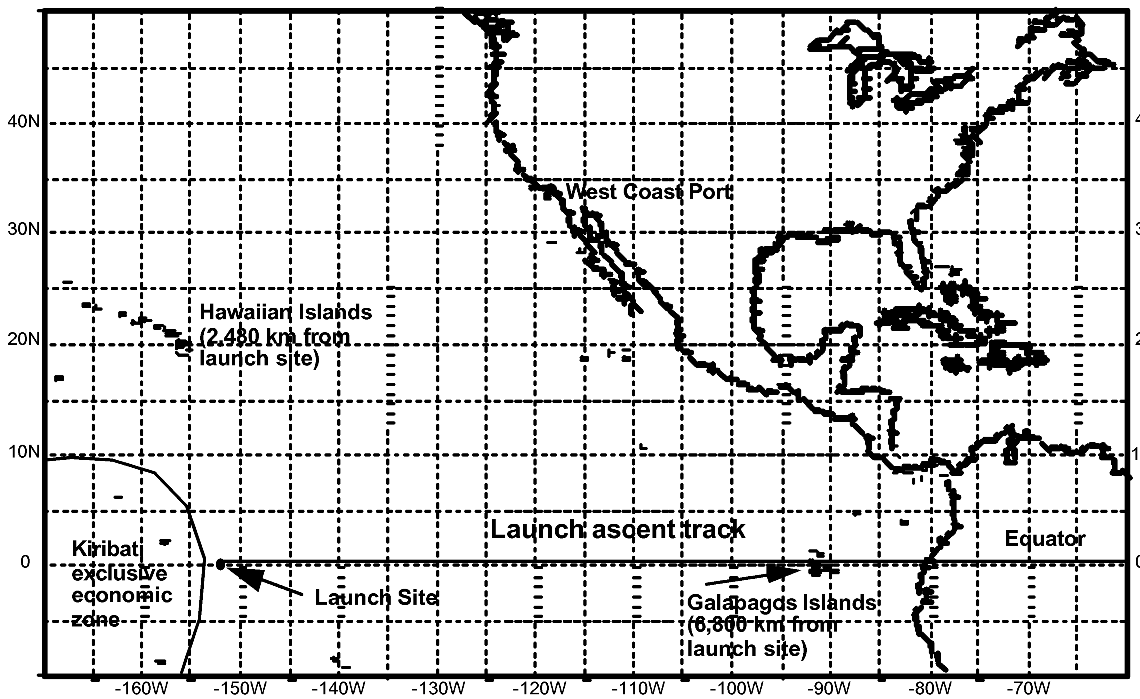

Figure 3.2-1. Launch Location

In this process, new seafloor has accreted to each plate where the plates meet southwest of Panama. This accretion has enlarged and displaced the existing Pacific Plate, resulting in the uniformly deep and homogenous waters of the central Pacific Ocean (Springer, 1982). The increasing age of the seafloor, from east to west, is reflected in its depth, which is roughly 2,300 m near the Galapagos to roughly 4,200 m approaching the Kiribati.

3.3 PHYSICAL, CHEMICAL, AND BIOLOGICAL REGIMES AND FOOD CHAIN

Ocean surface waters in the central- and east-equatorial regions of the Pacific Ocean (Figure 3.3-1) are driven by the easterly trade winds and by Coriolis forces. These winds and forces circulate the waters north and south of the equator in clockwise and counter-clockwise directions, respectively. Waters along the coast of South America flow to the north and the waters along the coast of Central America flow to the south. They converge in the vicinity of the Galapagos Islands and form a west-flowing, surface-water current that is generally centered on the equator. North and south of the westward equatorial current are weaker counter currents which provide a return flow of water to the east (Fox, 1997). Below the surface, water masses flow in response to gravity (where density is determined by temperature and salinity) and hydrostatic gradients (formed by distant surface winds and currents). (Pickard, 1975)

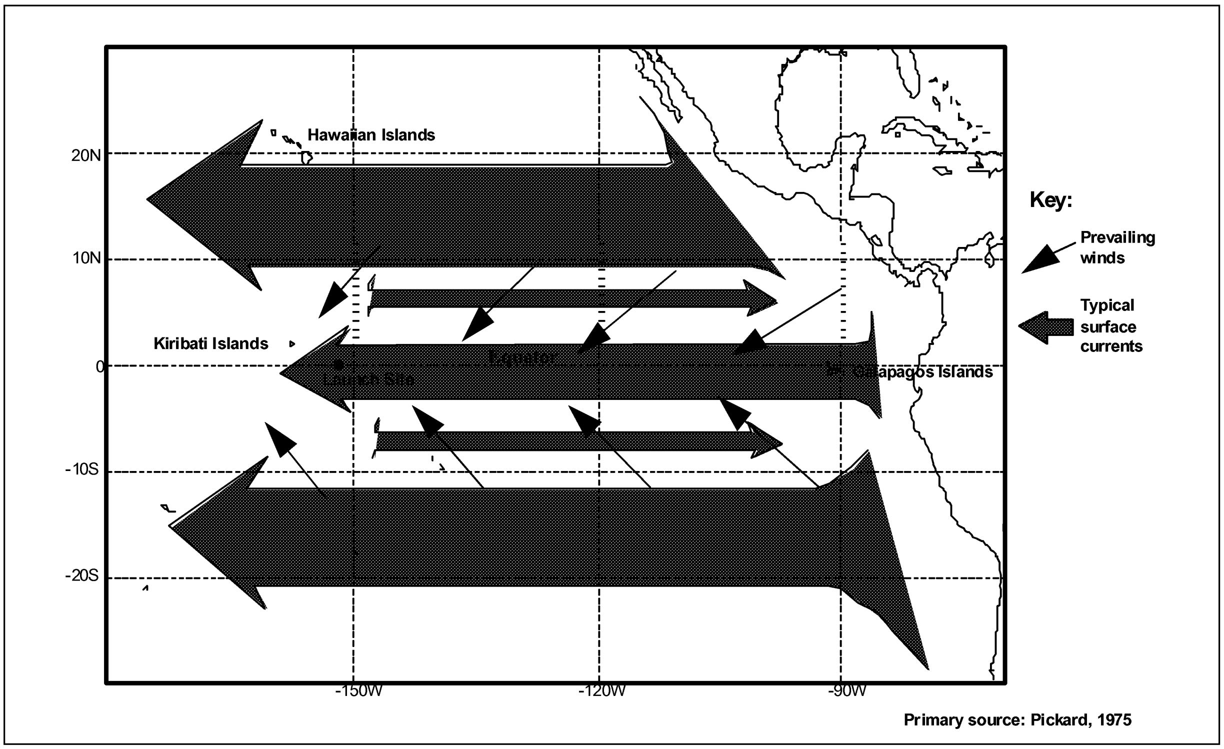

Figure 3.3-1. Launch Area Winds and Surface Currents

Ocean currents have strongly influenced the growth and behavior of the biological populations found in the area (Yoder, 1994). In the case of the east-equatorial Pacific Ocean along the coast of South America, the environment is dominated by the upwelling of nutrient-rich ocean waters that are pushed by Coriolis forces and pulled by the westward flow of surface waters. Over time this upwelling has nurtured an exceptionally productive and diverse ecosystem. More recently, the upwelling has sustained the coastal economy's fishing and ecotourism industries.

The upwelling and its effect on both the environment and human populations are, however, a relatively local phenomena. With the westward flow of the equatorial surface current, biological diversity and density diminish dramatically from the loss of favorable habitat as key nutrients are consumed and not replenished. Nutrient and biological productivity levels are largely equivalent (in statistical terms) at the launch location and points further east where Stage 1 and Stage 2 would fall; one has to be much closer to the Galapagos Islands to find meaningfully higher levels of productivity and biological activity. In the open ocean waters of the launch location and range, the primary phytoplankton and the grazing zooplankton they support are comparatively limited in species diversity and biomass, being constrained by the solar cycle and nutrient availability (Kolber, 1994; Vaulot, 1995; and Martin, 1994). The dominant phytoplankton species, *Prochlorococcus*, is at maximum density at 30 meters depth, being constrained by low light intensity at greater depths and by excessive solar radiation closer to the water surface (Vaulot, 1995). Plankton productivity is not uniformly distributed, however, having been shown to vary widely in space and time due to fluctuations in temperature, nutrient, and plankton species mix caused by localized upwelling at water mass frontal anomalies (Yoder, 1995; Murray, 1994; and Philander, 1992). Recent research also suggests the levels of maximum productivity are constrained by iron concentrations in the surface waters (Murray, 1994; and Kolber, 1994).

The following species are listed as Threatened or Endangered by the United States and may be found in the equatorial Pacific Ocean in the vicinity of the proposed Sea Launch activities. [1]

Whales

- Whale, blue *(Balaenoptera musculus)* endangered
- Whale, bowhead *(Balaena mysticetus)* endangered
- Whale, finback *(Balaenoptera physalus)* endangered
- Whale, humpback *(Megaptera novaeangliae)* endangered
- Whale, right *(Balaena glacialis)* endangered
- Whale, Sei *(Balaenoptera borealis)* endangered
- Whale, sperm *(Physeter macrocephalus (=catodon))* endangered

Sea Birds

- Petrel, Hawaiian dark-rumped *(Pterodroma phaeopygia sandwichensis)* endangered
- Shearwater, Newell's Townsend's (formerly Manx) (='a'o) *(Puffinus auricularis newelli)*

Sea Turtles

- Turtle, green sea *(Chelonia mydas)* endangered/threatened
- Turtle, hawskbill sea *(Eretmochelys imbricata)* endangered
- Turtle, Kemp's (=Atlantic) ridley sea *(Lepidochelys kempii)* endangered
- Turtle, leatherback sea *(Dermochelys coriacea)* endangered
- Turtle, loggerhead sea *(Caretta caretta)* threatened
- Turtle, olive (=Pacific) ridley sea *(Lepidochelys olivacea)* threatened

Consultations with Pacific fisheries experts revealed that while there are numerous high-scale fishing activities that take place in the Central and Eastern Pacific Region, none are specifically located in the vicinity of the proposed launch site.[2] The likelihood of Sea Launch operations impacting the fishing industry is very low as the Pacific Region is large and the boats are spread over a wide area. There does not appear to be any area in that part of the Pacific where fishing boats collect in high density.

Although the literature specific to the launch location and range is limited regarding resident and migratory populations of the more complex species (e.g., fish, birds, mammals and reptiles), much can be inferred from known ecological relationships. For example, the difference in productivity and, by inference, species diversity between upwelling, coastal, and open ocean environments is pronounced:

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[1] U.S. Listed Vertebrate Animal Species http://www.fws.gov/r9endspp/vertata.html

[2] Personal communications with Bill Gibbons-Fly. National Oceanic and Atmospheric Administration (NOAA) Pacific Fishing Specialist.

- In grams of carbon produced per square meter per year, the open ocean (50 gm) is one sixth as productive as upwelling areas (300 gm).
- In grams of carbon produced per square meter per year, the open ocean is one half as productive as coastal margins with long-shore currents (100 gm).
- In terms of carbon generated in fish stocks per year, the entire open ocean (which comprises 90% of the ocean's surface area) is calculated to be 60 times less productive than either the upwelling areas (0.1% of the surface area) or the other coastal margins (9.9% of the surface area) (Steele, 1974).

Regarding the launch location and range, relatively low levels of nutrients in this open ocean area sustain low levels of phytoplankton, which sustains low levels of zooplankton, which sustains few small fish, and so on up the food chain. Expressed conversely, large and diverse populations of fish, marine mammals, reptiles, and birds generally inhabit the coastal margins and seldom frequent the more desolate, less productive open ocean waters. The coast provides a much greater abundance and concentration of food stocks, and offers better opportunities for congregating and procreating.

It has been suggested that because of the requirement (or biological advantage) of staying near coastal margins, ancestral fish in the Pacific Ocean grew isolated and increasingly speciated along the coastal fringe and scattered island groups that separated during the process of plate tectonics (Springer, 1982). While this hypothesis may be extended to marine mammals, birds, and reptiles, individuals of many species are known to move widely throughout the Pacific Ocean (Bjorndal, 1979; Travis, 1995; Bioscience, 1990; Leatherwood, et. al., Evans, 1972; Harrison and Bryden, 1988; King, 1974; Hill, et. al., 1990; Croxall, et. al., 1982; Richardson, et. al., 1995; and Watson, 1981). These data indicate that although the area at and east of 154^{o} W on the equator may be traversed by a variety of mammal, bird, and reptile species, the region is not crossed by any known or predominant migration route and individuals do not reside or remain in the area for any length of time. Similarly, fish stocks and commercial fishing activity in the area are low to non-existent due the vastly easier access to more productive and, therefore, more commercially viable areas (van Trease, 1993).

Nutrients from plankton or fecal biomass in particulate or dissolved form either recycle in the surface waters or sink and accumulate in the cold, dark and oxygen-poor deep waters of the open ocean (Murray, 1994). Nutrients that do reach deep ocean waters are either sequestered in sediments or are recirculated to coastal surface waters along South America as part of the coastal upwelling process. Despite an abundance of nutrients at the bottom of the ocean, the area's benthic ecosystem is constrained by oxygen and light deficiencies and the immense weight of the overlying water. It can also be inferred from these conditions that resident population densities of the common benthic and demersal species (e.g., echinoderms and annelids) are low (Steele, 1974). The sulfur-based ecosystems present in the anaerobic environments of deep ocean crustal vents would not generally be present in the launch location and range area due to the absence of supporting tectonic features.

3.4 ATMOSPHERIC PROCESSES AND CHEMICAL MASS BALANCE

In the launch site and range area, the atmosphere and oceans continually interact in physical and chemical cycles. Generally, atmospheric conditions are thought to be controlled by ocean surface temperatures. A daily cycle of solar heat drives convective mixing (through changes in water density from changes in temperature and salinity) and molecular exchange across the air-water interface (Lewis, 1990; AIAA, 1991; and Mason, 1990). Superimposed on this daily cycle, however, is a more complex and regional process in which the trade winds from the east push equatorial surface water into a mound in the west-equatorial Pacific Ocean. For still unknown reasons, the trade winds occasionally weaken, causing a reverse flow of warm surface waters to the east which then mound against South America. The additional hydrostatic head of warm water in the east-equatorial Pacific Ocean inhibits and slows the upwelling of the more dense, cold, and nutrient-rich deep ocean water (Philander, 1992; and Lukas, 1992) in a phenomenon known as the El Nino/Southern Oscillation.

Each El Nino episode is now known to have a ripple effect on circulation throughout the Pacific Ocean and on global climatology that spans many years (McPhaden, 1994). Its most pronounced impacts are an extreme decline in ecosystem productivity along the coast of South America, and great fluctuations in the rates of radiative and convective heat and molecular exchange between the ocean and troposphere and stratosphere throughout the Pacific region (Lukas, 1992). In comparison to the pronounced effects on the coastal margins and global weather, El Nino has little effect on ecosystem productivity in the ocean waters of the launch location and range. At higher altitudes, the El Nino impact declines with the gradual decline in molecular densities in the mesosphere and ionosphere.

It has been estimated that these processes in the equatorial Pacific region annually cycle roughly 0.3 gigatons of carbon dioxide between the ocean and atmosphere, and about the same amount of particulate carbon (e.g., from dead plankton and fecal matter) settles to the deep ocean waters per year to be replaced by upwelling and the westward equatorial current. In addition, the mass balance flux of dissolved organic carbon from the surface to deep ocean waters has been estimated to be about three times as large as these related measures (Murray, 1994).

3.4.1 Atmospheric Boundary Layer

The atmospheric boundary layer (or lower troposphere) is the lowest part of the atmosphere and represents the portion of the atmosphere where the frictional effects of the earth's surface may be substantial. It extends from the surface to approximately 2 km above sea level, although the actual height is a function of surface roughness and temperature gradient.

3.4.2 Free Troposphere

The free troposphere is that portion of the atmosphere extending from the top of the atmospheric boundary layer to the bottom of the stratosphere. Exact elevations are a function of time and location, but for purposes of this analysis, the free troposphere is taken to be the atmosphere from approximately 2 to 10 km. The free troposphere frequently receives polluted air from the atmospheric boundary layer and, less often, ozone from the stratosphere. Emissions to or entering the free troposphere are subject to photochemical oxidation (primarily by OH_x radicals) and chemical reactions within cloud droplets. Most emissions that undergo such chemical reactions are returned to the atmospheric boundary layer or to the earth's surface by precipitation. The thermal heat balance of the earth's surface is due in great measure to the regulation of incoming and outgoing radiation by clouds and gases in the free troposphere.

3.4.3 Stratosphere

The stratosphere is that part of the atmosphere from approximately 10 to 50 km above the earth's surface. The temperature of the stratosphere rises from a minimum at its base to a maximum at its top. This increase in temperature as one rises through the stratosphere is due to the increased absorption of ultraviolet radiation energy by ozone. The stratosphere is the main region of ozone production in the atmosphere, and this ozone plays a critical role in protecting the earth's surface from ultraviolet radiation and in regulating the earth's heat energy balance. Increased ultraviolet radiation exposure has been correlated with increased incidence of certain skin cancers and can be expected to have an adverse effect on the growth of terrestrial and oceanic plant organisms that form the basis of the global food chain. In recent years, measurements have indicated the ozone layer in the stratosphere has been reduced, especially in the regions above the polar caps where “holes” in the ozone layer expand and shrink with the seasons, with maximum reduction of ozone occurring in the Spring, following highly stable conditions in Winter (O’Riordan, 1995).

It is estimated that approximately 350,000,000 kg of ozone are formed and destroyed daily by natural processes in the stratosphere (Manahan, 1994). Ozone (O_3) is formed from the break-up of molecular oxygen (O_2) into oxygen atoms (O) by incoming solar radiation, followed by the immediate joining of one oxygen atom with one oxygen molecule to form ozone. The ozone molecule is destroyed by the adsorption of ultraviolet radiation energy which triggers a series of reactions that combine one oxygen atom with one ozone molecule. The diminution of the ozone layer is due in part to the placement of certain chemicals into the stratosphere, primarily as a result of man’s activities, that serve to catalyze these reactions leading to the destruction of ozone. A typical ozone-destroying chemical is chlorine. A chlorine atom can catalyze the destruction of several hundred molecules of ozone before it is effectively neutralized by reacting with another atmospheric chemical such as methane to form a reservoir of non-reacting chemical species. The chemistry and physics of ozone production and destruction is not fully understood at this time, and the models used to predict ozone dynamics may be too simple to accurately reflect the complex phenomena occurring in the stratosphere.

3.4.4 Mesosphere and Above

The mesosphere extends from approximately 50 to 85 km and is marked by a drop in temperature with an increase in altitude. This drop in temperature is due to the absence of radiation adsorbing molecules. Above the mesosphere is the thermosphere where the temperature rises because of molecular adsorption of high energy solar radiation.

3.5 EXISTING SOCIAL AND ECONOMIC CONDITIONS

In this section, the existing conditions for the Kiribati Islands, the Galapagos Islands, and the Home Port area are described.

3.5.1 Kiribati Islands

The Kiribati Islands, specifically Malden and Kiritimati Island, lie immediately west of the launch location, but at distances that preclude environmental impacts to either island (Section 4). Kiritimati Island does, however, have some airport and seaport facilities that may be used for logistical support by Sea Launch. Although current plans call for only occasional air travel to Kiritimati Island by Sea Launch employees, a baseline description of the Islands is provided in the following paragraphs to allow consideration of impacts to the Islands from a limited, but possibly expanded, logistical use by Sea Launch (see Section 4.3).

Following the depletion of the Kiribati Islands' once-extensive guano (fertilizer) deposits around the time of independence from Great Britain in 1979, the islanders and their economy have been challenged by a scarcity of land and natural resources, by the extreme remoteness of their nation from world markets, and by the lack of funds sufficient to sustain economic development. Although there has been some recent interest in tourism, primarily for sports fishing, the Kiribati economy remains subsistence-based. International aid funds have built some infrastructure and nurtured agricultural exports of copra, fish, and seaweed, but these industries remain limited in scope and have yet to become self-sustaining.

Other commercial development has been sporadic. Most notably, the proximity of the Kiribati Islands near the equator attracted the Japanese satellite launching industry. The Japanese built a satellite tracking station on Kiritimati (Christmas) Island in the 1970s, and in the mid 1980s, considered building a space port on the Island as well. Despite the ongoing international funding and development of infrastructure on the Kiribati Islands, there is still little foreign commercial interest in Kiribati.

The hope and focus of the Kiribati people currently rests with the exploitation of ocean fish stocks, which are largely concentrated near the Islands themselves. Personal water craft, fish ponds, and a relatively modern fishing fleet (first funded in the mid 1970s to meet the nutritional needs of the population) along with seaweed cultivation, now offer the greatest potential for income. To capitalize on the apparent opportunity offered by ocean fish stocks, the relatively limited capital assets and manpower of the Kiribati people have been augmented by the sale of fishing rights in the Kiribati exclusive economic zone to foreign fleets. Even this opportunity, however, appears somewhat constrained by the distance of the fish resource to world fishing fleets and consumer markets.

Despite the vast size of the Kiribati nation, their economic and cultural interests are concentrated, along with roughly 93% of the population, in the western-most Kiribati Islands which are over 3,000 km from the launch location. In contrast, the population and economic activity on the eastern-most Kiribati Islands are extremely limited. In the western Islands, known as the Gilberts, a relatively extensive infrastructure including wastewater treatment and freshwater supply projects has been developed with international aid funds. Despite this, population growth and sanitary waste practices are seriously threatening the sustainability of the land. Given the reliance on subsistence fishing and other agricultural endeavors, population pressures are forcing consideration of migration to the central and eastern Islands which, unfortunately, lack an adequate infrastructure. These pressures will no doubt grow, as will attempts to develop an economic base so as to support current populations and allow some migration from the western population centers (van Trease, 1993).

3.5.2 Galapagos Islands

There was no permanent population before 1900 on the Galapagos and no significant population until the 1970s. Prior to the tourist boom during the 1970s, there were no more than 1,000 residents, primarily involved in subsistence activities. Tourism contributed to an influx of immigrants from the mainland, causing the Galapagos population to rise from approximately 3,500 in 1974 to 10,000 in 1990. Seeking to pull themselves out of poverty on the mainland, these immigrants tend to be low skilled workers without jobs, without family and without resources. Currently, the population is estimated to be 14,000. The immigration rate has been disproportionate to the local infrastructure, and is believed to have exceeded the carrying capacity of the land allotted for human use. If population numbers continue to increase, then it can be certain that protection efforts by the park will be threatened.

In 1959, the Charles Darwin Research Station was established on Galapagos as an international, non-governmental scientific, non-profit organization to help with conservation efforts. In the same year, the Ecuadorian government declared 97% of the Islands National Park, with the remainder available for the resident population. Since 1970 and through the following decades, tourism has dramatically increased, becoming the primary source of revenue for the Islands. The upgrade of two airports in the 1980s has allowed for larger-capacity jet aircraft, resulting in increased visitation. Between 1974 and 1994, tourism jumped from 7,500 visitors to over 50,000, the majority being foreign visitors. The

Galapagos Islands thus have an economy entirely generated by the tourism industry. There are millions of dollars generated annually, as each tourist to the Galapagos is charged an $80 entry fee.

3.5.3 Home Port

The social and economic conditions in the area of the Home Port are addressed in the Port of Long Beach Harbor Development Permit process and other permits, licenses, and documents required for Home Port activities (see Section 4.5.3), including the "Environmental Assessment for the Interim Lease of the Navy Mole, Naval Station Long Beach, Long Beach, California" (Department of the Navy, 1996). The Navy Mole (where the Home Port is located) is highly industrialized. The combined ports of Long Beach and Los Angeles are the third largest container port complex in the world. Land uses adjacent to the Navy Mole include port related/industrial activity interspersed with commercial and recreational uses. The Navy Mole site is currently underutilized and is being operated by the Navy under caretaker status. The buildings at the site have been vacated and operations have ceased. As a result, expenditures in the region and purchases of local materials and services have been reduced.

3.6 LEGAL FRAMEWORK

The following addresses international laws, including domestic United States laws, and agreements that govern Sea Launch operations at and downrange from the launch location.

Perhaps the most notable requirement governing the environmental aspects of the ongoing launch planning process and the launch activity itself are NEPA and the implementing CEQ regulations, 40 CFR 1500-1508, and E.O. 12114 (see Section 1). In addition, the U.S. environmental laws that typically govern domestic launch operations (e.g., the Clean Air, Clean Water, Endangered Species, and Marine Mammal Protection Acts) are addressed in Appendix B, Table B-1. The sovereignty of any other nation's environment or affairs are not substantially affected by the launch location and range activity (Section 4). Therefore, Sea Launch has primarily focused on international requirements that govern Sea Launch use of the global commons.

A broad array of international environmental agreements has been developed over the last century, with most being coordinated in the past few decades under the auspices of the United Nations (Sand, 1992). Their purposes have been to protect sovereign and global commons ecosystems, to establish and enforce processes to administer the commercial exploitation of sovereign and global commons resources, and to promote peaceful relations between neighbors that share an overused and stressed regional environment.

These agreements apply in varying degrees to launch operations and have been addressed in Sea Launch plans. The specific legal requirements are discussed in detail in Appendix E. In addition, numerous maritime regulations apply to the design, operation, and maintenance of the LP and ACS. These agreements are not detailed here because they are administrative matters managed under the jurisdiction of various responsible authorities overseeing the SLLP planning process (Section 4.1).