Draft

SEA LAUNCH
ENVIRONMENTAL ASSESSMENT

U.S. Department of Transportation
Federal Aviation Administration
Associate Administrator
for Commercial Space Transportation
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EXECUTIVE SUMMARY

INTRODUCTION

The proposed action is for the Federal Aviation Administration's (FAA) Associate Administrator for Commercial Space Transportation (AST) to issue a commercial space launch license to the Sea Launch Limited Partnership (SLLP). 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, in accordance with the National Environmental Policy Act (NEPA).

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, SLLP intends to conduct two launches; 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. §§ 70101-70119, 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 Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation (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. SLLP will initially apply 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 as described and configured in the operating plan detailed in Appendix A. SLLP would utilize a launch platform (LP), an assembly and command ship (ACS), and potentially, a smaller satellite tracking ship, the Selena-M. A floating oil drilling platform is being refurbished in Norway to serve as the self-propelled LP. The ACS is being built in Scotland specifically for Sea Launch operations.

The launch is proposed to occur at the Equator in the vicinity of 154^o W, maximizing inertial and other launch efficiencies, as well as conservatively satisfying all public safety criteria. The distances from South America (over 7,000 km) and from the nearest inhabited island (340 km) ensure that stage one, the fairing, and stage two would drop well away from land and coastal commercial activity.

CONSIDERATION OF ALTERNATIVES

Eliminated from consideration were launch vehicle assets not owned or efficiently 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 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.

NO ACTION ALTERNATIVE

Under the No Action alternative, FAA would not issue a commercial launch license to SLLP. Because the CSLA requires commercial launches to be licensed, 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 liquefied 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. 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, which would rapidly dissipate and degrade.

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 nominal 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. The fairing would flutter to the sea surface, perhaps break up on impact, float, gradually become waterlogged and less buoyant, and drift to the west. 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.

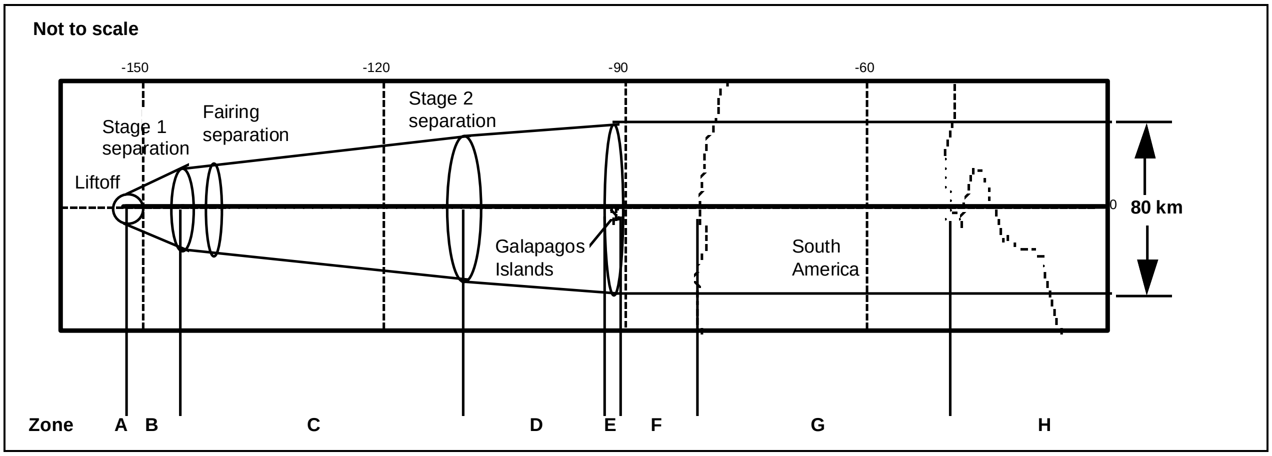


Figure ES-1. Stage 1 and 2 Impact Zones

Approximately 4,500 kg of kerosene would fall unburned in the 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 launch vehicle (ILV) during nominal 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 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 land masses. 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 after 36 hours of steady winds to the north-west (NOAA).

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 far away from Christmas and Malden Islands by the prevailing easterly trade 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 nominal 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 by migration or regeneration the destroyed ozone within a few hours.

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 and residues 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 worst case 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. This 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 (one in 4.3 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 which 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.

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 No Action 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 the CSLA would not be furthered. Predicted environmental impacts of the proposed launch activities would not occur and the area surrounding the proposed launch site would remain in its current state.

CUMULATIVE IMPACTS

There are no other foreseeable developments in the area of the proposed launch site, 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 no cumulative environmental effects are expected.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS .... **I**

LIST OF FIGURES .... **V**

LIST OF TABLES .... **VI**

LIST OF ACRONYMS .... **VII**

1. PURPOSE AND NEED FOR PROPOSED ACTION **1-1**

1.1 INTRODUCTION 1-1
1.2 PURPOSE AND NEED 1-1
1.3 BACKGROUND 1-2
  1.3.1 Sea Launch Limited Partnership *1-2*
  1.3.2 Environmental Assessment Scope *1-2*
  1.3.3 Public Involvement *1-2*
  1.3.4 Other Environmental Analyses *1-2*

2. ALTERNATIVES AND PROPOSED SEA LAUNCH ACTION **2-1**

2.1 PROPOSED ACTION 2-1
2.2 ALTERNATIVE ACTIONS 2-2
  2.2.1 Alternative Launch Vehicles *2-3*
  2.2.2 Alternative Launch Locations *2-4*
    2.2.2.1 Public Safety 2-4
    2.2.2.2 Environmental Protection 2-4
    2.2.2.3 Secondary Criteria for Launch Location Selection 2-5
2.3 NO ACTION ALTERNATIVE 2-5

3. AFFECTED ENVIRONMENT **3-1**

3.1 OVERVIEW 3-1
3.2 TECTONIC HISTORY 3-2
3.3 PHYSICAL, CHEMICAL, AND BIOLOGICAL REGIMES AND FOOD CHAIN 3-2
3.4 ATMOSPHERIC PROCESSES AND CHEMICAL MASS BALANCE 3-5
  3.4.1 Atmospheric Boundary Layer *3-5*
  3.4.2 Free Troposphere *3-5*
  3.4.3 Stratosphere *3-6*
  3.4.4 Mesosphere and Above *3-6*
3.5 EXISTING SOCIAL AND ECONOMIC CONDITIONS 3-6
  3.5.1 Kiribati Islands *3-6*
  3.5.2 Galapagos Islands *3-7*
  3.5.3 Home Port *3-8*
3.6 LEGAL FRAMEWORK 3-8

4. ENVIRONMENTAL IMPACTS **4-1**

4.1 OVERVIEW 4-1
4.2 IMPACTS OF NO ACTION 4-3
4.3 LAUNCH LOCATION AND RANGE ACTIVITIES 4-3
  4.3.1 Pre-Launch Operations *4-3*
  4.3.2 Launch and Flight *4-4*

4.3.2.1 Rocket Staging 4-4
4.3.2.2 Atmospheric Emissions 4-6
4.3.2.3 Atmospheric Boundary Layer 4-8
4.3.2.4 Free Troposphere 4-8
4.3.2.5 Stratosphere 4-9
4.3.2.6 Afterburning and Re-entry of Launch Vehicle 4-10
4.3.3 Post-Launch Operations 4-11
4.3.4 Failed Mission Scenarios 4-11
4.3.4.1 Explosion on the Launch Platform 4-11
4.3.4.2 Uncontrolled Upper Stage Loss 4-13
4.3.4.3 Prevention and Mitigation 4-14
4.4 SOCIAL AND ECONOMIC CONSIDERATIONS 4-14
4.5 OTHER ENVIRONMENTAL CONSIDERATIONS 4-15
4.5.1 Design, Operation, and Maintenance of the LP and ACS 4-15
4.5.2 Administrative Tasks 4-17
4.5.3 Home Port Activities 4-17
4.5.4 Energy Outputs 4-18
4.5.5 Coordination with Vessel and Air Traffic 4-19
4.6 CUMULATIVE IMPACTS 4-19

5. LIST OF REFERENCES AND CONSULTATIONS 5-1

5.1 REFERENCES 5-1
5.2 CONSULTATIONS 5-5

6. LIST OF PREPARERS 6-1

7. EA DISTRIBUTION 7-1

APPENDIX A - SEA LAUNCH SYSTEM COMPONENTS AND SYSTEM INTEGRATION A-1
A. OVERVIEW A-1

A.1 Launch Vehicle Description A-4
A.1.1 Vehicle History A-4
A.1.2 Zenit Stage 1 .... A-5
A.1.3 Zenit Stage 2 .... A-5
A.1.4 Block DM-SL - Upper Stage A-6
A.1.5 Payload Unit A-7
A.1.5.1 Payload Fairings A-8
A.1.5.2 Interface Skirt/Payload Structure A-8
A.1.5.3 Adapters A-9

A.2 Marine Systems A-9
A.2.1 Assembly and Command Ship A-9
A.2.2 Launch Vehicle Integration Area A-10
A.2.2.1 Block DM-SL Fueling Process A-10
A.2.2.2 Rocket Assembly Process A-11
A.2.2.3 Integrated Launch Vehicle Transfer from ACS to LP A-12
A.2.3 Launch Platform A-15
A.2.4 Transit Operations A-16
A.2.5 Platform Launch Operations A-16

A.3 Abort Operations A-17

A.4 Home Port Facilities and Services A-18
A.4.1 Spacecraft Processing Operations A-19
A.4.2 Payload Processing Facility A-19
A.4.2.1 Processing/Fueling Cells A-21
A.4.2.1.1 Propellant Cart Storage Rooms A-22
A.4.2.1.2 Propellant Carts/Tanks A-22

A.4.2.1.3 Summary of Propellant Operating Procedures A-22
A.4.2.2 Encapsulation Cell A-23
A.4.2.3 Air Lock A-23
A.4.2.4 Control Rooms A-23
A.4.2.5 Garment Change Rooms A-23
A.4.3 Solid Rocket Motor Storage A-23
A.4.4 Quantity Distance for Home Port Facilities A-24
A.4.5 Warehouse and Storage Facilities A-24
A.4.6 Home Port Administrative Facility A-25
A.4.7 Pier Facilities and Fueling Services A-25

A.5 Rocket Launch and Tracking Operations A-26
A.5.1 Zenit Stage 1 and Stage 2 Operations A-26
A.5.2 Block DM-SL (Upper Stage) Operations A-27
A.5.3 Range Tracking Assets A-28
A.5.4 Assembly and Command Ship A-28
A.5.5 Range Tracking Ship (Selena-M) A-28
A.5.6 Satellite Tracking System A-28
A.5.7 Launch Location A-28
A.5.8 Ascent Trajectory A-29

APPENDIX B - PRINCIPAL HAZARDS ASSOCIATED WITH THE SEA LAUNCH PROGRAM B-1

B. OVERVIEW B-1

B.1 Home Port Assessment B-3
B.1.1 Preliminary Hazard Analysis of Home Port Land-Based Operations B-4
B.1.1.1 Payload Processing Facility Operations B-5
B.1.1.2 Home Port Pier and Storage Facilities Operations B-5
B.1.1.3 Rocket Stages Processing B-6
B.1.1.4 Integrated Launch Vehicle Transfer B-6
B.1.2 Regulatory Agencies and Regulations B-7
B.1.2.1 U.S. Coast Guard B-7
B.1.2.2 Federal Occupational Safety and Health Administration B-7
B.1.2.3 Long Beach Department of Health and Human Services B-7
B.1.2.4 California Office of Emergency Management B-8
B.1.2.5 Long Beach Fire Department B-8

B.2 Launch Location Assessment B-10
B.2.1 Preliminary Hazard Assessment of Pre-Launch Operations B-10
B.2.2 Preliminary Hazard Assessment of Launch/Flight Operations B-11
B.2.2.1 Normal Operations B-11
B.2.2.1.1 Public Safety B-11
B.2.2.1.2 On-Orbit Safety B-12
B.2.2.2 Contingent Operations B-13
B.2.2.2.1 Public Safety B-13
B.2.2.2.2 On-Orbit Safety B-14
B.2.3 Preliminary Hazard Assessment the Post-Launch Operations B-15

B.3 Characteristics of Hazardous Material B-15

B.4 Hazardous Waste B-20

B.5 General Industrial Waste B-20
B.5.1 Home Port Facility Non-Hazardous Waste B-20
B.5.2 Shipboard Waste B-21

B.6 List of Hazardous Materials B-21

APPENDIX C - PARTNERSHIP DESCRIPTION C-1

C. PROJECT ORGANIZATION AND PARTNER RESPONSIBILITIES ..C-1
C.1 Boeing Commercial Space Company ..C-2
C.2 Kværner Maritime a.s ..C-3
C.3 KB Yuzhnoye ..C-3
C.4 RSC Energia ..C-3
APPENDIX D - GLOSSARY AND UNIT CONVERSION TABLE . D-1
D.1 GLOSSARY . D-1
D.2 UNIT CONVERSION TABLE . D-3

LIST OF FIGURES

Figure		**Page**
2.1-1	Sea Launch ACS, LP, and Launch Transit Routes	2-2
3.1-1	GTO Mission Ascent Groundtrack, IIP Trace, and Debris Footprint from Launch Location at 0°, 154° W	3-1
3.2-1	Launch Location	3-2
3.3-1	Launch Area Winds and Surface Currents	3-3
4.3.2-1	Flight Zones	4-5
4.3.4-1	Galapagos Area Overflight	4-14
A-1	Home Port Location and Vicinity	A-2
A-2	Spacecraft Processing Flow	A-3
A.1.1-1	Zenit-3SL Launch Vehicle	A-5
A.1.3-1	Zenit Stage 1 and Stage 2 Configuration	A-6
A.1.4-1	Block DM-SL	A-7
A.1.5-1	Zenit-3SL Payload Unit	A-8
A.2.1-1	Assembly and Command Ship	A-10
A.2.2-1	Launch Vehicle Processing and Mission Control	A-10
A.2.2-2	ACS and LP Mooring Arrangement During Integrated Launch Vehicle Transfer	A-13
A.2.2-3	Integrated Launch Vehicle Transfer Arrangement	A-14
A.2.3-1	Launch Platform	A-16
A.4-1	Sea Launch Home Port Complex	A-18
A.4.2-1	Payload Processing Facility	A-20
A.5.7-1	Potential Launch Region	A-29
A.5.8-1	Typical Flight Profile - GTO Mission	A-30
A.5.8-2	Typical GTO Trajectory Parameters - Stage 1 and Stage 2	A-31
A.5.8-3	Typical GTO Trajectory Parameters - Block DM-SL	A-32
B.2.2-1	Typical Ascent and Instantaneous Impact Point Groundtrack	B-12
B.2.2-2	Circular Disposal Orbit Regimes for Spent Stages	B-13
B.2.2-3	Flight Safety Angle Limits	B-14
C-1	Mission Operations Team	C-2

LIST OF TABLES

Tables **Page**

4.3.2-1 Sea Launch Zenit-3SL Fuel Profile 4-6
4.3.2-2 Zenit-3SL Kerosene - LOX 4-6
4.3.2-3 Solid Fuel Separation Rockets 4-7
4.3.2-4 Upper Stage Attitude Control/Ullage Motors 4-7
4.3.2-5 Ozone Destruction by Chemical Compounds 4-10
5.2-1 Agency Consultations (exclusive to Home Port) 5-5
A.5.1-1 Typical Mission Event Times - GTO Mission A-26
B.1.2-1 Receipt, Storage, and Transfer Spacecraft and Upper Stage Fuel B-8
B.1.2-2 Transfer of LOX, Kerosene, Nitrogen, and Helium from Transport Trucks to LP Storage Tanks B-9
B.1.2-3 Receipt, Storage, and Transfer to ACS of Solid Rocket Motors and Ordnance B-10
B.3-1 Summary of Integrated Launch Vehicle Hazardous Material B-15
B.6-1 List of Process Hazardous Materials (Preliminary) B-21

LIST OF ACRONYMS

^{0}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	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
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
DoT	Department of Transportation
EEZ	exclusive economic zone
EIS	Environmental Impact Statement
EMC	electromagnetic compatibility
EO	executive order
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FMH	free molecular heating
FSS	flight safety system
GN_2	gaseous nitrogen
GOST	government standard (Russian)

H_2	hydrogen
H_2O	water
HDP	Harbor Development Permit
HEPA	high efficiency particulate air
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

GSE	ground support equipment
GEO	geosynchronous orbit
GTO	geosynchronous transfer orbit
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
RG-1	kerosene (rocket fuel)
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
SCG	storage compatibility groups
SLLP	Sea Launch Limited Partnership
SLS	Sea Launch System
SOLAS	safety of life at sea
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
UDMH	unsymmetrical dimethylhydrazine
UN	United Nations
UPS	uninterruptible power supply
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 the FAA's Associate Administrator for Commercial Space Transportation (referred to as AST) to grant a license to the Sea Launch Limited Partnership (SLLP). 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 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.

1.2 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, Sea Launch (SL) intends to conduct two launches; six launches are proposed for each subsequent year.

The Commercial Space Launch Act of 1984, as codified at 49 U.S.C. Subtitle IX, Ch. 701, Commercial Space Launch Activities §§ 70101-70119, the Act was passed by Congress to accomplish, in relevant part, the following:

- Promote economic growth and entrepreneurial activity though use of the space environment for peaceful purposes;
- 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 Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation (AST). The 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 conducted by U.S. citizens abroad. If a foreign entity controlled by a U.S. citizen conduct a launch outside the United States and outside the territory of a foreign country, its launch must be licensed. 49 U.S.C. § 70104(a)(3). The FAA determined that SLLP is a foreign entity controlled by a U.S. citizen, Boeing Commercial Space Company. 49 U.S.C. § 70102 (1)(C); 14 C.F.R. § 401.5. Because it proposes to launch in international waters, outside the territory of the United States or any foreign country, SLLP must obtain an FAA license to launch. Sea Launch Limited Partnership will initially apply for a launch-specific license, and later plans to apply for a launch operator license.

The FAA's proposed action is to issue a commercial launch license for a program of Sea Launch launches. This EA is intended to support both launch specific and launch operator licenses.

Space transportation infrastructure for expendable launch vehicles 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). 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 Sea Launch Limited Partnership

The SLLP is an international commercial venture formed under the laws of the Cayman Islands with the objective of launching commercial satellites. It is organized under the laws of the Cayman Islands, BWI, and 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 (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 would have significant impact on the environment. Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions," which provides Federal agencies guidance with proposed actions outside the United States, its territories, and possessions also provided guidance in the preparation of this environmental assessment.

1.3.3 Public Involvement

AST will make a proposed Finding of No Significant Impact available for public review for 30 days because the nature of the proposed action, licensing of a launch from of an offshore facility in international waters, is one without precedent.

1.3.4 Other Environmental Analyses

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

2. ALTERNATIVES AND PROPOSED SEA LAUNCH ACTION

Under NEPA, the FAA is required to consider impacts to the human environment of the licensing of commercial space launch activities. The following sections include a description of the key aspects of the proposed Sea Launch operations that the FAA will consider for licensing; a description of the alternatives considered during the planning process; and a discussion of the No Action alternative. SLLP intends to conduct two launches in 1998 and six per year thereafter. The spacing of the launches will depend on launch market requirements. The lifetime of the Sea Launch system would be limited by the useful life of the launch platform (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 launch license for Sea Launch launches as described and configured in the operating plan detailed in Appendix A. Sea Launch operations would utilize an LP, an assembly and command ship (ACS), and potentially, a smaller satellite tracking ship, the Selena-M. A floating oil drilling platform is being refurbished in Norway to serve as the self-propelled LP. The ACS is being built in Scotland specifically for Sea Launch operations.

The launch vehicle that Sea Launch operations would use consists of a Zenit rocket, a 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. The tracking ship, Selena-M, is an existing asset of the former Soviet Union used for electronic surveillance and the monitoring of military spacecraft. 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^{o} 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, the Selena-M satellite tracking ship (if deployed), tracking satellites, and ground stations. Selena-M use, while specified in the baseline plan, is being reconsidered and may be replaced at less cost by a US Government, NASA space-based tracking system called Tracking and Data Relay Satellite System (TDRSS). The existing TDRS system is used for both commercial, military, and government telemetry and communications applications. Sea Launch would use TDRSs to telemeter data from the payload unit. 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).

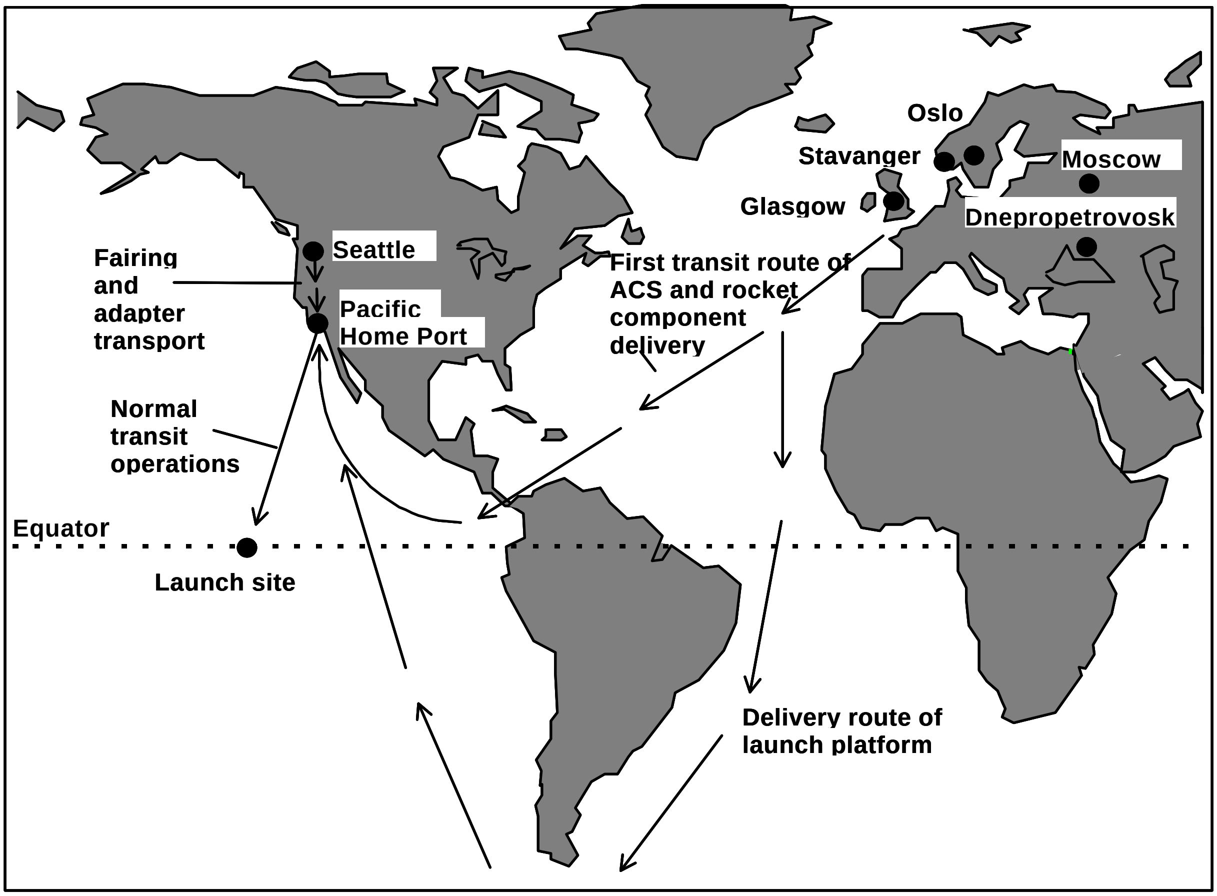


Figure 2.1-1. Sea Launch ACS, LP, and Launch Transit Routes

2.2 ALTERNATIVE ACTIONS

The applicant 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 NEPA and Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", the FAA is required to consider 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 proposed FAA action is to make a licensing determination regarding SLLP's proposed launch. As described in the following paragraphs, SLLP considered several alternatives to the proposed plan.

To select the best plan for SLLP Sea Launch operations, an analysis of reasonable alternatives was completed by the applicant. 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 selecting the proposed Sea Launch 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 the initial planning phase, the following criteria were used to define a successful SLLP partnership:

a) SLLP members would each contribute launch system assets.

b) 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.

c) Costs would be minimized to provide the best possible value for SLLP's customers.

d) Launch operations would be conducted in a safe and responsible manner.

Eliminated from consideration were launch vehicle assets not owned or efficiently 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, SLLP concluded that 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. Launch vehicles manufactured by non-partner firms were not considered because they were not available or were inappropriate for the proposed use. 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 integrated launch vehicle (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, the applicant began the process of selecting an equatorial launch location in the Pacific Ocean. An equatorial launch location is preferred because is maximizes intertial and other launch efficiencies. In this process, public safety and the potential for environmental impacts were weighted most highly. Secondary criteria also considered are summarized in the following subsections.

2.2.2.1 Public Safety

SLLP adopted the common collective risk value, an upper limit of one in a million casualty expectation, as the population protection criteria. 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 one, the fairing, and stage two 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^o E and 155^o W. The launch area, in the vicinity of 154^o 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 Considerations

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^o 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^o W but detours north around the main Galapagos islands, was evaluated and was selected to further reduce the 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 downrange 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^o W on the equator and conditions were found to be favorable:

a) weather conditions (particularly low frequency of lightning).

b) proximity to commercial activity (fishing, recreation, ship, and air traffic); and

c) 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 the upward force that is exerted by the earth's rotation on any object on the surface of the earth, including launch vehicles; this force is greatest on the equator and at a minimum at the North and South poles. An equatorial launch location would also afford the greatest flexibility in positioning satellites in their final orbits for a succession of launch customers. 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. 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, FAA would not issue a launch license to SLLP. Because the Act requires launches to be licensed, 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 at this time, and this assessment assumes that the no action alternative would result in no launch-related 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 115° 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.

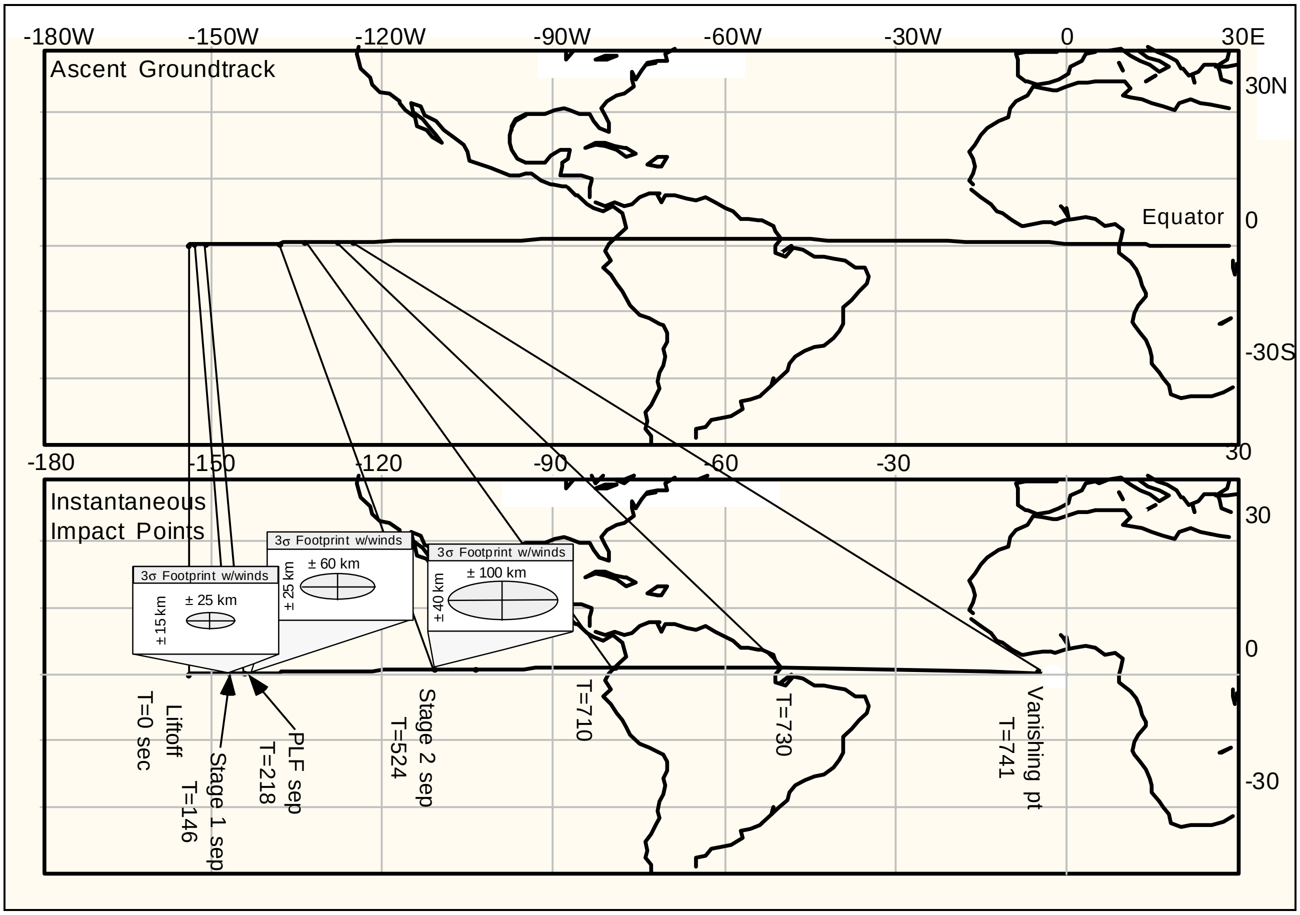


Figure 3.1-1. GTO Mission Ascent Groundtrack, IIP Trace, and Debris Footprint from Launch Location at 0°, 154° W

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 present 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, , and the next nearest land, Malden Island, lies uninhabited just over 380 km to the SW.. The nearest land downrange to the east, the Galapagos Island group, is roughly 6,900 km away. This relative distribution of land masses is a result of seafloor spreading of the Pacific, Nasca, and Cocos Plates (Springer, 1982).

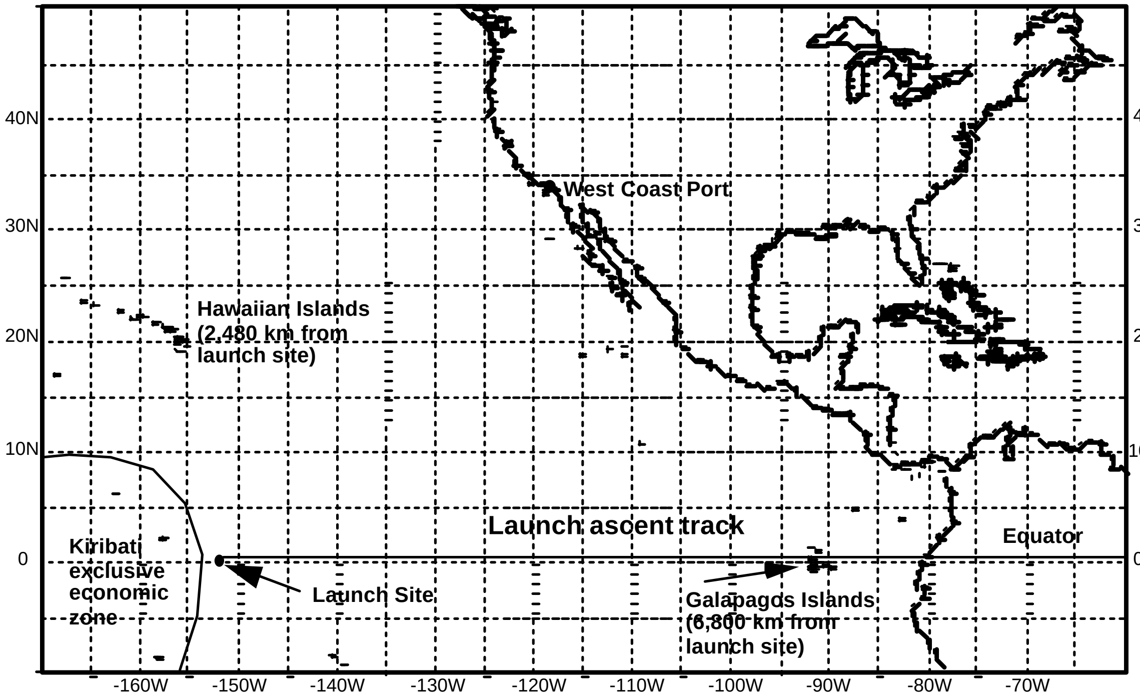
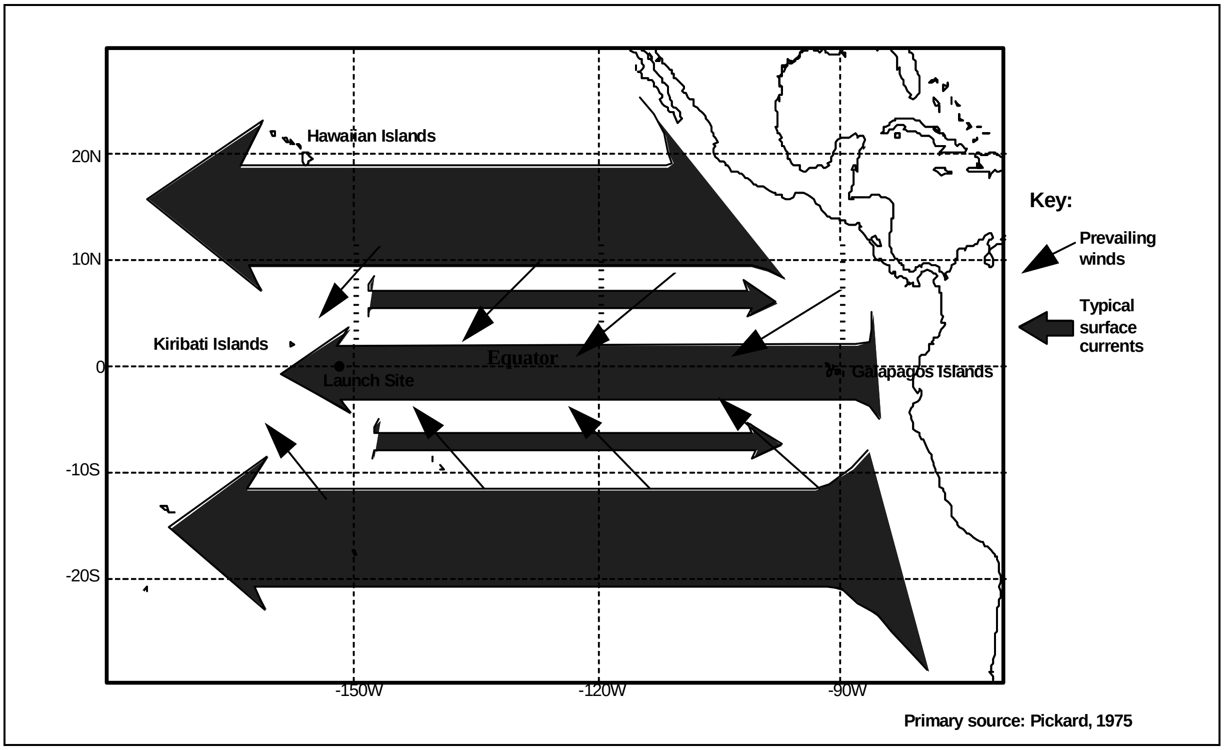


Figure 3.2-1. Launch Location

In this process, new seafloor has accreted to each plate where the plates meet SW 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)



Primary source: 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 from the loss of favorable habitat as key nutrients are consumed and not replenished. 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).

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:

a) 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).

b) 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).

c) 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 154^0 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 to 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 downrange 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, the closest being Christmas and Malden Islands, lie west of the launch location, but at distances that preclude environmental impacts to any island (Section 4). Christmas Island has an airstrip and shore facilities that could be used for logistical support by Sea Launch, however, current plans call for the ships to be self sufficient. As such, the only air travel to Christmas Island that may be necessary would be in emergency situations as with any maritime activity. Nonetheless, a baseline description of the Islands is provided in the following paragraphs to allow consideration of impacts to Christmas Island(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 capital for investment in economic development. Although there has been some recent interest in tourism, primarily for sports fishing, the Kiribati economy remains subsistence-based. International aid funds and other initiatives 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 focus of the Kiribati people currently rests with the ocean fish stocks, which are largely concentrated near the islands themselves. Fishing from 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 and live exotic fish exports now offer the greatest potential for income. To capitalize on the apparent opportunity offered by ocean fish stocks, the 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 is 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 is 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 1970’s. Prior to the tourist boom during the 1970’s, 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. 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 (CDRS) 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 1980's 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. Millions of dollars are 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 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 accompanying CEQ regulations (40 CFR 1500), and EO 12114 (see Section 1). As this particular report is prepared in response to these requirements, their role in governing Sea Launch operations is self-evident. In addition, the U.S. environmental laws that typically govern domestic launch operations are addressed in Section B-1-2, Regulatory Agencies and Regulations.

4. ENVIRONMENTAL IMPACTS

4.1 OVERVIEW

This section will focus on Sea Launch activities that would be conducted at the launch location, activities that may impact the range during normal launches, and failed missions (also known as anomalies, incidents, and accidents). For discussion purposes, Sea Launch operations at the launch location and range have been broadly grouped into pre-launch operations (i.e., everything prior to ILV ignition), successful launch and flight, post-launch operations, and failed missions. Each of these operational phases and their corresponding effects on the environment will be discussed. Sea Launch payloads (i.e., commercial satellites) would be fueled and sealed at the Home Port. They only become operational and expend their propellants at an altitude over 35,000 km. Accordingly, environmental aspects of payloads are not discussed here except in regard to failed mission scenarios (Section 4.2.4).

Some Sea Launch activities have been previously addressed or dictated by other international, domestic U.S., state and local requirements and are incorporated by reference and briefly summarized. These include:

a) The operations of the Sea Launch international partners, which are subject to the requirements of the environmental laws in their respective countries, including the laws of the United States, Norway and Scotland, and the laws of the former Soviet Union now administered separately by the Russian Federation and Ukraine.

b) The transport of cargo to the Home Port, and the management of all Sea Launch hazardous materials and wastes, which would be managed according to international maritime rules, agreements, and protocols (Section 4.4.1).

c) Design, construction, and operation of the Home Port, which would follow the safety and environmental planning and permitting processes administered by state, regional, county, municipal, and port officials according to a variety of laws and implementing regulations (including the California State Environmental Protection Act). These environmental impacts are addressed in the "Environmental Assessment for the Interim Lease of the Navy Mole, Naval Station Long Beach, Long Beach, California," (Department of the Navy, 1996), incorporated by reference in to this EA, and four Sea Launch Limited Partnership documents (SLLP, 1995a; SLLP, 1995b; SLLP, 1996a; and SLLP, 1996b).

d) The design and operational use of the LP and ACS in transit between the Home Port and the launch location, which would be subject to established international protocols and the laws of Liberia, the country of ship registration (see Section 4.4.1 and Norsk Standard NS 2780, 1985). These protocols, which must be fully met before each vessel is licensed, include detailed assurances of proper design, manufacture, testing, operation, and maintenance of safety and environmental control systems for the vessels' propulsion and power supplies, their means for cargo and waste handling, and their waste incineration equipment. SLLP plans and provisions to support these protocols are incorporated in LP and ACS specification documents (Kværner Moss Technology a.s., 1995a; and Kværner Moss Technology a.s., 1995b).

DOCUMENTS INCORPORATED BY REFERENCE INTO THIS EA

- Navy Mole EA (Department of the Navy, 1996). This EA contains an environmental impact analysis of the design, construction, and operation of the Home Port. Topics analyzed include topography/soils/seismicity; liquefactor and subsidence; hydrology, drainage, and flood control; water quality; biological resources; cultural resources; land use; traffic circulation; safety and environmental health; public services; utilities; aesthetics; socioeconomics; air quality; noise. This document analyzes the existing site in detail, and states that design and construction of the Sea Launch facilities would comply with Federal, state, and local building codes, environmental, fire, and California Occupational Safety and Health Administration regulations, NASA standards, and the NASA Kennedy Space Center Safety Plan to prevent adverse impacts to public safety or the environment. The EA resulted in a finding of No Significant Impact (FONSI), signed March 29, 1996.

- Port of Long Beach Harbor Development Permit Application (SLLP, 1995a). The Harbor Development Permit specifies that SLLP will follow all applicable Federal, state, and local laws and regulations including those pertaining to safety and the environment. This permit covers the management of wastes and hazardous wastes generated at the site. The permit stipulates that there will be no on-site disposal or treatment of any wastes at the Home Port, and that the Home Port will obtain a large quantity generator permit to ensure proper management of hazardous wastes at the site.

- Sea Launch Home Port Data Package (SLLP, 1995b). This presentation describes the character of the Home Port industrial operation. It demonstrates how the development and operations of the Home Port will ensure protection of the public and environment. Principle hazards to the public and environment are detailed by operation. Oversight agencies and relevant regulations are also provided for these principle hazards.

- Galaxy XI Preliminary Launch License Application (SLLP, 1996a). This document is the preliminary launch license application, part two of a three-phased approach for submitting necessary data to FAA for the inaugural Sea Launch mission (i.e., Hughes Galaxy XI mission) proposed by Sea Launch Limited Partnership. It provides for safe coordination with air, marine, and space traffic, and includes technical analyses and risk assessments regarding the mission.

- Sea Launch Electromagnetic Compatibility Control Plan (SLLP, 1996b). This plan addresses the safe management and control of possible risks to people and the environment from electromagnetic radiation outputs from the launch vehicle and related launch system hardware.

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. Associated safeguards and permits for specific hazardous materials used by Sea Launch for component manufacturing and vessel, Home Port, and launch operations are addressed in detail by these authorities and in the documents referenced above. This information collectively represents the total scope of the plan developed to integrate and manage SLLP assets, administrative processes, and regulatory requirements, including the combined objectives of safety and environmental protection in all facets of the Sea Launch program.

4.2 IMPACTS OF NO ACTION

The No Action alternative (defined in Section 2.3) could result from an FAA decision to deny a commercial launch license or from a decision by the applicant to withdraw its license application. With the no action alternative, the Sea Launch Limited Partnership would not launch Zenit rockets from the Pacific Ocean. The Port of Long Beach would remain available for other commercial or government ventures. Additionally, the goals of the Commercial Space Launch Act would not be furthered. The predicted environmental effects of the proposed action would not occur. The area around the proposed launch site would remain in its unaltered and natural state.

4.3 LAUNCH LOCATION AND RANGE ACTIVITIES

Potential environmental impacts caused by the launch location and range activities were evaluated by first correlating these activities with all aspects of the environment in the east-central equatorial Pacific Ocean. For this purpose, the environment was categorized into physical and chemical regimes, biological processes and the food chain, global environmental systems (specifically global warming and ozone depletion), and social and economic aspects.

The following discussion describes the effect of proposed Sea Launch activities on these environmental attributes. Routine activities and contingencies not tied to any one of the four phases of the Sea Launch process, such as LP and ACS operations and command of the launch process onboard the ACS, are consolidated in Section 4.4.

4.3.1 Pre-Launch Operations

Upon arrival at the launch location, the ILV would be ready for erection, fueling, and launch. Pre-launch operations would involve only LP and ACS positioning, the final equipment and process checks, the coupling of fuel lines to the ILV prior to fueling, the transfer of kerosene and liquid oxygen (LOX) fuels, and the decoupling of the fueling apparatus. All employees would be removed from the LP. The process would be remotely controlled from the ACS, located on the safety perimeter five km away. Normal operations would result in no loss of kerosene or LOX other than an incidental loss of vapors from the fuel connections, which would dissipate immediately and form smog without consequence.

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. Negligible impacts to the ecosystem would occur from the use of this water as the natural variation in plankton densities would ensure a nearly instantaneous recolonization in the water surrounding the LP following the input of heated freshwater.

Several seconds prior to ILV ignition, command from the ACS would be relinquished and computers onboard the ILV would assume remote control and monitor ILV and launch system performance. If performance is normal, clamps would be released when adequate thrust for liftoff is achieved. If performance is unacceptable, however, the ignition sequence or fuel combustion would be interrupted while the ILV remains in a stable position. In this latter case, automated defueling processes would be initiated remotely from the ACS. During defueling, some additional LOX would be lost as vapor, and approximately 70 kg of kerosene would be lost when the fuel line is flushed, which would be the only discharge to the ocean during this phase. If the launch process is halted after kerosene has entered the engine but before ignition (with an occurrence probability of 4×10^{-4}), the ILV would be defueled, lowered, and returned to the hanger, and approximately 800 kg of kerosene would be manually drained from the engine into storage containers. Under normal conditions no kerosene would be dumped into the ocean.

Sound transmitted into the water by LP and ACS power sources during routine operations, expected to range from 30 dB to 70 dB across a frequency range from 50 to 2000 Hz (Jensen, 1994), would have little effect on resident or transient populations given the very brief presence of the Sea Launch assets at the launch location. In a similar manner, the congregation of fish and the formation of an ecosystem around the LP that commonly occurs around oil drilling platforms would not have a chance to develop given the abbreviated length of time the LP and ACS would occupy the launch location during each launch cycle. A single ocean and weather data buoy would be deployed to transmit data used to orient the LP. As with other data buoys maintained by research agencies, the Sea Launch buoy would gradually attract a localized community that would be disrupted during periodic buoy maintenance.

4.3.2 Launch and Flight

Launch and Flight inputs to the environment from each launch would be:

a) Spent stages.

b) Residual fuels released from the spent stages to the ocean and atmosphere.

c) Combustion emissions released to the atmosphere.

d) Energy transferred to the atmosphere and to the deck of the LP, primarily in the form of heat and sound.

In 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 (see Figure 3.1-1). In normal launches, the probability of each input occurring in its defined zone is estimated as 99.73% (3σ), and the mass and energy of each input in its zone would be virtually the same for each launch. Zone E, by the Galapagos, is discussed in Section 4.3.4.

4.3.2.1 Rocket Staging

Stage 1 and Stage 2 would fall, rupture, and sink within the areas shown on Figures 3.1-1 and 4.3.2-1. The fairing, with a higher surface area relative to mass, would flutter to the sea surface, perhaps break up on impact, float, gradually become waterlogged and less buoyant, and drift to the west. Due to the low densities of higher trophic level organisms in that part of the Pacific Ocean (as described in Section 3.3), the probability of debris striking animals at the points of impact is very small. With the exception of the fairing pieces, all materials would sink and smother organisms in the immediate area of contact on the ocean bottom. Once settled, the debris would become part of the habitat, offering a new substrate and a protective residence in the benthic ecosystem.

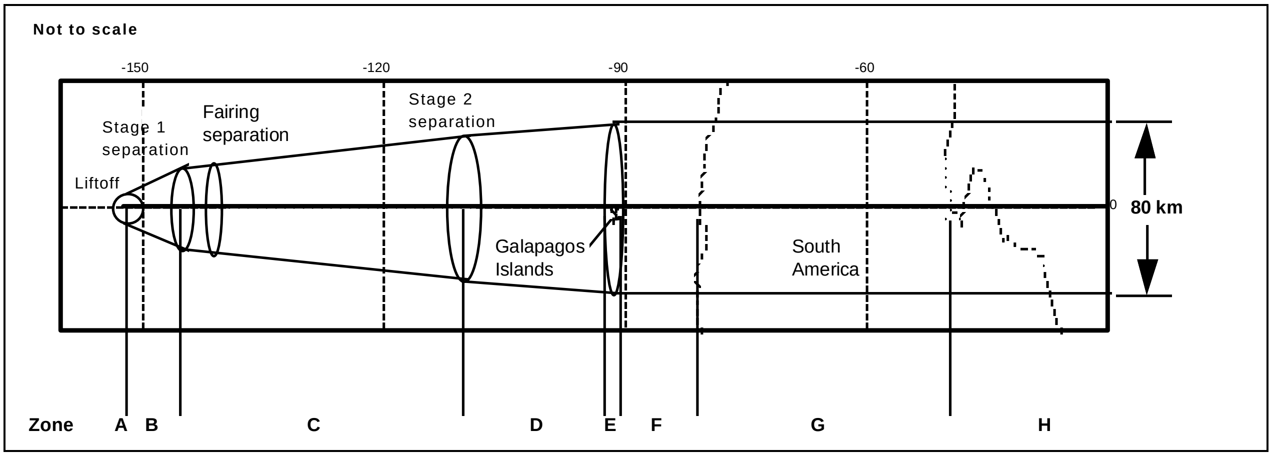


Figure 4.3.2-1. Flight Zones

These materials, while not totally inert, would remain in place and stable while slowly dissolving, dissipating, and being buried in the ocean bottom. The dry rocket is composed primarily of aluminum, steel, and a graphite composite with small quantities of various plastic, ceramic, and rubber products. In addition, small amounts of refractory metals are used in certain engine components that are consistent with general rocket design. These refractory materials include niobium and titanium for nozzle structures and storage bottles. The fairing and adapter are made of composite graphite and a honeycombed aluminum.

Historically, approximately 3,489 kg and 1,060 kg of kerosene, or about 3.9% and 4.7% of total Stage 1 and Stage 2 kerosene respectively, falls unburned in the 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 in 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. This would evaporate and disperse within a few hours. 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. The remainder would become entrained and dispersed by turbulence in the top few meters of the water column, and be assimilated primarily as CO_2 and H_2O through photochemical oxidation and microbial degradation processes within hours or days (Doerffer, 1992; National Research Council, 1985; and Rubin, 1989). The timing and exact percent of kerosene evaporated versus entrained in the water column in any instance would depend on the temperatures of the air and ocean surface, the wind velocity, and the sea state. 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 populations densities are at a maximum at around 30 meters below the surface. Inherent plankton patchiness would result in recolonization of the affected areas within hours or days (Section 3.3). The residual LOX would instantly vaporize without consequence. Greater efficiencies might be achieved in successive Sea Launch flights as fuel loads are optimized. The data used are from the Russian and Ukrainian partners who launch the Zenit over sparsely populated areas. If a greater quantity of kerosene is released, e.g., from a line failure during Zenit fueling, Kerosene would spread and be visible over as much as several hundred square kilometers, assuming a total release. The same evaporative and microbial processes discussed above would act to dissipate and break down the larger quantity of spilled fuel over a period of as long as a week or so.

The Block DM-SL upper stage would achieve a low earth orbit (LEO) at an approximate altitude of 180 km and a longitude of 110^0 W. The rocket motors would be fired as needed to position the payload in the orbit parameters specified by the customer. Following separation from the satellite payload, the upper stage would vent all gasses and propellants from its tanks and enter a safe configuration in its final disposal orbit. The Block DM may use either UDMH or MMH, while the typical communications satellite uses either MMH or AH. Although the differences are small, this assessment assumes the use of UDMH and MMH, respectively. In addition to the debris expended from the ILV during normal launches, some debris might be blown off the LP into the ocean during the launch process. These materials would be primarily shrapnel from the clamps that hold the ILV in place and perhaps other hardware used to erect the ILV. Bits of insulation material used to protect equipment from the intense heat might also be blown into the ocean. As these material inputs would be small in volume and largely inert, they would cause little disruption or impact to the ocean ecosystem. In addition, the noise from a launch is calculated at approximately 150 decibels at 378 meters (Sutherland, 1968); the equivalent sound intensity in the water at this distance is predicted to be less than 75 dB (Beranek, 1988; Jensen, 1994; and Frisk, 1994). 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. Estimated sound levels are not A weighted, since human speech interference criteria do not apply (Beranek, 1980). Current Zenit launches at Baikonur, Russia, place personnel in the open air one to two km away, indicating acceptably low noise levels at that distance. Any animal, including birds, that happens to be in the area would experience a startle reaction as now occurs at established land-based launch locations.

4.3.2.2 Atmospheric Emissions

Downrange from the launch location, the mass and energy of the rocket's emission into the atmosphere is a function of velocity and rate of combustion. Atmospheric effects caused by the flight of the Sea Launch rocket would arise from two factors: the combustion of onboard fuel stocks (Table 4.3.2-1) with the associated emissions of gases and particulate matter (Tables 4.3.2-2 through 4.3.2-4); and the physical passage of the ILV through the atmosphere. Consumption and emission quantities listed in Tables 4.3.2-2 through 4.3.2-4 are based on nominal trajectory without payload weight and fuels. Altitude ranges have been rounded to the nearest kilometer.

Table 4.3.2-1. Sea Launch Zenit-3SL Fuel Profile*

Fuel Type	Stage 1	Stage 2	Upper Stage (Block DM-SL)
LOX	231,052 kg	58,113 kg	10,594 kg
Kerosene	87,852 kg	22,524 kg	4,439 kg
N204/UDMH			57 kg

* Does not include payload fuels

Table 4.3.2-2. Zenit-3SL Kerosene-LOX

Altitude Range (km)	Propellant Consumed (kg)	Emission Products (kg)			
		CO	CO_2	H_2	H_2O
0.0 - 2.0	61,714	17,033	26,907	432	17,342
2.0 - 10.0	69,100	19,072	30,128	484	19,417
10.0 - 51.0	158,831	43,837	69,250	1,112	44,632
51.0 – 292	124,697	33,987	55,508	991	34,226
Total	414,342	113,929	181,793	3,019	115,616

Table 4.3.2-3. Solid Fuel Separation Rockets

Altitude Range (km)	Propellant Consumed (kg)	Emission Products (kg)					
		CO	CO_2	H_2	H_2O	N_2	Pb
0.0 - 2.0	0	0	0	0	0	0	0
2.0 - 10.0	0	0	0	0	0	0	0
10.0 - 51.0	0	0	0	0	0	0	0
51.0 – 292	105	40.5	14.8	21.5	12.3	15.8	0.1
Total	105	40.5	14.8	21.5	12.3	15.8	0.1

Table 4.3.2-4. Upper Stage Attitude Control/Ullage Motors

Altitude Range (km)	Propellant Consumed (kg)	Emission Products (kg)				
		CO	CO_2	H_2	H_2O	N_2
0.0 - 2.0	0	0	0	0	0	0
2.0 - 10.0	0	0	0	0	0	0
10.0 - 51.0	0	0	0	0	0	0
51.0 - 292	57	2.0	5.5	2.8	26.2	20.5
Total	57	2.0	5.5	2.8	26.2	20.5

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. Catastrophic failures, expected in fewer than one out of 25 launches, are discussed in Section 4.3.4. The materials emitted under such circumstances would be largely equivalent to those emitted during normal operations, but the release would occur in a smaller area than would be the case under normal operations. During normal operations of the first stage, the release would be distributed throughout the trajectory. Releases from the second stage and upper stage normally would occur well above the stratosphere, as first stage separation would occur at approximately 70 km altitude for the various mission and payload mass combinations.

The chemical compounds released during combustion are thought to contribute to several types of atmospheric environmental impacts, including global warming, acid rain, ozone layer destruction, and photochemical smog. Although CO_2 is a possible contributor of global warming, the amount released by Zenit rockets during a year of operation is less than the estimated amount of CO_2 cycled at the ocean surface in an hour in the region (Murray, 1994). The release of CO_2 cannot be avoided when carbon based fuels are used. Rocket programs in general have a negligible effect on acid rain, with the greatest effects attributable to chlorine compounds from solid rockets. Based on an analysis of nine Space Shuttle and six Titan IV launches per year, all rocket launches contribute less than 0.05% of the acid-producing chemicals as industrial processes, less than 0.045% as transportation, and less than 0.0091% as heating and power production (McDonald and Bennett, 1995). Sea Launch would not generate chlorine compounds, indicating an even further reduced risk of acid-rain impact due to the program. The launch location is remote and far removed from urban locations that are subject to smog formation.

The greatest risk for adverse environmental impact to the atmosphere due to normal emissions would be in the area of ozone layer destruction. Because the Zenit-3SL rocket does not release chlorine or chlorine compounds in or below the stratosphere, this impact should not be substantial (Section 4.3.2.5). Effects on ozone on the various layers of the atmosphere are discussed in more detail in the paragraphs that follow. There is a possibility that rocket emissions could affect the formation of ice nuclei, and thereby cloud formation, but this is not considered likely (Section 4.3.2.4). Potential effects due to the physical movement of the rocket and its components are also discussed in the following paragraphs.

4.3.2.3 Atmospheric Boundary Layer

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. The atmospheric boundary layer (or lower troposphere) is the lowest part of the atmosphere and represents the portion of the atmosphere where effects of the earth's surface would be most substantial. Current research and studies on emissions in the atmospheric boundary layer have focused on releases in proximity to populated land masses. Because the atmospheric boundary layer in the region surrounding the launch location is essentially free of combustion emissions, and because of the enormity 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 Christmas Island on the order of 1 mg/m^3 after 36 hours of steady winds to the north-west (NOAA).

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 far away from Kiritimati (Christmas) and Malden Islands by the prevailing easterly trade winds and by the local turbulence caused by solar heating. As dispersion occurs within hours, the planned six missions per year would preclude any chance from accumulation or chronic effect of normal emissions.

4.3.2.4 Free Troposphere

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), which is formed in the exhaust trail, would tend to form nitric acid. 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.

At this time there is insufficient information to determine the extent of cloud condensation that might be attributable to Sea Launch flights. However, reported measurements of ice nuclei in the third Space Shuttle launch exhaust cloud indicated no statistically significant difference from background measurements of such nuclei (AIAA, 1991). Although the Sea Launch and the Space Shuttle programs use different fuels, the Zenit's exhaust products are similar to those emitted by the Space Shuttle's liquid engines. This suggests that Zenit emissions would not be a significant source of cloud formation.

Carbon monoxide is considered to be a criteria pollutant under the Clean Air Act. Although the Clean Air Act is not directly applicable in the Pacific Ocean region of Sea Launch operation, it is useful to consider the dispersion of the CO during a launch. Most air pollution dispersion models have been developed for overland releases and for relatively short distances (Weinberg, 1997a; Gifford, 1995). While there has been some field research done for long-range over water diffusion, there do not appear to be any established models for a mid-ocean release; and in particular, the dispersion coefficients for such a release have not been established (Weinberg, 1997b, Gifford, 1995). What follows is an order of magnitude analysis based on available information.

Approximately 36,100 kg of CO would be released into the troposphere during the first 55 seconds of flight. This produces an emission rate of 656 kg/sec. These emissions would occur over the length of the trajectory, but are assumed to occur at the launch point (sea level) for purposes of this analysis. This would tend to over-estimate the concentration downwind. Although the emissions would occur for a short period, the model based on continuous emissions is used here. Again, this should overstate concentration. An equation for sea level center-line CO concentration C is given by the formula $C(x) = Q/\pi u\sigma_y\sigma_z$, where x is the downstream distance, Q is the emission rate (656 kg/sec), u is the downstream wind velocity (assumed here to be 3 m/sec) and σ_y and σ_z are standard deviations in the crosswind and vertical directions respectively (Wark and Warner, 1981). σ_y and σ_z are functions of the downstream distance.

To estimate concentration at the closest populated landmass (Christmas Island) it is assumed that the wind blows steadily in a path from the launch site to the island. This should maximize concentration at the island. The model assumes complete reflection of the CO from the surface of the water and no chemical processes that would serve to remove CO from the plume. As before these assumptions serve to over-estimate concentration. The island is approximately 340 km from the launch site, and generally accepted estimates of σ_y and σ_z are not available for such a long distance (Weinberg, 1997a and b; and Gifford, 1995). However, using values for σ_y and σ_z reported by Wark and Warner, 1981, assuming neutral meteorological conditions (this should again over estimate concentration) and extrapolating to 340 km, the following order of magnitude estimates for σ_y and σ_z are obtained: σ_y » 10^4 m, and σ_z » 7 x 10^2 m.

Substituting into the equation for concentration, the CO concentration at Christmas Island is 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.

Estimates for σ_y and σ_z can also be made using some data for "puff" models (Slade, 1968) and applying the equations therein outside their range of validity. Doing this yields σ_y » 0.74 x 10^4m and σ_z » 1.1 x 10^3m, and gives essentially the same result as above. Using unstable meteorological conditions would produce another order of magnitude reduction in concentration. It must be noted that the models are being applied well outside of the downwind distances for which they were developed. Actual CO concentration would be expected to be less than calculated above because the various assumptions employed in the calculation tend to over estimate concentration.

Field work in the Pacific has indicated that at wind speeds of 8 - 12 m/sec and under certain meteorological conditions, σ_z is on the order of 500 m (Weinberg, 1997b). At this windspeed, the time of transit to Christmas Island is approximately 9.4 hours, and using the values of long-range diffusion given by Gifford, 1995, σ_y is estimated to be 6 x 10^4m. Using these figures, with a wind speed of 10m/sec in the basic equation for concentration, the calculated concentration of CO at 340 km is 0.7 mg/m^3. The order of magnitude analysis is consistent with several computer runs using the HYSPLIT4 model (NOAA, 1997). The HYSPLIT4 Model (with 36 hour runs) indicated estimated maximum concentrations ranging from 0.1 mg/m^3 to 10 mg/m^3 at Christmas Island.

4.3.2.5 Stratosphere

Some analyses of the effects of rocket launches on stratospheric ozone have been carried out (AIAA, 1991; Bennett, 1996; McDonald and Bennett, 1995; and Tishin and Alexandrov, 1995). The Zenit rocket emissions released in the stratosphere would consist of Stage 1 fuel combustion by-products. In general, rocket exhaust components that may play a role in ozone destruction are chlorine compounds, nitrogen compounds, and hydrogen compounds. As shown in Tables 4.2.2-2 through 4.2.2-4, there would be no chlorine or chlorine compounds released during Stage 1 burn.

Due to nitrogen compounds in the exhaust trail of liquid propellant rockets like the Zenit-3SL, models predict a substantial, temporary reduction of ozone. However, recovery to near background levels occurs within a few hours. For example, satellite observations by the Nimbus 7 Total Ozone Mapping Spectrometer have shown no detectable reduction of ozone over the area around Kennedy Space Center several hours to one day after a Space Shuttle launch. Models and measurements of other space systems comparable to Sea Launch indicate these impacts are temporary, and the atmosphere is capable of replacing by migration or regeneration the destroyed ozone within a few hours (AIAA, 1991; and Harwood, et. al., 1991). Some of the regeneration is due to the recombination of O and O_2 in the exhaust trail. The bulk of the atmospheric effects are due to mixing of the rocket exhaust constituents with the ambient air (McDonald and Bennett, 1995). The actual volume where ozone depletion (to a level less than or equal to 90% of background) occurs for a typical Russian rocket, similar to the Zenit-3SL rocket, is a cylinder with an estimated radius of approximately 360 m along the rocket trajectory in the stratosphere (Tishin and Alexandrov, 1995).

The effects of rocket launches on global ozone is less well understood and studied. With the exception of one study, all studies completed prior to 1991 only examined the effects of chlorine. The one study that examined other compounds (HO_x and NO_x in addition to chlorine) for a series of Space Shuttle and Titan IV launches indicated that the HO_x and NO_x increases attributable to the launches would be substantially less than the increase in chlorine compounds (AIAA, 1991). There is a possibility that solid particles in the exhaust might provide surface area for heterogeneous chemical reactions to occur that might lead to the destruction of stratospheric ozone, however, this area has not been adequately studied.

Table 4.2.2-5 (derived from McDonald and Bennett, 1995) shows the relative impact on ozone destruction due to the principal classes of ozone destroyers. Specifically, the portion of the impact attributable to rocket launches is less than 0.034%. From these data, it can be seen that in relative terms, chlorine releases constitute the greatest impact of rocket emissions world wide. Since the Zenit-3SL vehicle would not be releasing chlorine or chlorine compounds, it is concluded that the Sea Launch program would have no significant impact on the global ozone layer. This is consistent with conclusions reached by Russian scientists (Tishin and Alexandrov, 1995).

Table 4.3.2-5. Ozone Destruction by Chemical Compounds

Chemical Compound	Ozone Destruction Contribution	Portion Attributable to All Rockets
Nitrogen Oxides	32%	0.0005%
Hydrogen/Hydroxyl	26%	0.0012%
Oxygen	23%	<0.00005%
Chlorine	19%	0.032%

(McDonald and Bennett, 1995)

4.3.2.6 Afterburning and Re-entry of Launch Vehicle

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).

4.3.3 Post-Launch Operations

Following launch, crews would reoccupy and refurbish the LP in preparation for the transit back to the Home Port. The fuel burned during the buildup of thrust and lift-off would scorch coatings and insulation materials onboard the LP, evaporate most if not all of the flame deluge water, and leave carbon residues on the LP. Debris that remains on the LP from the launch process (e.g., shrapnel from the clamps that hold the ILV in place until launch and damaged insulation used to protect equipment from the intense heat) would be collected and held for proper disposal at the Home Port. 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 and residues would be generated from a launch; this, as noted, would be collected and handled onboard as solid waste for later disposal at the Home Port.

4.3.4 Failed Mission Scenarios

Two worst-case scenarios are considered. The first catastrophic loss scenario would be an explosion on the LP (discussed in Section 4.3.4.1). The second significant loss scenario in terms of environmental impact, for an optimal flight ascent groundtrack fixed on the equator, would be a failure of the rocket's upper stage over the Galapagos Islands resulting in debris striking the islands. Although this risk of impact is very small, an alternative flight path that would deviate to the north of the main group of islands was selected, thereby virtually eliminating any possible risk to the Galapagos Island group. Deviation around the Galapagos would be possible due to the high degree of Zenit-3SL in-flight maneuverability. This northern route and the corresponding risk and impact potential is described in Section 4.3.4.2. After the first few launches, this northern route would be re-evaluated by using actual flight and failure probability data to weigh the risks from Galapagos overflights against fuel burn inefficiencies and other costs of a deviated flight path.

Uncontrolled loss of the upper stage over South America is also possible but remote. Specifically, the dwell time over South America would range from 20 to 40 seconds based on the mission. Using the most conservative risk calculation, which considers mission failure to be equally likely at all times during the flight, the likelihood of a failure occurring over South America is approximately 3 in 1000. This risk calculation is conservative since it applies averaged Zenit and Block-DM historical loss data to all trajectory dwell seconds, and it does not fully reflect improvements made to the systems to eliminate the causes of those losses or the very high historical reliability of the Block-DM during that phase of the mission. Because the South American instantaneous impact point passage would occur when the Block-DM is nearly orbital, a failure during this time would result in only a few dozen pieces reaching the earth’s surface due to aerothermal ablation from atmospheric reentry. In addition, since individual pieces of debris from a failure (described in Section 4.3.4.2) are small and would impact a very small area, i.e., a few square meters, relative to the vast ecological regimes found along the equator in South America, this scenario was not analyzed further.

4.3.4.1 Explosion on the Launch Platform

In a normal launch, the possibility of catastrophic inputs to the environment diminish as ILV fuels and stages are consumed over a large area of the atmosphere and ocean surface. As such, the corresponding disruptions to the environment diminish predictably in terms of scale and duration, especially since the launch environment is very uniform. It follows that the worst case scenario is an ILV failure and explosion on the LP where the ILV contains the maximum amount of fuel and materials.

Catastrophic failure on the LP 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 well, as far as three km away. The smoke plume would rise and drift in a downwind direction. Depending on the wind speed, particulate materials would be distributed up to a few kilometers distance before dissipating. Supplies and other materials on the LP, other than those directly connected to the ILV itself, would be sheltered from a catastrophic failure on the LP. The ACS, located five km uprange from the LP during launch, would be positioned to be well outside of the area potentially exposed to scattered debris and concentrated smoke.

In this scenario, in the course of about one minute the entire matter and energy of the ILV would be put into the environment in a fairly concentrated area of the Pacific Ocean. Disruptions to the ecosystem would occur from:

a) Intense heat generated at the ocean surface.

b) Debris and noise released during the explosion.

c) Emissions released to the atmosphere.

d) Subsequent cleanup needed on the LP.

Despite this concentrated input of ILV heat and debris, the disruption, relative to the scale and characteristics of the ocean environment, would still be short term and localized. As with the more incremental disruptions to the environment caused by the unburned fuel and debris dropped during normal launches, the vertical and horizontal patchiness of plankton populations would rapidly recolonize the affected area, precluding any lasting or discernible impact to the environment.

Specifically, the ocean surface would deflect and absorb, through evaporation, the thermal energy that does come in contact with the water. It is estimated 100% of the fuels would be consumed or released to the atmosphere through combustion and evaporation. Unburned fuel and combustion by-products would settle on the water, evaporate or become entrained in the water column, and be degraded by microbial activity and photochemical oxidation (Doerffer, 1992; National Research Council, 1985; and Rubin, 1989). Such an incident would likely result in the deaths of plankton and, conceivably, some fish in the immediate area of the explosion over the course of several days or a week or so. The physical, chemical and biological effects of this type of spill would be similar to recorded spills of volatile hydrocarbons such as kerosene throughout the world, and on which the referenced sources are based. In the Sea Launch scenario - and relative to other industrial operations throughout the world - the open and tropical Pacific Ocean ecosystem would not experience a significant impact. This is due to the combined influences of the relatively high air and water temperatures in the tropics (which serve to hasten the evaporation, dispersion and breakdown of spilled kerosene), the relatively low levels of biological productivity in the open Pacific Ocean (which limit the immediate toxic effects of the kerosene), and the relatively expansive area involved (which allows rapid plankton recolonization of the affected area).

The thermal energy and chemical compounds released to the atmosphere during a concentrated explosion of ILV fuels and materials would be dwarfed by the natural climatological and air-ocean surface processes occurring in the area. Disruptions to the atmosphere and the ocean would be assimilated and the environment would return to background conditions within several days. Noise from an explosion on the LP would be deafening, however, impacts to higher trophic level organisms are considered unlikely because of their low probability of being present (Section 3.3).

The LP is designed to survive an explosion of the fully-fueled launch vehicle. LP cleanup following an explosion would include stabilizing the vessel’s systems and stores, and collecting debris for disposal at the Home Port. The LP would be moved under its own power or towed by the ACS to the Home Port or, depending on the damage, a major port facility for repair.

4.3.4.2 Uncontrolled Upper Stage Loss

The other worst case scenario to consider involves the possible failure of the upper stage. While the probability of an uncontrolled loss of the upper stage of the rocket and the payload is very low, one scenario (loss in the vicinity of the Galapagos Islands) warrants discussion.

In the event of loss and re-entry of the upper stage and payload, most of the material and all of the fuels involved would be heated from friction in the atmosphere and vaporize. SLLP estimates a few dozen objects (ranging from 0.15 m to one meter in size and from 8 kg to 22 kg in mass) would survive re-entry friction and reach the earth's surface. If these objects fall over deep ocean waters, they would momentarily disrupt the environment as the warm objects are cooled and sink, with an extremely remote chance of striking an animal of the higher trophic level species. The effect would be essentially the same as for Stage 1 debris, less the effect of residual fuels (see Section 4.3.2.1). Loss and re-entry of the upper stage and satellite debris would not occur over the main group of Galapagos Islands, since these islands are found south of the southern-most impact limit line as shown in Figure 4.3.4-1. However, two of the Galapagos Islands, Wolf and Darwin, do lie within the impact limit lines of the northern route, and must be evaluated in terms of impact risk and scale.

The risk of debris striking either island is approximately 4.3 in one million which is the same proportion of the Darwin and Wolf Islands' land area of 12 square kilometers to the area of the surrounding water for flight increment. Harm to either island would occur if the debris directly strikes an individual or if a habitat is damaged from debris landing on fragile materials. Surviving debris is expected, after an initial period of ablation, to be cooled to safe temperatures by convection as it falls to earth. Recovery from damage caused by debris impacts could take several years to reestablish the damaged habitat in such an arid terrain. The probability of harm is reduced from that associated from simple land impact, however, due to the relative distribution of ecosystems on the islands. Galapagos habitats are dependent on factors such as island size, topography, prevailing winds, precipitation, and the presence of soil or the soil depth to bedrock (Thornton, 1971; and Bowman, 1966). The small size of Wolf and Darwin Islands, each being only a few kilometers across, their relative isolation from the other islands, and their arid climate has greatly limited the development, size, and distribution of potentially harmed habitats and resident populations.

The risk of debris falling on these two islands, therefore, is remote, and the risk of harm to resident populations or habitat even less. The greatest harm would be caused by debris falling onto a vulnerable area, but this is unlikely given the sparse distribution of woody or grassy habitat on these small and arid lands. These factors, given the decision to deviate to a more northern flight path, collectively eliminate the loss of the third stage over the Galapagos Islands as an area of concern.

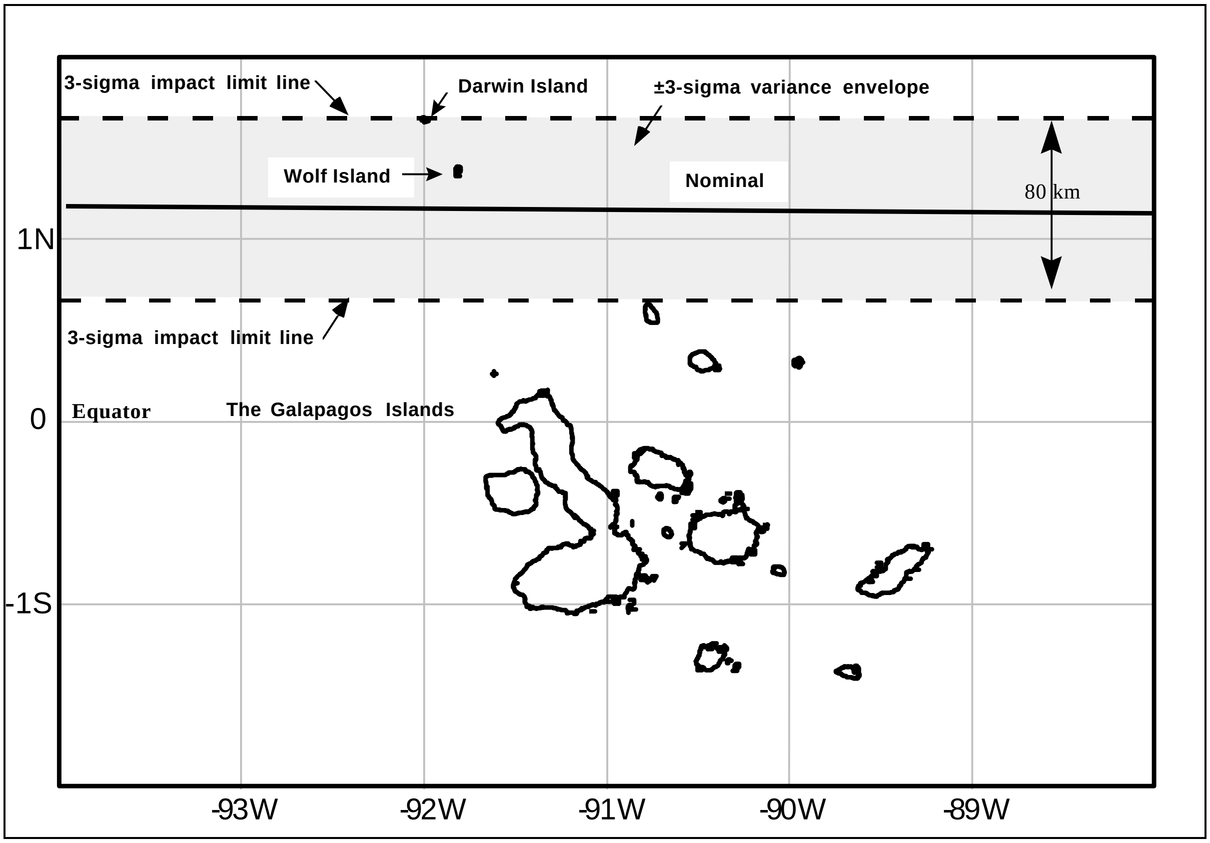


Figure 4.3.4-1. Galapagos Area Overflight

4.3.4.3 Prevention and Mitigation

Explosion on the launch pad, uncontrolled upper stage loss, and other similar but less catastrophic scenarios have been analyzed. These conditions would be addressed through the proper design and manufacture of the LP, ACS, and ILV, and through the repeated testing of launch equipment and procedures. Launch and management system rehearsals at the Home Port before the first launch, and as part of ongoing operations, would be used to continually examine and improve the designs and procedures. In this way, the risk of unintended outcomes would be continually managed and reduced to ensure the success of the Sea Launch program for all stakeholders. Contingency measures, referenced in Appendices A and B, include emergency response plans, training protocols, onboard monitoring and detection systems, and redundancy in key mechanical, electrical, and communication systems. All are part of an integral program to jointly manage safety and environmental protection objectives.

4.4 SOCIAL AND ECONOMIC CONSIDERATIONS

SLLP proposes to conduct two launches in last half of 1998 and six launches per year thereafter. SLLP assets would occupy the launch location for two to seven days (allowing for an aborted launch) during each launch cycle. For each launch, the LP and ACS would sail directly to the launch location and return directly to the Home Port. The relatively brief duration of the LP and ACS at the launch location, and the relative degree of isolation of the launch location activity, would provide an effective barrier between Sea Launch and the cultural and economic character of the Kiribati society. The baseline plan for operations does not include any use of facilities based on Christmas Island. Impacts to the island associated with employees transiting Christmas Island on an emergency basis would be positive, given that expenditures would be an addition to the local economy. As discussed in Sections 3.5 and 4.3.4, social and economic aspects related to Ecuador, Colombia and Brazil, the South American countries transited by the Block-DM, do not warrant consideration here.

4.5 OTHER ENVIRONMENTAL CONSIDERATIONS

As noted in Section 4.1, the Sea Launch program includes considerations that are outside of the immediate environmental assessment required for launch licensing. These are introduced here but in a brief manner to avoid duplicating the more focused considerations fulfilled through other Federal, state, local or international requirements. Additional information is referenced in Section 4.1 and in Appendices A and B.

4.5.1 Design, Operation, and Maintenance of the LP and ACS

The LP and ACS would be designed for and would remain fully allocated to the Sea Launch program. As seagoing vessels, they would be designed, built, and operated and maintained in accordance with the applicable rules and regulations of Det Norske Veritas (DNV) (an international standard setting body), the United Nations, the United States, and other international regulations. This includes conventions for safety and environmental protection, material stowage and transfer, waste handling and disposal, and emergency preparedness and response. Because the LP and the ACS would be moored at and will sail to and from the Home Port, located in the Port of Long Beach, California, the U.S. Coast Guard would be fully involved in the certification and licensing of the vessels, as noted in Appendix B. The transport functions served by the LP and ACS, therefore, are equivalent to past and current ocean shipping commerce in terms of the regulations that apply, the level of preparedness in place given the risk of accidents with other traffic, and the type of environmental impacts that occur from normal sailings or that could occur during an accident.

The LP would be refurbished and outfitted in Norway with diesel-electric motors. The LP and its inventory, equipment and machinery would be built and maintained in accordance with the rules and regulations of Det Norske Veritas, with the following notations: DNV + 1A1 Column Stabilized Unit BO HELDK DYN POS. In addition, the following regulations would apply:

a) International Convention of Load Lines, 1966
b) IMO MODU Code (which incorporates SOLAS)
c) Liberian National Regulations the Flag under which the Vessel will operate
d) International Convention for the Prevention of Pollution from Ships, 1973
e) International Convention for Tonnage Measurement of Ships, 1969
f) ILO Code practice, Safety and Health in dock work, 1958
g) U.S. Coast Guard Regulations, relevant for foreign vessels trading in US ports
h) Safety and Health regulations for longshoring, US Department of Labor (OSHA)
i) IMO Resolution A468(XII), “Code on Noise Levels onboard Ships”
j) Certificate of Financial Responsibility (COFR), US OPA 90 law

The ACS, which would be built in Scotland, would also be outfitted with diesel-electric motors, a common source of vessel power. It would be built and licensed and maintained in accordance with the following DNV notations: DNV + 1A1 General Cargo Carrier RO/RO E0-ICEIC HELDK DYN POS AUTS. In addition, the following regulations would apply:

a) International Convention of Load Units, 1966

b) IMO Resolution A.534(13), Code of Safety for Special Purpose Ships/International Convention for the Safety of Life at Sea (SOLAS), 1974

c) IMO Resolution A.649(16), Code for Construction and Equipment of Mobile Offshore Drilling Units regarding helicopter facilities

d) Liberian National Regulations, the Flag under which the Vessel will operate

e) Suez and Panama Canal Navigation Rules, including tonnage measurement and certification

f) International Convention for the Prevention of Pollution from Ships, 1973

g) International Convention on Tonnage Measurement of Ships, 1969

h) ILO Code practice, Safety and Health in dock work, 1958

i) U.S. Coast Guard Regulations, relevant for foreign vessels trading in US ports

j) Safety and Health regulations for longshoring, U.S. Department of Labor (OSHA)

k) Vibration level testing to ISO guidelines 6954

l) IMO Resolution A468(XII), “Code on Noise Levels onboard Ships”

m) Certificate of Financial Responsibility (COFR), US OPA 90 law

Basic LP and ACS operational and maintenance controls would be superior to most seagoing vessels, given the particularly rigorous specification associated with the launch operations. This includes provisions for the physical stress and corrosive conditions found in the marine environment. To protect sensitive equipment, for example, both vessels would be outfitted with systems to condition air to minimize the infiltration of salt compounds into the launch vehicle processing areas and rooms. This precaution extends to the inclusion of scrubber filters in emergency air intakes to limit salt infiltration during shipboard emergency conditions. Monitoring of flight hardware and support equipment would be done on a daily basis along with routine vessel upkeep by the ship operators to ensure vessel integrity.

Component transport ships have not yet been selected, as the current plan calls for chartering existing ships from the market. The ships would be classed with a recognized Classification Society, and would comply with all relevant national and international rules and regulations for the intended transportation.

The Marine Manager of the ACS and LP would comply with International Safety Management Administration (ISMA) requirements and hold an ISMA certification. All officers and other marine crew members would comply with the 1997 Standard for Training, Certification, and Watchkeeping (STCW) Code.

Crew quarters and training would be comparable to or better than those typically provided on other maritime vessels. Waste generated onboard would be incinerated or stored and disposed of at the Home Port as dictated by regulations. The captains of the LP and ACS would be responsible for environmental protection and emergency response measures as with any maritime operation. The estimated life of the LP is approximately 20 years, while the estimated life of the ACS is considerably longer.

At around 20 years, therefore, options for decommissioning the combined assets of the Sea Launch system would be appraised for either upgrading, reallocation to other projects, or sold as scrap as appropriate. The decommissioning activities would be done in accordance with all applicable laws and regulations. If the system was sold for scrap, all components would be removed from the environment. If an upgrade were the desired approach, the potential environmental effects of such an upgrade would be reviewed through the NEPA process.

Emergency repairs, major repairs, and overhauls would be performed at the Home Port or an equivalent facility where repair and other services, including safety and environmental safeguards, are available.

Transit of the LP and ACS from the home port to the launch site is expected to be like other normal ship transit from a coastal port through the ocean. Typical diesel combustion emissions would be emitted from the LP and ACS throughout the journey. These emissions would not be unusual for this type of vessel or the port in general. Some emissions components (e.g., particulates) are regulated by the Federal government control on air quality through the National Ambient Air Quality Standards. Regional air quality is controlled by the South Coast Air Quality management District through the Air Quality Management Plan. The diesel emissions and other port emissions were considered in a conformity analysis in the Navy Mole Environmental Assessment and determined to be within regional plans and Federal conformity requirements (Department of the Navy, 1996). The majority of the time spent en route would not be near coastal or habitable areas but through the open ocean. In such a route to the equator, normal ship operations would not affect any sensitive areas or the ocean environment. However, during transit, the LP and ACS would be carrying fuels and other hazardous materials. Release of such materials to the port or ocean environment could cause impacts. However, the LP and ACS would follow maritime protocol to prevent collisions and protect the cargo integrity in the same way as any other seagoing vessel carrying hazardous materials. Out in the ocean, the LP design for high seas and storms would enable it to withstand conditions that could otherwise jeopardize the vessel and cause the release of hazardous materials. Also, the overall concern about ecological damage and impact from transit is minimal because the route would be in the open ocean which is less biologically rich than upwelling and other coastal areas (see Section 3.3). Any release of kerosene fuel would break down, disperse in the large water reservoir, or evaporate within hours in the warm ocean climate.

4.5.2 Administrative Tasks

Engineering and supervisory tasks involved in the preparation and operation of the ILV and other assets during a launch cycle, including staff supervision, launch command, data processing, and similar administrative functions, would be office functions and pose no particular risk to the environment.

4.5.3 Home Port Activities

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 which is being surplused by the U.S. Navy. As part of the California Environmental Quality Act Process, the U.S. Navy submitted the Navy Mole EA to the California Coastal Commission Review. The response indicated that the proposed action was consistent with the Coastal Zone Management Program (Ernst 1997).

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. This also applies to the receipt of wastes from the LP and ACS following each launch mission. To ensure proper management of wastes at the Home Port, including those contributed from vessel operations, a large quantity generator permit will be in place. This permit may be downgraded if it is determined that the amounts generated on the vessels and at the Home Port are less than 1,000 kilograms per month. There would be no on-site disposal or treatment of any wastes at the Home Port (SSLP, 1995a).

Sea Launch would utilize numerous vendors for delivery of hazardous materials for use at the Home Port and on the LP and ACS. Transportation of these materials would be in accordance with all applicable Federal, state, and local regulations. All hazardous materials, except kerosene and low level explosive devices would be scheduled for “just in time delivery,” eliminating the need for storage of these materials at the Home Port.

The City of Long Beach also has a variety of permitting and approval functions. These include, but are not limited to, building permits (approved by the Planning and Fire Departments), zoning variances, Risk Management Prevention Plan (City of Long Beach Fire Department), Industrial Wastewater Discharge Permit (City of Long Beach Department of Public Works), Business Emergency Plan (City of Long Beach Fire Department), Hazardous Waste Generator’s permit (City of Long Beach Health Department), and Storage, Handling, and Transfer Permit for Hazardous Materials (City of Long Beach Fire Department).

The maximum population expected at the Home Port is approximately 300 (including ship crews, transient visitors, and part-time employees). The City of Long Beach has over 500,000 people, and the greater metropolitan region of Los Angeles County and Orange County has a population of over 10,000,000 people. The City of Long Beach and the Port of Long Beach have given approval for Home Port development and operation. Details of the economic and social conditions at the Home Port, current and projected, are contained in the Harbor Development Permit.

The proposed action would result in additional transport of hazardous materials to the Long Beach port. However, the Long Beach port is a developed industrial area that has accommodated many types of materials including toxic and flammable substances. Under the reuse of the port, the port would have adequate traffic capacity to address hazardous materials shipments (Department of the Navy, 1996). DOT transport requirements for hazardous materials would assure the integrity of the containment. Unloading and loading operations would be assured by detailed procedures and adequate training in them. Hazards at the storage facilities are discussed in B1.1.2. Throughout the handling of these hazardous materials, Sea Launch would have in place protective equipment and systems that are common practice in the industry (e.g., static electricity protection, power backup systems, and personal protective measures).

4.5.4 Energy Outputs

Electromagnetic radiation outputs from the launch vehicle and related launch system hardware are regulated and managed to control possible risks to people and the environment (SLLP, 1996b). In general, and according to regulations and industry standards, shielding is incorporated into the design of equipment, and areas affected by radiation sources are evacuated during hazardous operations.

Thermal energy contributed by Sea Launch operations might have some effect on the micro-climate in the immediate vicinity of the rocket trajectory. Generally, the weather in the launch location and range, as elsewhere, is the result of solar energy inputs to the stratosphere, troposphere and boundary layer, and exchanges with the ocean surface. To consider the relative effect of the Zenit-3SL, the following analysis is used.

Human activities are an obvious source of energy input into the earth's ecosystem, but the magnitude of these sources is less than that of natural energy sources. Specifically, outside of the earth's atmosphere, the solar energy flux is estimated to be 1,350 Joules per second per square meter. Due to scattering and absorption, about 1,000 Joules per second per square meter reaches the earth's surface. Solar radiation is absorbed at the earth's surface and in the atmosphere at a rate of approximately 1.03×10^{17} Joules per second (UN, 1992). Of this amount, it is estimated that roughly 2%, or approximately 2.06×10^{15} Joules per second, drive the climatological processes and the earth's weather (Herman and Goldberg, 1978). (The above figures are based on averages across the earth's surface, and the energy flux due to solar radiation will be much higher in the tropics.) Global energy consumption by man in 1992 was estimated to be 9×10^{12} Joules per second (UN, 1992). In contrast, each Zenit launch would emit 4.95×10^{12} Joules at an average rate of 1.0×10^{6} Joules per second. Given the relative magnitude of these sources of thermal inputs, it appears unlikely that the thermal energy released from the Zenit-3SL could discernibly influence the weather in the region.

4.5.5 Coordination with Vessel and Air Traffic

For each launch, SLLP would give notifications to FAA (Central Altitude Reservation Function), the U.S. Coast Guard (14th District), and the U.S. Space Command (Onizuka Air Station in Los Angeles), who would issue necessary information to coordinate air, marine, and space traffic (SLLP, 1996a).

4.6 CUMULATIVE IMPACTS

This section summarizes the cumulative environmental effects that would occur as a result of the proposed Sea Launch in combination with other known and foreseeable activities.

Foregoing analyses in the EA indicate that Sea Launch activities at the proposed launch site and at the home port, as well as the other connected action of including transportation to and from the home port, would cause only minor and temporary impacts to the environment. Additional information on the environmental aspects of individual missions, and any substantial changes to the plan as presented here, including revisions to operations and the flight plan, would be evaluated and documented for AST review and approval as supplements to this report.

There are no other foreseeable developments in the area of the proposed launch site, and therefore, no cumulative impacts are expected. However, the Navy Mole 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. This development could reach the level historically experienced at the Navy Mole, which would increase economic activity in the immediate vicinity. The cumulative socioeconomic effects in the area of the home port might reach a level equivalent to that of previous Navy Mole actions, but no cumulative environmental effects are expected.

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5.2 CONSULTATIONS

Table 5.2-1 Agency Consultations (exclusive to Home Port)

Organization	Purpose Of Contact
FAA Central Altitude Reservation Function Washington, D.C.	Establish procedures for aircraft coordination and launch notification
US Coast Guard, 14th District Honolulu, Hawaii	Establish procedures for maritime coordination and launch notification
US Space Command/Onizuka Air Station Los Angeles, California	Establish procedures for space community coordination and launch notification
Defense Mapping Agency (now referred to as the National Imagery and Mapping Agency) Washington, D.C.	Establish procedures for military maritime coordination and launch notification
US State Department Washington, D.C.	Assess foreign government contact plan

World Bank Washington, D.C.	Political evaluation
International Maritime Organization London, England	Maritime operations
Federal Communication Commission Washington, D.C.	Frequency compatibility
Bureau of Alcohol, Tobacco & Firearms Washington, D.C.	Immigration, import/export regulations

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