FINAL

ENVIRONMENTAL ASSESSMENT FOR THE SEA LAUNCH PROJECT

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

by

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

<u>Responsible FAA Official</u> <u>Date</u>

EXECUTIVE SUMMARY FOR THE SEA LAUNCH FINAL ENVIRONMENTAL ASSESSMENT

INTRODUCTION

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

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

PURPOSE AND NEED

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

The Commercial Space Launch Act (CSLA) of 1984 (Public Law 98-575), as amended, 49 U.S.C. Subtitle IX, ch 701 – Commercial Space Launch Activities, authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launch operations and issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary is implementing this authority through FAA AST. FAA exercises licensing authority in accordance with the Act and Commercial Space Transportation Licensing Regulations, 14 CFR Ch.III, which authorize the FAA to license the launch of a launch vehicle when conducted within the U.S. and those operated by U.S. citizens abroad. SLLP has applied for a launch-specific license, and later plans to apply for a launch operator license.

DESCRIPTION OF PROPOSED ACTION

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

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

CONSIDERATION OF ALTERNATIVES

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

NO ACTION ALTERNATIVE

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

ENVIRONMENTAL IMPACTS

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

Pre-Launch Operations

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

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

Launch and Flight

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

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

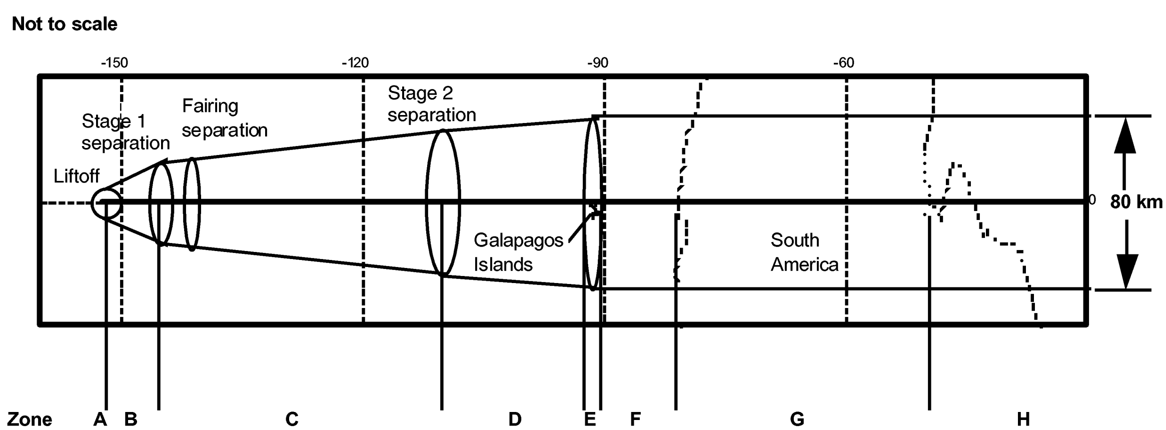

Figure ES-1. Stage 1 and 2 Impact Zones

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

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

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

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

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

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

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

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

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

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

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

Post-Launch Operations

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

Failed Mission Scenarios

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

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

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

Other Environmental Considerations

Home Port

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

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

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

Notices to Mariners

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

Environmental Monitoring Plan

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

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

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

Environmental Justice

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

No Action

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

CUMULATIVE IMPACTS

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

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

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

1. PURPOSE AND NEED FOR PROPOSED ACTION

1.1 INTRODUCTION

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

1.2 PURPOSE AND NEED FOR ACTION

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

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

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

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

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

1.3 BACKGROUND

1.3.1 Boeing Sea Launch Limited Partnership

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

1.3.2 Environmental Assessment Scope

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

1.3.3 Public Involvement

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

1.3.4 Other Environmental Analyses

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

2. ALTERNATIVES AND PROPOSED SEA LAUNCH ACTION

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

2.1 PROPOSED ACTION

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

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

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

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

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

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

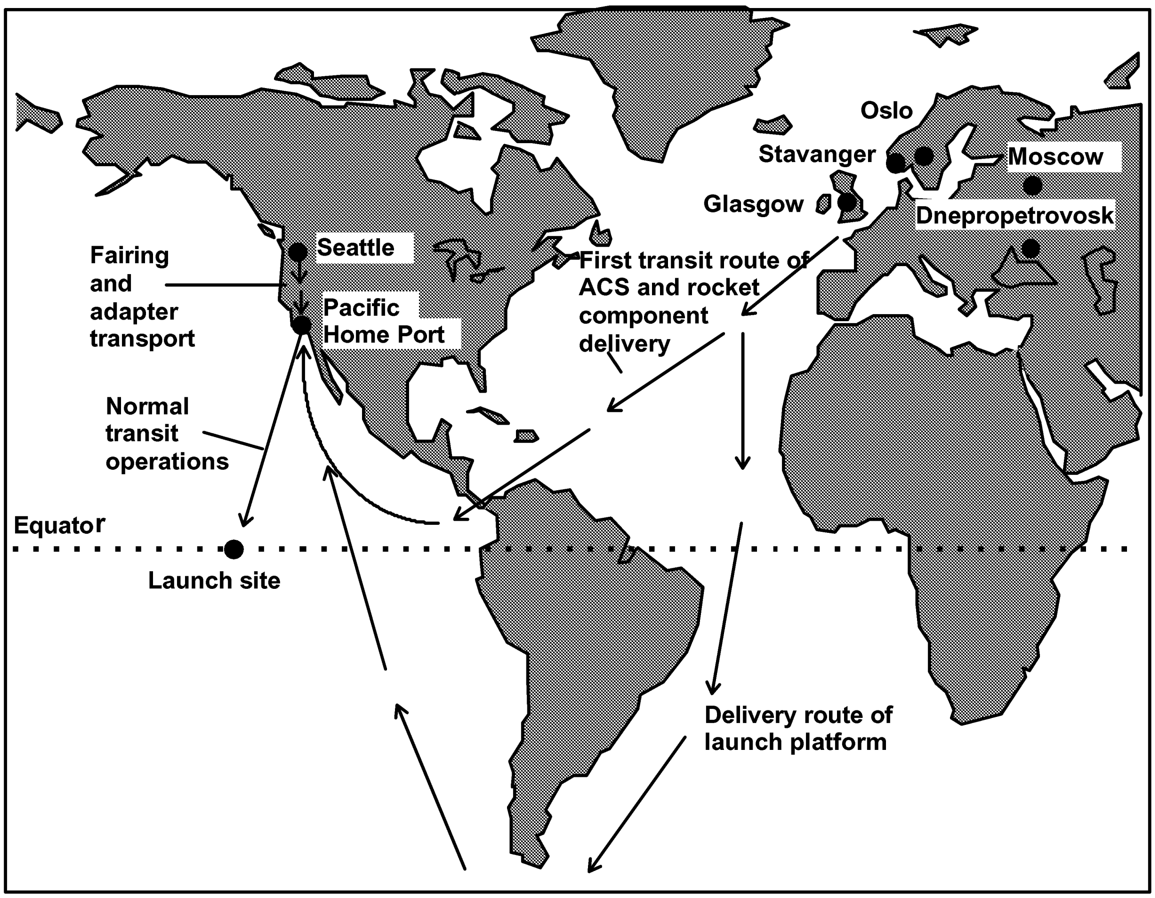

Figure 2.1-1. Sea Launch ACS, LP, and Launch Transit Routes

2.2 ALTERNATIVE ACTIONS

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

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

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

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

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

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

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

2.2.1 Alternative Launch Vehicles

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

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

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

2.2.2 Alternative Launch Locations

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

2.2.2.1 Public Safety

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

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

2.2.2.2 Environmental Protection

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

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

2.2.2.3 Secondary Criteria for Launch Location Selection

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

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

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

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

2.3 NO ACTION ALTERNATIVE

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

3. AFFECTED ENVIRONMENT

3.1 OVERVIEW

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

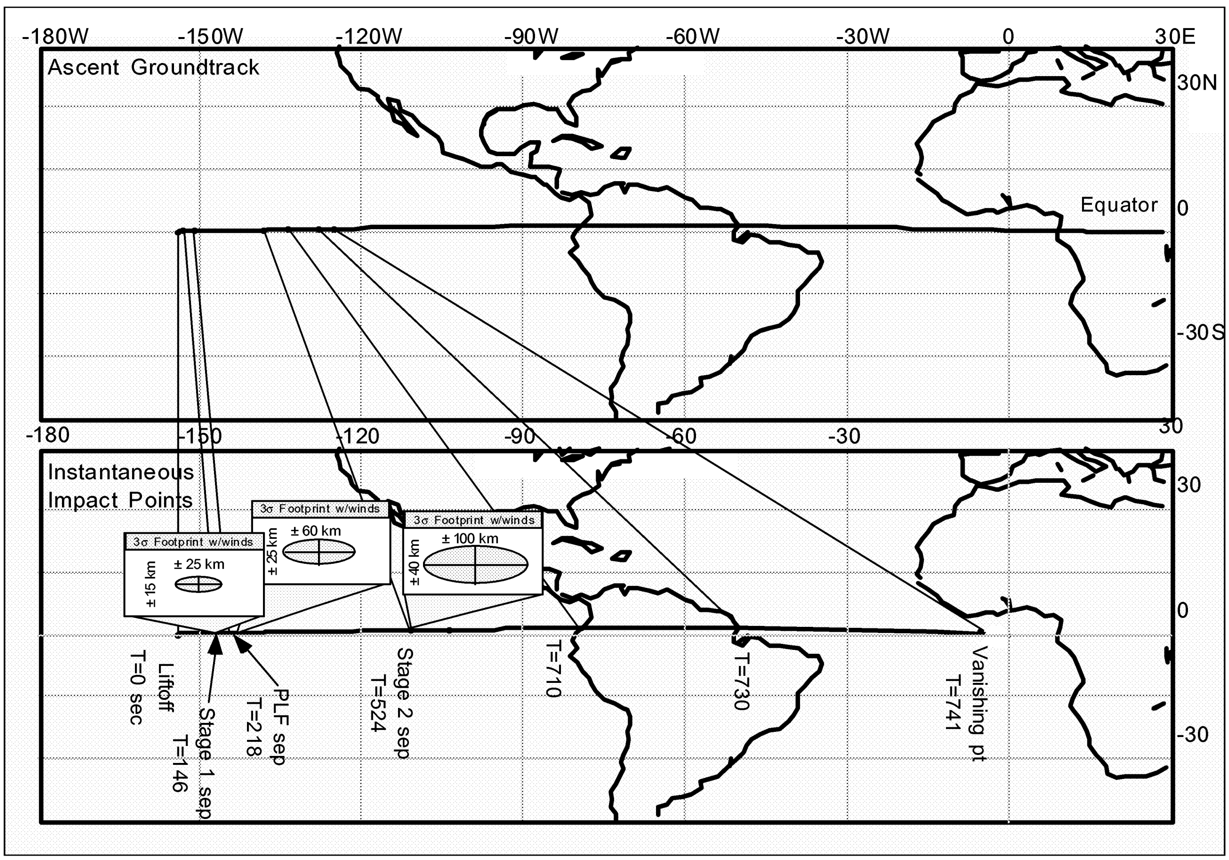

Figure 3.1-1. GTO Mission Ascent Groundtrack, IIP Trace, and Debris Footprint from Launch Location at 0°, 154° W

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

3.2 TECTONIC HISTORY

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

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

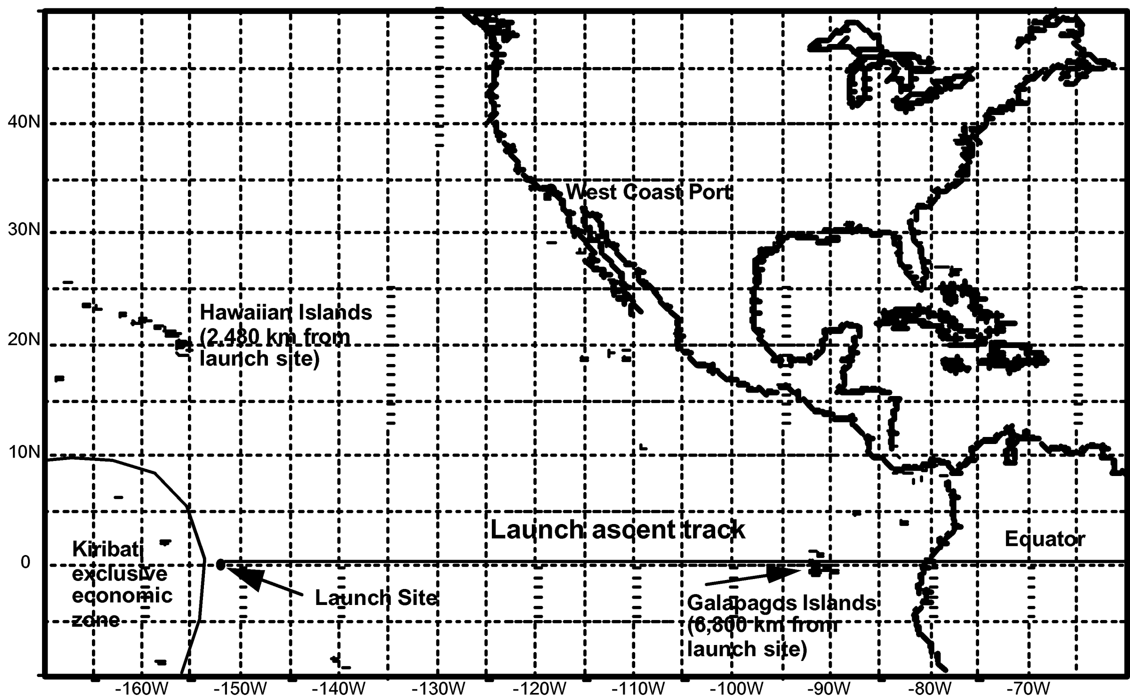

Figure 3.2-1. Launch Location

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

3.3 PHYSICAL, CHEMICAL, AND BIOLOGICAL REGIMES AND FOOD CHAIN

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

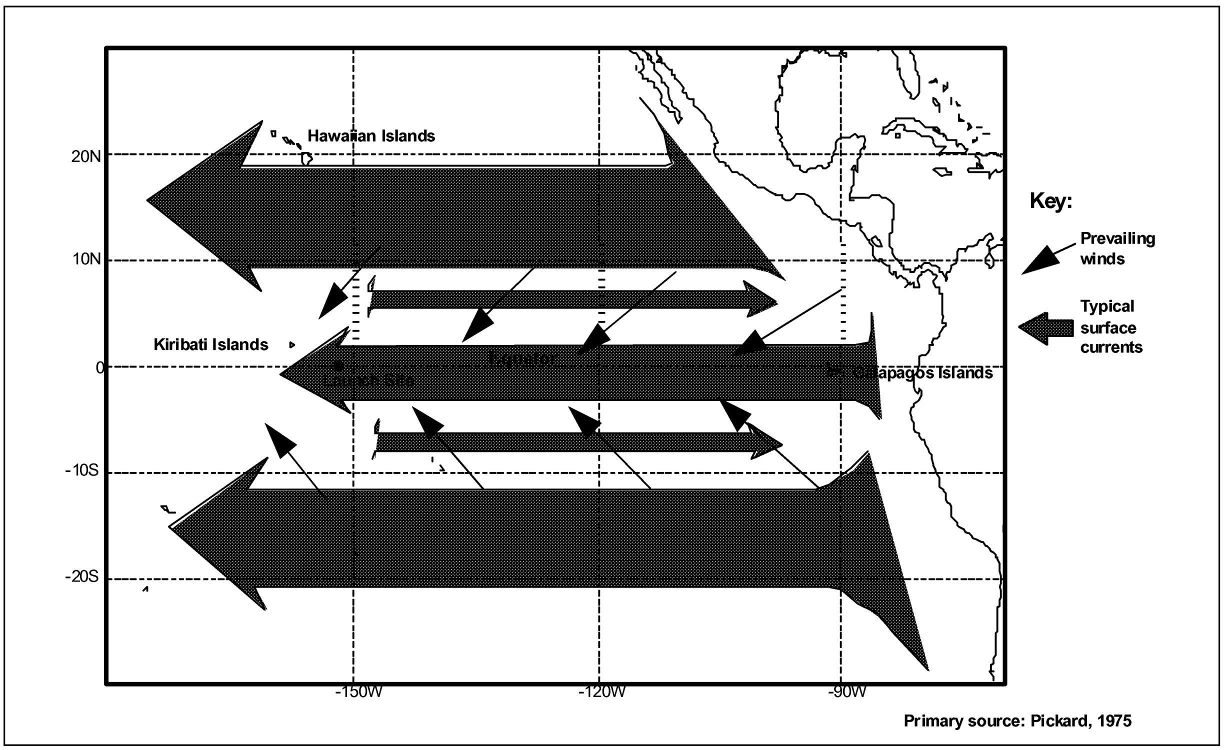

Figure 3.3-1. Launch Area Winds and Surface Currents

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

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

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

Whales

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

Sea Birds

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

Sea Turtles

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

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

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

[1] U.S. Listed Vertebrate Animal Species http://www.fws.gov/r9endspp/vertata.html
[2] Personal communications with Bill Gibbons-Fly. National Oceanic and Atmospheric Administration (NOAA) Pacific Fishing Specialist.

- In grams of carbon produced per square meter per year, the open ocean (50 gm) is one sixth as productive as upwelling areas (300 gm).

- In grams of carbon produced per square meter per year, the open ocean is one half as productive as coastal margins with long-shore currents (100 gm).

- In terms of carbon generated in fish stocks per year, the entire open ocean (which comprises 90% of the ocean's surface area) is calculated to be 60 times less productive than either the upwelling areas (0.1% of the surface area) or the other coastal margins (9.9% of the surface area) (Steele, 1974).

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

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

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

3.4 ATMOSPHERIC PROCESSES AND CHEMICAL MASS BALANCE

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

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

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

3.4.1 Atmospheric Boundary Layer

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

3.4.2 Free Troposphere

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

3.4.3 Stratosphere

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

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

3.4.4 Mesosphere and Above

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

3.5 EXISTING SOCIAL AND ECONOMIC CONDITIONS

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

3.5.1 Kiribati Islands

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

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

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

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

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

3.5.2 Galapagos Islands

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

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

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

3.5.3 Home Port

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

3.6 LEGAL FRAMEWORK

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

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

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

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

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 4.3.4). Calculated launch failure probability figures are not affected by the substitution of an inert, demonstration payload. Should the first demonstration launch result in a failure, the effect on the environment associated with the demonstration payload would be somewhat smaller than that which could possibly occur from the loss of a normal, communications satellite payload. Specifically, the welded steel structure of the demonstration payload would largely survive a rocket failure at any altitude, and fall to earth and sink as described with other solid debris from the failed rocket. As there are no hazardous materials incorporated in the demonstration payload, however, the payload itself would not contribute to the explosive impact of a failed rocket or contribute to the release of toxic materials to the ocean environment and atmosphere.

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:

- 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.

- 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).

- 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).

- 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

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.

- Department of Transportation Programmatic Environmental Assessment for Commercial Launch Vehicles (1986). This document addresses the potential environmental consequences of launching commercial launch vehicles. This document could be used in conjunction with other documentation, to assess the environmental impacts of the operation of commercial launch vehicles, and to support licensing of such operations.

protocols (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).

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 the FAA making a negative determination regarding the issuance of a commercial launch license or from the applicant's withdrawal of 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 location would remain in its unaltered and natural state.

If FAA made a negative determination regarding the issuance of a commercial launch license to SLLP, SLLP's recourse would be to apply to an alternative licensing authority.

The benefit of commercial satellite launches is improved quality of life for people throughout the world as data transmissions and verbal and visual communications are enhanced by a greater number of satellites. By planning to use launch vehicles designed in the 1980s by the former Soviet Union and launch from a mobile, floating platform, the Sea Launch plan would allow more satellites to be launched more economically and with lower social and environmental effects than those launched by its competitors. This is because the rocket would be assembled and transported horizontally, erected prior to launch, and remotely fueled and controlled. This design would be unique for the payload lift capacity of this vehicle. In addition, the rocket's liquid, commonplace propellants would generally be less hazardous and cause fewer and smaller environmental impacts than the solid and hypergolic propellants employed by most competing launch services. Given the competition in the marketplace for launching satellites, it is reasonable to assume that in the absence of Sea Launch, potential SLLP customers would contract with alternative launch services, and the relative benefits of the Sea Launch plan would be lost.

4.3 LAUNCH LOCATION AND RANGE ACTIVITIES

To ensure that any potential environmental impacts caused by launch location and range activities are not overlooked, these activities were first correlated 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 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 dissipate immediately and form smog without consequence.

The use of a freshwater spray from a tank on the LP and saltwater, pumped from the ocean into a shallow dike area in and around the LP's flame bucket, are being considered as a means of dissipating heat and absorbing sound during the initial fuel burn. The fresh water tanks on the Launch Platform hold 27,474 gallons. It is estimated approximately 80 percent of this water would be evaporated by the heat of the rocket exhaust, while the remainder would be dispersed by the force of the exhaust and settle over a wide area on the ocean surface. Negligible impacts to the ecosystem would occur from the use of either water source. In the case of saltwater, the natural variation in plankton densities would ensure a nearly instantaneous recolonization of the removed plankton population in the water surrounding the LP, while the freshwater source would be a negligible input to the ocean.

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 and no kerosene is released at this point. 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 defuelling processes would be initiated remotely from the ACS. During defuelling, some additional LOX would be lost as vapor, and approximately 70 kg of kerosene would be lost when the fuel line is flushed. Most of this would wet the exhaust deflector and evaporate, and very little if any would be lost to the ocean. 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.

Sound transmitted into the water by LP and ACS power sources during routine operations is expected to range from 30 dB to 70 dB across a frequency range from 50 to 2000 Hz (Jensen, 1994), and 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.

4.3.2 Launch and Flight

Inputs to the environment from each launch would be:

- Spent stages, fairing and sleeve adapter.
- Residual fuels released from the spent stages to the ocean and atmosphere.
- Combustion emissions released to the atmosphere.
- 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

Deposition of spent Stage 1 and 2 hardware (dry weight of Stage 1 is 28,569 kg and Stage 2 is 9,109 kg) for each launch results in a maximum impact area of approximately 404 and 127 square meters of ocean surface, respectively. This conservatively assumes the tubular shape of the rocket is opened and flattened, which maximizes the potential for falling material to strike something on the surface or contact something on the seafloor. The material would fall onto an area roughly defined by the ovals shown in figure 4.3.2-1, covering 1,178,000,000 square meters for stage 1 and 12,570,000,000 square meters for stage 2. Thus, for any launch, at most only 0.00003% and 0.000001% of the ocean surface in the Stage 1 and Stage 2 impact zones, respectively, would be impacted by falling debris. In the case of the fairing (dry weight 2,000 kg), the maximum size if flattened would be 149 square meters, the fairing deposition area would be 4.712 x 10^9 square meters, and at most only 0.000003% of the ocean surface would be at risk from fairing debris. Over the planned 116 launches, using the figures stated above for Stages 1 and 2 and assuming the pieces lie perfectly flat on the bottom of the ocean floor and not overlap, the maximum amount of sea floor that could be covered by the rocket debris is roughly 17,280 square meters, or 0.0004% of the total area of 13,750,000,000 square meters at risk on the sea floor.

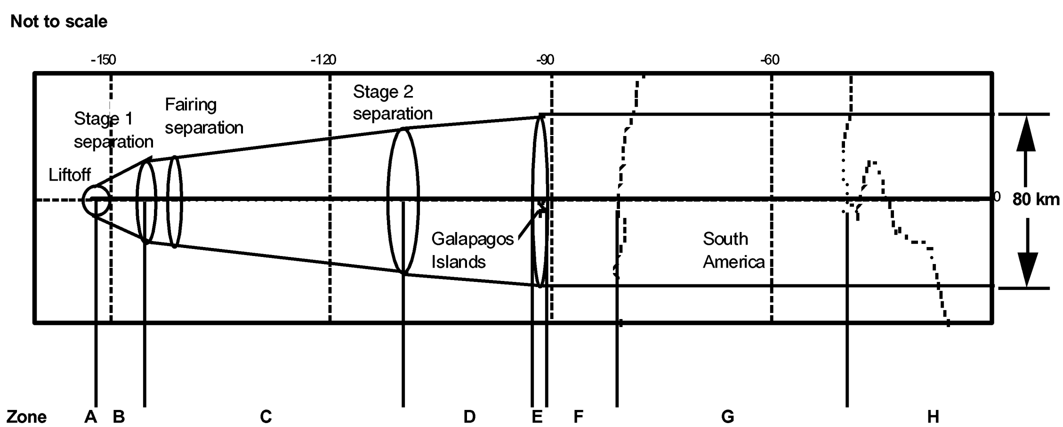

Figure 4.3.2-1. Flight Zones

Data available on the strength properties of Stages 1 and 2 and their historical use in the former Soviet Union support the conclusion that Stage 1 will sometimes break up during descent, while Stage 2 will always break up during descent at a high altitude. This process can be described as being similar to the behavior of an egg, which is strong when compressed along its long axis, from point to point, and weak if compressed in the middle. In the same manner, each stage is designed to be very strong when travelling vertically in a straight path, and the rocket motors are configured to continually correct the orientation of the rocket in flight to ensure this preferred alignment. When stressed side-to-side, however, the rocket has severely reduced structural strength.

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 a composite graphite and a honeycombed aluminum.

The fairing, with a higher surface area relative to mass, would flutter to the sea surface, perhaps break up on impact, float at or below the surface for a number of years and drift under the effects of local surface currents and wind or become waterlogged and less buoyant and sink within a few days. Based on the launch industry's experience with composite fairings, the two halves of the Sea Launch fairing will break up into a number of rigid pieces. Unlike plastic debris such as fishing nets, rope, string, and packaging materials that readily ensnares or is ingested by sea life, fairing pieces are relatively large, solid sheets of material. As such, floating fairing pieces will offer resting places for sea birds and provide smaller sea life shade and some protection from predators. 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.

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, fell unburned in the Zenit fuel tanks. However, given the incentives of launching commercial satellites where each kilogram of payload is critical, the Russian and Ukrainian partners have improved the efficient use of propellants and as a result have reduced the amount of unused kerosene to 2,000 kg (629 gallons) in Stage 1 and 450 kg (141 gallons) in Stage 2. When the thrust of each stage is terminated and each stage is separated from the remaining rocket, the speed of Stages 1 and 2 would be 2,620 m/s and 6,380 m/s respectively. The guidance system that ensures proper orientation of the hardware would also be terminated for each stage, causing each stage to tumble. The respective speeds and physical forces on each tumbling stage would possibly cause the rupture and release of the remaining propellants in the case of Stage 1, and would definitely rupture and release in the case of Stage 2. These releases of kerosene would occur above 60 and 160 km respectively. Research done on the release of fuel from airplanes has shown that jet fuel, which is similar in chemistry and physical behavior to kerosene, is completely evaporated within 1,000 meters from the point of release.[3] At the point of release, winds disperse the released liquid over a wide area resulting in a mist. Evaporation of all but the largest droplets then occurs within a few minutes, because evaporation is affected more by droplet size, i.e., the surface area on the drop, than the cold temperatures at high altitudes. The resulting kerosene vapors will then breakdown with the addition of heat from the atmosphere and sun to the carbon dioxide and water. 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. 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). Kerosene also can be toxic to other marine organisms. However, in the open ocean, marine organisms such as fish and whales would

[3] The Boeing Company, 1980 analysis. Available publicly through FAA.

not be expected to be harmed by the small kerosene release. These organisms can swim away from a spill by going deeper in the water or around the spill. Marine animals that generally live closer to shore, such as turtles, seals, and dolphins could be impacted by a kerosene spill near the shore, however, the kerosene from the spent stages is not expected to be released near or travel to any coastline (*Sensitivity of Marine Habitats*, U.S. Environmental Protection Agency, Oil Spill Program, Web site www.epa.gov/oerrpage/oilspill/habitats.html). 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.

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^{o}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.

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. Sections of metal 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, heavy and largely inert, they would sink and 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 normal 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	235,331 kg	58,703 kg	10,543 kg
Kerosene	89,773 kg	22,950 kg	4,325 kg
N204/MMH			95 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 (end of first stage)

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 (places payload in correct orbit)

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, 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 landmasses. 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).

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 by 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 650 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 650 km, the following order of magnitude estimates for σ_y and σ_z are obtained:
σ_y » 10^4 m, and σ_z » 2×10^3 m.

Substituting into the equation for concentration, the CO concentration at Christmas Island is estimated to be 3.48 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 » 1.3×10^4 and σ_z » 1.7×10^3, 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 18 hours, and using the values of long-range diffusion given by Gifford, 1995, σ_y is estimated to be 9 x 10^4. Using these figures, with a wind speed of 10m/sec in the basic equation for concentration, the calculated concentration of CO at 650 km is 0.46 mg/m^3. The order of magnitude analysis is consistent with several computer runs using the HYSPLIT4 model available from the NOAA Air Resources Laboratory on the Internet (http://www.arl.noaa.gov/ready/hysplit4.html). Because of prevailing winds, the modeled plume never reached Christmas Island and concentrations were estimated to be less than 1.0 mg/m^3 in less than 600 km.

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%

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 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. Disposal of any debris would be accomplished in accordance with all federal, state, and local requirements at the Home Port.

4.3.4 Failed Mission Scenarios

Two severe accident 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. 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 very few (i.e., 2 or 3) 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) 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:

- Intense heat generated at the ocean surface.
- Debris and noise released during the explosion.
- Emissions released to the atmosphere.
- 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 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 approximately 10 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.

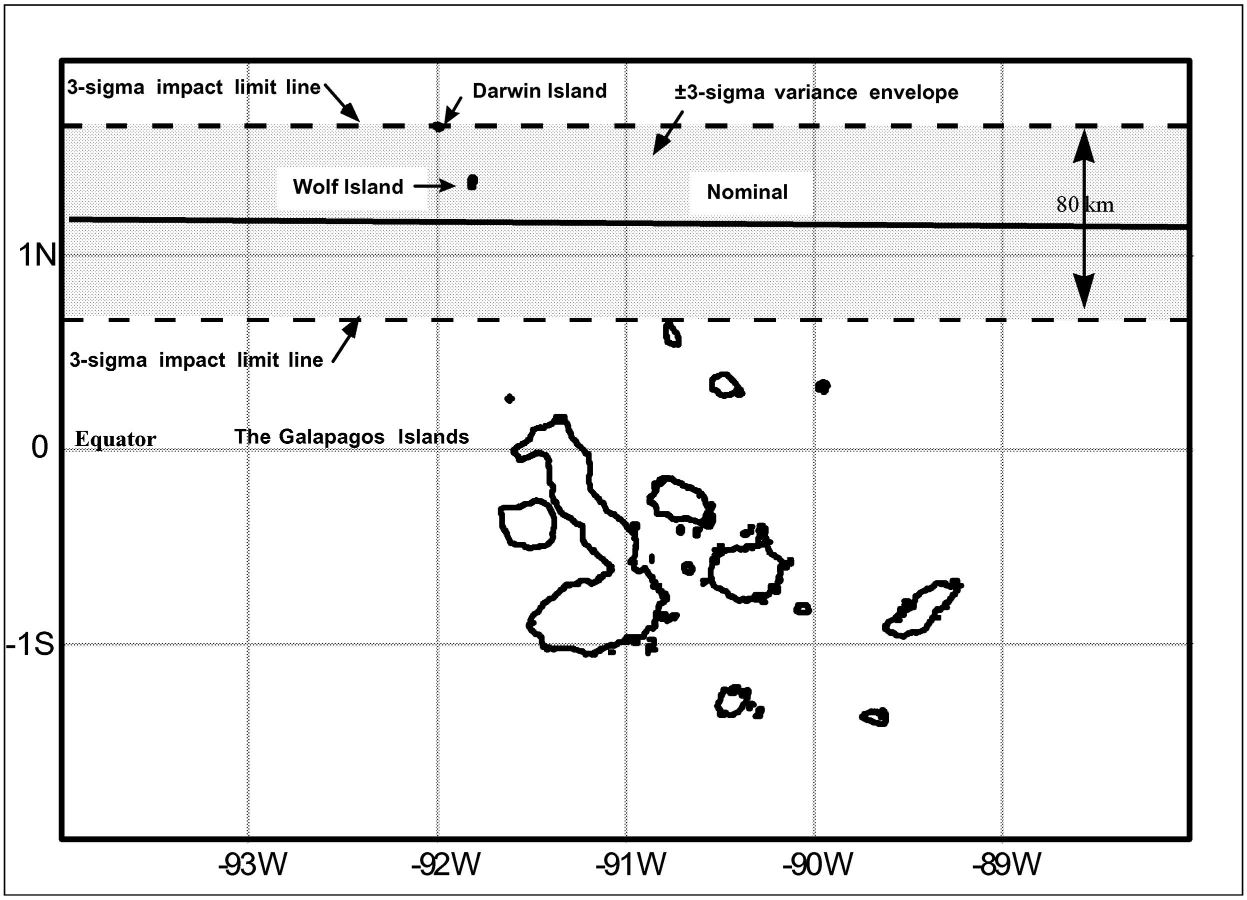

Figure 4.3.4-1. Galapagos Area Overflight

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 three launches in 1999 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.

With the possible exception of air passenger service, the baseline plan for operations does not include any normal or emergency use of facilities based on Kiribati. Impacts to the Kiribati Islands associated with employees transiting Kiritimati Island on an occasional or even greater basis would be positive, given that expenditures for lodging, food, and other services would be an addition to the local economy and be welcomed commerce. Sea Launch has no plans for using Kiribati for any launches. During the rare instances of an emergency medical conditions that can not be treated by on-board medical staff, Sea Launch will need to route people through Kiritimati. 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. Further discussion of international treaties and agreements applicable to the Sea Launch project are contained in Appendix E.

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 be complied with:

- International Convention of Load Lines, 1966
- IMO MODU Code (which incorporates SOLAS)
- Liberian Regulations (the Flag under which the Vessel will operate)
- International Convention for the Prevention of Pollution from Ships, 1973
- International Convention for Tonnage Measurement of Ships, 1969
- ILO Code practice, Safety and Health in dock work, 1958
- U.S. Coast Guard Regulations, relevant for foreign vessels trading in U.S. ports

- Safety and Health regulations for longshoring, U.S. Department of Labor (OSHA)
- IMO Resolution A468(XII), "Code on Noise Levels onboard Ships"
- Certificate of Financial Responsibility (COFR), U.S. 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 be complied with:

- International Convention of Load Units, 1966
- IMO Resolution A.534(13), Code of Safety for Special Purpose Ships/International Convention for the Safety of Life at Sea (SOLAS), 1974
- IMO Resolution A.649(16), Code for Construction and Equipment of Mobile Offshore Drilling Units regarding helicopter facilities
- Liberian Regulations (the Flag under which the Vessel will operate)
- Suez and Panama Canal Navigation Rules, including tonnage measurement and certification
- International Convention for the Prevention of Pollution from Ships, 1973
- International Convention on Tonnage Measurement of Ships, 1969
- ILO Code practice, Safety and Health in dock work, 1958
- U.S. Coast Guard Regulations, relevant for foreign vessels trading in U.S. ports
- Safety and Health regulations for longshoring, U.S. Department of Labor (OSHA)
- Vibration level testing to ISO guidelines 6954
- IMO Resolution A468(XII), "Code on Noise Levels onboard Ships"
- Certificate of Financial Responsibility (COFR), U.S. OPA 90 law

Further discussion of international treaties and agreements applicable to the Sea Launch project are contained in Appendix E..

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 were sold for scrap, all components would be removed from the environment and the area restored to its previous condition. If an upgrade were the desired approach, the potential environmental effects of such an upgrade would be reviewed in subsequent NEPA documentation.

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 enroute would not be near coastal or habitable areas but through the 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, and requirements of applicable international agreements will be complied with. 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 upwell and 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.

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 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 B1.1.12. Throughout the handling of these hazardous materials and fuels, Sea Launch would have in place protective equipment that is common practice in the industry (e.g., static electricity protection, power backup systems, personal protective measures as specified in AF-127).

4.5.4 Energy Outputs

Electromagnetic radiation outputs from the launch vehicle and related launch system hardware (different systems release energy at different times, but never all systems at the same time) are typical of the launch industry. As such, these energy sources are regulated and managed to control possible risks to people and the environment (SLLP, 1996b).

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's 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 (14^{th} 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). Several months before the first launch, Sea Launch Company intends to work with the Republic of Kiribati and representatives of industrial fishing fleets that operate in the region to coordinate the administrative process by which notice would be given. No launches would be conducted unless all fishing vessels are clear of the predetermined safety zone surrounding the Launch Platform. Visual and radar sensors will be used to verify this.

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

4.5.6 Environmental Monitoring Plan

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

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

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

4.5.7Environmental 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.

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. The system is designed to minimize the amounts of wastes generated in accordance with current pollution prevention objectives. 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

Appendix E contains comments received from government agencies and interested parties and FAA's response to these comments.

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 risk insurance
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

Table 5.2-2 Agency Consultations

Organization	Purpose Of Contact
South Pacific Regional Environment Programme (SPREP)	Response to comments on EA
U.S. State Department Washington, D.C.	Coordination with foreign governments and compliance with U.S. requirements
National Aeronautics and Space Administration (NASA)	Response to comments on EA
U.S. Coast Guard, Washington, D.C.	Compliance with Coast Guard Regulations
National Oceanic and Atmospheric Administration (NOAA), Washington, D.C.	Information on marine mammals and atmospheric conditions in Pacific
National Oceanic and Atmospheric Administration (NOAA), Honolulu, Hawaii	Oceanographic record of the equatorial Pacific
National Marine Fisheries Service (NMFS) Honolulu, Hawaii	Information on fisheries in the equatorial Pacific
U.S. Fish and Wildlife Service Region 1, Portland, Oregon	Information on threatened and endangered species
Australian Government	Response to comments on EA
Republic of Kiritibati	Exchange of information
Government of Ecuador	Response to comments on EA
Government of New Zealand	Coordination with proposed activities

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A. OVERVIEW

Sea Launch is a new, innovative system for launching commercial satellites from a platform at sea. It is being developed in response to high market demand for a more dependable and affordable commercial satellite launching service. The Sea Launch program is an international joint venture owned by Boeing Commercial Space Company, RSC Energia, KB Yuzhnoye, and Kværner Maritime a.s.

The system will utilize the proven Block DM-SL and Zenit rocket, manufactured by RSC Energia of Russia and KB Yuzhnoye of the Ukraine, to launch its satellite payloads (spacecraft) from equatorial locations in the Pacific Ocean. The rocket will be launched using two vessels: the assembly and command ship (ACS) and the launch platform (LP), which are provided by Kværner Maritime a.s of Norway. In port, the ACS will serve as the rocket assembly and integration facility and as the mission control center at the launch location. The LP is a converted, semi-submersible drilling platform. It will transport the integrated launch vehicle (ILV) to the launch location and will be used as a steady launch pad for the conduct of launch operations.

The Home Port is proposed as the staging area for Sea Launch operations. It will provide the facilities and personnel necessary to prepare for launch missions. The principal operations to be conducted in the Home Port are spacecraft processing, encapsulation and integration of the spacecraft payload, assembly and checkout of the rocket, vessel maintenance and resupply, and mission operations planning.

The proposed Home Port location for Sea Launch is in Long Beach, California, USA. Sea Launch will lease a portion of the former Long Beach Naval Station from the Port of Long Beach. The 17-acre facility is located on a narrow strip of land, known as the "Navy Mole." This location offers advantages from the perspective of security as well as offering a controlled access location for the conduct of spacecraft fueling operations. From a marine perspective, this location is adjacent to the harbor entrance, offering ready access to the deep water channel, as well as possessing a large turning basin for maneuvering the vessels. Refer to Figure A-1.

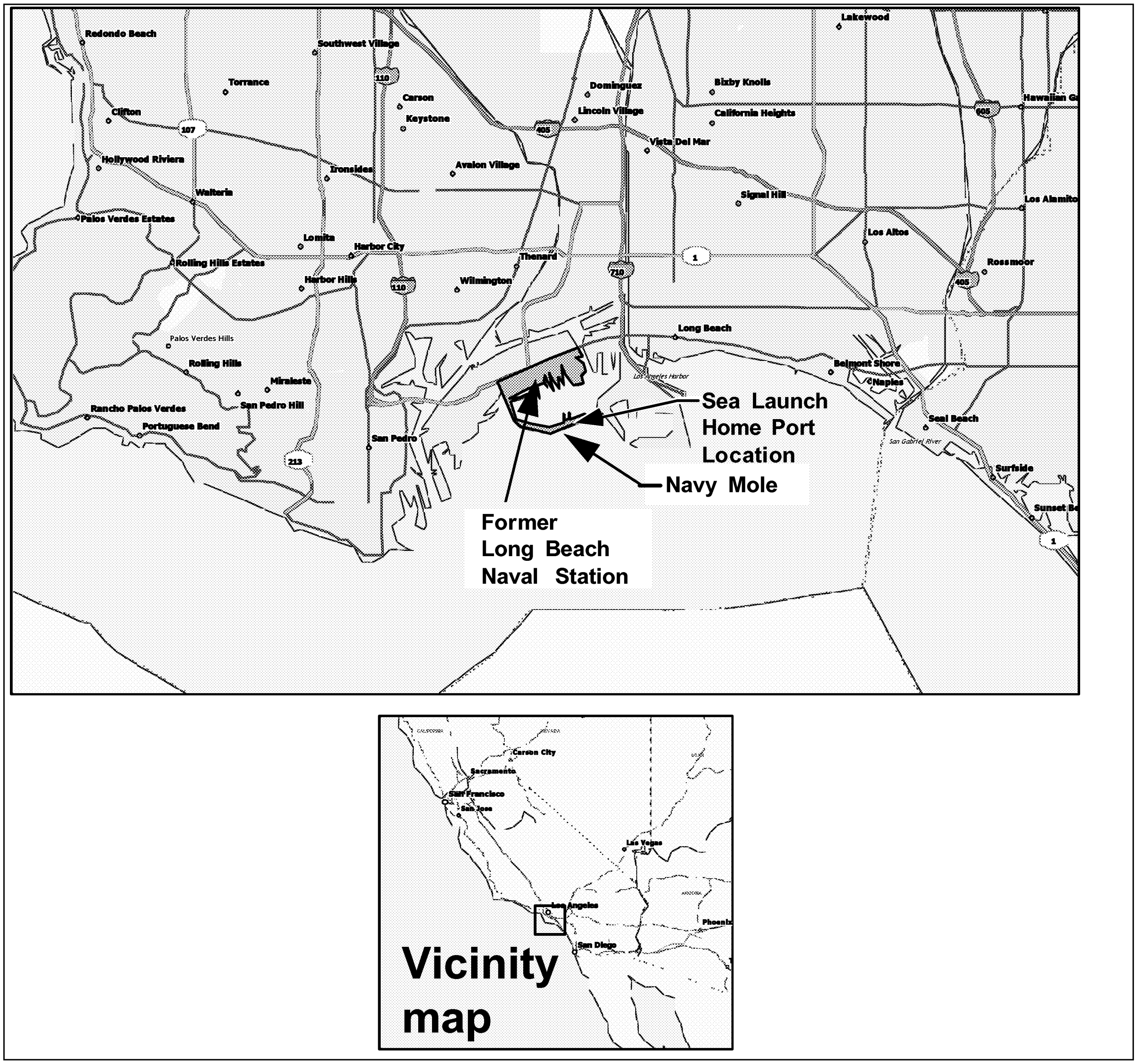

Figure A-1. Home Port Location and Vicinity

The integrated rocket and spacecraft to be launched by Sea Launch will be processed in the Home Port according to the following generalized scenario. The processing flow diagram is shown in Figure A-2.

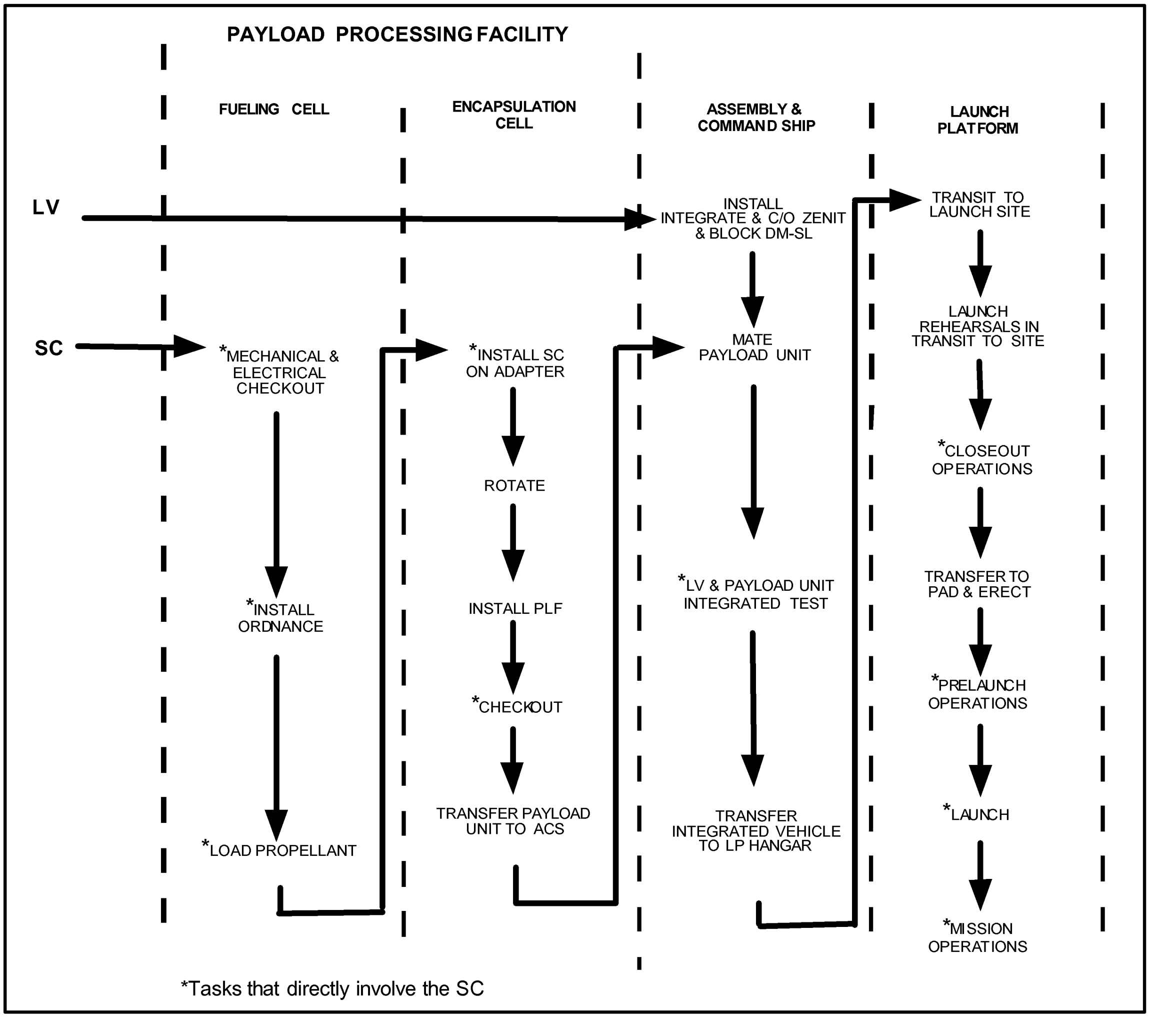

Figure A-2. Spacecraft Processing Flow

1. The spacecraft and its ground support equipment (GSE) will be delivered to the payload processing facility (PPF) by the customer (spacecraft manufacturer). The spacecraft will then be moved to its processing cell and the GSE is set up in the adjacent control room. Processing of the spacecraft will be the final phase of the assembly sequence. Processing will consist of electrical, mechanical and pneumatic functional checks, ordnance installation, and propellant loading.

2. After propellant loading operations are complete, functional tests will be run, the spacecraft will be installed on its adapter, rotated into the horizontal position, encapsulated in the fairing (which has been stored in an on-site warehouse), and tested as required. When encapsulation is complete, the encapsulated payload is considered ready for transfer to the ACS.

3. Individual, inert rocket stages, which are delivered via commercial ships, will be stored at the Home Port. Small solid rocket motors (SRMs), which are used to separate the rocket stages in flight, will be stored separately until they are loaded on the ACS with the rocket stages. Parallel to spacecraft processing, the three inert stages of the rocket will be transferred from the warehouse to the ACS where they will be processed and mated together. During the processing, the upper stage (Block DM-SL) will be partially fueled prior to mating to the second stage. Once

the rocket processing, assembly and checkout have been completed on the ACS, the encapsulated payload will be transferred to the ACS for integration with the rocket.

4. On the ACS, the encapsulated payload will be mated to the rocket and the interfaces checked out and verified. When the launch vehicle checks are complete, the ACS and LP will be positioned end to end and the integrated rocket will be transferred from the ACS to the LP. Prior to leaving the Home Port, rocket fuel components and compressed gasses will be delivered and transferred onto the LP. (Note: Fueling of the rocket occurs at the launch location just prior to launch.)
5. Both vessels will depart the Home Port at the same time for the equatorial launch region and conduct of launch operations.
6. After launch, the vessels will return to the Home Port. In preparation for the next user, the spacecraft GSE will be removed from the processing facilities, ACS, and LP.

The Home Port facilities will consist of an office building, a payload processing facility, warehouse buildings, and the pier. Each of these areas is described briefly below, and in more detail in Section A.4.

1. The office building is a two-story structure of approximately 2,230 m^2 which currently exists on the location. It contains offices, conference rooms, and a marketing, training, and break area. This will serve as the Home Port management and engineering area in addition to customer offices.
2. The PPF will be a new building constructed approximately 94.5 m east of the existing buildings in the Home Port complex. The building will be approximately 3,000 m^2 with a high bay height of 19.8 m for the encapsulation cell. This facility will be used for spacecraft processing and short-term (less than 30 days) storage of spacecraft propellants. This facility will consist of two processing cells, an encapsulation cell, control rooms, change rooms, fuel cart storage areas, and a central air lock. All spacecraft processing areas will be constructed to Federal Standard 209 Class 100,000 cleanliness standards.
3. The warehouse facilities consist of existing buildings which are located near the office complex, with a total area of approximately 9,290 m^2. The large warehouse building (building 4, Figure A.4-1) will be used for storing inert rocket stages, fairings, and adapters. The remainder of the buildings will be used for storage of spares and consumables necessary for Home Port operations, spacecraft customer spares, and shipping containers. Modifications (e.g., installing doors and shelving) and cosmetic maintenance will be required.
4. The pier is an existing structure adjacent to the other facilities. It is a concrete structure supported by wooden pilings and is capable of supporting any loads which can be transported over highways. It is approximately 335 m by 18.3 m and is accessible from both sides for moorage of the vessels. Water depth at the pier is 10.7 m to 11.6 m, which is capable of supporting SLLP vessels. The pier is equipped with facilities for electrical power, water, sewage, and moorage fittings. Minor modifications to the waterfront adjacent to the pier will be required to provide a ramp landing capable of roll-on/roll-off loading of inert rocket stages and encapsulated payloads to the ACS.

A.1 LAUNCH VEHICLE DESCRIPTION

A.1.1 Vehicle History

The Zenit-3SL is a liquid propellant, launch vehicle system capable of transporting spacecraft to a variety of orbits. Figure A.1.1-1 shows the Zenit-3SL principal components.

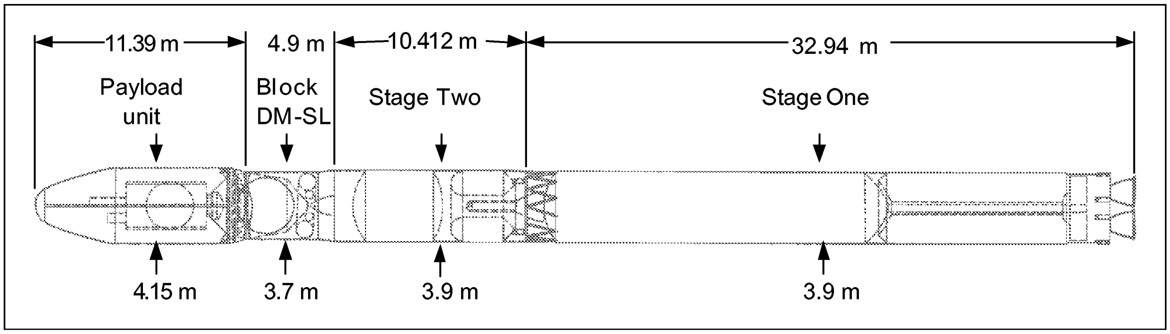

Figure A.1.1-1. Zenit-3SL Launch Vehicle

The first two stages of the Zenit-3SL are manufactured by KB Yuzhnoye in the Ukraine. The basic two-stage Zenit was developed to provide a means of quickly reconstituting military satellite constellations with design emphasis on robustness, ease of operation, and fast reaction times. The result is a highly automated launch system requiring only a small launch crew. First flown in 1985 from the Baikonur Cosmodrome in Kazakhstan, the Zenit's original use was as a launcher for electronic intelligence satellites. As of 1998, the Zenit has completed 26 missions in 31 launch attempts. Additionally, Stage 1 of the Zenit is virtually identical to the strap-on boosters used with the RSC Energia heavy lift launch vehicle. Four strap-ons are used for each Energia launch.

The Block DM-SL constitutes the upper stage of the Zenit-3SL. The Block DM is built by RSC Energia in Russia, and has had a long and successful history as the fourth stage of the Proton launch vehicle. The Block D upper stage model series has completed 196 missions in 204 launch attempts. The Block DM model used by Sea Launch has completed 98 missions in 103 launch attempts.

A.1.2   Zenit Stage 1

The Stage 1 principal structure is aluminum with integrally machined stiffeners. The RD-171 engine that powers Stage 1 burns liquid oxygen (LOX) and kerosene (RP-1). The LOX tank is positioned above the kerosene tank, and the lower dome of the LOX tank is located in the concave top of the kerosene tank. A single turbopump feeds four thrust chambers, and four differentially-gimbaled thrust nozzles provide directional control during Stage 1 powered flight. Stage 1/Stage 2 separation is accomplished through the use of forward firing solid propellant thrusters located in the aft end of the first stage.

A.1.3   Zenit Stage 2

The second stage of the Zenit also employs integrally stiffened aluminum construction. Stage 2 propellants are LOX and kerosene, and the lower kerosene tank is toroid shaped and the LOX tank is a domed cylinder. This stage is powered by a single nozzle RD-120 engine.

Three-axis control is provided by a RD-8 vernier engine which is mounted in the aft end of Stage 2. The RD-8 uses the same propellants as the RD-120, with one turbopump feeding four gimballing thrusters. The RD-8 produces 8100 kg of thrust. Stage 2/Block DM-SL separation is accomplished through the use of forward firing solid propellant thrusters located near the aft end of the second stage. Stage 1 and Stage 2 of the Zenit configuration are shown in Figure A.1.3-1.

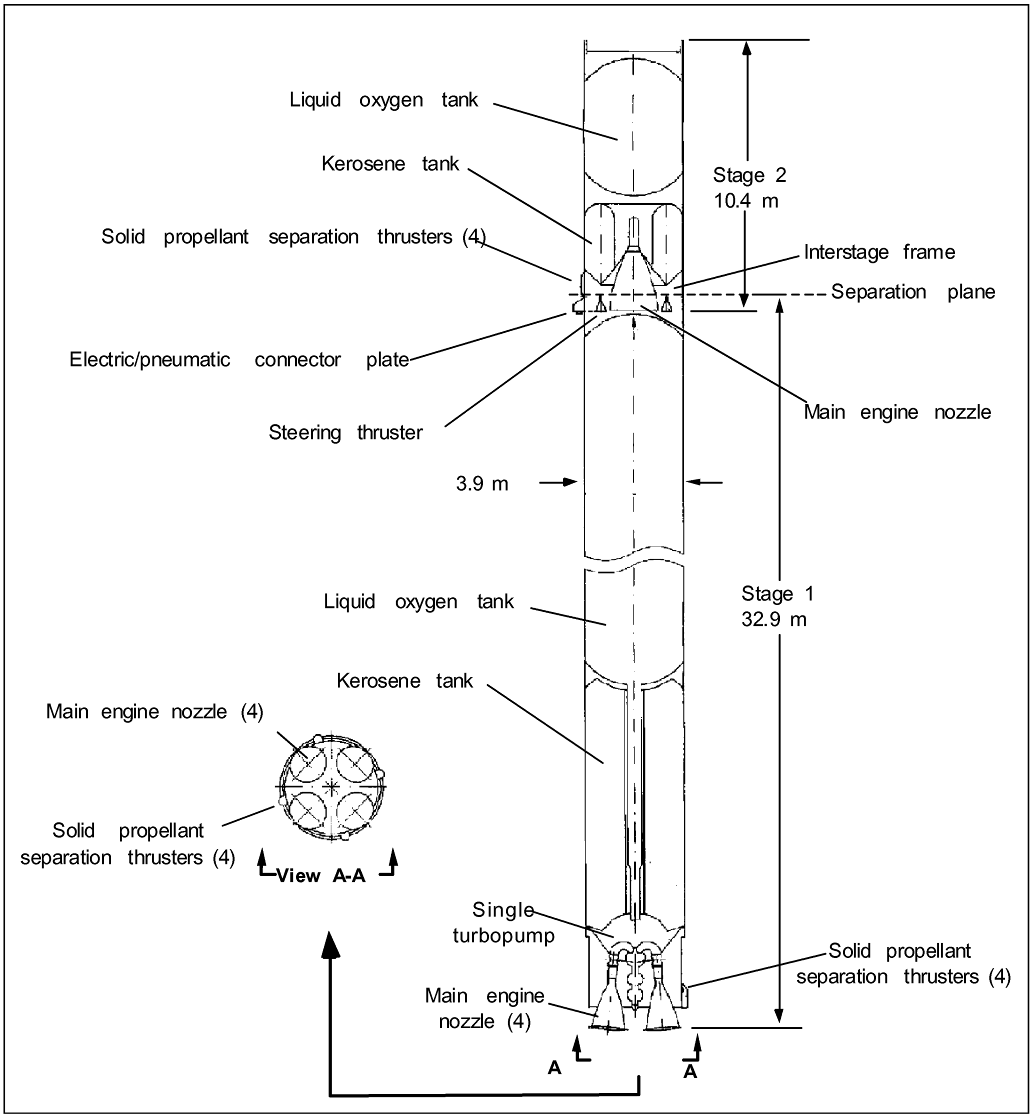

Figure A.1.3-1. Zenit Stage 1 and Stage 2 Configuration

A.1.4 Block DM-SL - Upper Stage

The Sea Launch Block DM-SL (Figure A.1.4-1) is a restartable upper stage which is capable of restarting up to seven times during a mission. The Block DM-SL is enclosed in an interstage cylinder of aluminum skin and stringer construction. All but the upper section of the interstage is jettisoned prior to the first firing of the Block DM-SL main engine. Avionics are housed in a toroidal equipment bay at the front end of the Block DM-SL.

Propulsive capability for the upper stage is provided by the 11D58M engine which operates on LOX and kerosene. The kerosene is contained in a toroidal tank which encircles the main engine turbopump. The spherical LOX tank is located above the kerosene tank. The 11D58M has a single gimballing nozzle which provides directional control during propulsive phases.

Three-axis stabilization of the Block DM-SL during coast periods is provided by two attitude control/ullage engines. Each engine has five nozzles that are grouped in clusters on either side of the main engine nozzle. The attitude control system uses the hypergolic propellants nitrogen tetroxide (N_2O_4) and monomethylhydrazine (MMH).

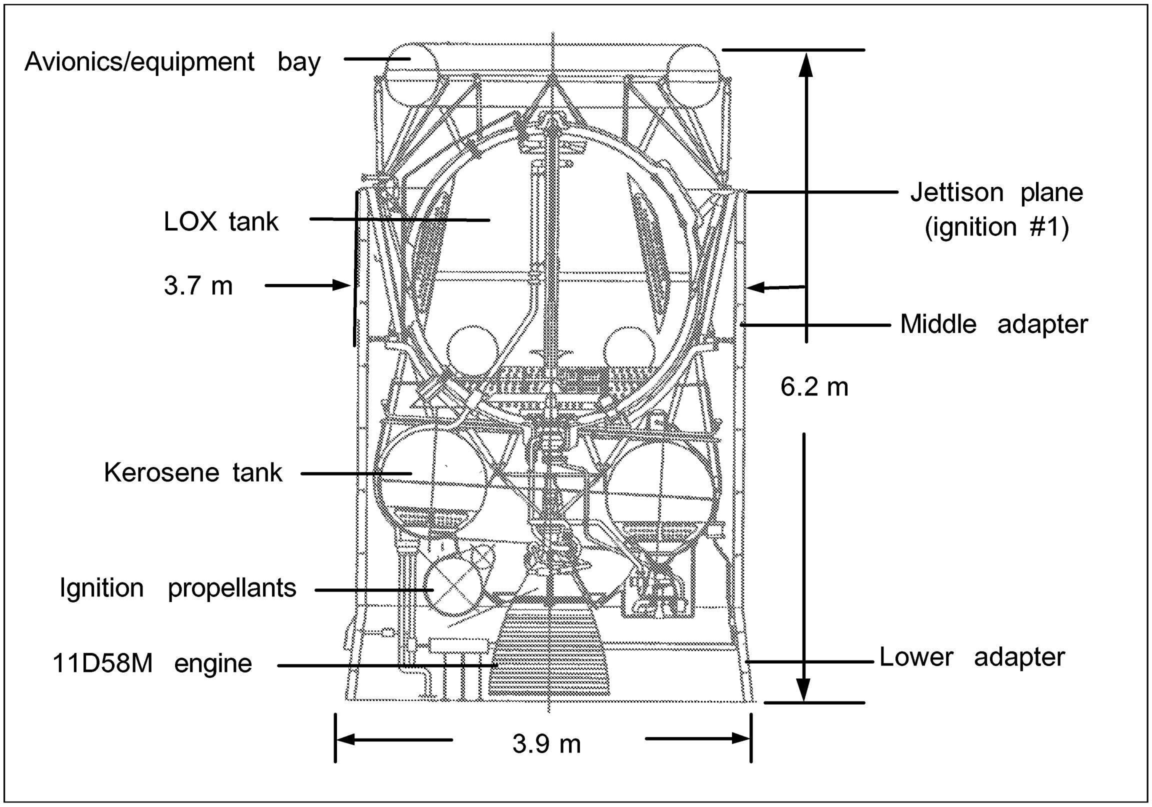

Figure A.1.4-1. Block DM-SL

A.1.5 Payload Unit

The payload unit (PU) consists of the spacecraft, adapter with spacecraft separation system, interface skirt, payload fairing (PLF), and the flight instrumentation package. The PLF, payload adapter (PLA), interface skirt, and spacecraft form a single, transportable item during ground processing (fig. A.1.5-1). These elements are brought together at the payload processing facility (PPF) in the Home Port and are integrated with the launch vehicle as a package onboard the ACS. The PU interface skirt mates to the interfacing ring of the Block DM-SL and encloses its toroidal equipment bay. The PU is 11.39 m long, as measured from the tip of the nose cap to the interface skirt/upper stage interface. The PU has an internal diameter of 3.9 m and an external diameter of 4.15 m.

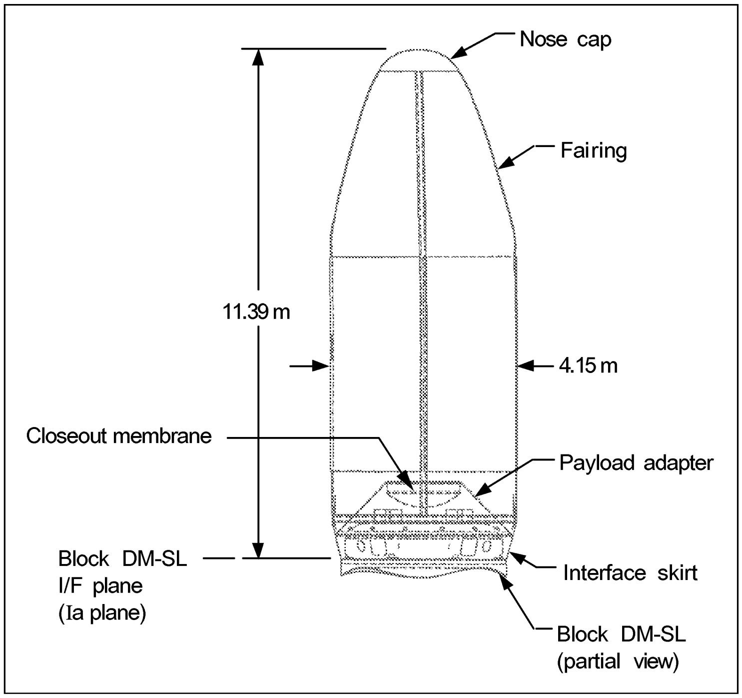

Figure A.1.5-1. Zenit-3SL Payload Unit

A.1.5.1 Payload Fairings

Sea Launch PLFs provide environmental protection for the spacecraft from the time of encapsulation through launch and ascent and can accommodate a wide range of payloads.

The PLF is 10.58 m long and is constructed in two sections of graphite composite external and internal skins. The PLF has a honeycomb core with a metallic nose cap device.

Prior to roll out to the launch pad, access to the spacecraft is gained through the access hatches in the payload fairing. The baseline design includes two PLF access hatches, approximately 0.61 m in diameter, located on opposite sides of the PLF longitudinal separation plane and at least 17^0 from the separation plane. Within PLF structural constraints, variations in the number, location, and size of the hatches can be accumulated.

Prior to launch, conditioned air is provided to the payload fairing volume. The cooling air flows from the forward end of the PLF to the aft end where it exits through one-way valves on the payload structure.

External thermal insulation protects the PLF structure and limits the interior PLF surfaces from reaching temperatures above 65^0C during ascent. The PLF is jettisoned at a time sufficient to ensure that the spacecraft's dispersed maximum free molecular heating (FMH) never exceeds 1,135 W/m^2. The time of PLF jettison (and associated maximum FMH) can be tailored by the customer.

A.1.5.2 Interface Skirt/Payload Structure

The interface skirt/payload structure, which joins the PLF and adapter to the upper stage, is constructed of aluminum with integral stiffeners. The interface skirt portion is 0.81 m long and accommodates the transition from a 3.715 m diameter on the Block DM-SL to a 4.15 m diameter on the PLF. The payload structure portion provides the structural tie between the spacecraft adapter and the interface skirt portion. The interface skirt/payload structure assembly includes an encapsulation membrane and acts as a contamination barrier between the PU and the Block DM-SL. One-way valves in the adapter structure permit airflow out of the PLF while maintaining positive differential air flow (or pressure differential) in the PLF during all operations.

A.1.5.3 Adapters

The spacecraft adapter, payload structure, and the interface skirt serve as the interface between the spacecraft and the launch vehicle. They physically support the spacecraft in a horizontal attitude for integration with the launch vehicle, during transportation to the launch location, and in a vertical attitude while on the launch pad.

The adapter mechanical interface to the spacecraft is either a bolted or a Marmon clamp design. Spacecraft separation from the adapter is accomplished with separation ordnance or through the release of this clamp.

A.2 MARINE SYSTEMS

The marine segment of the Sea Launch system includes the ACS and the LP, which together will support the integration of the launch vehicle, transportation to the launch location, and launch.

A.2.1 Assembly and Command Ship

The ACS will perform four functions for Sea Launch operations:

1. It will serve as the facility for assembly, processing, and checkout of the launch vehicle.
2. It will house the mission control center, which monitors and controls all operations at the launch location.
3. It will act as the base for tracking the initial ascent of the launch vehicle.
4. It will provide accommodations for the marine and launch crews during transit to and from the launch location.

A first aid clinic will be provided on both the ACS and LP with capability of functioning as a casualty support location in the event of a serious accident.

The ACS (Figure A.2.1-1) is designed and constructed specifically to suit the unique requirements of Sea Launch operations. The basic structure of the ACS is based on a Roll-On/Roll-Off (Ro-Ro) cargo vessel. The ship has an overall length of approximately 200 m and a beam of 32.26 m. Its overall displacement is approximately 30,830 metric tonnes.

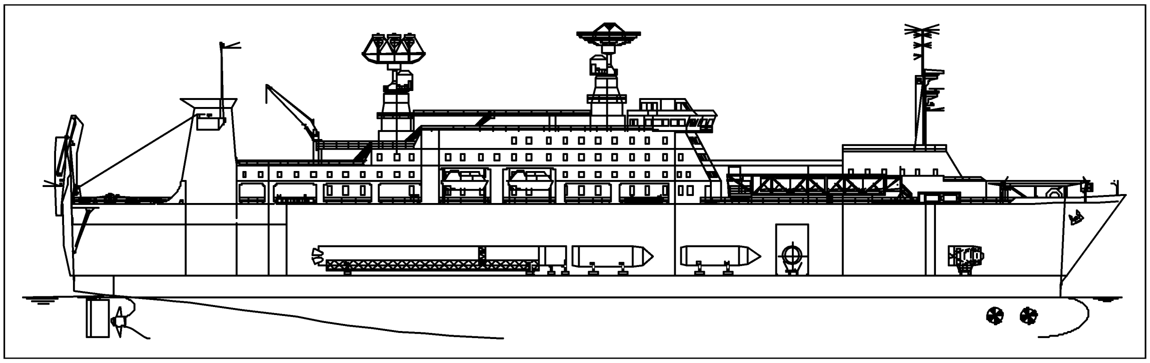

Figure A.2.1-1. Assembly & Command Ship

A.2.2 Launch Vehicle Integration Area

Launch vehicle stages will be loaded onboard the ACS in the Home Port through the stern ramp (Figure A.2.2-1). Processing and assembly of the stages will be conducted on the rail systems in the rocket assembly compartment on the main deck, accommodating parallel processing of up to three launch vehicles at one time. A special area in the bow of the main deck will be dedicated for processing and fueling of the Block DM-SL upper stage. Processing and assembly of the launch vehicle will typically done in port in parallel with spacecraft processing operations, but many of these operations may also be accomplished during transit to and from the launch location.

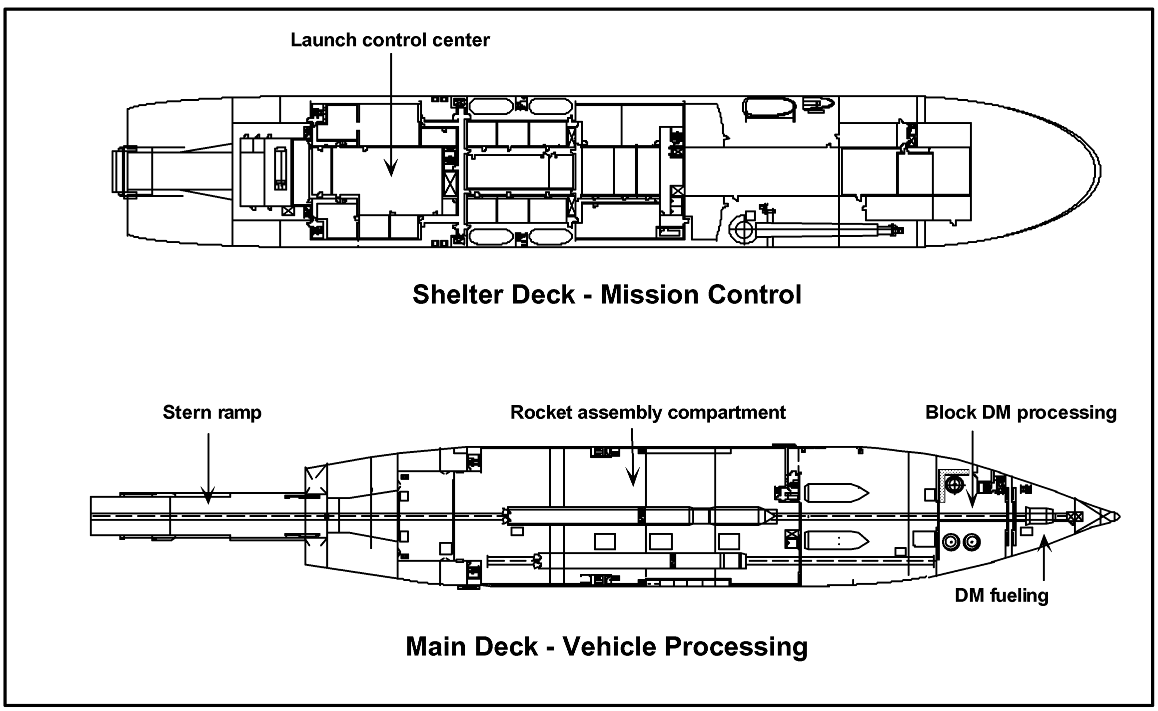

Figure A.2.2-1. Launch Vehicle Processing and Mission Control

A.2.2.1 Block DM-SL Fueling Process

Fueling of the upper stage will be accomplished onboard the ACS prior to mating with the first and second stages. This operation will be accomplished with the ship moored parallel to the pier which will also allow for easy personnel access. Normal ship evaluations and some limited launch support operations will continue during the upper stage fueling operation. The systems supporting this operation will be installed in four compartments located below the shelter deck between frames 221 and 189 (Figure A.2.2-1).

The upper stage fueling compartment (DM fueling) will be located on the main deck between frames 221 and 203. An air lock is provided directly aft of this compartment (frames 203 to 201) to isolate this space from the adjacent assembly areas. Access to the DM fueling compartment will be provided by a large set of sliding doors in the bulkheads at frames 203 and 201 to allow movement of the upper stage through the air lock. These doors will be provided with gas tight seals to maintain the air lock seal. A personnel access door will be provided through the air lock bulkhead on the port side, outboard of the lift/stairwell. This door will also be provided with gas tight seals. The air lock will cover the complete bulkhead between the main deck and the shelter deck. Stuffing tubes and related seals will be provided for all penetrations through the air lock bulkheads. The DM fueling compartment will contain facilities to connect the fuel transfer lines to the upper stage fuel fitting.

Fuel equipment compartments will be provided between the tank top and the main deck between frames 213 and 189. The two compartments directly under the main deck (tween deck) will contain the fuel service system for the two hypergolic components: MMH and N_2O_4. The two compartments will provide complete separation of the fueling components. A change room will be located forward of each compartment, which will also serve as an air lock between the fuel equipment compartments and the companion way/stair well.

A separate ventilation system, designed to control the potential accidental release of toxic and explosive vapors during fueling operations, will be provided. The supply and exhaust ventilation systems will be balanced to maintain a lower atmospheric pressure in the hazardous areas. The design of a means of scrubbing hazardous vapors from the exhaust air will be developed to achieve zero release of MMH or N_2O_4. The exhaust from this system will be located near the top of the forward mast, approximately 13 m above the weather deck. This location will also provide additional dilution if any release were to escape.

A.2.2.2 Rocket Assembly Process

Assembly of the integrated launch vehicle includes assembly of the Zenit Stages 1 and 2 and their mating, mating of the Block DM-SL upper stage to the second stage of the Zenit, and mating of the payload unit to the Block DM-SL upper stage.

The Zenit stages will be prepared for assembly by removing protective covers and fixtures used for transportation/shipping and positioned on the center rail in the rocket assembly compartment (Figure A.2.2-1). The first and second stages will be properly aligned and mechanically mated; electrical and piping connections will then be mated and verified. The onboard control system will be tested through the use of a computer-controlled test system. The test software will be verified in the factory prior to use onboard the ACS. Electrical test equipment will use unique connectors to preclude improper connections. Pneumatic test equipment connections will also be of unique configurations. The propellant tanks and piping (liquid oxygen: 1.8 kgf/cm^2) and kerosene tanks (1st stage - 1.6 kgf/cm^2 and 2nd stage 1.5 kgf/cm^2) will be leak tested. The pressurant system's nitrogen and helium tanks are charged to 220 (+10/-5) kgf/cm^2 and the propellant control and flow systems are leak tested at 15 kgf/cm^2. The four retro rockets (stage separation SRMs) will be installed on each stage. The Block DM-SL upper stage will be mated to the assembled Zenit stages and electrical interface connectors will be verified.

The encapsulated payload will be loaded onto the ACS from land through the stern ramp. Once onboard, the encapsulated payload and its transportation dolly will be positioned on the center rail in the rocket assembly compartment for integration with the launch vehicle. The payload unit will be mated to the Block DM-SL and interface electrical connections will be verified.

After the payload is integrated with the launch vehicle and all checkouts are complete, the integrated launch vehicle will be transferred to the launch platform. Environmental conditioning and monitoring of the encapsulated spacecraft is continuous from spacecraft encapsulation through launch. The only breaks are during transfer from stationary to mobile environmental conditioning units (less than three minites). Monitoring equipment will be mounted near the conditioned air exhaust from the spacecraft and upper stage.

A.2.2.3 Integrated Launch Vehicle Transfer from ACS to LP

Transfer of the ILV from the ACS assembly area to the LP hangar will be accomplished just prior to the LP departing the Home Port for the launch area. At this time, all other operations related to provisioning the LP and preparation of the ILV will have been completed. The following general sequence of operations will be accomplished to achieve the safe transfer:

1. The ACS will be moved from its portside berth and moored by its starboard side forward of the LP so both the ACS and LP centerlines are in a common straight line. The launch platform lies close to the pier, while the ACS has to be moored at some distance from the pier in order to be in centerline with the LP (Figure A.2.2-2).
2. The stern ramp will be lowered in horizontal position and a support cable system is attached between the end of the ramp and the LP. This support cable transfers some load from the ACS to the LP during the operation as well as supporting the stern ramp (Figure A.2.2-3).
3. Door and deck hatches in the front of the LP hangar will be opened and secured in the open position. The two LP hangar cranes will be moved into position to lift the ILV. Four guide cables will be installed (two on each side) between the ramp and the LP crane bridge. The guide cables will be kept taut by a tensioning system and will be used to guide and stabilize the ILV during hoisting.
4. The ILV and carriage will be moved out onto the ramp and positioned for lift. The ILV lifting equipment will be mounted on the rocket and prepared for connection to the LP crane hooks. The carriage prelift hydraulic system cylinders will now prepared to lift the ILV from the carriage.
5. The ILV lifting equipment includes transverse bars that will be attached to the crane hook. The ends will be equipped with rollers that attach to the guide cables and also to the hydraulic prelifting system. The transverse bars will be prepared for connection to the lifting crane hooks.
6. Both crane hooks will be lowered and connected to the lifting bars. Slack will be taken out of the crane lifting cables but no tension is applied at this time.
7. Hydraulic power will be applied to the prelifting cylinders and the ILV is lifted clear of the carriage to a predetermined height. Slack will be taken out of the crane lifting cables but no tension will be applied at this time.
8. Final checks for the lift operations will be accomplished. These include weather, the mooring arrangement, personnel on station, and ensuring that no other vessels are in positions which can lead to disturbances.

9. The ILV load will be transferred to the crane by lowering the prelifting cylinders.
10. The ILV will then hoisted by the cranes, which operate simultaneously to keep the rocket in a horizontal position, up to the level required to move it into the hangar. Once the ILV is at this level, the lifting bars will be released from the guiding rollers and the guide wires.
11. The ILV will then moved into the hangar position to be landed on the erector carriage.
12. The erector wagon will be moved into position under the ILV and the load will be lowered on to the erector carriage.
13. The ILV lifting equipment will be moved back to the carriage on the ACS stern ramp and the carriage will be moved into the assembly area.
14. The stern ramp will be released from the LP and both vessels will be readied for departure.

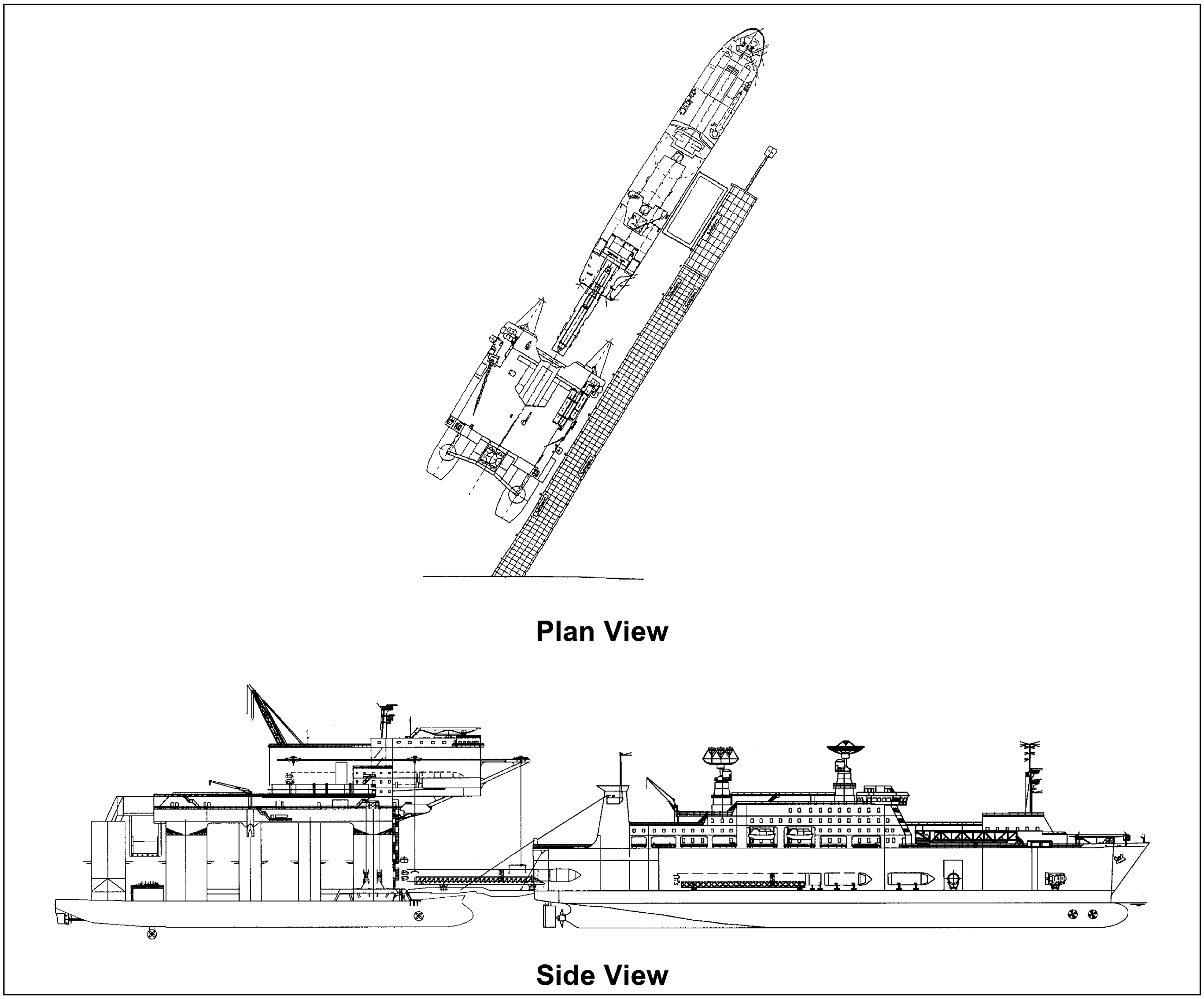

Figure A.2.2-2. ACS and LP Mooring Arrangement During Integrated Launch Vehicle Transfer

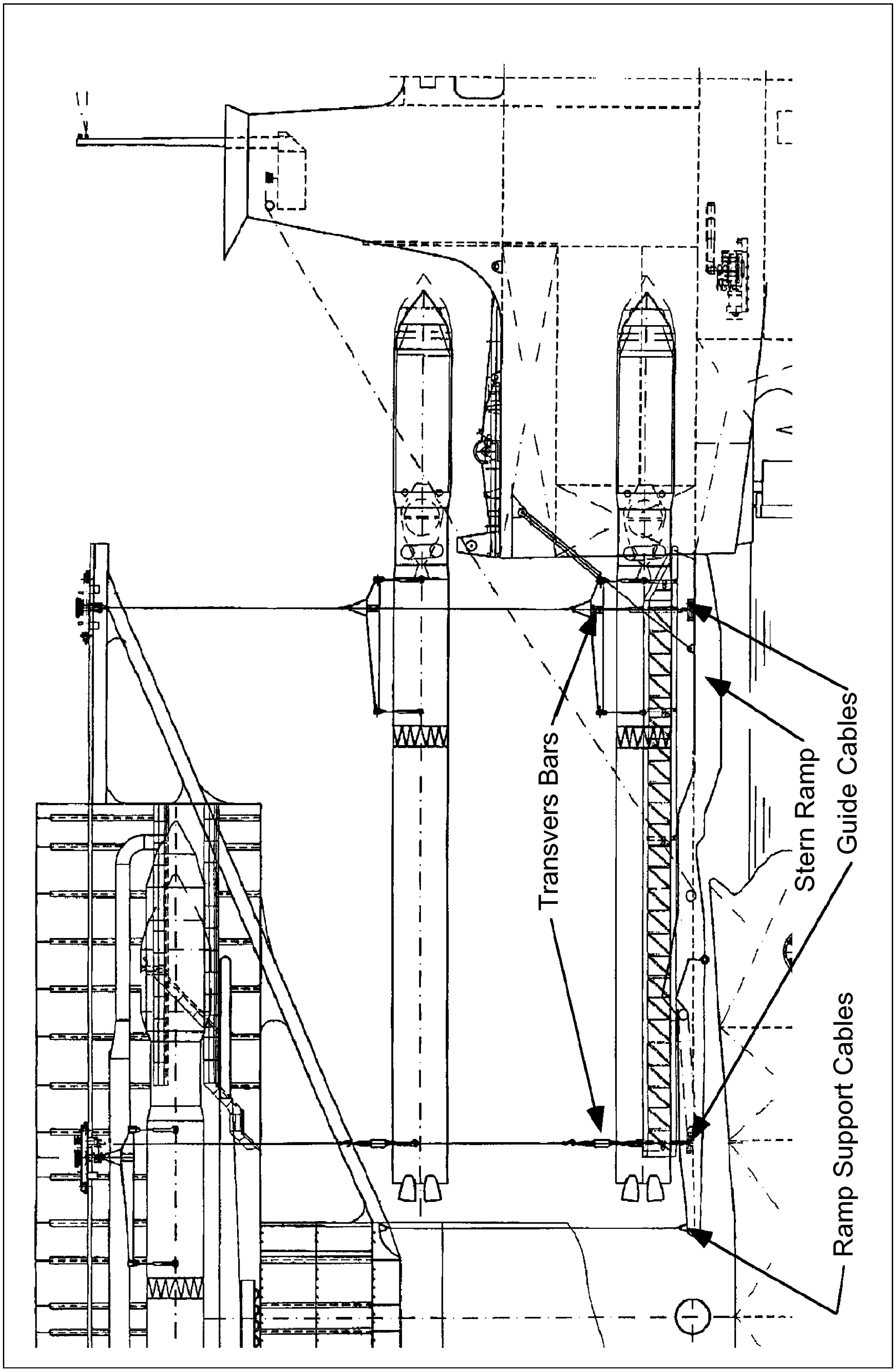

Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (1 of 2)

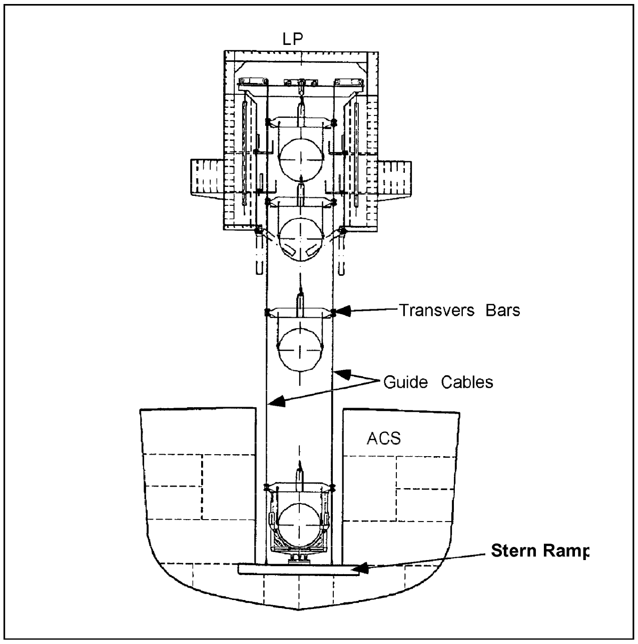

Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (2 of 2)

A.2.3 Launch Platform

The LP will serve as the transport vessel for the integrated launch vehicle and also serve as the launch pad. It will also provide accommodations for the marine and prelaunch crews during transit to and from the launch location. It will have all the necessary systems for launch vehicle erection, fueling, and for the conduct of launch operations.

The LP (Figure A.2.3-1) is a modification of an existing semi-submersible oil platform. This platform was designed for continuous operations in the extreme environment of the North Sea. In the relatively benign environment at the Sea Launch locations, this design will provide an extremely stable platform from which to conduct launch operations. The LP will be self-propelled by diesel-electric motors and will ride catamaran style on a pair of large pontoons. Once at the launch location, the pontoons will be submerged by ballasting to achieve the stable launch position, level to within approximately one degree. The LP will have an overall length (at the pontoons) of approximately 133 m and the launch deck will be 78 m by 66.8 m. Its overall transit displacement will be approximately 27,400 metric tonnes. Once transferred to the LP in the Home Port, the integrated launch vehicle will ride to the launch location in the enclosed hangar on the main deck. After LP ballasting at the launch location, the rocket will be rolled out to the launch pad and erected in preparation for launch.

After the launch vehicle has been erected and all launch system checks are complete, the crew members will be transferred to the ACS. Vessel station keeping and launch operations will be conducted from the ACS via redundant RF links.

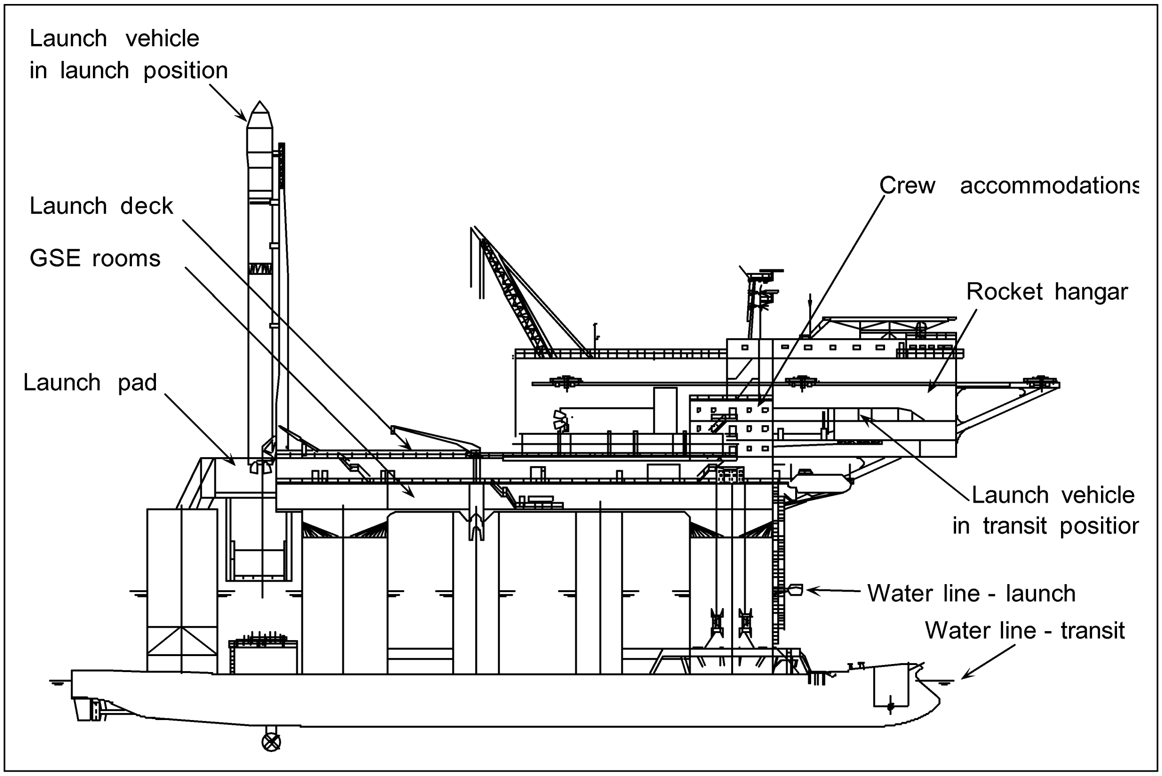

Figure A.2.3-1. Launch Platform

A.2.4 Transit Operations

The integrated launch vehicle, including the encapsulated payload, will be supported on the transporter/erector in the LP hangar during transit to the launch location. Accommodations for six customer technicians will be provided onboard the LP during transit.

While the ACS and LP are in route to the launch location, a mission rehearsal will be conducted. The rehearsal involves the launch personnel and customer personnel onboard the ACS, the tracking assets (Selena-M tracking ship, Altair satellite [sometimes called Luch satellite], ground stations, etc.), and the customer's spacecraft control center. The rehearsal will simulate the prelaunch operations and post launch operations up through spacecraft separation and completion of the Block DM-SL's contamination and collision avoidance maneuver (CCAM). The launch vehicle operations on the LP will be simulated while the launch vehicle remains in the hangar. Successful completion of the launch rehearsal is a prerequisite to launch. These operations are simulated to a major extent and systems that could pose a threat to the environment are not exercised.

Transit of the two vessels between the Home Port and the launch area will be a normal maritime operation and is controlled by existing regulations as noted in Section 3 and in Appendix B.

A.2.5 Platform Launch Operations

At the launch location, the LP will be lowered from the transit draft to the launch draft, and the ACS and LP will moor alongside each other. The launch draft provides a more stable platform. The launch may be accomplished in mean significant wave heights up to 2.5 m. This launch position will be accomplished at least 17 hrs before scheduled launch time (T). A connecting bridge will be extended between the two vessels to allow prelaunch processing personnel access to the LP. Final spacecraft "hands-on" operations (i.e., ordnance arming) will be accomplished and payload fairing hatches will be closed out. (Ordnance is used for stage separation and launch; please see Appendix B-20 for further information.) Launch management personnel and the customer will be polled and approval will be given to roll out the integrated launch vehicle (ILV) from the hangar to the launch pad.

The hangar hatches will be opened and the automatic sequence that moves the Zenit-3SL to the launch pad will be initiated. As the launch vehicle moves to the pad, the electrical, pneumatic, hydraulic, and propellant lines will be automatically connected. At the launch pad the launch vehicle will be rotated to a vertical position. Prior to rotation, the portable conditioned air supply will be switched to the launch pad conditioned air supply system.

At this time, the majority of the LP and launch support personnel will leave the LP and the ACS maneuvers to a position approximately five km from the LP. The repositioning of the ACS will occur at approximately T-15 hrs.

The transfer and verification of launch systems control and LP systems control will be started. Initial purging and conditioning of launch vehicle fueling systems will be started and final preparations accomplished. When the transfer of control and the prelaunch checkouts are completed and the results have been verified, the remaining LP and launch support personnel will be transferred by motor launch to the ACS prior to rocket fueling. The LP will now be uninhabited and all critical systems will be controlled remotely from the ACS. The transfer of the remaining personnel to the ACS will occur between approximately T-5 hrs and T-3 hrs.

The fueling of the Zenit (LOX and kerosene) and LOX loading of the Block DM-SL will be started at approximately T-2.5 hrs and completed at T-24 min. The erector will be lowered to the horizontal position and moved into the hangar and the hatch doors will be closed. Fuel lines will be drained and purged with GN_2 prior to disconnecting.

Final launch sequence will be accomplished. In order to minimize exhaust effects on the LP and acoustic effects on the spacecraft, a freshwater deluge system will be used in the flame deflector. The water deluge to the flame trench/deflector will begin at T-5 sec. Stage 1 ignition will occur at T-3 sec. The main command to ramp up the main engines to launch thrust will be issued at T=0 after engine parameters have been verified by the onboard control system.

The Zenit-3SL will be held in place on the launch table by hold-down clamps at the base of the first stage. These clamps will be released after the computers confirm that the Stage 1 engine is operating properly and engine ramp up exceed 50% thrust.

If the engine parameter verification or the hold-down clamps release is not successful, the engine will be shut down by the onboard control system prior to lift off.

A.3 ABORT OPERATIONS

Launch abort operations are described in Section 5.2 as part of the environmental analysis, and they are further addressed as a part of mission definition in the license application submitted to AST (SLLP). In general, a launch abort is a controlled event in which the rocket would be stabilized and fuels extracted and stored for reuse. The launch vehicle would then be lowered to a horizontal position and moved into the hanger on the LP. The situation would then be assessed before a decision can be made to restart the launch sequence or return to the Home Port.

A.4 HOME PORT FACILITIES AND SERVICES

The Sea Launch Home Port complex will provide the facilities, equipment, supplies, personnel, and procedures necessary to receive, transport, process, test, and integrate the spacecraft and its associated support equipment with the launch system. It also will serve as the home base for launch operations with facilities to support and service the Sea Launch vessels, including office and storage facilities. There will be no provision to support major ship repair. This work will be accomplished at a commercial facility.

The proposed Home Port is located in southern California in the Port of Long Beach. This site is part of the former Long Beach Naval Station located on the southern side of Terminal Island within the Long Beach harbor district. The proposed Home Port is located at the east end of the "Navy Mole" (Figure A.4-1), which is a large breakwater forming the western and southern boundaries of Long Beach Harbor. Access to the site is via I-110 or I-710 off the San Diego freeway (I-405). Long Beach airport (21 km), Los Angeles airport (40 km), and Orange County airport (38 km) are all within close proximity.

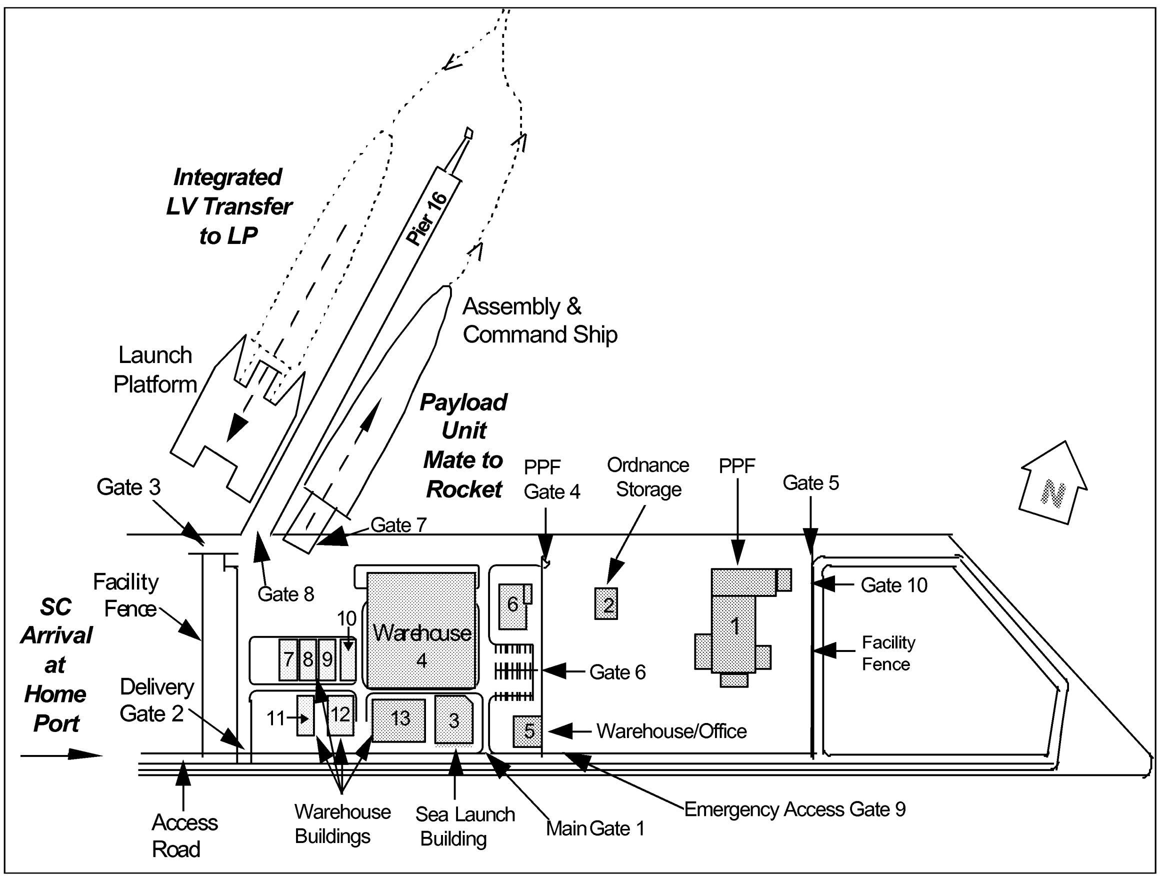

Figure A.4-1. Sea Launch Home Port Complex

The Home Port complex will consist of a payload processing facility (PPF), Sea Launch and customer office facilities, several warehouse buildings, and a pier. The complex is bounded by the access road to the south and the harbor to the north. A security fence encloses the property with access through three gates in the south side fence. The main entrance is through Gate 1, which is staffed 24-hours, seven days a week. Gates 2 and 3 allow oversize truck access to the pier and PPF respectively, and are normally locked. An interior fence separates the PPF area from the rest of the complex, and access to this area is controlled through Gate 4. Two additional emergency access gates, Gate 5 and Gate 6, are located at the northeast and northwest corners of the facility.

Water, sewage, and gas service will be provided to the site by local utility companies. Commercial electrical power will be supplied by Southern California Edison. This power will be distributed through transformers, panel boards, and circuit breakers to all areas within the complex. Emergency power for the PPF will be provided through a 500 kW backup generator with an automatic switching system. To provide further limited protection during test periods, an uninterruptible power supply (UPS) will be available in the processing area.

Industrial waste generated during program procession will be processed in accordance with existing state and federal regulations.

A.4.1 Spacecraft Processing Operations

After delivery to the Home Port, electrical and mechanical checkout of the spacecraft will be conducted in the PPF. After stand-alone testing, the spacecraft will be placed on a customer-provided fueling stand. The customer will be required to perform all required ordnance installation operations prior to fueling. (Please see Appendix B-20 for further details regarding ordnance.) Initial mass properties can be determined at this time. After the customer's fueling team propellant loading operations are complete, final mass properties determinations will be conducted.

While the customer conducts spacecraft ordnance and fueling operations, Sea Launch personnel will transfer the payload fairing and adapter from storage to the PPF encapsulation cell and prepare them for installation. When spacecraft processing is complete, the spacecraft will be transferred to the encapsulation cell and mounted vertically on the flight adapter. The adapter and spacecraft will then be rotated to a horizontal position to accommodate the installation of the payload fairing. Communication checks will be conducted on the spacecraft. Conditioned air flow will be initiated and the payload unit (consisting of the spacecraft, adapter, fairing, and upper stage interface skirt) will be transported to the ACS as a single unit. Spacecraft and equipment environments will be monitored throughout the entire process.

Once onboard the ACS, the payload unit will be mechanically and electrically mated to the previously assembled and tested rocket. Integration tests will be performed between the PU and the rocket. Upon the completion of testing, the integrated launch vehicle (ILV) will be transferred onto the LP and stowed in the LP hangar. The ACS and the LP will then depart for the launch location.

A.4.2 Payload Processing Facility

The PPF (Figure A.4.2-1) is located in Building 1 on the east side of the Home Port complex (Figure A.4-1). In support of the trend in the industry towards "ship and shoot" spacecraft processing operations, this facility will provide common cells for the conduct of both non-hazardous and hazardous spacecraft operations. All spacecraft processing, propellant transfer operations, pressurization, ordnance preparation, and payload fairing encapsulation operations will be accomplished in the PPF. This area will be separated from the rest of the complex by an interior fence with controlled access through Gate 4 during hazardous spacecraft operations.

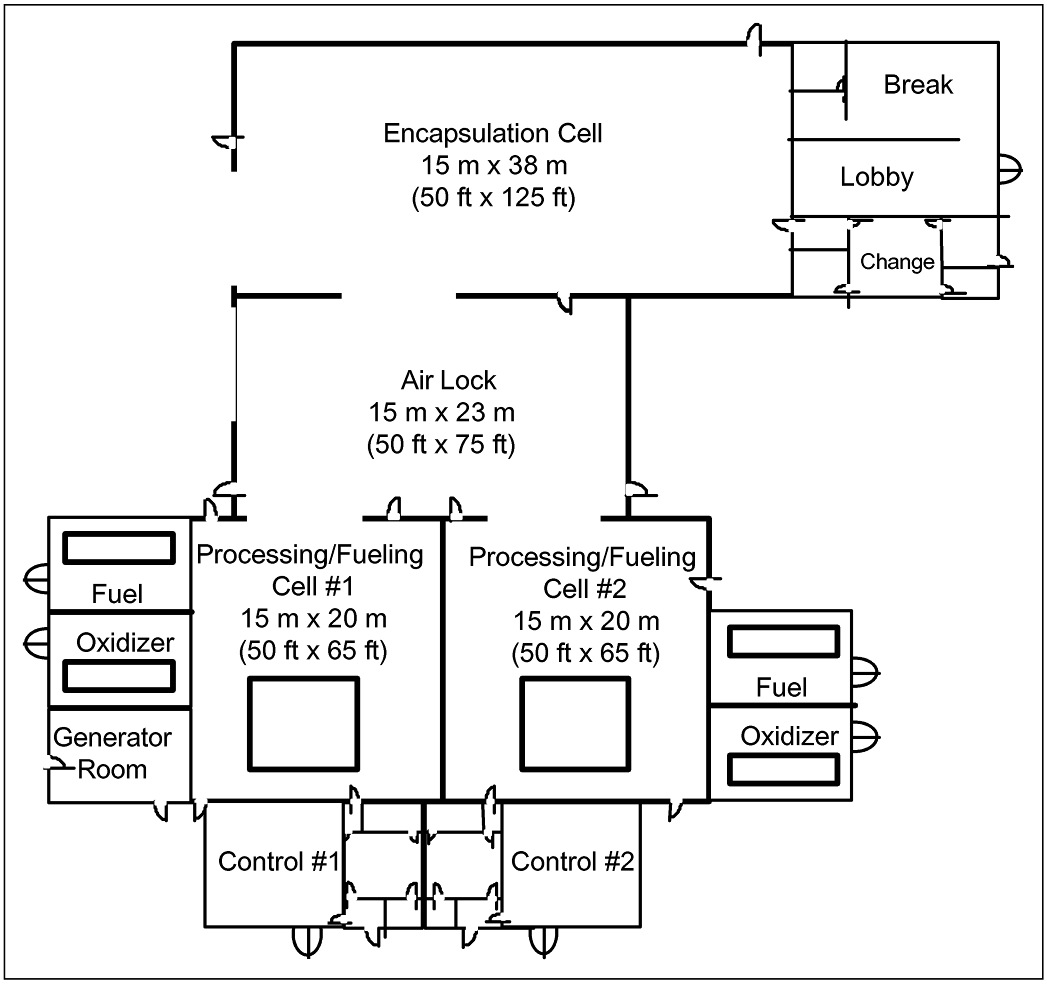

Figure A.4.2-1. Payload Processing Facility

Building 1 will have an overall area of approximately 3,900 m^2, and its major features will include:

1. Processing/fueling cells.
2. Fuel storage rooms.
3. Oxidizer storage rooms.
4. Encapsulation cell.
5. Common air lock.
6. Control rooms.
7. Garment change rooms.
8. Lobby/break area.
9. Generator room.

The processing/fueling cells, encapsulation cell, and air lock are cleanrooms will be maintained to Federal Standard 209 Class 100,000 cleanliness standards. Air filtration will be provided by pre-filters and high efficiency particulate air (HEPA) final filters. To facilitate cleanliness control, the interior wall surface of these areas will be enamel-coated gypsum board and the ceiling surfaces will be vinyl-faced gypsum panels. The floor coverings will be electrically static dissipative and will be compatible with either wheeled dollies or air bearing pallets. Temperature in the air lock, processing/fueling cells, and encapsulation cell will be maintained to 21°C $\pm$3°C. Relative humidity will be maintained between 35%

and 60%. Card readers on personnel doors to high bays and control rooms will provide for controlled access.

A.4.2.1 Processing/Fueling Cells

The PPF will provide two separate, high bay processing/fueling cells configured to support spacecraft processing operations. In order to support spacecraft fueling operations, each cell is equipped with a 7.6 m by 7.6 m fueling island in its center. This island will be surrounded by a covered trench which will drain to one of two dedicated 18,192 L fiberglass, reinforced polypropylene tanks for emergency spill containment. To maintain cleanroom standards, access to each high bay will be controlled via a garment change room. Each processing/fueling cell will be equipped with the following features:

1. Work areas of approximately 300 m^2.
2. Motorized steel rollup access door with manual chain drive backup mechanism. Clear opening measuring 6.1 m by 12.3 m.
3. Personnel access from the air lock through a steel personnel door or from the garment change room through an air shower.
4. Emergency exit only personnel doors along outside walls.
5. Overhead traveling crane with capacity of 13,600 kg with maximum hook height of 15 m.
6. Breathing air system and protective garments for fueling crews.
7. Gas monitoring/detection system for spacecraft fuels.
8. Power receptacles.
9. Potable water hose bibbcock.
10. Vacuum ports with quick disconnect connectors and vacuum line.
11. Closed-circuit television cameras.
12. Wall-mounted telephone.

The two processing and fueling areas will have heating, ventilation, and air-conditioning systems that will provide these areas with an adequate ventilation rating. These areas will be classified Class I, Division 2, up to 3 m above the finished floor. Pits or trenches in the floor will be classified as Class I, Division 2. The areas above 3 m will not be classified in regard to electrical hazard grouping.

Operating personnel will be advised of potential safety concerns through the use of the processing facility public address system, a warning beacon system located on the exterior of the building, and a fire detection and alarm system. The warning beacon system will provide green, amber, and red beacons. The green beacon will be illuminated whenever the building is in a normal state with no fueling operations in progress. Manual switches will activate the amber beacon whenever a potentially hazardous operation is taking place. The red beacon will be activated by the toxic gas monitoring system.

Two single point toxic gas monitors will be provided in the processing, air lock and encapsulation areas, and one single point toxic gas monitor will be provided in each fuel staging cart room. The monitors are capable of monitoring for both components: nitrogen tetroxide (N_2O_4) and monomethylhydrazine (MMH). The alarms will be sounded locally and will also activate the red warning beacon on the exterior of the building. Two alarm set points will be provided; the lower will be set at 75% of the toxic limit, and the higher will be set at 25% of the lower explosive limit (LEL) which will activate the ventilation system purge system for the area. Remote alarm indication will be provided in the main office building.

The payload processing facility fire suppression system will be a dry pre-action system. This system will have compressed air in the lines, maintaining a "dry pipe" condition. The system will be activated by two independent but necessary actions: a smoke/heat detection alarm signal from any of the mounted detectors or from a manual pull station; and an intense heat source sufficient to melt a fusible link in the sprinkler head. The first alarm system action will open a valve which charges the system with water. A high intensity heat source must then be present to melt the fusible plug. This system will provide some protection from water damage to high value hardware in case of a false alarm.

The facility will contain a ground loop system consisting of ground rods and bare copper cable installed around the building. The loop will be tied to every other perimeter building column. A ground buss will be provided in each propellant cart area, each control room, and in the processing and encapsulation areas. Lightning protection per NFPA-78 will be provided.

Access to the facility will be limited to authorized personnel and is controlled by a card reading access control system. The access control system will be a part of the Security Information Management System.

A.4.2.1.1 Propellant Cart Storage Rooms

Two propellant cart storage rooms for each processing and fueling cell will be provided for temporary storage of fuel (N_2H_4 or MMH) and oxidizer (N_2O_4) carts and associated ground support equipment (GSE). The rooms will have an approximate floor area of 37 m^2 with a clear vertical height of approximately 2.7 m and steel access doors measuring 2.4 m by 2.4 m. Emergency drains to the respective fuel and oxidizer containment tanks (18,168 L) will be provided in each room as well as a gas monitoring/detection system for spacecraft fuels.

A wet scrubber system will be provided for the processing fumes that may be released during the fueling operation or in case of an accident. One scrubber will be provided which can be connected to either containment tank via the vent piping system.

A.4.2.1.2 Propellant Carts/Tanks

Propellants will be delivered from the vendors in tanks approved by the U.S. Department of Transportation (DoT) in accordance with Code of Federal Regulations (CFR) 49, Transportation. Tanks planned for use are DoT 110A500W tanks (maximum 908 L capacity) or DoT 4BW tanks (maximum 454 L capacity). Both types of transport/storage tanks will be used for the direct transfer of propellants into the spacecraft by way of a closed-loop system.

A.4.2.1.3 Summary of Propellant Operating Procedures

The amount of propellant to be loaded will be a function of the spacecraft's weight, its mission, and altitude. The satellites that will be processed through the payload fueling facility will have a mass ranging from 1,500 kg to 3,500 kg. The propellant weight fraction will be between 50% and 70% of the overall payload mass.

Liquid propellant, N_2O_4 and MMH, will be received and staged (temporary storage) in DoT approved containers (i.e., in accordance with CFR 49). The typical container contains 908 liters of liquid propellant. The propellants will be stored in separate rooms until they are needed to fuel the spacecraft. The normal load for a spacecraft requires the transfer of propellant from one tank for each fuel component. Normal practice is to have a second tank of each fuel component available as a backup.

When the spacecraft is fueled, one tank of fuel will be moved into the processing cell at a time. Following transfer of that fuel component into the spacecraft tanks, the processing cell will be cleared of all traces of that component prior to handling the next tank. This will maintain complete separation of the two components at all times.

Although the facility will have two processing cells, only one spacecraft will be fueled at any given time. Even in the instances where the operation requires the preparation of two spacecraft for a dual payload launch, the spacecraft will not be fueled simultaneously. Once fueled, the spacecraft will be moved into a separate cell for encapsulation in the payload unit.

A.4.2.2 Encapsulation Cell

An encapsulation cell will be provided in the PPF for the preparation of payload fairings and adapters, payload mating, and encapsulation. To maintain cleanroom standards, access to the encapsulation cell wil be controlled via the garment change room and the air lock.

A.4.2.3 Air Lock

An air lock will be located between the encapsulation cell and the payload processing and fueling cells. This air lock will provide an isolated area to establish required cleanliness levels for new equipment arriving prior to being moved into one of the clean processing areas and will allow movement between clean areas.

A.4.2.4 Control Rooms

A control room for contractor GSE will be located adjacent to each processing/fueling cell.

A.4.2.5 Garment Change Rooms

The garment change rooms associated with each processing/fueling cell will provide an area for personnel to don cleanroom garments and fueling suits prior to entering the cells. Each room will have a floor area of approximately 27.9 m^2 and will contain personnel lockers, garment racks, fueling suit storage, cleanroom supply storage, a rest room, and benches. An air shower and a rotary brush shoe cleaner will be located at the entrance to each processing/fueling cell.

A.4.3 Solid Rocket Motor Storage

The ordnance storage in Building 2 (Figure A.4-1) will be located on the east side of the Home Port complex. (Please see Appendix B-20 for information regarding ordnance.) This building will provide storage for 24 Zenit separation motors and one spacecraft motor. Solid rocket stages include the solid propellant separation motors of the Zenit stages and a solid propellant stage that may be included in some spacecraft.

The solid rocket motor storage building will be a single story, concrete masonry structure with a steel joist roof framing system. Beyond the usual loads required for any building, this facility must also meet the design requirements for the storage of solid propellants prescribed by the Department of

Defense (DoD 6055.9 STD), the Uniform Building Code, and the Uniform Fire Code. The motors to be stored in this facility are classified Hazardous Division 1.3 or mass fire hazard. A mass fire hazard is one in which the item will burn vigorously with little or no possibility of extinguishing the fire in storage situations. Explosions will normally be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast over pressures beyond the quantity distance (Q-D) requirements prescribed in DoD (6055.9 STD) and by the Chemical Propulsion Information Agency (CPIA). The building will not be designed as an explosive resistant structure since the primary hazard is mass fire, not an explosion.

A.4.4 Quantity Distance for Home Port Facilities

The determination of Q-D requirements for safe and segregated storage and handling of spacecraft propellants is based on proposed operations and on criteria established by various governmental agencies. The proposed operating procedures used in the analysis are based on the procedures currently used at other U.S. commercial spacecraft processing facilities. The criteria used to determine Q-D requirements are contained mostly in U.S. Department of Defense (DOD) publications, but also include criteria contained in a joint agency document developed by CPIA. The criteria in these manuals was applied to assumptions made by using the procedures currently employed by the spacecraft industry. This resulted in establishing of a Q-D of 94.5 m for inhabited buildings and 56.7 m for public traffic routes. For solid propellant stage separation motors stored on site, the required Q-D is 29.3 m for both inhabited buildings and public traffic routes.

Q-D reference documents:

CPIA Publication 394 - "Hazards of Chemical Rockets and Propellants, Volume 1, Safety, Health, and Environment."

DoD 6055.9 STD - "DOD Ammunition and Explosives Safety Standard," dated October 1992.

Establishes storage compatibility groups (SCG) for explosives. These SCGs are used to keep incompatible materials away from each other during storage. Nitrogen Tetroxide (N_2O_4) is a hazard group I (fire hazard); SCG A (initiating explosive) and monomethylhydrazine (MMH) is a hazard group III (fragment hazard); and SCG C (items that upon ignition will explode or detonate).

TM 5-1300 - "Structures to Resist the Effects of Accidental Explosions," dated November 28, 1990. NAVFAC P-397, AFR88-2.

A.4.5 Warehouse and Storage Facilities

The high bay area in Building 4 (Figure A.4-1) will be used for storage of inert launch vehicle stages and payload fairings.

Building 5 is a small warehouse/office building that will be used to house a small machine shop and contains offices for Sea Launch resident technicians.

Buildings 7, 8, 9, and 10 offer approximately 1,486 m^2 of storage for customer supplies, equipment, and shipping containers. They are constructed of corrugated steel walls and ceilings with slab on grade floors. Each building is approximately 12 m by 30 m with a vertical height of 6.1 m.

Access for equipment is through a single door in the end of each building measuring 2.4 m by 3 m. A single steel personnel access door is located on the end of each building measuring 0.9 m by 2 m. The storage buildings do not contain overhead cranes. Equipment loading is accomplished by either forklifts or wheeled dollies.

Buildings 11, 12, and 13 will be used for the storage of Sea Launch equipment and supplies. With prior coordination, additional customer storage may be arranged in these facilities if necessary.

A.4.6 Home Port Administrative Facility

The Sea Launch office in Building 3 (Figure A.4-1) will provide facilities for the resident Home Port administrative and professional staff and customers. It is a two-story structure with an area of approximately 2,230 m^2. It will consist of a marketing area, a training area, offices, conference rooms, and a break area.

A.4.7 Pier Facilities and Fueling Services

The pier provides facilities for moorage, servicing, and resupply of the Sea Launch vessels. It has a concrete surface over pilings and is approximately 335 m by 18.3 m. It has provisions for electrical power, communications, water, and sewer services to the vessels while in port. It will also have equipment for loading fuels, compressed gasses, and cryogens. Mooring provisions will allow securing the vessels to both sides of the pier for rocket integration and vessel provisioning operations. The vessels can also be secured in tandem on the west side of the pier for transfer of the integrated rocket from the ACS to the LP. Encapsulated payloads will be loaded onto the ACS using the stern ramp.

Kerosene and liquid oxygen are the primary propellants for Stage 1 and Stage 2 of the Zenit rocket and the Block DM-SL upper stage. The only primary propellant fuel loaded onto the launch vehicle prior to leaving the Home Port will be a small quantity of kerosene on the Block DM-SL upper stage. The remainder of the kerosene and all the liquid oxygen will be carried in bulk storage tanks on the LP and transferred to the ILV at the launch location.

Liquid oxygen, liquid nitrogen, and pressurized gaseous helium will be commercially procured for delivery to the Home Port pier in the supplier's mobile equipment. This equipment is designed to meet the applicable requirements for highway transport set by DOT standards in CFR 49. To support their mobile equipment, the supplier may also provide generic equipment that meets appropriate standards.

The following approximate quantity of material will be required for each launch cycle:

Oxygen -	500 metric tonnes
Nitrogen -	240 metric tonnes
Helium -	1 metric tonne
Kerosene (RP-1) -	120 metric tonnes

A.5 ROCKET LAUNCH AND TRACKING OPERATIONS

A.5.1 Zenit Stage 1 and Stage 2 Operations

Zenit first and second stage flight operations are completely automatic. For a typical GTO mission, duration of Stage 1 flight is approximately 2 min and 30 sec, while Stage 2 separates at about 8 min and 41 sec into the mission. A flight event timeline is included in table A.5.1-1.

Table A.5.1-1. Typical Mission Event Times - GTO Mission

Time (min:sec)	Event
00:00	Liftoff
00:08	Begin pitch hover
01:04	Maximum dynamic pressure
01:49	Stage 1 begin gradual throttle to 75%
02:09	Stage 1 begin throttle to 50%
02:21	Stage 2 vernier engine ignition
02:23	Stage 1 shutdown command
02:26	Stage 1 separation
02:31	Stage 2 main engine ignition
03:37	Payload fairing jettison
07:09	Stage 2 begin main engine gradual throttle to 85%
07:29	Stage 2 main engine shutdown command
08:44	Stage 2 vernier engine shutdown
08:44	Stage 2 separation
08:49	Block DM-SL middle adapter jettison
08:54	Block DM-SL ignition #1
12:46	Block DM-SL shutdown #1 / LEO park orbit
42:46	Block DM-SL ignition #2
49:02	Block DM-SL shutdown #2/ GTO
49:17	Spacecraft separation

All Stage 1 and Stage 2 events will occur within the view of either the ACS or the Selena-M tracking ship. The spent stages will fall in the Pacific Ocean, well short of the coast of South America and the major coastal shipping lanes. Any deviation of flight trajectory from preprogrammed limits will cause onboard systems to automatically terminate propulsion and end the mission. This approach to flight safety obviates the need for the traditional range safety officer with a finger on the destruct button.

At second stage separation from the Block DM-SL, four solid propellant rocket motors at the base of Stage 2 will fire to back the stage away from the Block DM-SL. The pause between Stage 2 shutdown and Block DM-SL first firing will be approximately 10 sec. Half way through this period, the Block DM-SL middle adapter will be jettisoned.

Following Stage 1 engine ignition and liftoff, the aerodynamic loads will be minimized by flying with a near zero angle of attack through the high dynamic pressure (Q) regime. A maximum Q of 5300 kgf/m^2 will occur 65 sec after liftoff. A maximum axial acceleration of four g's will occur at 110 sec. At this point the engine will gradually throttle to 75% over a period of 20 sec and then immediately will throttle to 50%, which it will hold until the engine shutdown command at 143 sec. Stage 1 separation will occur at 145 sec.

The Stage 2 engine will ignite slightly before the Stage 1 engine shutdown command, and the main engine will ignite five seconds after separation. To satisfy spacecraft thermal requirements, the payload fairing will be jettisoned at about 220 sec. At 430 sec, the main engine will gradually throttle to 85% over a period of 20 sec. This will be immediately followed by an engine shutdown command at 450 sec. The vernier engines will continue burning for an additional 75 sec, at which time they will shutdown and Stage 2 separation will occur.

A.5.2 Block DM-SL (Upper Stage) Operations

Prior to launch, the Block DM-SL onboard systems will be turned on and initialized, its oxidizer will be loaded, and power will be transferred from the LP umbilical to the Block DM-SL internal power supply. During Stage 1 and 2 flight phases, the Block DM-SL will remain inactive, except for preparations for autonomous flight. Upon reaching the interim orbit, the Block DM-SL will separate from the launch vehicle. Final insertion to a low earth orbit (LEO) park orbit will be achieved with a single main engine burn at the interim orbit apogee with no change in inclination. Prior to each subsequent main engine firing, the Block DM-SL will perform a settling burn using the attitude control system. Burn program options include, but are not limited to, two- or three-impulse insertion of the spacecraft directly into geosynchronous orbit (GEO), one- or two-impulse insertion into geosynchronous transfer orbit (GTO), and multiple burns (up to a maximum of seven) to medium earth orbit (MEO) or planetary escape. Launches from the equator will take up to eight hours to reach geosynchronous orbit.

Block DM-SL ignition will occur 10 sec after Stage 2 separation. Immediately after separation, the Block DM-SL middle adapter will be jettisoned. The Block DM-SL engine will burn for 230 sec to establish an intermediate LEO park orbit. After a 30 min or more coast in this park orbit, the engine will restart and burn for an additional 375 sec to inject into GTO. The 30 min coast will allow for sufficient engine thermal conditioning at the time of restart, and applies to all Block DM-SL restarts.

The LEO park orbit, combined with the equatorial launch location, may be used to deliver a spacecraft to any GTO apogee longitude in a relatively short period of time. Alternatively, the park orbit may be eliminated so that the Block DM-SL directly injects into GTO with a single 605 sec burn. This option cannot be used to deliver directly to any longitude, but it does complete the mission quickly without a coast phase or engine restart.

The Block DM-SL is capable of performing seven engine restarts and can handle a variety of missions and injection strategies. For example, intermediate and high earth orbit satellites may be delivered to either a transfer orbit or the final orbit. Additionally, the Block DM-SL has the capability to perform the phasing to the final desired location in that orbit. During the intermediate coast phases, the Block DM-SL can accommodate sun-angle pointing and continuous thermal rolls.

Tracking and telemetry return will be provided by the ACS, Altair communication satellites, existing Russian-controlled ground stations, and TDRS. During passive flight phases, specific attitude control maneuvers (i.e., a thermal roll) may be conducted by using the attitude control/ullage propulsion engine to meet spacecraft requirements.

Optional functions include establishment of a spin rate of up to 30 rpm prior to spacecraft separation and establishment of a specific orientation at separation. The spacecraft target orbit parameters will be determined and insertion accuracy will be verified for the moment of separation.

Following spacecraft insertion to the target orbit, the Block DM-SL will separate from the spacecraft and perform a contamination and collision avoidance maneuver (CCAM). Disposal options include transfer of the Block DM-SL to a higher or lower disposal orbit or establishment of a low enough orbit to ensure re-entry. The final operation of the Block DM-SL will be to vent all volatile liquids and gasses to prevent explosive destruction.

A.5.3 Range Tracking Assets

The current Sea Launch baseline range tracking assets will be centered on the ACS. Other tracking assets include: a satellite system called Altair (also called Luch or Lutch); ground tracking stations in and around Russia, including the Moscow Center; and TDRS. Other assets continue to be considered. For example, western tracking satellites and mobile tracking stations; however, these assets are not currently part of the baseline. The following paragraphs (Sections A.5.4 to A.5.7) apply to launch vehicle telemetry reception and routing. Payload unit and satellite telemetry handling baseline have not yet finalized.

During the ascent, the Zenit-3SL will be tracked by a combination of ships and satellites. For the first 410 sec the trajectory will be visible to the ACS, which is located five km from the launch platform. Throughout the remainder of the ascent to LEO park orbit, the trajectory will be tracked by TDRS. The Russian Altair tracking and data relay satellite system will provide additional coverage for subsequent Block DM-SL burns.

A.5.4 Assembly and Command Ship

The launch sequence/countdown for the integrated launch vehicle (ILV) will begin several hours before launch and will be controlled remotely from the ACS. After the launch the ACS receives telemetry from the LV until the LV is acquired by downrange assets.

A.5.5 Tracking Downrange System

Launch vehicle telemetry will be received by TDRS. This telemetry will be collected and re-transmitted via communication satellites to the mission control center (MCC) on the ACS and to the Moscow Center.

A.5.6 Satellite Tracking System

After orbital insertion, the Block DM-SL will continue to broadcast telemetry to the Altair satellite system. When the Block DM-SL is within line-of-sight of an Altair, it will broadcast telemetry to the Altair which will relay the telemetry (via communication satellites and ground stations) to the ACS and to the Moscow Center. When the Block DM-SL is not within line-of-sight of an Altair, it will store the telemetry and transmit the data after it comes within view.

A.5.7 Launch Location

Since the Zenit-3SL is launched from a mobile, sea-based launch platform, there is some flexibility in the location of the launch. However, considerations such as stage impact points, weather, and LP transit times restrict the vehicle from being launched at any location. Figure A.5.7-1 identifies the launch region in the Pacific Ocean. All data in this section assume an equatorial launch location with coordinates 0^0 N, 154^0 W. This is approximately 10 days LP sailing time from the Home Port, and less than one day ACS sailing time from Kiritimati (Christmas) Island.

A.5.8 Ascent Trajectory

The Zenit-3SL ascent trajectory will be tailored to optimize the mission's critical performance parameters while satisfying spacecraft and launch vehicle constraints. This section gives an overview of the ascent trajectory and flight profile.

Table A.5.1-1 (Section A.5.1) and Figures A.5.8-1 through A.5.8-3 illustrate a typical Zenit-3SL ascent trajectory for a GTO mission. Table A.5.1-1 is a listing of the times at which the main mission events occur, and Figure A.5.8-1 shows the ascent groundtrack and illustrates the tracking coverage. Figures A.5.8-2 and A.5.8-3 show the flight profile to GTO, with key events and parameters labeled.

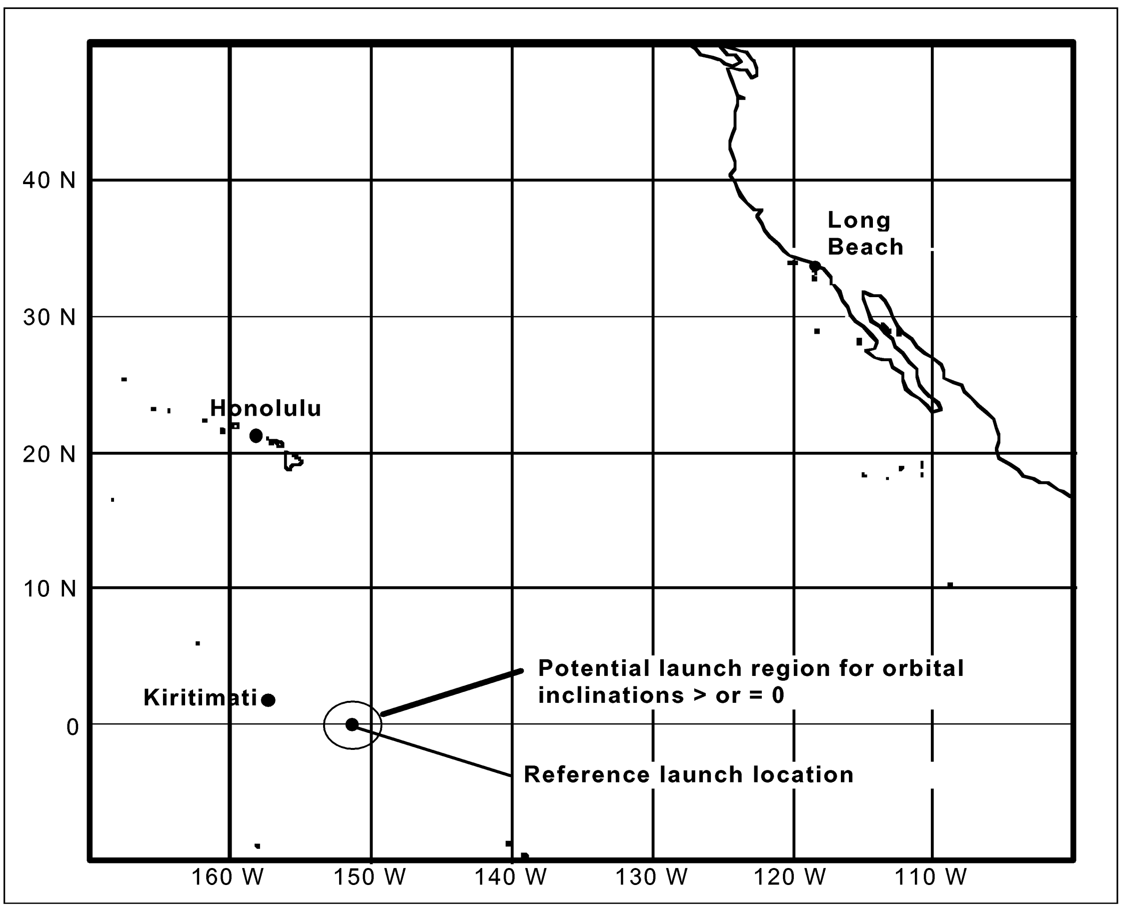

Figure A.5.7-1. Potential Launch Region

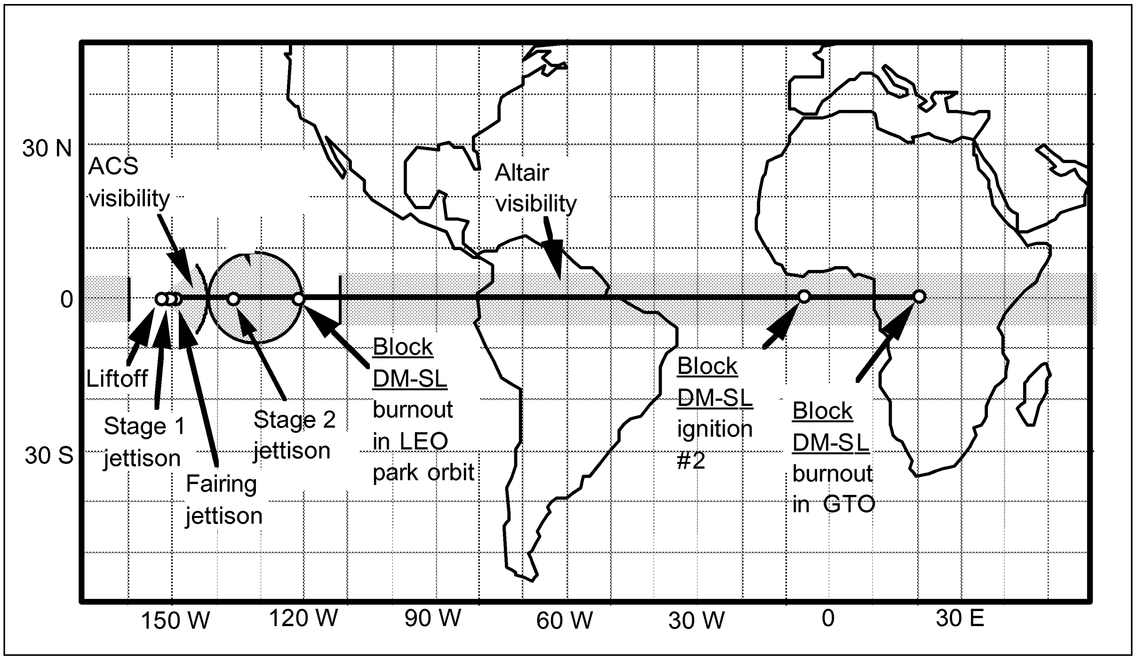

Figure A.5.8-1. Typical Flight Profile - GTO Mission

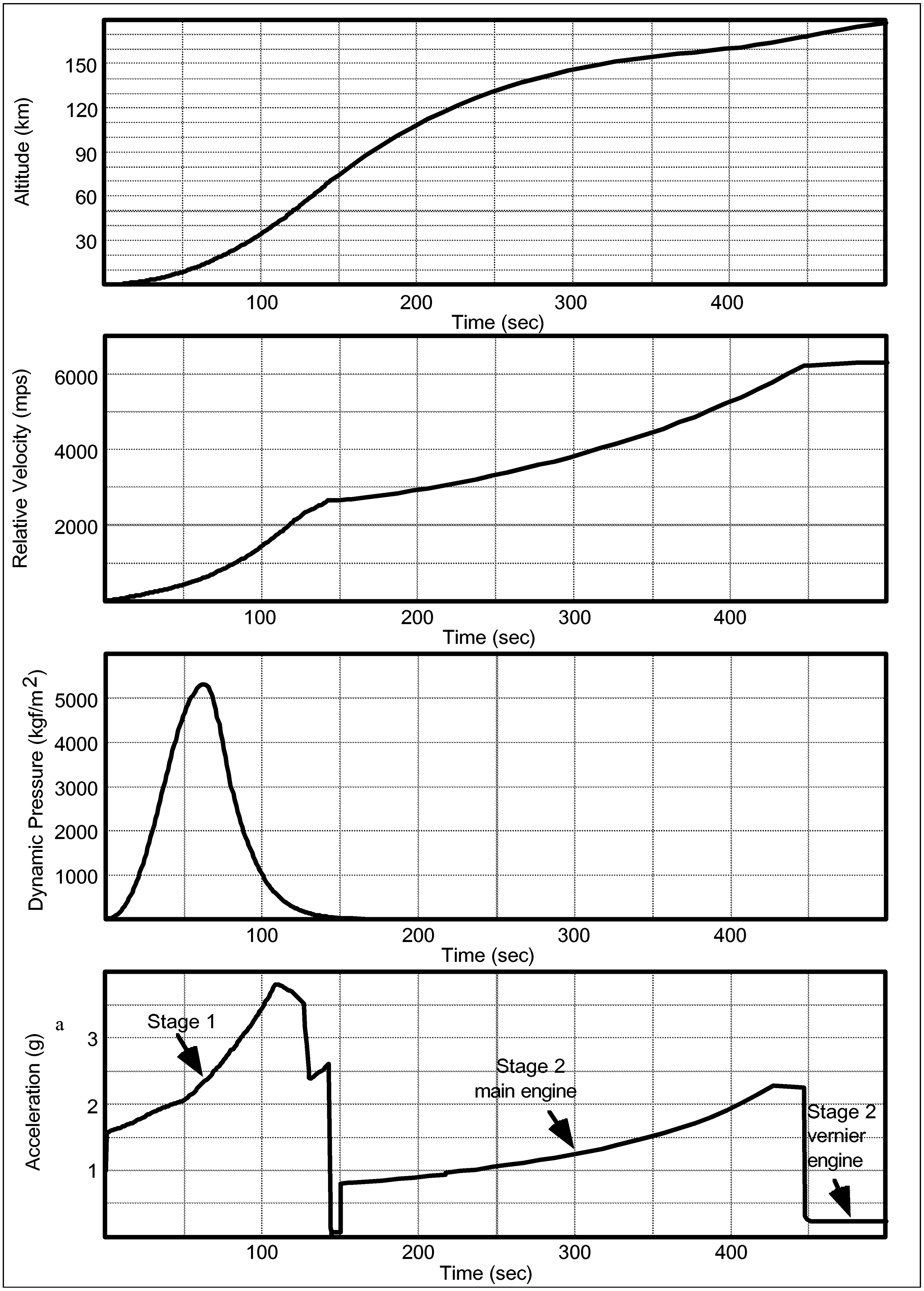

Figure A.5.8-2. Typical GTO Trajectory Parameters - Stage 1 and Stage 2

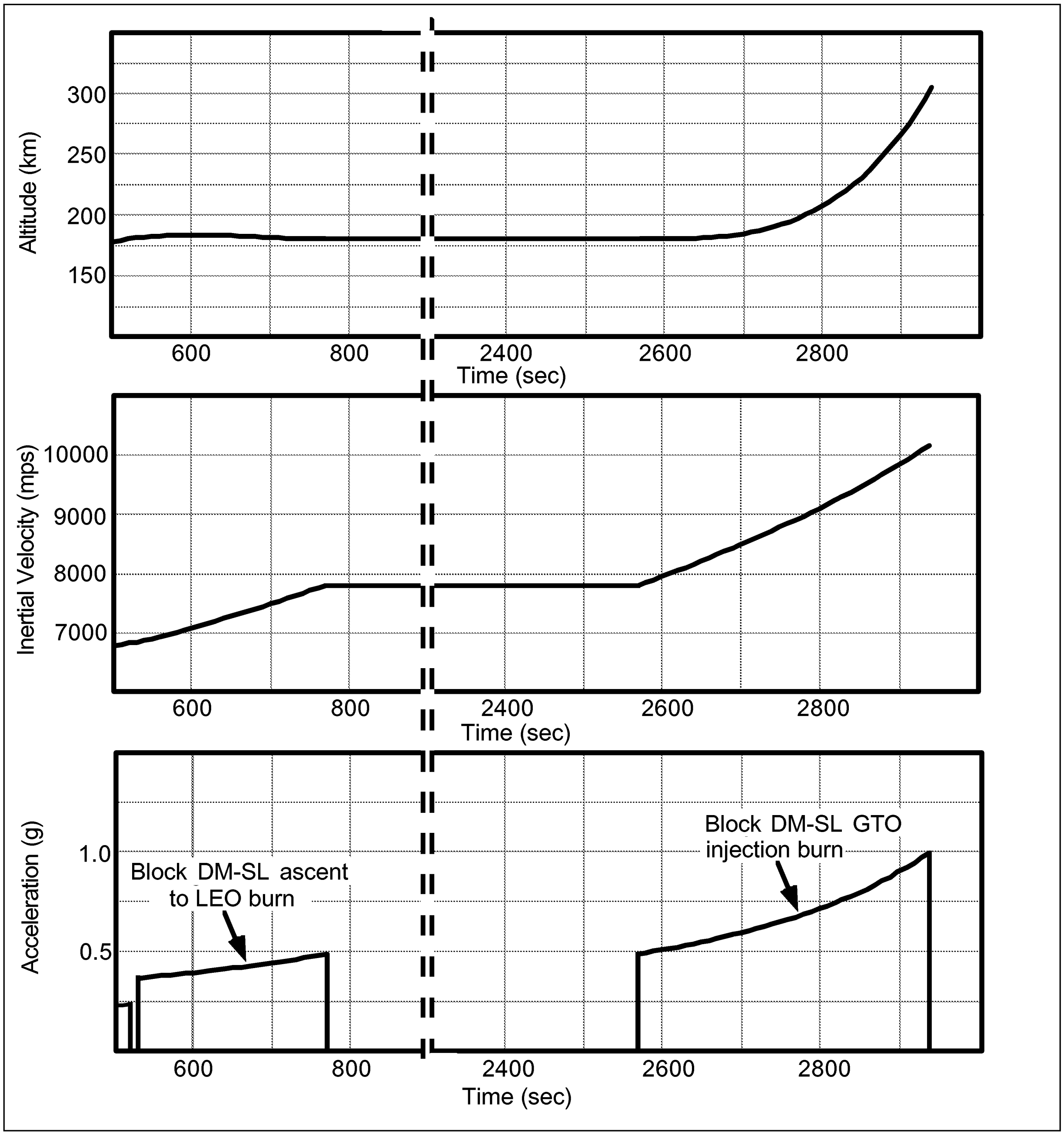

Figure A.5.8-3. Typical GTO Trajectory Parameters - Block DM-SL

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B. OVERVIEW

This appendix describes the hazards that may pose a threat to the public or the environment from Sea Launch operations. Hazards that Sea Launch systems or operating personnel may encounter that do not pose a threat to the public or the environment are not discussed. The following subsections are included: B.1 Home Port Assessment, B.2 Launch Site Assessment, B.3 Characteristics of Hazardous Materials, B.4 Hazardous Waste, B.5 General Industrial Waste, and B.6 List of Hazardous Materials.

The proposed Sea Launch Home Port is an industrial operation common with other daily industrial and commercial activities at the Port of Long Beach located in the Los Angeles area. The Port and City of Long Beach and State of California are highly experienced in regulating varied businesses, many of which are inherently much more hazardous than Sea Launch. Oversight will be provided by the local regulatory agencies responsible for ensuring safety at the Home Port.

The facilities at the Home Port have been specifically designed to minimize the potential for any accidents, and in the rare event of an accident, to minimize the potential impacts. It should be noted that there are no public areas on the Navy Mole. The open space located to the east of the Home Port is being used for the relocation of trees from the Navy Shipyard, supporting the Port of Long Beach in its efforts to obtain air quality credits. The Port of Long Beach has no plans to allow public access to this area. Industrial facilities do not currently operate on the Navy Mole. The Port of Long Beach intends to lease the adjoining property for use as a container storage area, which be similar to the other container storage facilities in the Port of Long Beach.

Risks due to hazardous material spills, explosions, or other catastrophic events will be minimized by the design of the facilities and the required plans and permits for the operation of the Home Port. The facilities have been designed to meet several criteria. The Codes that were followed include: Uniform Building Code, Uniform Fire Code, National Electric Code, DOD Ammunition and Explosives Safety Standards, and Chemical Propulsion Information Agency (CPIA) guidance. In addition to meeting a variety of design criteria, operation of the Home Port will not occur until Sea Launch has prepared numerous plans which are required by Federal, state, and local regulations. These include, but are not limited to: Chemical Import Certification, Hazardous Materials Emergency Plan, Spill Prevention Control and Countermeasure Plan, Facility Response Plan, Operations Manual, Stormwater Pollution Prevention Plan, and Hazardous Materials/Dangerous Cargoes permit.

Under these plans, Sea Launch will develop designs (e.g., dikes, berms) to contain spills of petroleum and will outline responsibilities and perhaps conduct simulations to respond to catastrophic hazardous material or other events. Sea Launch will actively work with local emergency organizations (e.g., fire and police departments) to ensure these preparedness and response plans are based in reality. Sea Launch has the benefit of designing the facility with safety in mind. Safety distance requirements for storage and handling of propellants were determined to be adequate to protect inhabited buildings and public traffic routes (Department of the Navy, 1996). Employees will be informed of work hazards and trained to follow proper operating procedures and to respond to anomalies. Response to spills into the port or navigable waterways and other environmental areas will be coordinated logistically and procedurally with Coast Guard and other proper authorities.

Although the results of a potential accident could be substantial, between the design of the facility and the plans and procedures that are required to be in place by regulations, it is anticipated that any impacts to public safety and the environment would be minor and mitigatable.

Specialized facilities and equipment are being designed and will be constructed for the dedicated purpose of Sea Launch Home Port operations. A primary objective of the design and construction will be to ensure safety of not only Sea Launch employees, customers, and extremely high value equipment, but to safeguard the public, property, and the environment.

Sea Launch will provide new seagoing vessels which will be used to perform the final steps in the rocket assembly process. These vessels will contain unique features which will enable Sea Launch personnel to support launch vehicle assembly operations and ensure safe operations. Local port regulations, national and international maritime regulations, and design standards will be adhered to in the design of the vessels and in the operations carried out onboard.

Sea Launch will provide a working marine facility where provisioning, storage, and fueling will be performed in support of the maritime operations. Existing buildings, the pier, driveways, and utilities will be upgraded for the dedicated functions performed on the vessels and through the use of its support equipment. Operations will be comparable to other marine terminal and industrial facility activities currently being performed in the port area.

Sea Launch will conduct a thorough and formal safety analysis of designs and operations prior to the start of testing or to the start of normal operations. This effort will be led by Boeing Commercial Space Company (BCSC) personnel, who have gained a high level of experience in the safety analysis process from years of work in the defense and aerospace industries. The Boeing Company's policies emphasize safety and environmental protection in all operations for commercial, non-commercial, and internal ventures. Sea Launch management stresses safety and environmental protection as a key issue throughout the program planning and development phases. The development structure used within Boeing and carried over to Sea Launch is to build in safety by identifying and mitigating potential hazards early in the preliminary design phase.

This safety analysis approach has several important benefits to Sea Launch:

1. Economy in lower rework costs and lower costs due to liabilities.
2. Efficiency due to improved delivery response and fewest interruptions.
3. Protection for employees, the public, public property, Sea Launch assets and investments, and the environment.
4. Prevention of fines and stop work orders by ensuring compliance with applicable regulations.

The Home Port will be located on the converted Long Beach Naval Base breakwater known as the "Mole." The property will be owned by the Port of Long Beach which has controls in place to limit public access. The facilities surrounding the Home Port consist of container cargo terminals, heavy industrial manufacturing plants, shipyards, oil drilling, and other comparable industrial and maritime activities. Considerable distances separate the Home Port property from non-industrial activities. The Queen Mary (the nearest tourist attraction) is 2.4 km away. The Interstate 710 freeway area is a major traffic artery feeding the port area and is over 1.6 km away at its closest point. Nearest urban development containing small businesses, residences, and major shopping centers is 3.2 km to 6.4 km away.

Home Port operations will mainly consist of the receipt, processing, and transferring of payload elements at the land-based facilities, and the receipt, processing, and transferring of rocket elements onboard the vessels at the pier. A new perimeter security fence will fully enclose and control access to Sea Launch property. The final spacecraft assembly, checkout, fueling, and encapsulation will take place in the newly constructed payload processing facility (PPF). The PPF is located inside a separate perimeter fence and provides a completely controlled environment for critical operations. The existing pier will be upgraded to provide moorage and utilities for the Sea Launch vessels. The basic structure of the pier will not be modified. A landing will be constructed to interface with the ACS stern ramp for roll-on/roll-off of cargo and rocket components.

Maritime operations will include pier side loading of supplies and equipment, vessel fueling (which will not occur at the Home Port), and transit between the Home Port and the launch location. At the launch location, the LP will be ballasted to a deeper draft to gain greater stability. The process of ballasting is not unique to Sea Launch and will present no hazard. The transfer of the launch vehicle on the vessels and movement of propellant from storage tanks to the launch vehicle requires appropriate shifting of water ballast to maintain the required vessel pitch and trim. Fueling of the launch vehicle will be accomplished after all personnel have been evacuated from the launch platform. The fueling system will be designed to preclude the release of RP-1 fuel (kerosene) into the environment during normal operations. The launch vehicle will be defueled in the event of a launch abort. During an abort after first stage engine ignition, approximately 70 kg of RP-1 will be lost from the fuel lines (Section 4.3.1). The propellant fueling system will be designed to retain all of the RP-1 fuel during the LV de-tanking operation. There will be some loss of oxygen due to boil-off during the tanking and de-tanking operations, but this loss will have no environmental impact or safety implications. Liquid nitrogen will be used to condition the fueling system and is converted to gaseous nitrogen to purge fueling system of vapors prior to disconnect of fueling fittings. This operation will prevent spillage of propellant components (kerosene and liquid oxygen) when disconnect occurs. During the purging process some kerosene vapors will be released into the environment.

B.1 HOME PORT ASSESSMENT

The detailed operations performed at the Home Port are summarized as follows:

1. The operations will begin with several warehouse and terminal type activities.
    - a) Delivery of spacecraft and ground support equipment (GSE).
    - b) Delivery of rocket stages.
    - c) Delivery of flammable liquids.
    - d) Delivery of compressed gases.
2. The use of crane and materials handling operations to place components in storage or processing as appropriate.
    - a) Use of cranes to move payload and rocket elements in PPF and ACS.
    - b) Use of dollies and trolleys to move rocket and fairing elements in warehouse.
    - c) Use of transport vehicles to move encapsulated payload between buildings and vessels.
    - d) Use of handling fixtures and stands to align and mate launch vehicle elements during final assembly.
3. Assembly and test steps involve systems checkout, final installations, and pressure tests of spacecraft and stages.

4. Cargo handling, terminal and bulk plant type operations, transfer components between vessels, and land facilities.

    a) Loading of flammable liquids and compressed gases from trucks to vessel tanks.

    b) Transfer of integrated launch vehicle from ACS to LP.

    c) Crane lifting of fairing containers from barge to pier or from truck to transport dolly.

5. Warehousing and shipping operations will involve unpacking and uncrating, receipt of maintenance supplies, materials storage, fairing container handling, and forklift and hoist operating.

B.1.1 Preliminary Hazard Analysis of Home Port Land-Based Operations

Preliminary hazard analysis of the Home Port operations began with the development of a list of high-level hazards that are based on materials and equipment involved in the operation. Four areas of concern were also determined for inclusion in the evaluation. They are as follows:

1. Public safety.
2. Sea Launch and customer personnel safety.
3. Damage to equipment or equipment safety.
4. Environmental protection.

The four principal hazards and general tasks identified which may have impacts on the public or the environment are:

1. Handling propellants for spacecraft and upper stage; transport and fueling with MMH, N_2H_4, and N_20_4.
2. Handling solid rocket motors and pyrotechnic devices; shipping and installation of SRMs, explosive bolts, pin pullers, cable cutters, and pyro-activated valves.
3. Loading launch vehicle gases and fuel on vessels; receipt and transfer of LOX, nitrogen, helium, and kerosene to bulk tanks onboard the LP and ACS.
4. Handling rocket stages and the assembled launch vehicle, crane lifts and wheeled dolly movements of fueled vehicle elements, and crane transfer of the assembled launch vehicle to LP.

In assessing potentially hazardous operations, all of the tasks contained in the operations were evaluated. Those that met the principal hazards criteria were grouped together in related generic operational categories. The categories of tasks identified as potentially hazardous are discussed in the following paragraphs.

It should be noted that all of the operations identified as potentially hazardous will be conducted in Sea Launch facilities which are uniquely designed to support the operation. The Navy “Mole” is designated as Port of Long Beach property, and public access to the location is limited. The Home Port site is fully fenced and patrolled by 24-hour security. Access to areas supporting hazardous operations will be strictly controlled.

B.1.1.1 Payload Processing Facility Operations

Four operations related to the processing of spacecraft at the payload processing facility have been identified as potentially hazardous due to the potential for a hazardous material release and employee exposure during a release. The major hazards involved in these operations are summarized here from detailed information and analyses prepared as part of Home Port permitting and licensing by Federal, state and local government agencies (Port of Long Beach Harbor Development Permit application):

1. Handling of flammable fuels and toxic oxidizers for spacecraft processing.
2. Handling of small pyrotechnics valves, pin pullers, and cable cutters during installation in the spacecraft and fairing.
3. Operating pressurized systems containing high pressure gas or toxic/flammable liquids onboard the spacecraft.
4. Crane handling of fueled spacecraft from the fueling stand, to the dolly, and to the encapsulation stand.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch and customer employees.
3. Minor impact to public safety or to the environment is anticipated due to the small quantities of hazardous materials present, and because the Home Port's location is relatively isolated from the general public.

The potential for major, adverse impact to Sea Launch employees, customers, and property from these operations is a driving force behind the design of the facilities and equipment described in the introduction of this section (Appendix B). Labor, building design and construction, and environmental regulations at the national, state, and local level must be satisfied before Sea Launch will develop and operate these facilities. Compliance with these regulations will aid in ensuring a safe environment in which to conduct Sea Launch operations, and will provide protection for the public and the environment.

B.1.1.2 Home Port Pier and Storage Facilities Operations

Operations related to materials handling operations at the pier, storage facilities, and throughout the Home Port site have been identified as potentially hazardous. The major hazards involved in these operations are:

1. Transfer of high pressure gasses and cryogenics from trucks to vessel bulk tanks, and the transfer of flammables and combustibles in transportable tanks to vessel storage areas and bulk tanks.
2. Handling of fueled and pressurized spacecraft from the PPF to the ACS via driveways and the stern ramp.
3. Transport of low explosive devices in shipping containers from delivery trucks and vessels to storage facilities and to vessel storage and assembly compartments.

4. The handling of unfueled rocket stages and support equipment via driveways, the stern ramp, and cranes from delivery vessels to storage facilities and to vessel assembly compartments.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch and vendor employees.
3. Minor impact to public safety or to the environment because of the small quantities of flammables and low explosives present and due to the isolation of the location.

B.1.1.3 Rocket Stages Processing

Major hazards involved in operations related to processing rocket stages and assembling the integrated launch vehicle onboard the ACS have been identified as follows:

1. Handling of combustible fuel, flammable fuel, and toxic oxidizer for upper stage processing.
2. Handling of low explosives devices and pyrotechnic devices during installation on stages.
3. Crane handling and moving rocket stages on wheeled dollies during processing and assembly.
4. Handling of fueled and pressurized spacecraft with the crane and wheeled dolly for alignment and mating to upper stage.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch employees.
3. Minor impact to public safety or to the environment due to the small quantities of flammables and low explosives present and due to the isolation of the location.

B.1.1.4 Integrated Launch Vehicle Transfer

One operation that has been identified as potentially hazardous is the transfer of the integrated launch vehicle from the ACS to the LP. The major hazard involved in this operation is in the crane handling of the integrated launch vehicle (consisting of the fueled spacecraft, partially fueled Block DM-SL, and unfueled rocket stages with solid rocket retro motors installed) during the transfer from the ACS stern ramp to the LP rocket hangar.

The potential impacts in the areas of concern are:

1. Minor impact to public safety or to the environment due to the small quantities of flammables and low explosives present and due to isolation of the location.
2. Potential for major impact from injuries which could occur to Sea Launch employees.

3. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.

B.1.2 Regulatory Agencies and Regulations

The types of potentially hazardous operations (listed above) identify the areas that are being assessed in detail and will receive oversight in facility and equipment development. The regulatory environment in California provides considerable oversight to this development with numerous controls on the Home Port development and operation. Tables B.1.2-1 through B.1.2-3 illustrate the four basic areas of concern (public safety, personnel safety, equipment safety, and environmental protection) and the regulatory focus for the previously identified operations. The table title contains the general description of the type of operations included. The matrix provides a general breakdown of regulatory agencies, and regulations related to each area of concern are shown for three levels of government.

The matrix can be used as a road map to show the application of regulations and agency oversight on identified potential hazards. It also serves as a preliminary "check-off" tool to verify compliance with the laws imposed on the Home Port design and operations.

B.1.2.1 U.S. Coast Guard

Because of the marine nature of the Home Port development, one of the most prominent agencies that Sea Launch will be working with is the U.S. Coast Guard. The U.S. Coast Guard has the charter to enforce the safety and security of ports and to enforce laws relating to the protection of the marine environment in the United States.

B.1.2.2 Federal Occupational Safety and Health Administration

The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) is chartered to develop and promulgate occupational safety and a California agency is tasked with administering federal and the state's OSHA regulations. While occupational safety is not specifically public safety, it is mentioned here because attention to occupational safety will be a contributing factor to public safety. For example, OSHA regulations address crane operations, hazardous material handling, and safety analysis of hazardous operations. Regulation of these occupational hazard areas will additionally reduce potential for adverse impacts to public safety and the environment.

B.1.2.3 Long Beach Department of Health and Human Services

The Department of Health and Human Services is chartered to protect the public from exposure and/or the adverse health effects of hazardous substances. Hazardous substance requirements are also a matter of concern for the California Department of Toxic Substances Control, the Long Beach Health Department, and the Long Beach Fire Department.

Table B.1.2-1. Receipt, Storage, and Transfer Spacecraft and Upper Stage Fuel

Description, Hazard, Area of Concern	U.S. and International Agencies	State of California Agencies	Local Agencies
Public Safety	49 CFR, Transportation including: 171, General 177, Explosives 178, Packaging 32 CFR 650, Storage of Hazardous Materials 40 CFR 112, Oil Pollution 40 CFR 300-350, SARA	California Dept. of Toxic Substances Control, California State Office of Emergency Services	Long Beach Fire Dept., Risk Management and Prevention Program, Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 119, Process safety management of highly hazardous chemicals	California Health and Safety Code, California Labor Code/ calico California Department of Health Services	
Equipment Safety	National Fire Protection Association 30, Chapter 4, Flammable and Combustible Liquids Code		City of Long Beach Dept. of Planning & Building
Environmental Protection	40 CFR, Protection of Environment, Environmental Protection Agency	California Environmental Protection Agency, California State Water Resource Control Board, Cal. Coastal Commission	Port of Long Beach, South Coast Air Quality Management District, Regional Water Quality Control Board

B.1.2.4 California Office of Emergency Management

The Office of Emergency Management is chartered to prevent or mitigate damage to human health and the environment. This requirement is promulgated through the Business Emergency Plan, which is submitted to and evaluated by the Long Beach Fire Department.

B.1.2.5 Long Beach Fire Department

The Long Beach Fire Department is responsible for the protection of life and property within the community. One of the major permits that Sea Launch must obtain is the Risk Management & Prevention Plan (RMPP). The RMPP includes an intensive system safety evaluation of the design of equipment, work practices, system reliability, and preventive maintenance procedures. It also includes risk assessment for specific equipment, emergency response planning, and the internal or external auditing procedures.

Table B.1.2-2. Transfer of LOX, Kerosene, Nitrogen, and Helium from Transport Trucks to LP Storage Tanks

Description, Hazard, Area of Concern	U.S. and International Agencies	State of California Agencies	Local Agencies
Public Safety	49 CFR, Transportation	California Dept. of Toxic Substances Control, California State Office of Emergency Services, California Harbor and Marina Code	Long Beach Fire Dept., Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration	California Health and Safety Code, California Labor Code/ Calico, California Department of Health Services	
Equipment Safety	National Fire Protection Association 30, Chapter 4, Flammable and Combustible Liquids Code 49 CFR, Transportation	California Harbor and Marina Code	City of Long Beach Dept. of Planning & Building
Environmental Protection	40 CFR, Protection of Environment, Environmental Protection Agency	California Environmental Protection Agency, South Coast Air Quality Management District, California State Water Resource Control Board, Cal. Coastal Commission	Port of Long Beach, Regional Water Quality Control Board

Table B.1.2-3. Receipt, Storage, and Transfer to ACS of Solid Rocket Motors and Ordnance

Description, Hazard, Area of Concern	U.S. and International Agencies	State of California Agencies	Local Agencies
Public Safety	27 CFR, Chapter 1, Part 55, Bureau of Alcohol, Tobacco, and Firearms, Commerce in Explosives 29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 109 Explosives	California Health and Safety Code, Division 11	Long Beach Fire Dept. Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 109 Explosives	California Health and Safety Code, California Labor Code/ Calico	Long Beach Fire Dept.
Equipment Safety	National Fire Protection Association 495, Explosive Materials Code, Chapter 6, Above Ground Storage of Explosive Materials		Long Beach Fire Dept. Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Environmental Protection		No Impact (unless fire or other event releases chemicals to the environment (see 40 CFR)	

B.2 LAUNCH LOCATION ASSESSMENT

B.2.1 Preliminary Hazard Assessment of Pre-Launch Operations

Pre-launch operations will take place at the launch location and involve positioning the vessels, doing final processing of launch vehicle and satellite hardware, and staging and preparing equipment on the vessels to enable the launch. These operations are described in paragraph 5.2.1 as part of the assessment of environmental impacts. Employee safety considerations are addressed in the Safety Risk Assessment which is part of the Sea Launch license application (SLLP Launch License Application D688-10121-1). The Safety Risk Assessment includes provisions for readiness reviews and rehearsals prior to each launch to demonstrate that the Sea Launch personnel, policies, and procedures meet or exceed all safety standards and requirements imposed by AST.

B.2.2 Preliminary Hazard Assessment of Launch/Flight Operations

Flight operations for Sea Launch will begin with the liftoff of the launch vehicle from the launch platform and continue until the spacecraft is separated and the Block DM-SL is placed in a safe disposal orbit. For a typical geosynchronous transfer orbit (GTO) mission, the total elapsed time until spacecraft separation is approximately 50 minutes, of which nearly 20 minutes is in a thrusting state. Upon reaching low earth orbit (LEO), approximately 13 minutes after liftoff, the potential for hazards affecting the earth are significantly reduced. Potential hazards resulting from flight operations can be grouped into two primary categories: normal operations and contingent operations. In each of these categories, hazards can also classified into two subsets: public safety and on-orbit safety.

B.2.2.1 Normal Operations

B.2.2.1.1 Public Safety

During normal flight of the launch vehicle, all operations prior to attainment of LEO occur over open ocean waters. An important parameter used to quantify hazard potential is the instantaneous impact point (IIP). The IIP is the location on the earth's surface where the launch vehicle would impact if the thrust were terminated. The IIP can be used to predict areas in which pieces of the rocket will impact the earth's surface at various times in the ascent trajectory. Additional effects, such as launch vehicle dispersions, atmospheric drag and winds, can also be applied to the IIP to give higher confidence to the regions in which returning debris is likely to fall. Because of the remote launch location, all pieces of debris normally returning to earth fall in open ocean waters.

Figure B.2.2-1 shows the ascent groundtrack and IIP as functions of time for a typical GTO mission. During staging operations prior to the attainment of LEO, the spent stages are jettisoned and return to earth under gravitational influence. Additionally, shortly after Stage 2 ignition, the protective fairing surrounding the spacecraft is also jettisoned for return to earth. A sleeve adapter surrounding the lower portions of the Block DM-SL is also jettisoned during Stage 2 separation. As shown in the figure, all pieces of debris return to earth over broad ocean waters. Shipping traffic routes indicate that the vessel density in the equatorial debris fall zones is among the lowest in the world. Since no debris impacts on populated areas, the risk to public safety from normal operations is negligible.

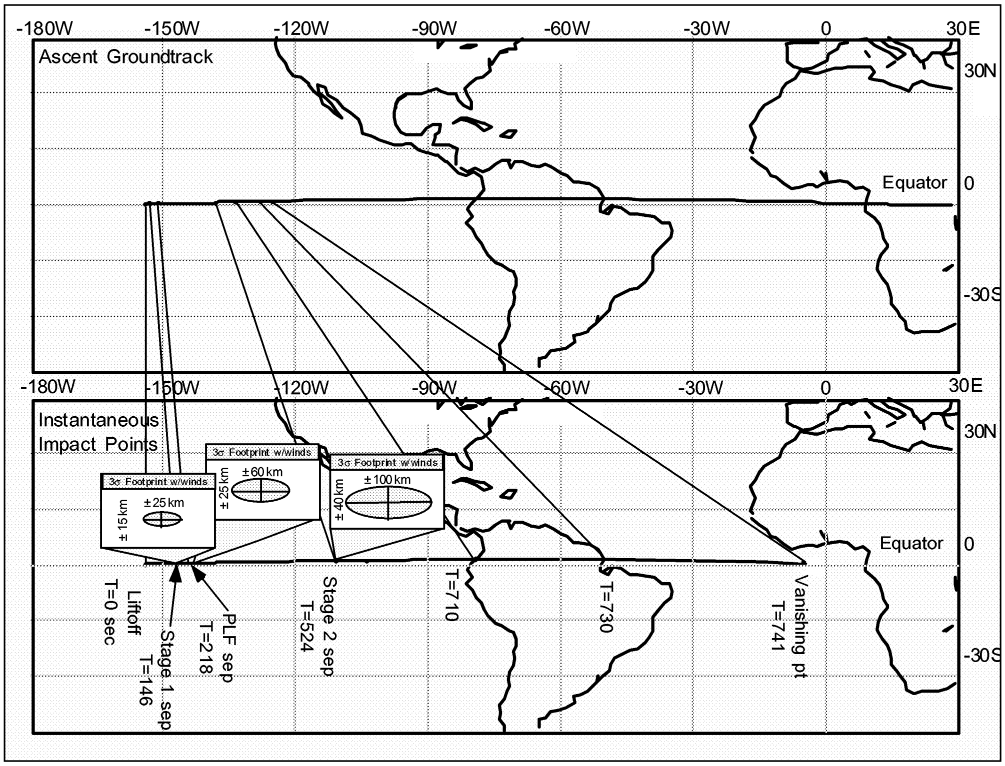

Figure B.2.2-1. Typical Ascent and Instantaneous Impact Point Groundtrack

B.2.2.1.2 On-Orbit Safety

After the vehicle reaches LEO, the primary hazards associated with the flight operations are related to the generation of orbital debris. This is most important during separation and after mission completion when the spent Block DM-SL is left in a disposal orbit. During separation, there is the potential for the generation of orbital debris from pyrotechnic bolts or releasing mechanisms. Sea Launch requires that no orbital debris be generated during spacecraft separation, thus mitigating the hazard risk of orbital debris generation from separation bolts or debris. For long-term storage of spent upper stages, Sea Launch has adopted NASA 1740.XX ("Guidance and Assessment Procedures for Limiting Orbital Debris," 1995) as a program goal for mitigating the risk of on-orbit debris. This NASA document defines characteristics for both normal and contingent operations. One of the critical parameters for normal operations is the spent upper stage final disposal orbit. Figure B.2.2-2 shows the acceptable regions for circular disposal orbits. For transfer orbits, the projected life until atmospheric reentry should not exceed 25 years. Shortly after successful spacecraft separation, the Block DM-SL vents all propellants and gases. This procedure mitigates potential problems associated with previous Block DM ullage motor tanks exploding while in the post-mission storage orbit and provides for a safe storage configuration.

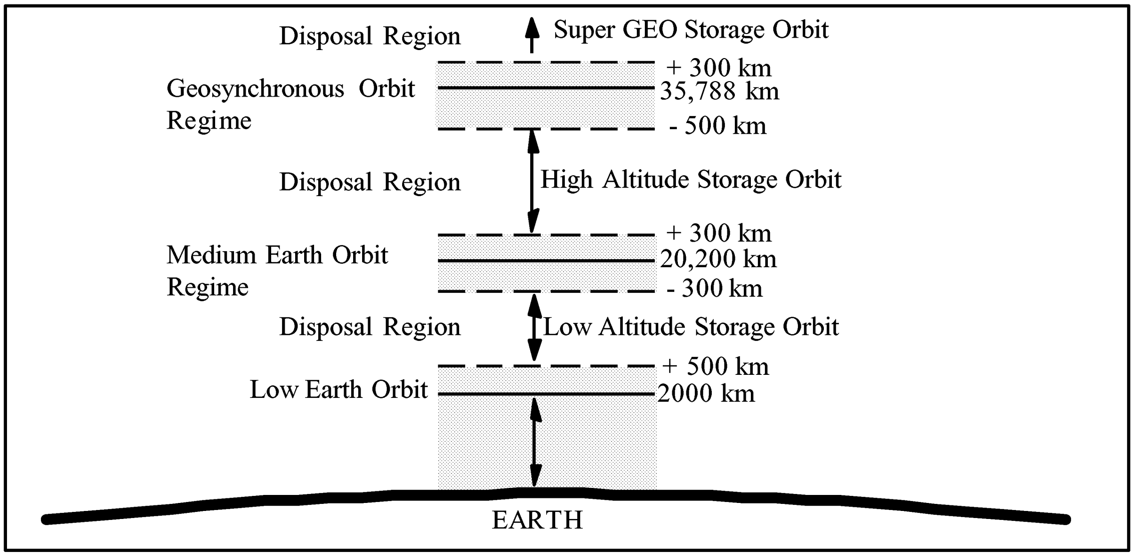

Figure B.2.2-2. Circular Disposal Orbit Regimes for Spent Stages

B.2.2.2 Contingent Operations

B.2.2.2.1 Public Safety

Contingent operations include the various failure modes that cause the vehicle to operate in an unsafe or unplanned trajectory. Such operations include, but are not limited to, rocket motor failures, explosions, control system failures, and electronic system failures. Since the launch occurs in remote ocean waters, the vast majority of the IIP dwell time is spent over ocean waters. Because of this fact, the flight hazards that potentially affect the general public are reduced. In order to assess the hazard risk during IIP passage over populated areas of South America, a quantifiable measure of risk must be used. One such measure of safety commonly used is the casualty expectation, which is the probability of a fatality due to flight operations. A typical level of safety for rocket launches is one casualty for each one million launches. This casualty value has been adopted as the Sea Launch objective for overall flight safety based on its functional equivalence to the values used at U.S. Government launch ranges. A comparison between Sea Launch and traditional functions performed by the U.S. at the Eastern Test Range (ETR) (Cape Canaveral) and the Western Test Range (WTR) (Vandenberg) was considered (SSLP, 1997).

Sea Launch safety assurance will be primarily obtained through proper analysis, testing, mission planning, and design of the Zenit flight safety system, and is described fully in the Sea Launch System Safety Plan. Determination of the casualty expectation is a function of the system failure rate, impact debris size, population density, and the time the IIP remains over populated areas (i.e., dwell time). For a typical GTO mission, the casualty expectation is considerably less than the one in a million safety objective (SSLP, 1997).

To ensure safe launch vehicle operations in the event of a flight contingency, the Zenit-3SL will incorporate an autonomous flight safety system (FSS) that reduces the hazard risk presented to the public. The FSS will use the Zenit-3SL flight control computers to monitor both computer health and status and mission performance. In the event of a failure in the computer or in the overall launch system, a thrust termination system will be activated that terminates engine thrust. In order to assess the flight computer health and status, three processors will be used in a voting scheme to filter out anomalous signals or failed processors. If the computer determines it is operating without sufficient redundancy, it will issue a command to terminate the launch vehicle thrust. Flight performance verification will be accomplished by comparing the actual launch vehicle flight angles with preplanned flight angles. Whenever the actual angles exceed predetermined tolerance limits, the flight computer will terminate main engine thrust, preventing errant rocket trajectories. Figure B.2.2-3 illustrates these angles for a typical GTO mission. By conducting computer simulations of a wide variety of failures at various times in the ascent trajectory, impact limit lines (ILL) can be determined for the purposes of determining where debris could fall. A statistical confidence level, such as three standard deviations, is commonly used to quantify the dispersions that could cause the debris to fall within this flight corridor if a catastrophic failure were to occur. The ILLs include dispersions in launch vehicle guidance, navigation and control systems, as well as atmospheric wind effects.

Through the combination of a remote launch location and the autonomous FSS, hazards to the public will be minimized and kept well within acceptable levels.

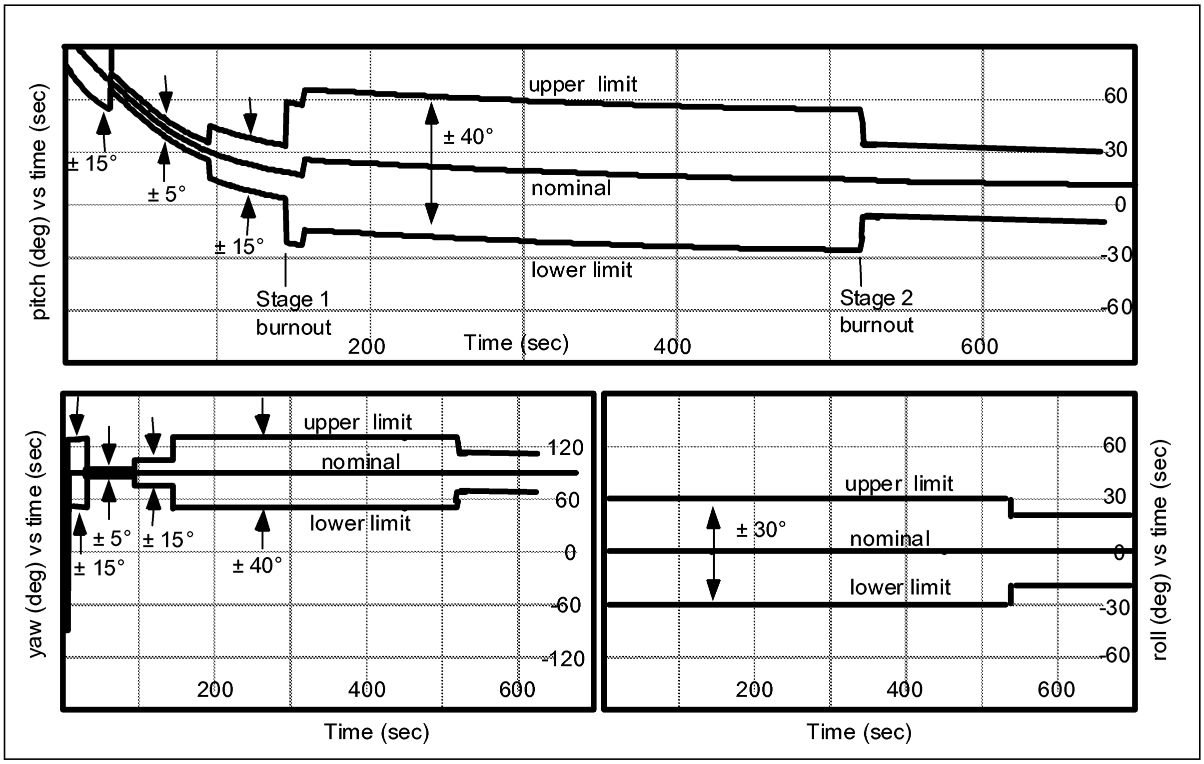

Figure B.2.2-3. Flight Safety Angle Limits

B.2.2.2.2 On-Orbit Safety

Once in orbit, potential hazards to other spacecraft will occur if a flight contingency occurs. As discussed in Section 5, paragraph 5.2.4, contingent flight operations will result in two primary failure modes. The first is when an in-flight fire or explosion destroys the Block DM-SL and spacecraft, dispersing fragments in orbit. This failure mode is more hazardous for on-orbit safety, since a potentially large number of pieces propagate through space, creating the potential for orbital collisions with viable spacecraft. In the second failure mode, the FSS system terminates thrust and separates the spacecraft prior to its intended orbit. This failure mode is desirable because the Block DM-SL vents all gasses and propellants and remains intact in orbit. Additionally, the spacecraft is also separated, thus providing for potential mission salvage through the spacecraft onboard systems.

B.2.3 Preliminary Hazard Assessment of Post-Launch Operations

Operations data for this section are very preliminary; more detailed information will be available in 1997 and may be requested from Sea Launch Limited Partnership (SLLP) at that time.

B.3 CHARACTERISTICS OF HAZARDOUS MATERIAL

The principal hazardous material handled at Sea Launch facilities are the chemicals used in the propulsion systems of the integrated launch vehicle. These include liquids, solids, and ordnance used to operate propulsion system valves, to operate each stage of the rocket, and to operate the spacecraft (see Table B.3-1 for a listing of ILV hazardous materials). Ordnance is also used to initiate spacecraft appendage deployment after launch.

Table B.3-1. Summary of Integrated Launch Vehicle Hazardous Material

Rocket Vehicle	Approximate Mass
1. Propellant mass loaded on Stage 1:	325,100 kg
a. Liquid oxygen	235,330 kg
b. RP-1 fuel	89,775 kg
c. Starting fuel	4.25 kg
2. Propellant mass loaded on Stage 2:	81,650 kg
a. Liquid oxygen	58,700 kg
b. RP-1 fuel	22,950 kg
c. Starting fuel	4.25 kg
3. Upper stage, Block DM-SL:	
a. Main propellant mass loaded	14,870 kg
b. Liquid oxygen	10,545 kg
c. RP-1 fuel	4,325 kg
d. Propellant mass loaded in the auxiliary propulsion system & main engine starting fuel	
(1) Nitrogen tetroxide	35 kg
(2) Monomethylhydrazine	60 kg
(3) Nitrogen (pressurization)	2 kg
(4) Starting fuel (mixture of triethylaluminum and trimethylaluminium)	2 kg
Data On Pyrotechnics	**Quantity of Hardware**
1. Stage 1:	
a. Solid rocket retromotors (21.1 kg propellant each) within the separation system	4
b. Pyrotechnic valve in the propellant system	1
c. Pyrotechnic valves in the pressurization system (helium supply from submerged high pressure vessels)	5
2. Stage 2:	
a. Solid rocket retromotors (5.25 kg propellant mass each) in the stage separation system	4
b. Explosive bolts for separation from Stage 1	10
3. Upper stage (Block DM-SL):	
a. Explosive bolts for separation from Stage 2	10
b. Explosive bolts for sleeve separation	8

Liquid fuels and oxidizers will be used as propellants. The spacecraft will be primarily fueled with monomethyl hydrazine (MMH); however, some spacecraft will use anhydrous hydrazine (AH). The oxidizer used by the spacecraft is primarily nitrogen tetroxide (N_2O_4). These components are handled at ambient conditions without elevated pressures or reduced temperatures. They are volatile and, when in contact with one another, will spontaneously ignite, liberating extremely large quantities of heat and gas (hypergolic). A particular spacecraft may require only fuel (i.e., monopropellant system) or both fuel and oxidizer (i.e., bipropellant system).

The upper stage (Block DM-SL) attitude control/ullage propulsion engines use monomethylhydrazine (MMH) and N_2O_4. The two stages of the Zenit and the main engine of the upper stage use kerosene (RP-1) for fuel and liquid oxygen as the oxidizer. The upper stage fuel is loaded prior to mating with the Zenit second stage. The remaining fuel and oxidizer are loaded during pre-launch processing at the launch location after personnel have evacuated the launch platform.

The following quantity of material represents the maximum expected for any launch:

1. Spacecraft propellant for a typical spacecraft.

   a) Monomethylhydrazine - 680 kg (1,500 lb)

   b) Nitrogen tetroxide - 1,043 kg (2,300 lb)

2. Upper stage (Block DM). To provide backup, the total quantity on location may be twice this amount.

   a) MMH - 35 kg

   b) N_2O_4 - 60 kg

Note: The propellant quantities listed in Section 4, table 4.2.2-1, may be different because they are mission specific.

The major hazard from these propellants result from the flammability and reactivity characteristics. These propellants have properties similar to other hazardous chemicals, which are routinely transported throughout the U.S. on the nation's highways, and are manufactured and used in a variety of industrial operations. Hydrazine is a key ingredient in a variety of agrochemicals, including many common pesticides, fungicides, algaecides, bactericides, and herbicides.

Hydrazines are volatile chemicals that react readily with carbon dioxide and oxygen in the air and will also decompose some metals on contact. Hydrazine is slightly less dense than water; the vapors are more dense than air. If hydrazine vapor is released into the air in sufficient concentrations, it may ignite or react to form ammonia and oxides of nitrogen. Further oxidation will form ammonia-based nutrients and will ultimately return to earth as nitric acid rains.

Hydazines are also corrosive, poisonous, and can present serious health hazards upon direct contact with sufficient quantities of either the liquid or vapor. The most severe exposures occur through dermal (i.e., skin) contact with liquid and inhalation. Contact of the chemical on the skin can cause severe burns and can enter the bloodstream, leading to similar effects caused by inhalation. These effects may include damage to the central nervous system which can result in tremors, convulsions, or death in the case of extremely high concentrations of the chemical. According to the American Council of Industrial and Government Hygienists, hydrazine is also a suspected human carcinogen.

Nitrogen tetroxide is a thick, heavy, and very volatile liquid. Its vapor pressure is about 50 times that of water and about five times that of acetone. Though not flammable itself, N_2O_4 enhances the combustion of most fuel sources and may ignite organic materials. Nitrogen tetroxide reacts with water in a vigorous reaction that produces nitric and nitrous acids and NO_2. Contact with corrosive N_2O_4 liquid or vapor may lead to burns of the skin and eyes. Inhalation of a sufficient quantity of N_2O_4 vapor causes adverse health effects and may initially occur without great discomfort. A few hours later, however, more severe symptoms of tightness in the chest, coughing, and breathing difficulty may begin and could result in pulmonary edema, and in severe cases, death.

The principal environmental and personnel protection method employed is through system design. A principle of zero planned release of hydrazine into the environment has been incorporated in the design of the systems and development of procedures used for their processing. The potential for accidental release has been assessed and appropriate containment for the operating area and scrubber systems is being incorporated into the facilities design.

Procedures have been written that will help safeguard and instruct the operating personnel. These procedures define proper sequencing of critical events, provide detailed instruction where required, define use of personnel protection equipment, define the establishment of controlled areas, and define the limitation of access to essential personnel in potentially hazardous operating areas.

Waste containment and neutralization systems serve the fuel and oxidizer propellant operating areas. All propellant vapors released in processing areas will be processed through these systems. Tanks collect any liquid spillage which could occur during propellant transfer operations.

The greatest hazard during operations with these components is the potential of mixing hypergolic materials. The principal defense for this potential hazard is to separate components. Separate storage areas and processing systems have been incorporated into the design of both the PPF and the ACS. The principal operational control is in processing one component at a time and in complete cleanup following that operation prior to starting the next operation.

The potential for an explosive environment developing in the hydrazine processing area has been considered and the design requirements for these areas have been incorporated. The PPF is designed per the National Electric Code, Section 70, of the National Fire Protection Association Codes. The ACS Block DM-SL fueling compartment is designed per Det Norske Veritas, Rules for Classification of Ships. Static grounds are provided for fueling equipment, and adherence to written procedures will ensure proper connection during operations.

The danger of a tank leaking toxic material during handling is mitigated by compliance to 49 CFR, Transportation. DOT approved tanks for hypergolic fuels and oxidizers are used for transportation, temporary storage of spacecraft, and upper stage hazardous fuel components.

Exhaust gas composition for N_2O_4 and hydrazine[1] is as follows:

1. CO - 0.03561
2. CO_2 - 0.09563
3. H - 0.00006

[1] AIAA Workshop Report dated 1 October 1991, Atmospheric Effects of Chemical Rocket Propulsion, Table 8.

4. H_2 - 0.04969
5. H_2O - 0.45886
6. OH_x - 0.00003
7. N_2 - 0.36012

The primary hazard from solid propellant in the SRMs processed in Sea Launch facilities is due to its flammability. Solid propellant is classified by the DOD as a Class 2, Division 1.3 (non-mass - detonation, mass-fire hazard). (Reference DOD Directive 6055.9, DOD Ammunition and Explosives Safety Standard, July 1984). The material itself is not explosive; however, a solid propellant produces large volumes of gas when burning, which can result in the rupture or propulsion of the case.

The solid propellant used in the Zenit separation motors is a nitrocellulose base with less than 10% nitrogen. This chemical composition relates to a hazard class of flammable solid, DOT Class 1.4. Because the packaging of the chemical is in a motor case, it is considered a DOT Class 1.3.

1. Zenit first stage: four solid rocket retromotors (21.1 kg propellant each) within the separation system.
2. Zenit second stage: four solid rocket retromotors (5.25 kg propellant mass each) in the stage separation system.

Exhaust gas composition for the SRM exhaust plume is as follows:

1. CO - 0.3858
2. H_2O - 0.1411
3. H_2 - 0.2045
4. N_2 - 0.1171
5. CO_2 - 0.1506
6. Pb - 0.0009

Liquid oxygen is not an environmental hazard. The volume of liquid oxygen required to support a launch cycle is 500 metric tonnes.

The significant hazards related to operations involving liquid oxygen are:

1. Oxygen enriched atmosphere supports accelerated combustion of fuels.
2. Extreme low temperature. The systems used to handle cryogens will be designed and operated in accordance with industry standards.

The combination of kerosene and liquid oxygen has been used as a propellant system in launch vehicles by most countries since space programs started. This use of liquid oxygen/kerosene has resulted in high vehicle reliability, an excellent safety record, and efficient launch operations. Its good performance and high density is well suited for the minimum-size launch vehicle. The ease of handling and ambient storage temperatures of kerosene make it suitable for a shipboard-based launch system. Safety requirements for handling kerosene onboard a ship are similar to those of handling diesel fuel.

The emissions from liquid oxygen and kerosene have minimal effect on the environment. Exhaust product composition for LOX and kerosene are:

1. CO - 0.35954
2. CO_2 - 0.14479
3. H_2 - 0.26265
4. H_2O - 0.23301

As the exhaust is discharged into the atmosphere, afterburning will occur, modifying the mole fractions and introducing some new compounds (i.e., NO_x) which are eventually released in the atmosphere. Quantitative data on the products generated by afterburning as a function of altitude are not available.

Nitrogen is not a hazardous substance and will not, under normal conditions, pose a threat to the public. For each launch cycle, 240 metric tonnes of liquid nitrogen is loaded onboard the LP and 10 metric tonnes of gaseous nitrogen is loaded on the ACS.

It may be a public hazard under the following conditions:

1. Release of nitrogen gas in an enclosed space may result in an oxygen deficient environment that will not support life. This condition is addressed in the design of the ACS and LP. Oxygen monitors have been included in spaces that could potentially contain an oxygen deficient atmosphere.
2. Operating procedures and instructions will include provisions to ensure access control of confined spaces as required by existing regulations.
3. The extreme low temperature of liquid nitrogen is a hazard. The systems used to handle cryogens will be designed and operated in accordance with industry standards.

Helium gas is not a hazardous substance and will not, under normal conditions, pose a threat to the public. It may be a public hazard when a large volume is released in an enclosed or confined space resulting in an oxygen deficient environment. The approximate amount of gaseous helium loaded on the LP (at 400 kgf/cm^2 pressure) in support of each launch cycle is 0.9 metric tonnes; the ACS is 0.5 metric tonnes.

Ordnance devices employed are defined as electroexplosive devices, detonators, squibs, primer, pyrotechnic devices, solid rocket motors, and energy transfer systems. The hazards produced by ordnance are the potential for ignition or detonation.

Ordnance items being transported to Sea Launch facilities from within the U.S. will be examined in accordance with CFR 49, Part 173.56, by the Association of American Railroads, Bureau of Explosives or U.S. Department of Interior, Bureau of Mines, and assigned a recommended shipping description and hazard classification. Ordnance items will be approved for transportation by the U.S. Department of Transportation. For ordnance items originating outside of the U.S., the Associate Administrator for Hazardous Materials Safety acceptance of an approval, issued by the competent authority of the country of origin as listed by the International Maritime Dangerous Goods (IMDG) Code, will be required.

Written acknowledgment of acceptance must be received before shipment. Copies of the acknowledgment and of the competent authority approval must accompany each shipment.

Both the ACS and LP are built in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) to control the discharge of oil into the environment. There is no greater risk to the environment from Sea Launch vessels than from any other ship. The following is the estimated usage of fuels for each round trip between the Home Port and proposed launch location:

1. Diesel oil - ACS 1,350 m^3; LP 1,450 m^3
2. Lube oil - ACS 6 m^3; LP 8 m^3

Helium gas is not a hazardous substance and will not, under normal conditions, pose a threat to the public. It may be a public hazard when a large volume is released in an enclosed or confined space resulting in an oxygen deficient environment. The approximate amount of gaseous helium loaded on the LP (at 400 kgf/cm^2 pressure) in support of each launch cycle is 0.9 metric tonnes; the ACS is 0.5 metric tonnes.

B.4 HAZARDOUS WASTE

The hydrazine and nitrogen tetroxide processing system design will minimize the generation of hazardous waste. Excess hydrazine and nitrogen tetroxide remaining after an operation will be returned to the manufacturer for recycling. Spillage of any hydrazine and nitrogen tetroxide will be neutralized in the collection tanks and properly disposed of. Other hazardous materials used during launch vehicle assembly, conducted at the Home Port and onboard ships, will generate a minimum amount of waste. The materials used include paints, cleaning agents/solvents, and various adhesives. The following is a generic list of typical items:

1. Acetone.
2. Ethyl alcohol.
3. Gasoline.
4. Isopropyl alcohol.
5. Lacquers.
6. Polyamide resins.
7. Lubricants.

Disposal of all hazardous waster will be accomplished in accordance with all international, federal, state and local requirements of the Home Port.

B.5 GENERAL INDUSTRIAL WASTE

B.5.1 Home Port Facility Non-Hazardous Waste

The Home Port is expected to generate a relatively limited amount of nonhazardous waste similar in quantity to that required to support the maintenance and operations of a small office complex. Nonhazardous waste will be removed from the site by a locally contracted waste management company. Site wastes will be managed according to their source and characteristics and options for recycling and reuse. Plans coordinated with local officials as noted will address as appropriate the separation of hazardous from nonhazardous wastes, waste collection, training and instructions for employees, and planning for process changes and their associated wastes.

B.5.2 Shipboard Waste

Approximately 100 liters of diesel or kerosene is used per month onboard each vessel for general cleaning of machinery. Approximately four liters of Electro-clean (white spirit) is used per month onboard each vessel for general cleaning of electrical equipment.

Waste products onboard the ACS will be collected in containers and burned in the ship's incinerator during the voyage or transferred to the Home Port for disposal/recycling.

Bilge water is normally separated onboard each vessel during the voyage. However, arrangements have to be provided for transferring the bilge water ashore during long stays in the Home Port. The ACS is provided with a bilge water tank of 160 m^3, and the LP has a tank of 30 m^3.

Sewage/gray water will be discharged to publicly-owned treatment works via the Home Port shore facilities while in port. During sea operations, the sewage treatment plant on the ACS and LP will handle sewage/gray water in compliance with Annex IV, Regulations for the Prevention of Pollution by Sewage of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

Oil sludge will be separated onboard each vessel. Onboard the ACS, waste oil products will be burned in the ship's incinerator during the voyage. In port, shore connections for delivery of oil sludge will be provided for each ship.

Garbage will be handled during the voyage in accordance with Annex V, Regulations for the Prevention of Pollution by Garbage of MARPOL 73/78. Garbage suitable for burning will be burned in the ACS incinerator during the voyage. Other garbage onboard the ACS and all garbage onboard the LP will be collected in containers and transferred ashore when in port.

B.6 LIST OF HAZARDOUS MATERIALS

Table B.6-1 provides a listing of hazardous materials identified to date. Any hazardous waste generated during spacecraft and launch vehicle processing will be controlled in accordance with EPA hazardous waste regulations and transported in accordance with DOT regulations. The table contains a preliminary listing of hazardous material and the approximate quantity used during processing of each launch vehicle. Data on the documents listed for reference have been provided by the Sea Launch Limited Partnership.

Table B.6-1. List of Typical Hazardous Materials

Material	Approximate Quantity Used Per Launch	References, Remarks
Acetone	1.5 L (B-DM) 0.5 kg (Zenit)	GOST 260-79
Adhesives (various)	1.22 kg (B-DM)	
Diethyleneglycolurethane	0.02 kg (B-DM)	
Ethyl alcohol	6.0 L (B-DM) 20 kg (Zenit)	GOST 5962-67 Highly flammable fluid. Rate 3
Gasoline	2.0 L (B-DM)	Highly flammable fluid. Rate 3
Isopropyl alcohol	TBD	Highly flammable fluid. Rate 3
Lacquer	0.5 kg (B-DM)	Highly flammable fluid. Rate 3
Lubricants	0.6 kg (B-DM)	Highly flammable fluid. Rate 3
Methyl ethyl ketone	TBD	Highly flammable fluid. Rate 3
Paints	2 kg (B-DM)	Highly flammable fluid. Rate 3
White spirit	1 kg (Zenit)	GOST 313-18. Highly flammable fluid. Rate 3

Material	Approximate Quantity Used Per Launch	References, Remarks
Cold carrier "Chladon-113"	30 kg (Zenit)	GOST 23844-79. Non-flammable, low toxic fluid. Rate of hazard defined by PEL in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 mg/m)
Nefras-S3-80/120	1 kg (Zenit)	GOST 443-76. Highly flammable fluid. Rate 3
Working fluid "L3-MG-2"	14 kg (Zenit)	TY-38.10128-81 Highly flammable fluid. Rate 3
Hermetic paste "VGO-1"	4 kg (Zenit)	TY 38.303-04-04-08 GOST 12.1.004-85 Group IV Flammable product.
Hermetic paste "YG-5M2"	4 kg (Zenit)	TY-6-01-2-670-88 Highly flammable fluid. Rate 3
Glue "BF-4"	0.1 kg (Zenit)	GOST 12172-74 Highly flammable fluid. Rate 3
Glue "88-CA"	0.5 kg (Zenit)	TY 38-105760-87 Highly flammable fluid. Rate 3
Glue "88-NP"	0.5 kg (Zenit)	TU 38.105540-73 Highly flammable fluid. Rate 3
Glue NT-150	0.5 kg (Zenit)	TY-38.105789-75 Highly flammable fluid. Rate 3
Glue "VK-9" consisting of:	(Zenit)	GOST 92-0949-74.
a. Resin "ED-20"	0.3 kg	GOST 10587-84, Moderately dangerous substance Rate 9
b. Resin "PO-300"	0.2 kg	TY 6-10-1108-76
c. Product "AMG-3"	0.0029 kg	Highly flammable fluid. Rate 3
d. Product "ADZ-3"	0.001 kg	Highly flammable fluid. Rate 3
e. Titanium dioxide	0.025 kg	Fire & explosive safe material. Rate of hazard defined by PC in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 gm/m)
Glue "K-300-61" consisting of:	(Zenit)	GOST 92-0949-74
a. Resin "SEDM-6"	0.6 kg	GOST 6-05-5125-82, Fire & explosive safe material. TY 6-05-1123-73, Fire & explosive safe material.
b. Polyamide resin "L-020"	0.24 kg	Fire & explosive safe material. Rate of hazard defined by PC in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 gm/m)
c. Titanium dioxide	0.18 kg	
Nitroglue	0.2 kg (Zenit)	TY 6-10-1293-78, Highly flammable fluid. Rate 3

Notes:

1. This list provides an indication of the launch process potential impact. Industrial materials used to operate and maintain the vessels and maintain the Home Port facilities have not been identified.
2. The launch operations supported by the vessels and Home Port facilities includes the assembly of manufactured components, but does not include manufacturing processes that use hazardous chemicals or metals.

C. PROJECT ORGANIZATION AND PARTNER RESPONSIBILITIES

The entity responsible for environmental concerns on the Sea Launch Program is the Sea Launch Limited Partnership (SLLP) acting through its General Partner, the Sea Launch Limited Duration Company (LDC). Both the SLLP and the Sea Launch LDC are organized under the laws of the Cayman Islands, B.W. I. The SLLP is responsible for the development work and for entering into launch contracts with customers and performing those contracts. The address and telephone number of the Sea Launch Limited Partnership, the Sea Launch LDC, and the Launch Platform Limited Partnership are:

Sea Launch Company, LDC
Windward I, Safehaven Corporate Centre West Bay Road
P.O. box 10168 APO
Grand Cayman, Cayman Islands British West Indies

phone: 1-345-945-8390

fax : 1-345-945-8388

There are four companies involved in this venture:

1. Boeing Commercial Space Company
2. Kværner Maritime a.s
3. KB Yuzhnoye
4. RSC Energia

The LDC is the General Partner of the SLLP and will perform under The Company Law (Revised) of the Cayman Islands. The LDC will issue contracts with the Partners for the development work on behalf of the SLLP.

The principal responsibilities of each company are illustrated in Figure C-1. A short description of each company's responsibility follows this introductory section.

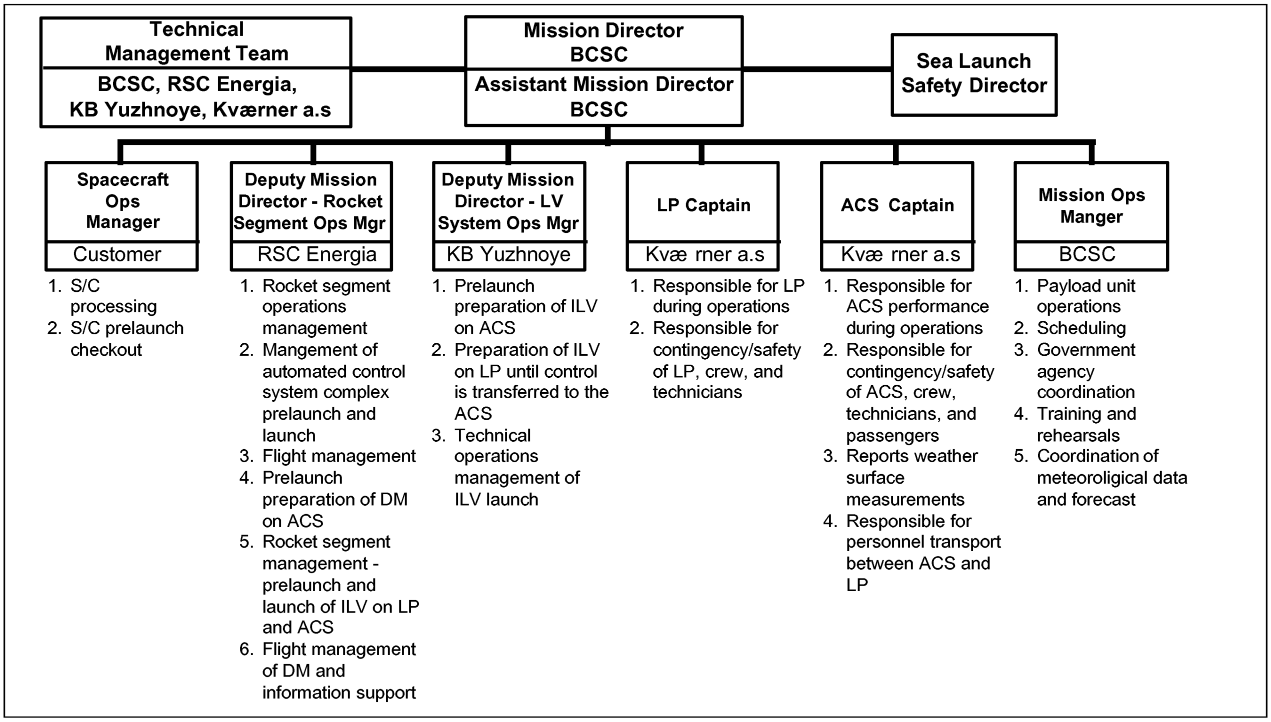

Figure C-1. Mission Operations Team

All launches will be licensed through the Office of the Associate Administrator for Commercial Space Transportation (AST), an office within the Department of Transportation's (DOT) Federal Aviation Administration (FAA). Sea Launch is marketing its services to United States and international spacecraft manufacturers. The Sea Launch payloads will be communication, navigation, or remote sensing satellites. Payloads will be licensed by appropriate U.S. agencies and/or foreign countries. Registration of space objects is required by United Nations, Article IV of 1975 Convention on Registration of Objects Launched into Outer Space. The process Sea Launch has established for payload registration begins 60 days before launch with notification to AST. Thirty days before launch, Sea Launch will notify U.S. Space Command (USSC), 1st Command and Control Squadron, Combat Analysis Code J30XY, of the initial orbit parameters, points of contact, launch vehicle description, launch vehicle size, and description of object(s) to be orbited. On launch day, USSC will be notified that the launch has occurred. Within 30 days of the launch, AST will be provided with the international designator, date and location of launch, orbital parameters, and general information of the space object(s). For U.S.-owned payloads, AST transfers this information to the State Department, which notifies the United Nations within five months. The process is not yet determined for non-U.S.-owned payloads.

C.1 BOEING COMMERCIAL SPACE COMPANY

Boeing Commercial Space Company (BCSC) has the responsibility for project management, will submit the launch license application data package to AST, and will plan the missions and interface with the customer and/or spacecraft manufacturer. In addition, BCSC will develop and manufacture the payload fairing (PLF), the payload adapter (PLA), and will develop the Home Port (HP). The development of the HP includes environmental analysis sufficient to satisfy all government jurisdictions (i.e., California governmental agencies, the City of Long Beach, the Port of Long Beach, local fire departments, and the U.S. Coast Guard). Also, BCSC will operate the HP and market the Sea Launch Venture. During the operational phase, BCSC will lead the Mission Operations Team.

C.2 KVÆRNER MARITIME A.S

Kværner Maritime a.s is constructing the assembly & command ship (ACS), refurbishing the launch platform (LP), and will manage all maritime activities including all environmental analysis for maritime activities. During operational phase, Kværner will contract to operate the ACS and the LP.

The ACS Limited Partnership has entered into a contract with Kværner for building the ACS and for providing the ship to the LDC. In addition, it is responsible for related maritime planning, licensing, and operations.

The LP Limited Partnership has entered into a contract with Kværner for building the LP, providing the vessel to the LDC, and providing planning, licensing, and operations related to the LP.

C.3 KB YUZHNOYE

KB Yuzhnoye will modify and manufacture the Zenit's first and second stage hardware and software in order to meet new requirements levied by Sea Launch customers. During the operational phase, Yuzhnoye will support launch activities associated with the Zenit and associated Zenit ground support equipment. In particular, Yuzhnoye will support the pre-launch preparation of the integrated launch vehicle (ILV) on the ACS and the preparation of the ILV on the LP until control is transferred to the ACS during the countdown phase.

C.4 RSC ENERGIA

RSC Energia is modifying and manufacturing the Block DM-SL upper stage hardware and software in order to meet new requirements levied by Sea Launch customers. In addition, Energia will install all launch vehicle vessel support equipment. During the operational phase, Energia will support launch activities and in particular will:

1. Manage the rocket segment operations.
2. Manage the automated control system complex during pre-launch and launch.
3. Manage the flight segment.
4. Execute the pre-launch preparation of the Block DM-SL on the AC.
5. Manage the rocket segment pre-launch and launch activities onboard the LP and ACS.
6. Manage the information support function during the flight of the Block DM-SL.
7. Manage the range assets including the ground stations in Russia.

D.1 GLOSSARY

accretion	Gradual buildup of land or seafloor formed by magma rising to the surface along some tectonic plate boundaries.
anaerobic	Absence of oxygen.
annelids	Multi-segmented, worm-like animals.
ascent groundtrack	The projection, on the surface of the earth, of the launch vehicle flight path from liftoff until orbit insertion.
benthic	Pertaining to or found at or on the sediment-water interface of a large body of water.
biomass	The dry weight of living matter present in a species or ecosystem population for a given habitat area or volume.
boundary layer	The lowest portion of the atmosphere where the frictional effects of the earth's surface are substantial.
Coriolis force	Inertial momentum causing deflection of a moving object relative to the earth's surface; objects moving north and south of the equator are deflected to the right and left respectively.
demersal	Living at or near the bottom of the sea.
echinoderms	Demersal marine organisms with an internal skeleton and a system for flushing water through the body to permit movement, respiration, nourishment, and perception.
ecosystem	A conceptual view describing the interrelationships, including the flow of materials and energy, between living and non-living features of a natural community.
exclusive economic zone	An offshore boundary, usually set at 320 km, establishing a nation's economic sovereignty over the resources present within that perimeter.
food chain	Scheme for describing feeding relationships by trophic levels among the members of a biological community.
habitat	The physical environment in which a plant or animal lives.
instantaneous impact point	The point on the surface of the earth where an airborne mass would strike without atmospheric (e.g., wind) or continuing propulsive effects; the area containing impact points is described by impact limit lines.
ionosphere	That part of the earth's upper atmosphere which is ionized by solar ultraviolet radiation so that the concentration of free electrons affects the

	propagation of radio waves.
mass balance	The accounting of all energy and/or matter that is in flux between or stable within subdivisions of a physical process or ecosystem.
mesosphere	That part of the earth's atmosphere above the stratosphere characterized by a temperature that generally decreases with altitude.
ozone	A form of oxygen, O_3, naturally found in the ozonosphere within the stratosphere.
phytoplankton	Passively floating or weakly self-propelled aquatic plant life.
primary productivity	New organic matter produced by plant life.
stratosphere	That part of the earth's atmosphere between the troposphere and the mesosphere in which the temperature increases with altitude.
tectonics	Movement and deformation of the earth's surface caused by fluid circulation beneath the surface.
thermosphere	That part of the earth's atmosphere extending from the top of the mesosphere to outer space, including the exosphere and ionosphere, marked by more or less steadily increasing temperatures with altitude.
trophic level	A broad grouping of organisms within an ecosystem defined as being in the same tier in the food chain hierarchy; most generally, the first trophic level is the photosynthetic plants, the second is the herbivores, and the third is the carnivores.
troposphere	That part of the atmosphere extending from the earth's surface to an altitude of 10 to 20 km, in which the temperature generally decreases with altitude.
upwelling	The process by which water rises from a deeper to a shallower depth; may be caused by a variety of physical phenomena.
zooplankton	Passively floating or weakly self-propelled aquatic animal life.

D.2 UNIT CONVERSION TABLE

Length

1 km (kilometer)	=	0.621 mile
1 m (meter)	=	3.28 feet
1 cm (centimeter)	=	0.394 inch
1 mm (millimeter)	=	0.0394 inch
1 µm (micron)	=	0.0000394 inch

Mass

1 kg (kilogram)	=	2.20 pounds
1 g (gram)	=	0.0353 ounce
1 mg (milligram)	=	0.0000353 ounce

Energy

1 J (joule)	=	0.239 calories

Velocity

1 km/second	=	2,240 miles/h
1 m/second	=	2.24 miles/h

Force

1 N (Newton)	=	0.225 pound (force)
1 kgf (kilogram force)	=	2.205 pound (force)

Volume

1 L (liter)	=	0.26 gallon

Probability (example)

1 in 1 million	=	$1x10^{-6}$
Degree of Latitude	=	Each 15^0 of latitude represents approximately 1,034 miles

Mr. James Seger

Comment 1

- "The proposed action is an FAA license of "all possible launches by SLLP at the specified launch location." This action is overly broad considering the limited scope of the EA. The EA does not cover all possible launches, it covers only those made with certain launch vehicles. Either the EA must be expanded or the action should be limited to cover only those launch vehicles and other operations specifically analyzed in the EA. Additionally, only those payloads of types and constructed with materials accounted for in the EA should be covered by the proposed action. The payloads are not covered by the EA."

FAA Response: The EA is intended to support an environmental determination on the consideration of a launch operator license including up to six launches per year. This EA would require re-evaluation by FAA to determine whether additional NEPA assessment and documentation is needed if Sea Launch proposed a significant change to the plan it originally submitted to FAA as part of the launch license application. Examples would be a change in the launch location, significant increases in the number of launches, significant changes in the type of payloador any changes in launch trajectory.Sea Launch has indicated it does not foresee any such changes in the near future. Sea Launch also has no intention of using a launch vehicle other than that covered by the EA (EA Section 2.2.1).

Satellite payloads currently manifested by Sea Launch are all common, earth-orbiting data transmission satellites. The environmental effects of these satellites, including possible contamination from a failed mission scenario, have previously been analyzed and determined to be non-significant by FAA in its 1986 Programmatic Environmental Assessment (EA Section 1.3.4). Therefore, the FAA analyzed only unique aspects of the Sea Launch license application for potential environmental significance.

Comment 2

- The finding of no significant impact is fatally flawed because the scope of the environmental assessment arbitrarily excluded consideration of the payload. The document puts forth as a rationale for not considering payloads arguments that have no logical basis. Specifically, it is stated that because the payloads will be fueled and sealed prior to leaving the home port and will not become operational until an altitude of 35,000 km is reached there is no reason for consideration of the possible environmental effects of the payloads. Yet the document includes failed mission scenarios that entail explosion of the launch vehicle at different stages of the launch. A parenthetical statement indicates that the intent is to launch commercial satellites. This description of payload covers any object of any kind that might be launched for commercial purposes (commercial purposes of SLLP or its client). Clearly, there are possible payload contents that may have serious environmental effects if dispersed or ignited by an explosion. The environmental effects of products and residues of the payload are not considered to some extraordinary levels of detail. Yet the possible residues of the payload are not considered for reasons totally unrelated to the possible involvement of the payload in a failed mission scenario. The fact that the payload is fueled and sealed prior to leaving home port and will not be activated until an altitude of 35,000 km has no bearing or relationship of any kind to the possible environmental effects of the residues of the payload after an explosion of the kind specified in the failed mission scenario. Thus, there is no basis for not considering the payloads as part of the analysis of impacts for the failed mission scenarios. For this reason, the environmental assessment must be considered fatally flawed and thus there is not a sufficient basis for a no significant impact determination. Without a basis for such determination, the determination must be found arbitrary and capricious.

FAA Response: Please see FAA response to Comment 1 and Appendix C, Page C-2, Paragraph One

Government of Ecuador

Comments on the Sea Launch Environmental Assessment were provided by the Government of Ecuador to the FAA via the Embassy of Ecuador, Washington, DC. Individual comments were made by the following Ecuadorian institutions:

- The Navy Oceanographic Institute
- The Ministry of Defense, Office of Maritime Interests
- The Center of Integrated Survey of Natural Resources by Remote Sensors (CLIRSEN)

Comment 1

- The fate and effect of kerosene released on the ocean surface and the risk associated with the rocket's second stage.

FAA Response: With the launch location at 154° West, the furthest east kerosene and stage 2 could fall to the Earth's surface is in the vicinity of 110° West, or roughly 1,900 kilometers from the Galapagos Islands. This statement is based on the fact that by around 135° West, stage 2 has consumed all of its propellant during its ascent. During descent from that point, the stage's eastward momentum would cause the hardware to land at around 110° West.

Thus, the closest distance stage 2 and its kerosene fuel could ever come to the Galapagos Islands is about 1,900 kilometers away. Data now available on the strength properties of stages 1 and 2 and their historical use in the former Soviet Union also indicate that during their descent, the stages are likely to rupture and disintegrate from stresses induced from uncontrolled tumbling. Specifically, the probability of stage 1 remaining intact is low, while stage 2 would always be destroyed during descent. As the stages break up, residual propellants are dispersed at very high altitudes. Fuel dispersed from stages 1 and 2 would evaporate in minutes and within a few thousand feet, as is the case when a pilot lightens a plane by dumping jet fuel. The relatively small amounts of residual kerosene from stage 1 that do make it to the ocean surface will dissipate by evaporation and decomposition within hours (references cited in EA Section 4.3.2.1). Early loss of stage 2 would give a similar result. At the distances involved, the kerosene involved would be of no consequence to Wolf and Darwin Islands. For these reasons, therefore, it was concluded it would be impossible for stages 1 and 2 or their kerosene fuels to have any negative effect on Wolf and Darwin Islands.

Comment 2

- The risk to Wolf and Darwin Islands and the need to assess potential impacts to either island.

FAA Response: The risk of an impact to either island would only occur in a very unlikely event in which stage 3 suffers a particular kind of catastrophic failure during a few particular seconds of its flight (EA Section 4.3.4.2). SLLP selected a more northerly route to reduce still further the risk to the Galapagos Islands in consideration of their special character.

Before the details of this scenario are discussed, it is useful to consider what is meant by the term “risk”. For the launch industry in general, “risk” is a measure based on the chance of some unsafe event occurring, the area potentially affected by the event, and the susceptibility and value of the resources in the area that could be damaged.

Given this, FAA’s assessment evaluated risk to Wolf and Darwin Islands in terms of three factors:

- The chance that a stage 3 failure occurs during two specific time intervals of around 250 milliseconds each (0.25 seconds).
- The area on the Earth’s surface potentially affected by falling debris.
- The vulnerability of the resources likely to be present in those affected areas.

All components of the rocket are rigorously tested to ensure they are ready for flight. After liftoff, the onboard flight safety computer continuously checks to ensure the rocket is performing as planned. Deviations are automatically corrected and the rocket is returned to the programmed flight plan. A deviation from the flight plan that cannot be corrected results in the rocket’s engine being turned off. This type of failure is rare, and when it does occur, other launches are postponed until the reason for the failure is fully identified, understood and corrected.

In addition, and based on historical use, stage 3 failures typically occur either when an engine first starts or near the end of its designed operation time. The time span of relevance to Wolf and Darwin Islands safety is centered between these two periods of engine performance. Failure would have to occur during one of two specific instances in time for stage 3 debris to fall on either island. FAA believes that the probability of a failure occurring at these times is so remote as to pose no basis for concern.

During the type of failure considered above and as is described in EA Section 4.3.4.2, stage 3 and satellite components would return to Earth through the atmosphere at an initial velocity of nearly 6 kilometers per second. Stage 3 and the satellite are largely made of lightweight and fragile materials. As the pieces re-enter the atmosphere, nearly 99% of the material would burn up from exposure to extreme temperature and deceleration forces. Most importantly, all propellants and potentially hazardous materials would burn up at an altitude of 50 kilometers or more. Only very durable pieces of the third stage and spacecraft, such as bolts, fittings, and engine parts made of special metals would survive reentry and reach the surface of the Earth.

After atmospheric reentry, the few remaining pieces – which on average are about 25 centimeters in diameter weighing about 20 kg – would slow to what is called their terminal velocity. As they fall at slower speeds, they would begin to cool in the denser portions of Earth’s atmosphere, and they would be differentially scattered based on their shapes and wind resistance. Due to the relative size and distribution of the land masses in the region, it is most likely the pieces would land harmlessly in deep ocean waters (EA Figure 4.3.4-1). When this happens, the debris pieces would quickly decelerate and sink to the bottom, much as if a rock were thrown into the water. Should pieces hit Wolf or Darwin Islands or their offshore waters, they would hit at a speed as though dropped from an airplane. The result on land is that the pieces may bounce a few times and then come to a stop or, depending on the surface composition, become imbedded a small distance in the ground. In no case would falling debris be hot enough to pose any risk of fire.

Because of their relative size, arid habitat, and great distance to the other, larger Galapagos islands, Wolf and Darwin Islands are less able to support large and stable populations than the clustered, more sizable and popular islands to the south. Thus, it is remotely possible that an individual of a species could be struck by falling debris, but the low density of the Wolf and Darwin ecosystem residents makes this very unlikely.

It has been suggested that it would be useful to study the islands to assess the risk of harm relative to the precise density and distribution of resident populations. Based on available data, however, FAA believes new data on this subject would not change the basic conclusion reached by the current assessment. In effect, the chance of any harm coming to the ecosystems of either island is minimal, and any damage that could possibly occur would not significantly impact the ecosystems present on either island.

In summary, damage to Wolf and Darwin Islands could occur only following an extremely improbable series of events:

- A failure that cannot be corrected by onboard safety systems occurs during two specific time periods of around 250 milliseconds each;
- One or more of a few dozen pieces of debris fall on Wolf or Darwin Island;
- One or more pieces strike and harm flora or fauna on either island; and
- Harm to an individual of a species causes significant harm to the ecological community.

Data and experience available from the conduct of thousands of launches over nearly forty years, and the information available on the environments of Wolf and Darwin Islands, indicate this series of cause-and-effect relationships would not occur.

Comment 3

- The advisability of shifting the launch site further north in order to bypass Wolf and Darwin Islands.

FAA Response: A shift in launch site to the north by itself would not necessarily result Wolf and Darwin Islands being bypassed, because of the effect of inertial forces on the flight of the rocket. The current plan to deviate north of the main island group relies on the rocket's maneuverability. The distance flown to the north of equator would be determined by both the launch point and launch azimuth, which is the angle measured from north that the rocket flies. As a rocket flies further north of the equator, whether as the result of the launch point or launch azimuth or both, the rocket and satellite consume more fuel in getting to final orbit. The result is that the satellite has a shorter life span in orbit due to the initial use of propellant. Because a reduced satellite life span causes less operating revenue, satellite operators typically want to minimize the deviation from the equator during launch. In the case of Sea Launch, the Sea Launch Company negotiated with its satellite customer to plan the current deviation north of the Galapagos main island group, despite the loss in revenue represented by this change. Further deviation north of Wolf and Darwin Islands, however, would cause a more pronounced loss in orbital energy and, therefore, revenue. FAA believes that the Sea Launch Company and its customer have found an acceptable balance between lost energy and the very small risk regarding Wolf and Darwin Islands.

In effect, a launch from any point in the world requires a trade off of factors. The objective is to conduct a commercial launch that maximizes safety for people and the environment, while remaining viable for the launch operator and satellite operator.

International Legal Obligations of Concern to SPREP

Comment 1

- Articles 5, 6, 9, 10, 14 and 16 and SPREP Dumping Protocol particularly kerosene as an "oil".

FAA Response: The United States is a party to the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (SPREP Convention) and the Protocol for the Prevention of Pollution of the South Pacific Region by Dumping (SPREP Protocol). The SPREP Convention is designed to protect the marine environment of the South Pacific Region from a variety of sources of marine pollution. The area covered by the Convention generally encompasses the 200 nautical mile zones of twenty-four states and territories located in the South Pacific Region and the area of the high seas beyond 200 miles that are entirely enclosed by those areas. Article 2(f) of the SPREP Convention defines pollution as "the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities."

The Sea Launch proposed launch site is outside the SPREP Convention Area, and, under a normal launch scenario, debris from a launch is not anticipated to fall within the SPREP Convention Area. The FAA has, however, conducted an extensive environmental assessment that meets the requirements of Article 16 of the SPREP Convention. The FAA consulted with interested parties on the proposed project and analyzed potential environmental effects of the project. The assessment indicates little, if any, impact on the marine environment. Nevertheless, the FAA has, consistent with the Convention, used best efforts to assure that any effects on the marine environment related to the Sea Launch project are minimized. Through the consultation process, an environmental monitoring program is being developed to aid in assuring that any project effects are kept to a minimum. Additionally, any hindrances to marine activities will be minimized by, among other things, notification to seamen and fishermen of impending launches.

The SPREP Protocol regulates within the Convention Area the deliberate disposal at sea ("dumping") of wastes and other matter. In addition, Article 10 of the SPREP Convention requires Parties, in key part, to "take all appropriate measures to prevent, reduce and control pollution in the Convention Area caused by dumping…" Article 2(b) of the SPREP Convention defines "dumping" for both the SPREP Protocol and the SPREP Convention. That definition is identical to the definition of "dumping" in the London Dumping Convention of 1972. As discussed below, the anticipated rocket discharges are not "dumping" within this definition.

See the separate FAA response to comments from Ecuador on what happens to any kerosene associated with spent rocket stages.

Comment 2

- London Dumping Convention and 1996 Protocol with reference to Precautionary Principle and reverse Listing Process. Not yet in force but indicating current global view.

FAA Response: The United States is a party to the London Dumping Convention (LDC) of 1972. The LDC is intended to prevent pollution of the sea by dumping waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea. The FAA understands that Sea Launch ships, including the Assembly and Command Ship and Launch Platform ship, will comply with applicable requirements of the LDC.

With respect to discharges of stages and residual kerosene, which are part of the normal operations of rockets regardless of whether the rockets are launched from land or sea, such discharges are not covered by the LDC or by the 1996 Protocol to that Convention. They do not fall within the meaning of "dumping" as that term is defined in Article III, section 1 of the LDC or Article 1, Section 4 of the 1996 protocol. To the best of the FAA's knowledge, the international community shares this view. The FAA understands that such normal operational rocket discharges have not generally been viewed by countries as dumping within the LDC, and that the International Maritime Organization Secretariat has received no country reports indicating that countries have subjected such operational discharges to the LDC regime.

Comment 3

- UNCLOS: Part XII as well as Articles 87, 91 (Liberia) 116-120 conservation of living resources.

FAA Response: The United States is a signatory, though not a party, to the United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS sets forth a comprehensive framework governing uses of the oceans. It allocates jurisdiction, rights and duties among States that carefully balances the interests of States in controlling activities off their own coasts and the interests of all States in protecting freedom to use the ocean spaces without undue interference. It sets forth a comprehensive framework for protecting the marine environment.

Turning to the specific Articles referenced by SPREP, the proposed Sea Launch project appears consistent with Article 87, which expressly provides for freedom of the high seas. Article 91 of UNCLOS states that each vessel will fly the flag of the State in which it is registered. The FAA understands that Sea Launch will comply with this requirement.

Turning now to Articles 116-120 concerning living resources on the high seas and Part XII of UNCLOS, pertaining to protection and preservation of the marine environment. Article 194(1) of UNCLOS, in key part, requires States "to prevent reduce and control pollution of the marine environment … using for this purpose the best practicable means at their disposal and in accordance with their capabilities …" Article 194(2) in key part, requires States "to take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment…" The FAA's actions meet these requirements.

The FAA has conducted a thorough environmental assessment of the Sea Launch project, including assessment of the effects on any resident or migratory species populations. The FAA has also consulted with other governments in the region. Based on the results of this process, the FAA believes that the environmental impact, if any, of the proposed project on the marine environment is nominal. The project is not anticipated to cause damage by pollution to other States and their environment. As discussed in the response to SRPEP Comment on the SPREP Convention above, the FAA has taken steps to minimize any impacts. In addition, if the FAA issues a license for the proposed Sea Launch project to proceed, it will require the implementation by Sea Launch of an environmental monitoring program, subject to approval by the FAA and consultation with SPREP and countries in the South Pacific region. The FAA will use data from this monitoring program to confirm or revisit FAA environmental findings reached as an ongoing part of its environmental review process concerning the proposed Sea Launch project. This is consistent with Article 204 of UNCLOS. The FAA intends to provide data generated from the monitoring program to SPREP and make it available to other interested parties consistent with Article 205 of UNCLOS. Moreover, were the United States Government to become aware of imminent or actual damage to the marine environment, it would notify other States consistent with Article 198 of UNCLOS.

Comment 4

- MARPOL Convention Annex 1 - flushing of fuel lines into ocean after launch. Annex 5 – post-launch debris to be blown into ocean a[s] spent rocket stages.

FAA Response: The United States is a party to the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships of 1973 as Amended (MARPOL) and Annexes I, II, III and V to MARPOL. The Sea Launch Assembly and Command Ship and the Launch Platform ship are expected to comply with all applicable MARPOL requirements.

With respect to normal debris released by Sea Launch launch vehicles (rockets) after launch, such debris is not covered by MARPOL. MARPOL applies to ships. After lift-off from the Launch Platform ship, Sea Launch rockets and their payloads are not ships within the meaning of MARPOL. The debris released by the Sea Launch rockets is not different than debris released by rockets which are launched from land. To the best of FAA's knowledge, MARPOL has not been interpreted to apply to such rockets. Similarly, MARPOL has not been understood to apply to airplanes.

During normal launch operations of the rockets themselves, there is no flushing of fuel lines into the ocean. During normal launch vehicle ignition, there is no loss of kerosene other than an incidental release of vapors from the fuel connections that dissipates immediately.

In the case of a launch aborted on the Launch Platform ship, resulting in engine shutdown, which probability estimates indicate may be expected to occur roughly only once every 87,000 launches, fuel lines would be automatically uncoupled. Such a shutdown could result in potential release of a total of approximately 70 kg of kerosene (less than 15 gallons) which is the total capacity of the fuel lines. Nearly all of this kerosene would be contained by the structural members of the flame bucket on the Launch Platform ship; however, some portion of this kerosene may leak or splash on to the ocean surface. In the unlikely event that such a release occurs, Sea Launch will follow MARPOL reporting requirements.

Comment 5

- Outer Space Treaty 1967, 1972 Space Liability Convention: on liability for damage.

FAA response: SPREP notes concerns regarding two treaties governing activities in outer space. The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410 (commonly referred to as the Outer Space Treaty) describes the obligations of states party to the treaty. The Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 961 U.N.T.S. 187, establishes liability for damage caused by space objects. The treaty provisions apply as relevant. Also, the financial responsibility requirements of 49 U.S.C. Subtitle IX, ch. 701--Commercial Space Launch Activities apply as well.

Greenpeace Pacific

The following comment codes have been used to address specific concerns addressed in this letter:

Air Quality Impact Comments	Comments A#
Waste Comments	Comments W#
Noise Comments	Comments N#
Biological/ecological Comments	Comments B#
Health and Safety Comments	Comments H#
Threatened and Endangered Species Comments	Comments TE#
Cumulative Impacts Comments	Comments CI#

Comment B1

- "The release of heated freshwater from pre-launch preparations, which would have impact on plankton in the water surrounding the LP."

FAA Response: The freshwater tanks on the Launch Platform hold 27,474 gallons. The FAA estimated that the heat of the rocket exhaust would evaporate approximately 80 percent of this or approximately 21,800 gallons, while the remainder would be dispersed by the force of the exhaust and would settle on a wide area on the ocean surface. Research in the region has documented natural patchiness of plankton densities and inherent variability in naturally-occurring stressors on the surface and also with depth (Yoder, 1995; Murray, 1994; Philander, 1992; and Vaulot, 1995). Any quantification of plankton mortality would therefore necessarily be statistically indeterminate.

Comment B2

- "The release of 4.5 tones of unused kerosene for each launch which would form a surface sheen covering several square kilometers, killing plankton."

FAA Response: 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, fell unburned in the Zenit fuel tanks. However, given the incentives of launching commercial satellites where each kilogram of payload is critical, the Russian and Ukrainian partners have improved the efficient use of propellants and as a result have reduced the amount of unused kerosene to 2,000 kg in Stage 1 and 450 kg in Stage 2. When the thrust of each stage is terminated and each stage is separated from the remaining rocket, the speed of Stages 1 and 2 would be 2,620 m/s and 6,380 m/s (meters per second), respectively. The control of the guidance system that ensures proper orientation of the hardware would also be terminated for each stage, causing each stage to tumble. The respective speeds and physical forces on each tumbling stage may cause the rupture and release of the remaining propellants in the case of Stage 1 and would ensure break up and release in the case of Stage 2. The FAA expects kerosene releases to occur above 60 km in either case.

Because much of the unused kerosene from Stages 1 and 2 during normal launches would be released at extremely high altitudes, the impact of kerosene on the ocean surface would be much reduced.. It is therefore appropriate to also consider its effect at high altitudes in the atmosphere.

Research done on the release of fuel from airplanes has shown that jet fuel, which is very similar in chemistry and physical behavior to kerosene, is completely evaporated within about 1,000 meters from the point of release*. (Note: The release of jet fuel is a common action taken by pilots who need to lighten the weight of a plane and shed flammable materials when in potentially dangerous situations.) At the point of release, winds disperse the released liquid over a wide area resulting in a mist. Evaporation of all but the largest droplets then occurs within a few minutes, because evaporation is affected more by droplet size, i.e., the surface area on the drop, than the breakdown with the addition of heat from the atmosphere and sun to the carbon dioxide and water.

* From an analysis performed by The Boeing Company, 1980. This is publicly available through the FAA.

Comment A1

- "The release of 181 tonnes of carbon dioxide (CO_2) in the lower troposphere from each launch."

FAA Response: To place Sea Launch emissions in context, consider the magnitude of other sources of man-made CO_2 in the atmosphere. For example, burning fossil fuels is estimated to place roughly five billion tonnes of CO_2 into the atmosphere each year[1]. The annual emission of CO_2 associated with the rocket launches is approximately 2,200 tonnes, assuming a one-to-one conversion of CO into CO_2. Sea Launch therefore, would contribute less than one-millionth of the effect due to fossil fuel combustion alone. This does not take into account other man-caused and natural sources of greenhouse gases. In summary, the FAA does not consider the emissions impact due to Sea Launch activities to be significant.

Comment A2

- "The release of 36,100 kg [~36 tonnes] of carbon monoxide (CO) into the troposphere."

FAA Response: From EA Table 4.3.2-2, the total release per launch of CO to the entire atmosphere is estimated to be 113 tonnes not the 36 tonnes mentioned in the comment. However, CO is not considered a major greenhouse gas-at least relative to CO_2, CH_4, N_2O, and various halogenated compounds. CO can, however, be oxidized to form CO_2, perhaps the most widely recognized of the greenhouse gases. Sea Launch would constitute less than one-millionth of the effect due to fossil fuel combustion.

Comment A3

- "The release of oxygenated organic compounds. Nitric and nitrous acids would reduce stratospheric ozone levels."

[1] O'Riordan, Timothy. Ed., 1995; Environmental Science for Environmental Management, Longman Group Limited, Essex, England.

FAA Response: Although more research would lead to a greater understanding of the various mechanisms that relate operation of rockets to stratospheric ozone, current research referenced in this EA section 4.3.2.5 indicates the effect of the rocket launching industry on stratospheric ozone is not significant. By extension, the effect of Sea Launch, which does not use the type of chlorine-based rocket fuel most associated with depletion of stratospheric ozone, would not be significant. One aspect of this research is the attempt to compare the impacts of emissions from solid rocket motors, in terms of significance and immediacy, versus those systems using a hydrocarbon fuel and LOX, like the proposed Sea Launch system. There is ongoing research conducted by the U.S. Government concerning the impacts of rocket emissions on stratospheric ozone (RISO Project). This research is under scrutiny by FAA and will be included in consideration for launch licensing environmental determinations once complete, validated and verified.

Comment W1

- "The dumping of spent stages and residual fuels in the ocean. The two rocket stages, weighing 36 tonnes and 11.5 tonnes respectively, and the fairing, weighing 2 tonnes, would fall into the ocean. The rocket stages would have impacts on benthic communities, and the fairing would float creating a maritime hazard."

FAA Response: Regarding debris that falls to the ocean and sinks, FAA believes the surface area of the debris to which the ocean is exposed, and not its collective mass, is a more meaningful measure of impact and risk. Stage 1 will sometimes break up during descent, while Stage 2 will always break up during descent at a high altitude. This process can be described as being similar to the behavior of an egg, which is strong when compressed along its long axis, from point to point, and weak if compressed in the middle. In the same manner, each stage is designed to be very strong when travelling vertically in a straight path, however when stressed side-to-side, the rocket has severely reduced structural strength. In the case of Stage 1 and 2 hardware, each launch results in a maximum impact area of approximately 404 and 127 square meters of ocean surface, respectively. This assumes the tubular shape of the rocket is simply opened and flattened, an approach that would conservatively maximize the potential for falling material to strike something on the surface or contact something on the seafloor.

For any launch, at most only 0.00003% and 0.000001% of the ocean surface in the Stage 1 and Stage 2 impact zones, respectively, would be impacted by falling debris. In the case of the fairing, the maximum size if flattened would be 149 square meters, the fairing deposition area would be 4.712×10^9 square meters, and at most only 0.000003% of the ocean surface would be at risk from impact from fairing debris.

Unlike Stage 1 and 2 pieces, the two halves of the Sea Launch fairing will break up into a number of rigid pieces. Each piece will either float at or below the surface for a number of years, or become waterlogged and sink within a few days. Unlike plastic debris such as fishing nets, rope, string, and packaging materials that readily ensnares or is ingested by sea life, fairing pieces are relatively large, solid sheets of material. As such, floating

fairing pieces will offer resting places for sea birds and provide smaller sea life shade and some protection from predators
In over 40 years of approximately 4,000 orbital rockets being launched from over thirty locations throughout the world, there have been no recorded instances of any impact or damage to ships or boats in areas where stages fall. This is the case despite the fact that these locations are situated in coastal areas characterized by relatively high rates of commercial, subsistence and recreational vessel traffic, and in direct proximity to the diverse and productive ecosystems that are common along many coastlines (e.g., Kennedy Space Center, Florida; Vandenberg AFB, California; Wallops Flight Facility, Virginia; Kagoshima Space Center and Lambda Launch Complex, Japan).

Several months before the first launch, Sea Launch Company intends to work with the Republic of Kiribati and representatives of industrial fishing fleets that operate in the region to coordinate the administrative process by which such notice would be given. All launch operators including Sea Launch Company are required to provide Notices to Mariners and Aviators as a condition of the proposed launch license. When properly coordinated and responded to this notice serves to further ensure safety of the public. No launches would be conducted unless all fishing vessels are clear of the predetermined safety zone surrounding the Launch Platform. Visual and radar sensors will be used to verify this.

Both ship traffic and the concentration of vulnerable marine life are known to be low in that part of the Pacific Ocean (van Trease, 1993) relative to other areas of the world's oceans that have been in the path of rocket launches throughout the world for decades without an incident.

Comment N1

- "No details are available on the effect of noise on maritime life in the vicinity."

FAA Response: Scientific literature, including those cited in the EA, indicates the noise generated by rockets and airplanes overflying marine life causes a startle reaction among mammals, birds, and reptiles that are on shore during the noise event. Louder or more prolonged noise will cause rushed movement into the water. Based on the studies and adaptability of marine life observed at rocket launching sites and airports situated in coastal regions throughout the world, including many tropical environments, there is no indication the marine organisms will be significantly affected by the occasional launches proposed by Sea Launch Company*

*Versar, Inc. *Final Environmental Assessment Vandenberg Air Force Base Atlas II Program.* August 1991.

*National Aeronautics and Space Administration. *Draft Tier I Environmental Assessment*. April 1996.

*ENSR Consulting and Engineering. *Environmental Information in Support of a Request for a Letter of Authorization for the Incidental Harassment of Pinnipeds by the Launches of McDonnell Douglas Aerospace Delta IIs at SLC-2W.* Camarillo: ENSR, July 1995.

*National Aeronautics and Space Administration. *Draft Supplemental Environmental Impact Statement for Sounding Rocket Program.* Washington, August 1994.

*Brown & Root Environmental. *Environmental Assessment of the Kodiak Launch Complex*. Aiken: Brown & Root Environmental, June 1996.

Comment CI 1

- "Cumulative effects over the proposed 20 year program include dumped debris rocket stages and fairings, emissions including greenhouse gases and ozone depleting substances, ocean contamination from kerosene, other fuels and heated water and the mortality of biodiversity including plankton, marine and bird species."

FAA Response: Please see responses to Comments W1, B1, A1, A2.

EA Section 4.3.2.4 indicates tropospheric impacts from Sea Launch rocket launches would be below levels of concern within a few days. With a gap of two or so months between launches and the rapid rate of dispersion of emissions in the troposphere, the effects from one launch would be non-detectable well before the next launch. Similar comments apply to the impacts in the stratosphere (see EA Section 4.3.2.5). The loss of ozone in the exhaust trails is temporary, and normal ozone levels are re-established within several hours to a day or so. With a two month period between launches, the very small loss of stratospheric ozone that may be attributable to a Sea Launch launch would be replaced by the natural generation and migration processes of the atmosphere, and return to natural levels long before the next launch. Research currently underway regarding the impacts of rocket exhaust on stratospheric ozone has indicated this is what normally happens to rocket emissions. However, the research, which is lead by Aerospace Corporation under the program management of Dr. Martin Ross, is on going and additional information will be considered as results are available.

*"Rocket Impacts on Stratospheric Ozone (RISO) Project Results," presented by Dr. Robert R. Bennett, Thiokol Propulsion Group, FAA, Washington, DC, April 8, 1998.

*Ross, M., "Rocket Impacts on Stratospheric Ozone," AIAA Paper 97-0525, Jan. 1997.

*Ross, M., "Local Impact of large Solid Rocket Motor Exhaust on Stratospheric Ozone and Surface Ultraviolet Flux," Journal of Spacecraft and Rockets, Vol. 33, No. 3, 1996, p.435.

Since, as stated above, the effects attributable to any one launch would not be detectable within a few days to a week or so after each launch. FAA has therefore determined there would be no significant cumulative effect over a twenty-year period. This conclusion is consistent with the known effects from launches from fixed space launch facilities (e.g., Cape Canaveral AS, FL; Vandenberg AFB, CA; and Kennedy Space Center, FL) in use for decades by the U.S. government. Studies conducted at Kennedy Space Center regarding the cumulative effects of Shuttle launches in terms of both near and far-field impacts on the environment (e.g., toxic effects of HCl or acid rain on vegetation) have shown minimal effects.*

*Schmalzer, P.A., C.R. Hall, C.R. Hinkle, B.W. Duncan, W.M. Knott, and B.R. Summerfield, 1993, "Environmental Monitoring of Space Shuttle Launches a Kennedy Space Center: The First Ten Years," Presented in the 31st Aerospace Sciences Meeting & Exhibit, Reno, NV, American Institute of Aeronautics and Astronautics, Washington, DC.

*Bionetics Corporation, "STS-5 Launch Effects Summary Report," Kennedy Space Center, Florida, KSC-STS-Effects-STS5, July 1983.

*Bionetics Corporation, "STS-32 Launch Effects Summary Report," Prepared for NASA Biomedical Operations and Research Office, Contract No. NAS10-11624. BIO-ENV-007, March 1990.

The relevance of carbon residue resulting from LOX-kerosene combustion is addressed in EA Section 4.3.3 is somewhat overstated because the amount emitted by rocket LOX-kerosene systems is usually considered to be incidental, on the order of a few kilograms, due to the rocket's combustion efficiency. This small quantity of particulate carbon would be readily incorporated into the ocean's carbon cycle (EA Section 3.4).

In regard to the Sea Launch project's threat to planktonic biodiversity, FAA believes that it appropriately considered plankton mortality in terms of its significance to the ecology of the launch area (EA Section 4.3.2). Given that research in the region has documented natural patchiness of plankton densities, any quantification of plankton mortality would necessarily be statistically indeterminate and of limited, if any, value.

Comment B3

- "An unsuccessful ignition attempt would release LOX vapor and kerosene. The failure and explosion of the integrated launch vehicle (ILV) would result in an explosion of the ILV fuels and the distribution of pieces of the LLV and LP around the vicinity. Particulates from the resulting smoke would drift downwind. Plankton and fish would be killed."

FAA Response: Based on the calculation of the Sea Launch partners who have experience with these systems, it is anticipated that an unsuccessful ignition and associated defueling would occur once every 87,000 missions. This is based on Russian and Ukranian reports that kerosene defueling of the Zenit rocket has never been required during an actual launch. FAA concluded that the lost LOX would mix with and be indistinguishable in the atmosphere within minutes from either one or two aborted launches. As described in EA Section 4.3.1, all but roughly 70 kg of kerosene would be returned to the Launch Platform's fuel tanks. The 70 kg of kerosene that would be lost would be released from the fuel lines during the automated uncoupling of the lines. The

LP deck configuration would cause the kerosene to fall to and wet the flame bucket. This structure is a tent-shaped structure, 18 meters long, designed to deflect the rocket's exhaust away from the water surface and in a horizontal direction to the starboard and port sides. This massive structure has numerous structural members that would serve to catch and contain virtually all of the spilled kerosene. While nearly all of the kerosene would be contained, some would likely splash off the deflector and fall into the ocean surface below. Because of safety concerns, no one would be on board the LP during this time, and Sea Launch would not attempt to recover the kerosene inadvertently released should defueling be necessary.

The kerosene lost to the air or ocean surface from defueling would be chemically or biologically broken down into more basic molecules as described in EA Section 4.3.2.1. The small quantity of kerosene released to the environment would cause an impact as described in EA Section 4.3.2.1, but over an area of a few square meters. Impacts from such an event would not be significant or even detectable over time.

Comment H1

- "Human safety concerns include fallout from launches, particularly failed launches, and the effects of kerosene slicks and floating debris on fishing and other vessels."

FAA Response: As with all launches licensed by FAA, notice will be coordinated with various appropriate authorities before each launch to alert those who may be in the area to reduce the risk associated with falling debris. The details of the necessary notification of local fishing boats will be worked out in continuing discussions with the Kiribati government. Comments B3 and CI 1 further addresses the releases of kerosene to the ocean environment.

Comment TE1

- "Potential impacts on rare and endangered species, such as sea turtles and whales, marine mammals and migratory birds, has not been addressed."

FAA Response: The EA states there are no threatened and endangered species that will be impacted by the proposed launch activities. FAA believes the EA accurately and consistently summarizes available data. The wide variety of migratory or highly mobile species that are known to pass through the east and central equatorial Pacific Ocean likely traverse the areas associated with the proposed launch activity. The individuals of these species, however, would not be at risk of significant impact due to their relatively low concentration and transience in those areas, the only occasional presence of the proposed launch activity, and the extremely small area of the ocean affected by the activity.

South Pacific Regional Environment Programme (SPREP)

Comments were sent to Mr. Nikos Himaras, FAA/AST, by Mr. Tamari'l Tutangata, Director of SPREP. The cover letter was dated May 28, 1998.

Background

SPREP is an intergovernmental organization charged by 22 member countries to promote cooperation and support protection and improvement of the Pacific environment, and to ensure its sustainable development. The SPREP Convention, to which the United States is a party, states that any assessment of major projects that could affect the SPREP region's marine environment shall be communicated to SPREP which shall make that assessment available to interested parties.

SPREP is the secretariat for two regional conventions, the Convention for the Protection of the Environment and Natural Resources of the South Pacific Region (the SPREP Convention) and the Convention on Conservation of Nature in the South Pacific (the Apia Convention). SPREP is also the regional secretariat for the Regional Seas Programme of the United Nations Environment Programme.

SPREP Comment Summary

The Sea Launch Company is a joint venture between United States, Ukrainian, Russian, and Norwegian partners. The company is based in Norway and organized under the laws of the Cayman Islands. Its ships are registered in Liberia. It has a homeport in Long Beach California, U.S.A.

According to the Environmental Assessment (EA), Sea Launch proposes to launch commercial satellites from international waters 20 km outside the Exclusive Economic Zone of Kiribati's Christmas Island. The satellites would be launched from a converted semi-submersible oilrig platform using 1980s Ukrainian Zenit rocket stages and a Russian Block DM upper stage. Each launch would emit 36 tons of carbon monoxide (CO) and 118 tons of carbon dioxide (CO_2) into the lower troposphere. The two rocket stages, weighing 36 tons and 11.5 tons respectively, and the streamlined fairing, weighing a total of 2 tons would fall back into the ocean. The rocket stages would sink, but the fairing would float on the surface for an indefinite period of time. Unused fuel — approximately 4.5 tons of kerosene for each launch — would form a kerosene slick several square kilometers wide. The rockets, called launch vehicles, and the satellites, would be carried to the launch site on custom-designed vessels built by the Norwegian partner in the joint venture. The company proposes to launch two satellites in 1998 and then six every year for 20 years.

> ***FAA Response***: The figures referenced by SPREP in the comment above refer to releases of tropospheric CO and total atmospheric CO_2 and should be cited as 36 tonnes and 181 tonnes respectively. Atmospheric emissions are further discussed in the response to Comment A6. Updates to figures cited by SPREP from the EA are

provided in the specific responses below. Regarding the issue of unused kerosene, we note that engine use efficiencies achieved by Sea Launch Company after the EA was drafted indicate that the quantity of unused kerosene remaining in various stage engines would be significantly reduced. In addition, Stage 1 may sometimes be expected to break up during descent, and Stage 2 is always expected to breakup during descent, releasing residual propellants such that much less kerosene would be expected to reach the ocean surface. (See detailed response to Comment B5). We also note that Sea Launch Company now proposes to launch no satellites in 1998 and three satellites in 1999.

Our Associate Administrator for Commercial Space Transportation has proposed an Environmental Finding Document: Finding No Significant Impact for the proposed project based on the EA.

SPREP has been sent a copy of the Sea Launch EA. SPREP is charged by 22 member countries to promote cooperation and support protection and improvement of the Pacific environment, and to ensure its sustainable development. The SPREP Convention, to which the United States is a party, states that any assessment of major projects which could affect the marine environment shall be communicated to SPREP which shall make that assessment available to interested parties. Having studied the EA of the Sea Launch proposal, SPREP has identified several concerns. These have been coded and addressed separately below. The first comments are general in nature; the rest deal with technical environmental issues. The comment codes are:

General Comments	Comments C#
Air Quality impact comments	Comments A#
Waste comments	Comments W#
Noise comments	Comments N#
Biological/ecological comments	Comments B#
Social and Economic comments	Comments S#
Health and Safety comments	Comments H#
Threatened and Endangered Species comments	Comments TE#
Energy Efficiency comments	Comments E#
Environmental Management comments	Comments EM#
Cumulative Impacts comments	Comments CI#
Pacific Policy comments	Comments P#

Comment C1

- There is very little time for comment, or for consultation with SPREP's member countries. Sea Launch customers announced in 1995 (Hughes Aircraft Co; San Jose Mercury News December 19 1995) and 1996 (Space Systems/Loral July 15 1996) that the first Sea Launch liftoff was scheduled for the second half of 1998, yet the Government of Kiribati and SPREP were not informed of the proposal until April 1998. The draft EA arrived at SPREP on April 30, 1998. Detailed comments are due to arrive by post in the office of the Associate Administrator for Commercial Space Transportation no later than May 26, 1998. The short time frame between delivery of the EA and the deadline for comments permits only minimal consultation between SPREP and its member countries.

FAA Response: It is our understanding that the Republic of Kiribati and SPREP were each provided copies of the draft EA on April 8 and 9, 1998, respectively, during visits by Sea Launch representatives to Kiribati and SPREP offices in Apia, West Samoa. The thirty day comment period is consistent with the time period under U.S. National Environmental Policy Act (NEPA) regulations to accommodate public comments. Sea Launch Company informed us that its first communication with the Government of Kiribati occurred in the Fall of 1997, and that the company regrets it was not able to successfully schedule a visit and provide information on the project at that time. However, we have indicated that we would consider and take into account comments and additional information regarding the EA after the close of the public comment period within a reasonable and practicable timeframe.

Comment C2

- The Pacific view of developments within the region, as reflected by South Pacific Forum decisions, is that the region should not be used as a dumping ground for other countries' wastes. The Forum has in the past opposed the use of the Pacific environment for potentially harmful actions of other nations, such as nuclear testing and the movement of nuclear and hazardous wastes through the Pacific, and has called on other nations to respect the wishes of its people.

FAA Response: We share SPREP's concerns and will consider the interests and wishes represented by the South Pacific Forum. We believe that a focused discussion and exchange of information on the proposed Sea Launch project in the region will satisfactorily address all points raised by the comments. We also wish to emphasize the proposed launch activity will not generate or involve nuclear wastes, and in fact it represents a new use for technology that previously had only defense-based applications.

Comment C3

- There are potential human safety concerns. The EA notes the Kiribati practice of fishing for ocean fish stocks to provide for nutritional needs. However, while there are plans to warn shipping of launch times, there is no mention of plans to warn Kiribati fishing boats of falling debris or potential kerosene slicks.

FAA Response: EA Section 4.5.5, "Coordination with Vessel and Air Traffic," indicates Sea Launch would provide all necessary warnings to mariners and aviators potentially affected by its launch activity. In this regard, prior to the first launch, Sea Launch Company intends to work with the Republic of Kiribati and representatives of industrial fishing fleets that operate in the region to coordinate the administrative process by which such notice would be given. Sea Launch Company would also like to work with SPREP and other appropriate groups in identifying how best to notify local fishing vessels.

Commercial launch operators throughout the world currently coordinate with affected governments and organizations to provide safety notices prior to each launch. For launches conducted under our authority, Notices to Mariners and Aviators are handled for all regions affected through the United States Coast Guard and our Central Altitude Reservation Function, respectively. Additionally, no launches would be conducted unless all fishing vessels are clear of the predetermined safety zone surrounding the Launch Platform. Visual and radar sensors will be used to verify this. The administrative details involved with issuing these notices will be worked out with the appropriate authorities.

Comment C4

- The EA fails to provide adequate detail in a number of areas, including potential impacts on rare and endangered species, marine mammals and migratory birds. It does not provide detail of the biological environment of the launch sites or the potential debris deposition areas.

FAA Response: We considered the record of oceanographic research conducted in the deep water region of the east-central equatorial Pacific Ocean that includes the proposed launch site and stage deposition areas. This research was found to support our conclusions regarding potential impacts made in the EA as detailed in the responses below.

Comment C5

- The EA provides no details of contingency plans in case of accidental or catastrophic release of pollutants. There is no indication that an Environmental Management System has been developed for the proposal. Neither is there an indication of whether any independent authority has a compliance role or a role in monitoring the implementation of the proposal. There is no provision for a Marine Pollution Contingency Plan or an Environmental Monitoring Programme.

FAA Response: EA Sections 4.1, "Overview" and 4.5.1, "Design, Operation, and Maintenance of the LP and ACS," clearly reference the requirements of maritime authorities responsible for approving and overseeing Sea Launch Company contingency plans. In particular, emergency preparedness and response would be separately regulated and administered by the International Maritime Organization (IMO), Liberia as Flag State, and the Government of the United States as Port Control State (including the U.S. Coast Guard). We have coordinated with appropriate entities to ensure these measures are in place. We will make these specific contingency and monitoring plans available to the relevant authorities upon request.

The environmental management system to be used by Sea Launch is included in the documents submitted to us to meet requirements of the launch licensing process. We will also make these documents available for review upon request. Sea Launch Company integrates the management of environmental safety with safety of people in a single safety plan for the launch system (EA reference SLLP, 1997). We believe this approach would effectively meet the intent of a standardized Environmental Management System discussed in international circles and noted in this comment by SPREP. Provisions for managing and measuring potential effects are discussed in the response to Comment EM3.

Comment C6

- While the EA holds out the prospect of significant socio-economic benefits for the community of Long Beach California, which would become the project's home base, there are no socio-economic benefits for the Pacific in general and Kiribati in particular. Instead, there may be significant environmental and human safety disadvantages, which cannot be quantified because the EA does not contain adequate detail.

FAA Response: We believe that SPREP's mission of promoting sustainable development in the Pacific and our mission of licensing and regulating safe commercial launches are compatible. With increased communications and discussions between Sea Launch Company and the Government of Kiribati regarding the Sea Launch operations in the Pacific region, this proposed project would support the SPREP mission and provide a benefit to the People and Government of Kiribati. Sea Launch has applied for a launch-specific license and later plans to apply for a launch operator license. We will reevaluate existing environmental documentation at that time to determine its adequacy.

Comment C7

- The proposal to license a launch from an offshore facility in international waters is acknowledged to be without precedent. (Section 1.3.3) Yet despite the unusual nature of the proposal, the Precautionary Principle has not been followed. On the contrary, in the absence of data it has been concluded that environmental values at the launch site and spent rocket stage disposal sites are low and impacts are likely to be negligible.

FAA Response: As discussed in specific comments below, we have followed a precautionary approach for this project and that data available for the region and, hence, for the launch and stage deposition areas, are adequate to demonstrate a finding of non-significance of impacts.

Comment C8 - SPREP Conclusions

- The information supplied in the Sea Launch Environmental Assessment of the impacts of the SLLP proposal on the environment is, in the opinion of SPREP, insufficient to permit a Finding of No Significant Impact (FONSI) to be issued. SPREP would recommend that the proponents be directed to carry out a full and comprehensive Environmental Impact Statement (EIS). This should encompass an Environmental Impact Assessment using the framework of the International Standards Organization (ISO) 14000 Series Standard Environmental Management System.

FAA Response: As indicated in response to Comment C7, we used available information to propose the finding of no significant impact, and we believe the additional analysis recommended by SPREP would not significantly change the results of the EA nor substantively change the conclusions. However, we agree that a focused monitoring program of effects of the proposed launch activity over time would be appropriate. We do find, additionally, that applicable environmental regulatory standards have been met.

SPREP Specific Environmental Comments on the Sea Launch Environmental Assessment and the Proposal by the Associate Administrator for Commercial Space Transportation to Issue a Finding of No Significant Impact

SPREP's technical comments have been made within a very brief time frame. The purpose of attaching these initial comments is to indicate the areas that require further investigation, preferably through the preparation of an Environmental Impact Statement by the proponents.

Air Quality

Comment A1

- Impacts to air quality may occur during coupling and de-coupling of fuel lines and apparatus prior to launch of the rocket (Section 4.3.1). The impacts are not quantified in the document.

FAA Response: Due to the design of the automated fueling equipment which would purge the lines after fueling, the coupling and de-coupling of fuel lines would result in the release of very little kerosene and liquefied oxygen (LOX) vapor. A small quantity of vapor would disperse and breakdown in the equatorial atmosphere to non-detectable levels very quickly, i.e., within hours, as is described in EA Section 4.3.2.1. Dispersion modeling (EA Section 4.3.2.4) of the launch CO plume (approximately 36,100 kg produced at the rate of 656 kg/sec for 55 seconds) indicated that the CO plume from each launch would dissipate in a matter of days. This does not take into account the effects of atmospheric processes. A much smaller release of vapor associated with the fuel lines, therefore, would dissipate even faster and over a much smaller area. The amount of vapor involved in this circumstance would not result in a quantifiable impact.

Comment A2

- An unsuccessful ignition attempt would release LOX vapor and approximately 70 kg of kerosene would be discharged into the ecosystem as fuel lines are flushed (Section 4.3.1). It is not stated how many unsuccessful attempts are likely to occur based on previous launch experience. The cumulative impacts of successive unsuccessful ignition attempts based on previous experiences have not been assessed.

FAA Response: Based on the calculations of the Sea Launch partners who have experience with these systems, it is anticipated that defueling would be required roughly once every 87,000 missions. This is based on Russian and Ukrainian reports that kerosene defueling of the Zenit rocket has never been required during an actual launch, although it has been done many times during testing of the launch erector and automated fuelling systems. As part of its own planning process, however, Sea Launch Company did consider the potential of a kerosene defueling, and these data were provided to us. For this reason, we addressed the defueling possibility in the EA.

Any potential incident is considered seriously by launch operators, and extensive testing is done to ensure a successful launch. The scenario referenced in this comment has particular relevance to Sea Launch since the LOX supply on the Launch Platform is sufficient for only two launch attempts for each disembarking from the Home Port. Thus, if a second launch attempt were unsuccessful for any reason (including kerosene defueling), both ships would have to return to the Home Port to correct the malfunction and re-provision the ships.

In its analysis of this scenario, therefore, we concluded the lost LOX would mix with and be indistinguishable in the atmosphere within minutes from either one or two aborted launches. As described in EA Section 4.3.1, all but roughly 70 kg of kerosene would be returned to the Launch Platform's fuel tanks. The 70 kg of kerosene that would be lost would be released from the fuel lines during the automated uncoupling of the lines. The Launch Platform deck configuration would cause the kerosene to fall to and wet the flame bucket. This structure is a tent-shaped structure, 18 meters long, designed to deflect the rocket’s exhaust away from the water surface and in a horizontal direction to the starboard and port sides. This massive structure has numerous structural members that would serve to catch and contain virtually all of the spilled kerosene. While nearly all of the kerosene would be contained, some would likely splash off the deflector and fall to the ocean surface below. Because of safety concerns, no one would be on board the Launch Platform during this time, and Sea Launch would not attempt to recover the kerosene inadvertently released should defueling be necessary.

The kerosene lost to the air or ocean surface from defueling would be chemically or biologically broken down into more basic molecules as described in EA Section 4.3.2.1. The small quantity of kerosene released to the environment would cause an impact as described in EA Section 4.3.2.1, but over an area of a few square meters. Impacts from such an event would not be significant or even detectable over time.

Comment A3

- Potential environmental impacts from combustion emissions released into the atmosphere over the twenty (20) year period have not been assessed (Section 4.3.2.2).

FAA Response: EA Section 4.3.2.4 indicates tropospheric impacts would be below levels of concern within a few days. With a gap of two or so months between launches and the rapid rate of dispersion of emissions in the troposphere, the effects from one launch would be non-detectable well before the next launch. Similar comments apply to the impacts in the stratosphere (see EA Section 4.3.2.5). Observations of ozone destruction in the exhaust trails of rockets indicate that the loss of ozone in these trails is temporary, and normal ozone levels are re-established within several hours to a day or so. With a two-month period between launches, the very small loss of stratospheric ozone that may be attributable to a Sea Launch would be replaced by the natural generation and migration processes of the atmosphere, and return to natural levels long before the next launch. Research currently underway regarding the impacts of rocket exhaust on stratospheric ozone has indicated these results. However, the research, which is lead by Aerospace Corporation under the program management of Dr. Martin Ross, is on going and additional information will be considered as results are available.

✳ "Rocket Impacts on Stratospheric Ozone (RISO) Project Results," presented by Dr. Robert R. Bennett, Thiokol Propulsion Group, FAA, Washington, DC, April 8, 1998.

✳ Ross, M., "Rocket Impacts on Stratospheric Ozone," American Institute of Aeronautics and Astronautics Paper 97-0525, Jan. 1997.

✳ Ross, M., "Local Impact of Large Solid Rocket Motor Exhaust on Stratospheric Ozone and Surface Ultraviolet Flux," *Journal of Spacecraft and Rockets*, Vol. 33, No. 3, 1996, p. 435.

Comment A4

➢ Launch effects on the atmospheric boundary layer up to 2000m would be short term. However the impact of prevailing winds on the dispersal of pollutants during El Nino could vary. Significant disruption to normal ocean and atmospheric conditions in the Pacific have occurred in previous El Nino events and the impact they would have on air quality in the vicinity of the launch and on downwind land areas during El Nino events has not been addressed. The reference to El Nino effects (Section 3.4) relates only to the productivity of ocean waters and not to altered wind patterns.

FAA Response: Under the influence of the El Nino effect, surface winds in the equatorial Pacific in the launch area are expected to be primarily to the east in direction. This would carry emissions away from Christmas Island. The closest land masses to the east, the Galapagos Islands, are approximately 6,900 km distant from the launch area. Winds that transport the launch emissions toward the Galapagos Islands would disperse the emissions to non-detectable levels well before reaching the islands. (See analysis in EA Section 4.3.2.4). Stagnant conditions would cause launch emissions to remain and gradually dissipate in the launch area.

Comment A5

➢ The cumulative effects on air quality of the planned six missions per year or 116 launches over the twenty (20) year period of the project (Section 2) have not been addressed.

FAA Response As discussed in response to Comments A3 and A6, and as shown in the analysis in EA Sections 4.3.2.2 through 4.3.2.6, the effects attributable to any one launch would not be detectable within a few days to a week or so after each launch. As such, we have determined there would be no significant cumulative effect over a twenty-year period. This conclusion is consistent with the known effects from launches from fixed space launch facilities (e.g., Cape Canaveral AS, FL; Vandenberg AFB, CA; and Kennedy Space Center, FL) in use for decades by the U.S. government. Studies conducted at Kennedy Space Center regarding the cumulative effects of Shuttle launches in terms of both near and far-field impacts on the environment (e.g., toxic effects of HCl or acid rain on vegetation) have shown minimal effects.*

✳ Schmalzer, P.A., C.R. Hall, C.R. Hinkle, B.W. Duncan, W.M. Knott, and B.R. Summerfield, 1993, "Environmental Monitoring of Space Shuttle Launches at

Kennedy Space Center: The First Ten Years," Presented in the 31st Aerospace Sciences Meeting & Exhibit, Reno, NV, American Institute of Aeronautics and Astronautics, Washington, DC.

✳ Bionetics Corporation, "STS-5 Launch Effects Summary Report," Kennedy Space Center, Florida, KSC-STS-Effects-STS5, July 1983.

✳ Bionetics Corporation, "STS-32 Launch Effects Summary Report," Prepared for NASA Biomedical Operations and Research Office, Contract No. NAS10-11624. BIO-ENV-007, March 1990.

Comment A6

- Each launch will produce 181 tons of carbon dioxide (CO_2) emissions and 36 tonnes of carbon monoxide (CO): two important greenhouse gases. Annual CO_2 emissions from the six launches proposed for each year will approach 1000 tonnes, with a further 200 tonnes of CO. The impact of these emissions from the total of 116 launches (the projected life span of the proposal) has not been addressed.

FAA Response: The figures referenced by SPREP in the comment above refer to tropospheric CO and total atmospheric CO_2. From EA Table 4.3.2-2, the total release per launch of CO to the entire atmosphere is estimated to be 113 tonnes, rather than the 36 tonnes mentioned in the comment. However, CO is not considered a major greenhouse gas - at least relative to CO_2, CH_4, N_2O, and various halogenated compounds. CO can, however, be oxidized to form CO_2, perhaps the most widely recognized of the greenhouse gases.

To place Sea Launch emissions in context, consider the magnitude of other sources of man-made CO_2 in the atmosphere. For example, burning fossil fuels is estimated to place roughly five billion tonnes of CO_2 into the atmosphere each year[2]. The annual emission of CO_2 associated with the rocket launches is approximately 2,200 tonnes, assuming a one-to-one conversion of CO into CO_2. Sea Launch, therefore, would contribute less than one-millionth of the effect due to fossil fuel combustion alone. This does not take into account other man-caused and natural sources of greenhouse gases. In summary, we do not believe emissions impact due to Sea Launch activities would be significant.

Comment A7

- Emissions to the troposphere come from combustion of LOX and kerosene. Emissions would form CO_2 and oxygenated organic compounds. During flight times emissions would include nitrogen oxide in the exhaust trail which would form nitric acid and nitrous acids and these nitrogen compounds would cause a reduction of stratospheric ozone. The document is unclear as to the level of global ozone depletion that would occur over the twenty-(20) year lifespan of the proposal (Section 4.3.2.5). As the EA says (Section ES-4): "The exact chemistry and relative

[2] O'Riordan, Timothy. Ed., 1995; Environmental Science for Environmental Management, Longman Group Limited, Essex, England.

significance of these processes are not known." The impact of the process that causes depletion of stratospheric ozone should be determined.

FAA Response: The quoted material in the SPREP comment refers to the effect of the rocket re-entry into the atmosphere, not to the general impact of rockets on stratospheric ozone. While we agree that more research would lead to a greater understanding of the various mechanisms that relate operation of rockets to stratospheric ozone, current research referenced in the EA indicates the effect of the rocket launching industry on stratospheric ozone is not significant. By extension, the effect of Sea Launch, which does not use the type of chlorine-based rocket fuel most associated with depletion of stratospheric ozone, would not be significant. As mentioned above, there is on going research concerning the impacts of rocket emissions on stratospheric ozone (RISO Project – see response to comment A3). One aspect of this research is the attempt to compare the environmental impacts of emissions from solid rocket motors versus those systems using a hydrocarbon fuel and LOX, like the proposed Sea Launch system. We are scrutinizing this research and it will be included in consideration for launch licensing environmental determinations once complete, validated and verified.

Waste

Comment W1

- It is not stated what quantity of particulate debris and residue would be generated by the launch and how it would be collected from the Launch Platform or from the water.

FAA Response**:** The materials referenced in this comment are particulate carbon residues resulting from LOX- kerosene combustion and any metal debris that would result from a launch. The relevance of carbon residue in EA Section 4.3.3 is somewhat overstated because the amount emitted by rocket LOX-kerosene systems is usually considered to be incidental, on the order of a few kilograms, due to the rocket's combustion efficiency. This small quantity of particulate carbon would be readily incorporated into the ocean's carbon cycle (EA Section 3.4).

The Launch Platform structure and the equipment installed on it were designed to withstand with minimal damage the force and heat of a launch. The EA acknowledged, however, that some debris might be produced during a launch if equipment and insulating metal shields are damaged. As indicated in EA Section 4.3.3, this hardware would be dismantled and handled on board as waste and returned to the Home Port for recycling or disposal. In addition, the rocket hold-down clamps mentioned as a type of debris in EA Section 4.3.3 are a part of the rocket. As explained in EA Section 4.3.1, the clamps stabilize the rocket by connecting it to the Platform and are forcibly released during a launch. The loose clamp debris that the EA assumed might be generated would be in quantities no greater than a few kilograms. Any debris generated during launch would be lost to the ocean as fragments or remain connected to Stage 1, while pieces that remain on the platform would be collected and brought to the Home Port. Disposal of any debris would be accomplished in accordance with all federal, state and local requirements at the Home Port.

Comment W2

- With 116 launches over a twenty (20) year period the cumulative impact of dumping approximately 6000 tonnes of debris (Stage 1 hardware, fairing halves, Stage 2 hardware and Block DM-SL sleeve adaptors, not including debris expelled from the launch platform during ignition) has not been considered or assessed.

FAA Response: This response addresses several issues identified in the comment including debris hitting the ocean surface, the same debris when it settles on the seafloor, and the fairing. Other platform debris is addressed in the Response to Comment W1.

First, regarding debris that falls to the ocean and sinks, we believe the surface area of the debris to which the ocean is exposed, and not its collective mass, is a more meaningful measure of impact and risk. In the case of Stage 1 and 2 hardware, while each stage weighs 28,569 kg and _9,109 kg total respectively and may likely break up on reentry, each launch results in a maximum impact area of approximately 404 and 127 square meters of ocean surface, respectively. This assumes the tubular shape of the rocket is simply opened and flattened, an approach that would conservatively maximize the potential for falling material to strike something on the surface or contact something on the seafloor.

This material would fall onto an area roughly defined by ovals, shown figuratively in EA Figure 4.3.2-1, covering 1,178,000,000 and 12,570,000,000 square meters respectively. Thus for any launch, at most only 0.00003% and 0.000001% of the ocean surface in the Stage 1 and Stage 2 impact zones, respectively, would be impacted by falling debris. These figures are much the same for any rocket launched anywhere in the world.

In the case of the fairing, the maximum size if flattened would be 149 square meters, the fairing deposition area would be 4.712×10^9 square meters, and at most only 0.000003% of the ocean surface would be at risk from impact from fairing debris.

The actual area at risk from any of this debris would be, therefore, very small. Further, the likelihood that falling debris would strike an animal on or near the surface, or strike a ship on the surface from one or from all proposed launches is considerably smaller.

Given these assumptions and this quantitative approach, it may also be useful to consider the historical effect of rocket debris from launches worldwide. In over forty years of approximately 4,000 orbital rockets being launched from over thirty locations throughout the world, there have been no recorded instances of any impact or damage to ships or boats in areas where stages fall. This is the case despite the fact that many launch sites are situated in coastal areas characterized by relatively high rates of commercial, subsistence and recreational vessel traffic, and in direct proximity to the diverse and productive ecosystems that are common along many coastlines (e.g.,_Kennedy Space

Center, Florida; Vandenberg AFB, California; Wallops Flight Facility, Virginia; Kagoshima Space Center and Lambda Launch Complex, Japan).

The Notices to Mariners and Aviators, required of Sea Launch Company and all launch operators as a condition of a launch license, when properly coordinated and responded to, serve to further ensure safety of the public. As explained in the Response to Comment C3, Sea Launch Company would work closely with all affected organizations in the months prior to the first and subsequent launches to ensure proper notices are provided.

The second part of this comment addresses the effect when the material settles to the seafloor. In this case, accumulation of debris from multiple launches may be of greater concern. Over the planned 116 launches, using the figures stated above for Stages 1 and 2 and assuming the pieces come to lie perfectly flat on the bottom and do not overlap, the maximum amount of sea bottom that could be covered by the rocket debris is roughly 17,280 square meters, or 0.0004% of the total area of 13,750,000,000 square meters at risk on the sea bottom. This further assumes the material does not drift during descent from currents in the water column beyond the perimeter of the impact area on the surface. More likely, however, the stages would land in curved and complex shapes. This would reduce still further the area on the bottom directly impacted by the debris, and would provide much more new surface area and nooks and crannies, i.e., the insides and outsides of the spent stages, that would begin to harbor marine life.

That sea life colonizes human-induced habitat such as shipwrecks, rip rap jetties, and breakwaters made from boxcars and tires is well documented. Therefore it is reasonable to infer the same thing would happen with rocket stages that settle in deep waters of the Pacific Ocean – even though that particular ecosystem happens to be less well studied.

Finally, based on the launch industry's experience with composite fairings, the two halves of the Sea Launch fairing will break up into a number of rigid pieces. Each piece will either float at or below the surface for a number of years, or become waterlogged and sink within a few days. Unlike plastic debris such as fishing nets, rope, string, and packaging materials that readily ensnares or is ingested by sea life, fairing pieces are relatively large, solid sheets of material. As such, floating fairing pieces will offer resting places for sea birds and provide smaller sea life shade and some protection from predators.

To summarize, our determination of safety with regard to falling rocket stages and fairing pieces is based on the frequency of ship and air traffic and biological activity in the down-range direction relative to the history of launches worldwide, and operational practices that will be implemented . Both ship and plane traffic and the concentration of vulnerable marine life are known to be low in that part of the Pacific Ocean - relative to other areas of the world's oceans that have been in the path of rocket launches throughout the world for decades without an incident. On the basis of the EA analysis as well as the long and successful history of government and industry launches throughout the world, we find there would be no significant effect from Sea Launch Company launches, as initially expressed in EA Section 2.2.2.

Comment W3

- This EA has been prepared to support a launch-specific license and launch operator licenses (Section 1-1). The document does not state if an environmental assessment will be required for each launch activity. As no detail is given of the satellite payload other than the description *telecommunications, scientific and research* (Section ES-1, ES-2) there is the potential scenario of unknown high level contaminants being transported to the Pacific and launched without assessment of their potential impacts under a failed mission scenario.

FAA Response: The EA is intended to support an environmental determination in the consideration of a launch operator license under which the proposed site is for the exclusive use of the license applicant including up to six launches per year. If Sea Launch proposes a significant change to the original plan submitted as part of the launch license application we would re-evaluate the EA to determine whether additional NEPA assessment or documentation is necessary. Examples would be a change in the launch location, significant increases in the number of launches, and significant changes in the type of payload. Sea Launch has indicated it does not foresee any such changes.

Satellite payloads currently manifested by Sea Launch are all common, earth-orbiting data transmission satellites. We have previously analyzed environmental effects of these satellites, including possible contamination from a failed mission scenario, and determined them to be non-significant in our 1986 Programmatic Environmental Assessment (EA Section 1.3.4). Therefore, we analyzed only unique aspects of the Sea Launch license application for potential environmental significance.

Comment W4

- The proponent, while stating compliance with the International Convention for Prevention of Pollution from Ships 1973 as amended by the Protocol of 1978 (MARPOL 73/78), has not provided any indication that monitoring, auditing or reporting of waste discharges will be carried out. (Section 4.5.1, B.5.2). A Marine Pollution Contingency Plan has not been provided in the document.

FAA Response: Please see response to Comment C5.

Comment W5

- It is noted that some discharge of wastes from the launch platform is proposed (e.g. flushing of fuel line in the event of a failed launch; debris blown from the launch platform during launch). Such a view of the ocean as a waste dump is contradictory to the intent of MARPOL.

***FAA Response*:** We and Sea Launch view the ocean as an environment and resource to be conserved and protected. While we are concerned about the occasional loss at sea of extremely small quantities of materials as a result of ordinary launch operations, we have determined that such occurrences would not constitute ocean dumping under MARPOL or any international convention. We are, however, requiring a monitoring program to ascertain continued adherence to applicable standards.

Comment W6

- A Marine Pollution Contingency Plan has not been provided in the Sea Launch EA document.

FAA Response: Please see response to Comment C5.

Noise

Comment N1

- In Section 4.3.2.1 no comparative examples of the generated noise level are provided to show the impact that the noise level of around 75dB would have on nearby marine organisms.

FAA Response**:** Scientific literature, including those cited in the EA, indicates the noise generated by rockets and airplanes overflying marine life causes a startle reaction among mammals, birds and reptiles that are on shore during the noise event. Louder or more prolonged noise will cause the wildlife to rush into the water. Based on the studies and adaptability of marine life observed at rocket launching sites and airports situated in coastal margins throughout the world, including many tropical environments, there is no indication the marine organisms will be significantly affected by the occasional launches proposed by Sea Launch Company. Additionally, 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. *

✳ Versar, Inc. *Final Environmental Assessment Vandenberg Air Force Base Atlas II Program*. August 1991.

✳ National Aeronautics and Space Administration. *Draft Tier I Environmental Assessment*. April 1996.

✳ ENSR Consulting and Engineering. *Environmental Information in Support of a Request for a Letter of Authorization for the Incidental Harassment of Pinnipeds by the Launches of McDonnell Douglas Aerospace Delta IIs at SLC-2W.* Camarillo: ENSR, July 1995.

✳ National Aeronautics and Space Administration. *Draft Supplemental Environmental Impact Statement for Sounding Rocket Program.* Washington, August 1994.

✳ Brown & Root Environmental. *Environmental Assessment of the Kodiak Launch Complex*. Aiken: Brown & Root Environmental, June 1996.

Biological and Ecological Impacts

Comment B1

- The description of the marine environment at the launch site and spent rocket stage disposal sites is inadequate. Significant inferences have been made in the EA from extremely limited and generally inferred data based on plankton ecology. From this limited data on plankton, conclusions have been derived about the importance of the area to fisheries and large marine animals, including marine mammals that may invoke requirements under the U.S. Marine Mammal Protection Act.

***FAA Response*:** We considered available data representative of all ecological communities in the Pacific Ocean region and data for the areas specifically affected by the proposed launch activity and our assessment of these data is reflected in the EA. As part of the routine administration of our responsibilities under E.O. 12114 with guidance provided by NEPA, our analysis took into account the standards in all U.S. environmental protection laws. See response to Comment W2.

Comment B2

- The area supports large-scale high technology export oriented industrial oceanic fisheries which rely on the functional integrity of the Western Pacific warm pool ecosystem. However, the Forum Fisheries Agency (FFA) and the Secretariat of the Pacific Community (SPC) have not been consulted about fisheries values and resources in the vicinity of the launch site.

FAA Response: Initial research by us and Sea Launch Company indicated low levels – and certainly low relative to the areas farther west in the Pacific - of both commercial and subsistence fish stocks and fisheries activity in the region at and east from the launch site. This conclusion was reinforced by an apparent lack of published data about catches in the area directly affected by proposed launches by Sea Launch Company. Consultations with Pacific fisheries experts revealed that while there are numerous high-scale fishing activities that take place in the Central and Eastern Pacific Region, none are specifically located in the vicinity of the proposed launch site.[3] The likelihood of Sea Launch operations impacting the fishing industry is very low as the Pacific Region is large and boats are spread over a wide area. There does not appear to be any area in that part of the Pacific where fishing boats collect in high density. We do, however, welcome the opportunity to review this subject in more detail and to avail itself of new data from these other sources.

Comment B3

- It is not stated what quantity of heated fresh water and residual contaminants from the flame bucket will be released into the ecosystem during the launch. (Section 4.3.1)

FAA Response: The fresh water tanks on the Launch Platform hold 27,474 gallons. It is estimated approximately 80% of this water would be evaporated by the heat of the rocket

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

exhaust, while the remainder would be dispersed by the force of the exhaust and settle over a wide area on the ocean surface. The residual contaminants from the Platform surfaces, including those remaining on the flame bucket, if any, and exhaust constituents are discussed in the response to Comment W1 and in EA Section 4.3.2, respectively.

Comment B4

- It is stated that there will be mortality of plankton from launch and flight activities, but this is not quantified. (Section 4.3.2.1).

***FAA Response*:** We believe plankton mortality was appropriately considered in terms of the significance to the ecology represented by plankton death or impairment that would result from the proposed launch activity (EA Section 4.3.2). Given that research in the region has documented natural patchiness of plankton densities and inherent variability in naturally occurring stressors on the surface and at various depths (Yoder, 1995; Murray, 1994, Philander, 1992; and Vaulot, 1995), any quantification of plankton mortality would necessarily be statistically indeterminant and of limited if any value.

Comment B5

- With 116 launches over a twenty (20) year period, the cumulative impact of the discharge to the ocean of approximately 550 tonnes of kerosene has not been considered or assessed.(Section 4.3.2.1).

FAA Response: The facts surrounding this comment need to be updated in two areas as was first indicated in our introductory Response to SPREP's opening Summary.

First, when the draft EA was prepared, the only information available to Sea Launch Company and us was the historical use of the rocket by the former Soviet Union, which developed the rocket to launch military satellites and other payloads. Sea Launch Company anticipated that there would be substantial improvements in propellant use as this technology was used to launch and deploy commercial satellite payloads (EA Section 4.3.2.1, pg. 4-5), but instead chose to report more solid, historical data.

Given the incentives of launching commercial satellites where each kilogram of payload is more critical, the Russian and Ukrainian partners have achieved some notable efficiencies in the use of the propellants and from refinements in launch planning. As a result, the initial figures provided for kerosene associated with falling stages (in EA Section 4.3.2.1) of 3,489 kg (1,097 gallons) and 1,060 kg (333 gallons) in Stages 1 and 2, respectively, have so far been reduced to 2,000 kg (629 gallons) and 450 kg (141 gallons). Sea Launch Company has directed its Russian and Ukrainian partners to do the work necessary to achieve additional reductions in unused propellants, given the clear benefit of weight reductions and material losses to the environment.

The second set of information that needs to be updated concerns the likelihood that Stages 1 and 2 would break up in flight and release the residual propellants high in the atmosphere rather than falling intact and breaking up in contact with the ocean surface. The EA (Section 4.3.2.1, pg. 4-5) described and considered the impact of both possibilities since at the time it could not be determined which scenario would be most probable.

Data now available on the strength properties of Stages 1 and 2 and their historical use in the former Soviet Union support the conclusion that Stage 1 will sometimes break up and release residual propellants during descent, while Stage 2 will always break up during descent and release its residual fuels at a high altitude. In explanation, each rocket stage would behave a bit like an egg, which is strong if compressed along its long axis from point to point and very weak if compressed about the middle. In the same manner, each stage is designed to be very strong when travelling vertically in a straight path, and the rocket motors are designed to continually correct the orientation of the rocket in flight to ensure this preferred alignment. When stressed side-to-side, however, the rocket has severely reduced structural strength.

When the thrust of each stage is terminated and each stage is separated from the remaining rocket, the speed of Stages 1 and 2 would be 2,620 m/s and 6,380 m/s (meters per second), respectively. The control of the guidance system that ensures proper orientation of the hardware would also be terminated for each stage, causing each stage to tumble. The respective speeds and physical forces on each tumbling stage would possibly cause the rupture and release of the remaining propellants in the case of Stage 1, and would ensure rupture and release in the case of Stage 2. We expect that in either case, kerosene releases would occur above 60 km.

Given the confirmation that much of the unused kerosene from Stages 1 and 2 during normal launches would be released at extremely high altitudes, the impact of kerosene on the ocean surface would be much reduced from that described in the EA as an initial and most conservative scenario. We find it appropriate, however, to consider its effect at high altitudes in the atmosphere.

Research done on the release of fuel from airplanes has shown that jet fuel, which is very similar in chemistry and physical behavior to kerosene, is completely evaporated within about 1,000 meters from the point of release.* (Note: The release of jet fuel is a common action taken by pilots who need to lighten the weight of a plane and shed flammable materials when in potentially dangerous situations.) At the point of release, winds disperse the released liquid over a wide area resulting in a mist. Evaporation of all but the largest droplets then occurs within a few minutes, because evaporation is affected more by droplet size, i.e., the surface area on the drop, than the cold temperatures at high altitudes. The resulting kerosene vapors will then breakdown with the addition of heat from the atmosphere and sun to the carbon dioxide and water.

✳ From an analysis performed by The Boeing Company, 1980. This is publicly available through the FAA.

Comment B6

- It is stated (EA Section 4.3.2.1) that fallout debris would settle, become assimilated and create new habitat areas. This statement is not supported by descriptions of existing benthic habitats in the proposal area and makes assumptions of the capacity of the environment to recolonise the areas disturbed by debris settlement. Assessments of the benthic communities of the proposal areas are inferred and not based on actual site data (EA Section 3.3).

FAA Response: We believe the general body of knowledge accumulated during research on the benthic and other habitats of the Pacific Ocean is directly applicable to the more specific – yet still very large – areas potentially affected by Sea Launch. In other words, it is likely that the 13 million square kilometers of ocean seafloor estimated to be potentially affected by rocket stage debris settling on the bottom (response to Comment W2) are representative of what has been learned for deep ocean waters in the region as a whole.

Comment B7

- Moreover the two worst case scenarios given in the document identify that the biological and ecological impacts would be significant in the short term. However, the cumulative effects of possible worst case scenarios are unknown and are potentially significant.

***FAA Response*:** A cumulative environmental effect due to multiple worst case events resulting from the proposed Sea Launch activity is not required to meet applicable standards for several reasons. Commercial launch service providers in the launch industry are motivated to have successful launches. Each failure is extensively studied to determine its cause, and another launch does not occur until the cause of failure is identified and corrected to ensure it will not occur again. Failures that may occur from different causes would most likely affect different locations, ensuring that the individual effect of each failure would be distinct and therefore the impacts would not accumulate. In the case of Sea Launch, multiple failures on the Launch Platform would damage the platform, but the ocean currents would serve to dissipate the short-term effect of each failure. This is in contrast to the effects that could occur due to multiple failures from launches conducted from a launch facility on land.

Comment B8

- As stated in the document the risk of debris striking land masses in the event of failure "is very remote"(Section ES-5, 4-13). However, according to the document the flight path in subsequent launches after the first launch would be re-evaluated according factors including commercial cost factors and may be re-routed to pass over the Galapagos Islands and the continental land mass including Ecuador.

FAA Response: While a flight directly over the Galapagos would conservatively meet risk criteria established for Sea Launch, SLLP selected a more northern routing to totally eliminate risk to the main island group during the first launches until routine successful operations have been established. It is common in the launch industry, however, to reevaluate and modify initial plans as more data become available on the reliability of the technology and the demonstrated success of the system. Sea Launch Company has identified debris striking a land mass as a remotely possible event, and, thus, it was included in the EA. As noted in response to Comment W3, this is an example of a change that would be subject to our re-evaluation as part of the NEPA process.

Comment B9

- The Precautionary Principle has not been adhered to. On the contrary, in the absence of data it has been concluded that environmental values at the launch site and spent rocket stage disposal sites are low and impacts are likely to be negligible.

FAA Response: We believe that Sea Launch has been conservative in providing information and analyses to us for the environmental finding to support its launch license application decisions.

Social and Economic Considerations

Comment S1

- The document offers the prospect of significant economic benefits for the community of Long Beach. There are no apparent economic benefits for Kiribati, the country nearest the launch site, or for the Pacific as a region.

FAA Response: We and Sea Launch believe the potential for economic benefits for Kiribati and, indirectly, for the region as a whole will be addressed more fully in the coming months in developing discussions between Sea Launch Company and the Government of Kiribati. The initial focus by Sea Launch Company would be on the types and extent of services that may be needed and available on Kiritimati Island to support the initial launch, followed by discussions of services that would be necessary or desirable on an ongoing basis.

Comment S2

- The document has stated a positive contribution to the economy of Kiritimati Island only in the event of an emergency situation. It has not quantified these supposed positive benefits (EA Section 4.4). Refer to Health and Safety for additional comments.

FAA Response: Emergency use of Kiritimati Island – as first considered by Sea Launch Company and documented in the EA - would involve the routing of Sea Launch personnel during rare instances of emergency medical conditions that can not be treated by on-board medical staff. This is expected to be comparable to existing activities for a passing cruise ship that needs to transfer and evacuate someone with a medical problem.

As the date of proposed first launch approaches, Sea Launch Company is planning for the possibility of medical evacuations and other emergency situations, while taking steps to protect and care for the people on board the vessels and eliminate the possibility of technical interruptions during a launch. Sea Launch Company hopes that discussions with the Government of Kiribati and potential service providers on Kiritimati Island in the months ahead will lead to specific plans for these and other needed services.

Comment S3

- Oceanic fishing, primarily for tuna, is undertaken by 1300 vessels from 21 countries, one-third of which are based in the Pacific islands employing 6-8% of the work force. These fisheries have an export value of $US 1.7 billion (1995) and contribute about 10% of the GDP of the Pacific islands. The EA implies that the Sea Launch operations will not impact on fisheries because there are few fish in the region to be affected by the proposal. There are no facts or statistics given to back up this claim.

FAA Response: We believe the data used in assessing the impacts of the proposed activity support its conclusion that - in relative terms and for the Pacific region as a whole - the area directly affected by the proposal is not currently exploited as much as other discrete areas by the fishing fleets operating in the Pacific region. Consultation with Pacific fisheries experts reveal that although there are numerous high-scale fishing activities that take place in the Central and Eastern Pacific Region, none are specifically located in the vicinity of the proposed Sea Launch launch site.[4] The fishing boats in the area do not have a specific area that they fish, or any pre-planned schedule for fishing activities in specific locations. The exact locations that each fleet or individual boat fishes is not generally known as they each have ideas about what areas are productive. Numerous countries fish in the Pacific including China, Japan, Taiwan, and the United States. There are approximately 30-35 boats from the United States at any given time in the Pacific. The number of fishing boats that may be found in the Pacific from other countries is unknown, however, it is estimated that Taiwan might have as many as 40 or 50 at a time.

Tuna occasionally “run” in the waters around the proposed launch site, the tuna fishing boats in the area frequently follow these schools of fish. On occasions when the tuna are “running” in the waters surrounding the launch site, Sea Launch would delay planned launch activities until the boats have cleared the launch area.

We would welcome additional relevant data regarding fisheries activities in the proposed launch area. However, we remain confident in our finding regarding the potential for and non-significance of any impact to the fishing industry, its target fish stocks, and the ecosystem that supports the industry.

Health and Safety

Comment H1

- The Sea Launch EA notes that the Kiribati economy remains subsistence-based, and that the focus of the Kiribati people currently rests with the ocean fish stocks (Section 3.5.1). “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) … now offer the greatest potential for income,” the EA says. However, despite the possibility that one or more Kiribati fishing boats may be in the vicinity of any launch, there are no details of plans to alert the people of Kiribati before each launch.

[4] Personal communication with Bill Gibbons-Fly. NOAA Pacific Fishing Specialist.

***FAA Response*:** As discussed in response to Comments C3 and W2 and as is the case with all launches that we license, notice will be coordinated with various appropriate authorities before each launch to alert those who may be in the area to reduce the risk associated with falling debris. The details of the necessary notification of local fishing boats will be worked out in continuing discussions with the Kiribati government.

Comment H2

- The South Pacific Forum Fisheries Agency (FFA) has indicated a desire to support SPREP's comments particularly on this point of human safety, noting that scientific observers from the Secretariat for the Pacific Community (SPC) frequently work on fishing boats in the region and would like to avoid the risk of rocket debris falling out of the sky towards them.

***FAA Response*:** Please see the response to Comment H1.

Comment H3

- It is not stated in the document, in the event of an accident or failure during launch processes which result in significant injury to employees, what evacuation contingencies are planned other than a possible evacuation to Kiritimati Island, Kiribati.

***FAA Response*:** Detailed coordination to support the possible evacuation of people with medical emergencies through Kiritimati Island is in the initial planning stages by the Sea Launch Company. In general, people needing medical care would be flown to Kiritimati Island onboard the Sea Launch helicopter. The assembly and command ship (ACS) would be positioned closer to Kiritimati Island to shorten the distance the helicopter would need to travel over water. Simultaneously, Sea Launch would request dispatch of an aircraft from a contract service to support an airlift from Kiritimati Island. Discussions with Honolulu-based U.S. government resources are currently in progress to address more extensive contingencies.

Emergency evacuation of people through Kiritimati Island would also probably require the contracting of some services on the Island, e.g., overnight lodging, or the use of vehicles or supplies. Detailed discussions with the Government of Kiribati as currently being planned would identify in advance the need and availability of resources on the Island. Discussions will also address how Island resources could be augmented in consideration of the demands that may be placed on them by Sea Launch operations.

In addition, Sea Launch Company has begun to address possible non-medical contingencies that may arise during equipment malfunctions such as the delivery of spare parts or critical technical experts to the ships. These contingencies, and the options available to address them, will be the subject of upcoming meetings between the Sea Launch Company and the Government of Kiribati.

Comment H4

- As stated in the document under Social and Economic Considerations above, there may be a need to evacuate employees associated with launch activities to Kiritimati Island on an emergency basis. It is unclear what type of emergencies are envisaged. It is understood that Kiritimati Island currently does not have the capacity or infrastructure to deal with emergency evacuation cases of the nature as stated above. Transport services between Kiritimati Island and Honolulu are tenuous and currently service a predominantly tourist trade. A detailed evacuation contingency plan has not been provided, nor any indication of the contents of the Sea Launch System Safety Plan.

***FAA Response*:** Please see responses to Comments H3 and S2. Detailed operating and contingency plans are not usually incorporated into or appended to an environmental assessment but are rather referenced and available for review by appropriate authorities. We are confident, however, that discussions begun between the Government of Kiribati and Sea Launch Company and between Sea Launch Company and U.S. authorities will address necessary details regarding emergency evacuation and other contingencies.

Comment H5

- The safety aspects of a launch as stated by the document have outlined that the launch area has been located further west, to reduce dangers from falling debris away from the continental land mass. However, as identified in Section 4.3.4.2, falling debris poses a risk to a number of island land masses in the Galapagos group and the Galapagos island if, after assessment of "the first few launches"(Section 4.3.4) the flight path is reoriented to the south.

***FAA Response*:** We are charged with ensuring the safety of licensed commercial launches conducted by U.S. companies. As noted in response to Comment W3, we would view any change to the basic mission flight plan - including Galapagos Island overflights - as a change posing a potentially significant impact requiring additional our reevaluation of the adequacy of existing environmental documentation and potentially NEPA analysis.

Comment H6

- Whether the instantaneous impact speed decreases the dwell time over South America is unclear (Section 4.3.4) nevertheless the potential risk as the rocket traverses land remains.

***FAA Response*:** The information provided in EA section 4.3.4, second paragraph was intended to document the relative risk of rocket failure over South America and for any launch in general. As the terms are used in the space launch industry, a rocket's 'instantaneous impact speed' and 'dwell time' are inversely related. In other words, the faster the rocket's speed, the less time it needs to traverse (or dwell over) a constant measure on the earth below. Thus, as the rocket advances over South America, it would traverse more and more land surface with every passing second.

During the first Sea Launch launch, for example, the third stage would ignite 555 seconds after launch and burn continuously until 826 seconds after launch. The following table shows the number of seconds after launch at which flight over points of interest would occur, and the speed of the rocket at those same points.

	Seconds after Launch	***Rocket speed (km/sec)***	***IIP* Speed (km/sec)***
Galapagos Island	709	7.42	36
West Coast of South America	744	7.57	55
East Coast of South America	775	7.71	60
Orbital velocity beyond S. America		8.05	

* IIP = Instantaneous Impact Point

Thus, the risk of a failure over any point of land under a rocket is calculated second-by-second and is relative to the rocket's speed and the corresponding length of time spent over the area of interest on the earth's surface. In addition, historical data show the risk of hardware failure is substantially greater in those few seconds when the engines are turning on or off. Accordingly, we conclude that the risk of failure during the period of continual engine burn over the Galapagos and South America is correspondingly low.

Threatened and Endangered Species

Comment TE1

- Section 3.3 which describes the biological environment covered in the proposal states that scientific literature specific to the launch location and range is limited and that inferences have been made to assess the impact on fish, birds, mammals and reptiles.

***FAA Response*:** True.

Comment TE2

- The region served by the South Pacific Regional Environment Programme is situated in the middle of the largest continuous marine habitat on the planet, the Pacific Ocean. Marine mammals (whales, dolphins, porpoises, dugongs, and seals) range throughout much of this huge region. Of the world's approximately 120 living marine mammal species, three-quarters occur in the Pacific (*cf.* Rice, 1977a). Of the 90 or so Pacific species, perhaps a third are known to be resident in the SPREP region or at least to visit it seasonally or occasionally. Due to the vastness of the region and the relative lack of research activity in it, however, very little is known about the marine mammals in the SPREP region. Much of what is known about the distribution and seasonal occurrence of large whales has come from 19th century American, French and British commercial whalers (cf. Townsend, 1935) and from researchers working in conjunction with modern Japanese whaling operations (cf. Miyashita *et al.*, 1995a). Much of what is known about the smaller whales, dolphins and seals comes from the non-systematic, often opportunistic efforts of individual scientists. (Reeves et al.)

***FAA Response*:** We and Sea Launch recognize that the South Pacific region as a whole is a vast and diverse ecosystem that supports a wide variety of marine life. The available data, however, support the conclusion that the specific areas potentially affected by the proposed launch activity on the periphery and east of the SPREP Convention area are relatively less populated by the species noted in the comment and less able to support the ecologically dense and diverse populations found in the SPREP region. We expect post-launch monitoring to confirm the preexisting data.

Comment TE3

- The document states there are no known threatened and endangered species that will be impacted by the proposed launch activities. It is known that two migratory threatened species inhabit these waters or nearby islands they being whales and marine sea turtles (Jefferson et al, 1993, Balazs, 1981). It is also recognized worldwide that although the open ocean can contain a low species diversity many species of migratory birds, mammals and reptiles move between land masses across these open waters. The conflicting statement made in Section 3.3 Paragraph 7 that a number of species of mammal, bird and reptile may traverse the proposal area but it is not crossed by a known migration route further emphasizes the lack of scientific knowledge that is available with which to make an accurate assessment of the impact of the proposal on threatened or endangered species.

***FAA Response*:** We believe the EA accurately and consistently summarizes available data. Briefly, the wide variety of migratory or highly mobile species that are known to pass through the east and central equatorial Pacific Ocean may traverse the areas associated with the proposed launch activity. The individuals of these species, however, would not be at risk of significant impact due to their relatively low concentration and transience in those areas, the only occasional presence of the proposed launch activity, and the extremely small area of the ocean affected by the activity. Please also see response to Comment W2.

Comment TE4

- The launch site is in the vicinity of a significant migratory fly-way associated with bird rookeries at Kiritimati Island. Impacts on this have not been properly assessed or addressed.

***FAA Response*:** Please see response to Comment TE3. We would welcome any additional available data on migratory birds in the area.

Comment TE5

- The impacts on diving and water-resting birds of the kerosene slicks that will result from rocket stage dumping have not been assessed.

FAA Response: The relatively brief presence and limited surface area of the kerosene would preclude a risk of significant impact to birds that might be in the area affected by the proposed launch activity and that would be vulnerable due to their feeding or resting behavior. Please also see response to Comment TE3.

Comment TE6

- It is recognised through their inclusion on the World Heritage List that the Galapagos Islands contain species which are both threatened and endangered (Carrasco, 1995). It has been stated that there is a potential risk of failure of the rocket therefore the fallout of debris poses increased danger to these species.

***FAA Response*:** The risk to Galapagos Islands' species would not be significant due to the extremely low probability of failure, the deviation to the north of the main islands for at least the first few launches - at which time new system reliability data would be assessed, as would the extremely small relative area that would be affected by surviving rocket hardware.

Relative Energy Efficiencies

Comment E1

- One of the environmental benefits mentioned in the Sea Launch EA is that fewer resources will be consumed and less pollution produced by launching from the equator compared to launches in higher latitudes. The resource consumption/waste production associated with transport to and from the launch site need to be factored into this equation.

***FAA Response*:** As part of the NEPA process, the Sea Launch EA was not intended to be a market analysis of the costs and benefits of the proposed launch system relative to other launch services. In this regard the marketplace of launch customers is expected to judge Sea Launch Company.

Environmental Management

Comment EM1

- There is no mention in the proposal that an environmental management system will be developed for the region in the vicinity of the launch site.

***FAA Response*:** The Sea Launch Company system for managing its environmental responsibilities is an integral part of its overall approach to managing safety. Please see response to Comment C5.

Comment EM2

- A comprehensive environmental monitoring programme should be developed for:

    - Marine water quality
    - Air quality
    - Underwater noise
    - Impacts on large marine animals including fish and marine mammals
    - Bird rookeries at Kiritimati Island

FAA Response: We and Sea Launch invite comment and technical input regarding study methodology on the following monitoring elements. Proposed elements are based on probability of harm or measurable effect to the environment that may be expected from the proposed launch activity. We will make the monitoring results available for review and arrange for their direct distribution to interested governments, government bodies, and scientists.

1. Launch area visual observation - periodic visual observation and recording from the bridges of both vessels (including the Launch Platform while manned) of number, sex, maturity and condition of mammal, reptile, bird, and fish individuals present in the vicinity of the launch platform immediately prior to, during, and following each launch.

2. Exhaust trail survey – high-resolution survey by Doppler weather radar of physical atmospheric processes during recovery of the hole made by the rocket and emission dispersion.

"Vessel of Opportunity" Research Ideas for Consideration

1. Sea Launch could offer data tapes from its oceanographic data buoy and Doppler weather radar surveys during each mission to interested atmospheric processes researchers.

2. Sea Launch could provide a 'guest scientist' with a berth after the first or second launch to coordinate and conduct scientific research that is consistent with mission success.

3. Sea Launch could adopt a grade school class(es) to plan and conduct science experiments under the direction of the 'guest scientist.'

Cumulative Impacts

Comment CI1

- The document states in the context of cumulative impacts that there will be no other foreseeable planned development in the area of the proposed launch location at this time. SPREP however views the context of cumulative impacts over the anticipated twenty (20) year life expectancy of the proposal as being:

  - the amount of randomly dumped debris (rocket stages, fairings);
  - the amount of emissions (greenhouse gases and ozone depleting substances);
  - the amount of ocean contamination (kerosene and other fuels); and
  - the level of mortality of biodiversity (plankton, marine and bird species)

FAA Response: Please see responses to Comments addressing these specific cumulative aspects (i.e., Comment W2; Comments A3, A5, A6, and A7; Comment W1; and Comment B4).

Pacific Policy Issues

Comment P1

- The people of the Pacific region are guardians of their ocean resources. Their socio-religious lifestyles previously dictated very strong cultural ties to their natural resources. In this context although the document states there will be no significant impact of the launch activities to archaeological and cultural resources, it remains the view of SPREP that potentially there could be significant impacts to the Pacific peoples' cultural resources.

***FAA Response*:** In reaching the proposed conclusions documented in the Sea Launch EA on this subject, we considered the record of economic development projects that either have been endorsed or are currently receiving serious and positive consideration by SPREP and many nations in the region. Given this broader context, in the course of discussions initiated between the Government of Kiribati and Sea Launch, the government will have the opportunity to minimize any significant negative impacts to the peoples of the Pacific or their cultural heritage. We believe discussions will demonstrate the proposed Sea Launch activity would be highly compatible with the expressed socio-economic aims of the people in the region, and it would be viewed over time as a significant and positive benefit to the Government and People of Kiribati.

Comment P2

- Pacific island countries have taken the stance in regional and international fora that the Pacific should not to be used as a dumping ground. This fundamental philosophy is directly at variance with the Sea Launch proposal, which appears to have selected its Pacific ocean site largely because it is a remote location far from population centres.

***FAA Response*:** EA Section 2 clearly states the opposite conclusion - that Sea Launch Company evaluated numerous launch locations and selected the area some distance to the east of Kiritimati Island precisely because that location appeared to maximize the safety of people and the environment. In its parallel and overarching assessment, we took into account that all launches licensed by nations throughout the world – many of which are conducted in the Pacific region – pose comparable or arguably greater risks to the people and the environment. We concluded the Sea Launch proposal compared favorably in this regard. The Sea Launch proposed project would comply with MARPOL maritime disposal standards and all other standards in applicable treaties (EA Appendix B).

Additional References

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Miyushita, T.; Kato, H. and Kasuya,T. (1995a) *World wide map of cetacean distribution based on Japanese sighting date (Volume 1).* National Research Institute of Far Seas Fisheries, Shizuoka, Japan.

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Rice, D.W.; (1977a) *A list of the marine mammals of the world*. NOAA Technical Report NMFS SSRF-711

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National Oceanic and Atmospheric Administration

Comment 1

- The proposed project may have some minor impacts on NOAA trust resources and we suggest that FAA consider including mitigation measures which include monitoring of the area around the site before and after each launch.

FAA Response: An Environmental Monitoring and Protection Plan is being developed as an integral part of Sea Launch plans for operations at sea, and its implementation involves the participation of both aerospace and marine crews. Proposed monitoring elements are based on probability of harm or measurable effect to the environment that may be expected from the proposed launch activity. The monitoring results are expected to be made available for review through the FAA as well as by direct distribution to interested governments, government bodies, and scientists.

- Launch area visual observation – hourly visual observation and recording from the bridges of both vessels during daylight (including the Launch Platform while manned) of number, sex, maturity, and condition of mammal, reptile, bird, and fish individuals present in the vicinity of the launch platform immediately prior to, during, and following each launch.

- Exhaust trail survey – high-resolution survey by Doppler weather radar of physical atmospheric processes during recovery of the hole made by the rocket and emission dispersion.

- Water sampling - surface water samples near the Launch Platform will be taken before and after the Launch. Several research ideas for consideration can be proposed to use Sea Launch presence at the launch site for scientific research. The sampling plan will be developed with an emphasis on personnel safety.

- Data tapes from Sea Launch oceanographic data buoy and Doppler weather radar surveys during each mission offered to interested atmospheric processes researchers.

- A 'guest scientist' could be provided with a berth after the first or second launch to afford the opportunity to coordinate and conduct scientific research on the condition that it is consistent with mission success.

- Adopt a grade school class to plan and conduct science experiments under the direction of the 'guest scientist'.

Comment 2

- The one area of the EA that could have used additional information is the description of the biological resources located in the general area of the launch site.

FAA Response: The FAA recognizes that the South Pacific region as a whole is a vast and diverse ecosystem that supports a wide variety of marine life. The available data, however, support the conclusion that the specific areas potentially affected by the proposed launch activity on the periphery and east of the SPREP convention area are relatively less populated by marine mammals such as whales, dolphins, porpoises, dugongs, and seals and less able to support the ecologically dense and diverse populations found in the SPREP region. Monitoring at the launch location is expected to confirm the preexisting data.

Comment 3

- Although the EA contains a short description of the biological environment surrounding the launch site, the information provided is primarily a description of lower trophic levels such as marine plankton and there is very little discussion of fish stocks or marine mammal populations found within the area. In particular, the statement that no endangered species are located in the area may be incorrect as several species of endangered and threatened large whales and endangered sea turtles are found throughout the region.

FAA Response: As noted in the preceding comment, the FAA and Sea Launch acknowledge the wide variety of marine life that inhabits the Pacific Ocean. Fish stocks are distributed throughout the Pacific region and are not concentrated in any one location. Fishing fleets from several countries, including the United States, are spread throughout the Central and Eastern portions of the region. As there are no known fishing fleets that specifically consistently fish in the vicinity of the proposed Sea Launch site, it is presumed that there is not a great density of fish in the area.[5]

Numerous marine mammals are present in the Pacific Ocean including whales, dolphin, seals, and sea turtles. None of these species are known to exclusively inhabit the proposed launch site.[6] While the possibility exists that marine mammals might enter the area during launch operations, visual inspections performed prior to launch would identify the mammal and its location and the launch would be delayed until it is out of harms way.

Comment 4

- While the project itself may pose only minor impacts to marine resources, the EA could be improved if additional information was included on the impacts of short term exposure to kerosene to both marine mammals and large pelagic fish which are found near the sea surface.

FAA Response: Organisms such as fish and marine mammals living in the open ocean are not expected to be harmed by the small amounts of kerosene released by the Sea Launch project. Generally, these organisms avoid open water spills by going deeper in the water or around the edge of the spill. Marine mammals that live closer to shore, such

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[5] Personal communication with Mr. Bill Gibbons-Fly, NOAA Pacific Fishing Specialist

[6] Personal communication with Dr. Beth Flint, US Department of the Interior, Fish and Wildlife Services, Hawaiian and Pacific Islands NWR Complex

as turtles, seals, and dolphins could be impacted by a kerosene spill near the shore, however, the kerosene from the spent stages would not be released near or travel to any coastline.[7]

Comment 5

- Another possible impact of the proposed project would be a short disruption in commercial fishing activities in the immediate launch area prior to the launch. This area of the Pacific does receive some commercial fishing effort from the U.S. fishing fleet, particularly vessels out of Hawaii and U.S. Trust Territories fishing for large pelagic fish like yellowfin and albacore tuna. To avoid any disruption in fishing activity we would suggest that an advance notice to mariners be sent to U.S. vessels as soon as a launch date and time is scheduled.

FAA Response: Commercial launch operators throughout the world currently coordinate with affected governments and organizations to provide safety notices prior to each launch. For launches conducted under FAA authority, Notices to Mariners and Aviators are handled for all regions affected through the United States Coast Guard and our Central Altitude Reservation Function, respectively. Additionally, no launches would be conducted unless all fishing vessels are clear of the predetermined safety zone surrounding the Launch Platform. Visual and radar sensors will be used to verify this. The administrative details involved with issuing these notices will be worked out with the appropriate authorities.

Section 4.5.5 of the EA, "Coordination with Vessel and Air Traffic," indicates that Sea Launch would provide all necessary warnings to mariners and aviators potentially affected by its launch activity. In addition, several months before the first launch, Sea Launch Company intends to work with the Republic of Kiribati and representatives of industrial fishing fleets that operate in the region to coordinate the administrative process by which such notice would be given. Sea Launch Company would also like to work with SPREP and other appropriate groups in identifying how best to notify local fishing vessels.

Comment 6

- To avoid any possibility of interaction with marine mammals we suggest that FAA consider including some mitigation measures with the proposed project that include monitoring before and after each launch.

FAA Response: Hourly visual observations from the bridges of the M/V Commander and the M/V Odyssey (when manned) and from helicopter when the M/V Odyssey is under remote control is planned to note and attempt identification of any species of interest that might enter the area prior to a launch. Records will be kept of the number of individuals observed, the proximity to and duration in the observation area, and the creatures behavior, bearing, and speed. If the individual is expected to be within 100 meters or so of the M/V Odyssey during rocket ignition, the launch would be delayed

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[7] *Sensitivity of Marine Habitats,* U.S. Environmental Protection Agency, Oil Spill Program, Web site www.epa.gov/oerrpage/oilspill/habitats.html.

until it had left the area. Observations of mammals outside the 100 meter area would continue throughout the launch period and after launch to determine any behavior differences that might be caused by the Sea Launch operations.

Comment 7

- A monitoring program which included overflights before and after each launch would reduce the possibility of marine mammal interactions and provide additional information on any long term impacts to the surrounding marine environment.

FAA Response: Please see response Part A above.

Government of Australia[8]

Comment 1

- Zenit-3SL is not the best available technology.

FAA Response: The Zenit-3SL is the most advanced kerosene-liquid oxygen propulsion launch system in the global launch industry today. This is demonstrated by the fact that the Zenit-3SL and other systems produced by the Commonwealth of Independent States (CIS) are frequently selected by satellite launch operators and customers for use on performance, reliability, and cost criteria. This is particularly true regarding the engines, which are selected by launch providers throughout the world to place their satellite payloads in orbit. The launch industry in Russia and Ukraine is also responsible for developing an innovative design for the horizontal integration and handling and the automated pre-launch processing of the Zenit launch vehicle. These fundamental improvements – unprecedented for a rocket of its size - greatly reduce the number of people involved with the more hazardous steps in the process.

In addition, the kerosene-liquid oxygen propellant combination is considered to be equivalent or superior to alternative propellant systems in terms of safety for people and the environment, although there are pros and cons to any propellant system. For example, a liquid oxygen and liquid hydrogen system burns cleanly, but imposes additional risks to people and operational constraints. Hypergolic systems, in which the fuel and oxidizer ignite spontaneously when in contact with each other, and solid propellant systems provide good performance characteristics, but each impose their own safety, operational and emission concerns and constraints.

Thus, each launch system has advantages and disadvantages. In any event, we note that under NEPA the Environmental Documentation is required to inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the human environment. The Zenit – 3SL is the best available technology that meets the requirements for this project.

Comment 2

- Is Sea Launch meeting United States oil rig disposal standards with regards to flushing of the kerosene lines? And should stationary oil platform standards apply to Sea Launch?

FAA Response: Flushing kerosene lines is not performed as a normal operating procedure on the Launch Platform after fueling a launch vehicle, but only occurs in the unlikely event of an unsuccessful ignition attempt during launch. An unsuccessful ignition attempt would result in an automatic de-coupling of the fuel lines, resulting in the release of approximately 70 kg of kerosene. The structural members of the flame bucket are expected to contain the kerosene, although a small portion could splash over

[8] No formal written comments were received from the Government of Australia, these responses are based on conversations with Australian representatives.

and reach the ocean surface. It is estimated that this defueling would occur only once every 87,000 launches.

When the Launch Platform is on location for a launch in the equatorial Pacific Ocean, it could be construed to be a stationary platform. The applicability of various U.S. and international standards appropriate to stationary oil platforms were considered, including the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), the Act to Prevent Pollution from Ships (33 USC 1901-1911), and the Oil Pollution Act of 1990 (OPA 90).

Under the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), a discharge of any amount of kerosene would be prohibited (Regulation 21) and therefore subject to the reporting requirements outlined in Article 2 (6). In the unlikely event that the kerosene is released, Sea Launch would promptly report the incident in compliance with MARPOL requirements. As discussed in the EA, a discharge of this nature would have only minor and temporary effects on the surrounding surface waters.

The proposed Sea launch activities at the launch site do not come under the jurisdiction of the Act to Prevent Pollution from Ships, 33 USC 1901-1911, as the Launch Platform is flying under a Liberian flag in international waters..

The Oil Pollution Act of 1990 (OPA 90), Section 1002 regulates discharges that occur into or upon the navigable waters, adjoining shorelines, or within the exclusive economic zone of the United States. As Sea Launch will be launching from international waters, Section 1002 does not apply. Section 1007 addresses claims for discharges of oil in or on the territorial sea, internal waters, or adjacent shoreline of a foreign country. The Launch Platform will be located 544 nautical miles outside the territorial sea, and outside the exclusive economic zone of Kiribati and is therefore not subject to the requirements of Section 1007.